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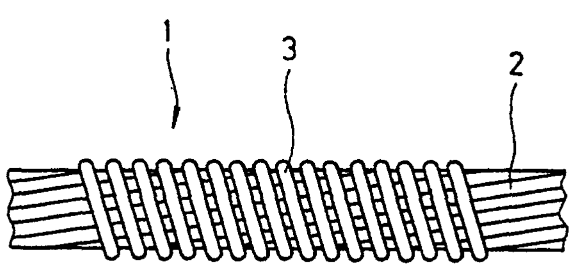
(54) Heat-generative electric wire.

(57) A heat-generative electric wire (1) comprising a Ni-Fe alloy wire member (3) which contains 45 to 80% by weight of Ni with the remaining portion being substantially Fe and which is wound on or stranded with the outermost layer of an overhead electric wire (2) exhibits adequate heat generation at low power transmission to melt adhered snow or ice and permits high power transmission without excessive heat generation.

Fig. 1



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HEAT-GENERATIVE ELECTRIC WIRE

This invention relates to a heat-generative electric wire capable of preventing the adherence and accumulation of snow or ice to and on overhead electric wires.

When snow or ice attaches to an overhead electric wire, the snow or ice extends and grows along the stranded groove of the overhead electric wire, and may finally develop into an extremely large cylindrical form of snow or an extremely large lump of ice. As a result, the load on the overhead electric wire increases and may thereby cause wire accidents such as breakage of the overhead electric wire and/or the fall of pylons.

A proposed solution to this problem involves a plurality of snow-adherence suppression rings being disposed at regular intervals in the longitudinal direction of the periphery of the overhead electric wire. This prevents the attached snow or ice from extending along the stranded groove and causes it to fall before it becomes excessively large. However, with this method, there is the problem that vinyl plastic hothouses, cars or the like lying directly below the overhead electric wire may be damaged by the fall of snow or ice.

Therefore various other methods have been proposed to solve the problem. For example, there is proposed a method of melting snow or ice on overhead electric wires by winding a magnetic substance on the wires. The magnetic substance generates heat by eddy current loss caused by the electric field of the current which flows in the overhead electric wire (Japanese Patent Disclosure No. 58-44609). Fe- and Ni-alloys such as Fe-Ni, Fe-Ni-Cr, Ni-Al, Ni -Si and Ni-Cr are preferred materials for the above magnetic substance.

The amount of heat generated by the above magnetic alloy varies signif icantly depending on the amount of electric power transmitted by the overhead electric wire. Generally, the heat generated is small when the amount of power transmitted is small, and tends to increase as the amount of power transmitted becomes larger.

However, adherence of snow or ice to overhead electric wires seldom occurs during the daytime when the amount of power transmitted is large. Also heat is generated by the resistance of the overhead electric wire itself, due to the large amount of power transmitted. Snow or ice tends to accumulate during the period of time between night and morning when the amount of power transmitted is small and the heat generated is low. Therefore, with the conventional magnetic alloy, the amount of heat generated is small when the amount of power transmitted is small and a sufficiently large melting effect of snow or the like cannot be attained.

Further, conventional overhead electric wire using the above magnetic alloy is excessively heated in the daytime by heat generation due to the resistance of the overhead electric wire itself and heat generation by the magnetic alloy, so that the temperature of the overhead electric wire may be excessively raised. As a result, the amount of transmission power in the overhead electric wire must be restricted, which could be problematic.

Further, electrolytic corrosion and rusting may occur in the overhead electric wire, depending on the composition of the magnetic alloy wound round the overhead electric wire, thereby reducing the effective diameter.

SUMMARY OF THE INVENTION

An object of this invention is to provide a heat-generative electric wire which can generate an amount of heat, even in the case of low electric power transmission, which is sufficiently large to melt snow or ice attached thereto and to prevent the formation of a cylindrical form of snow or lump of ice, but which does not generate excessive heating where a large amount of electric power is transmitted.

Another object of this invention is to provide a heat-generative electric wire in which electrolytic corrosion of an overhead electric wire due to the magnetic alloy is suppressed.

A still another object of this invention is to provide a heat-generative electric wire on which the magnetic alloy can be easily wound.

The inventors of this invention devoted themselves to research in view of the above and found that certain Ni-Fe alloys are suitable materials as the magnetic alloy. They made further experiments and researches to find that these Ni-Fe alloys may have different heat generating characteristics in cases where the power transmission is small and large, depending on the amount of Ni contained therein.

According to one embodiment of the invention there is provided heat-generative electric wire comprising a Ni-Fe alloy wire member containing 45 to 80 % by weight of Ni with the remaining portion being substantially Fe and which is wound on or stranded with the outermost layer of an overhead electric wire. The alloy wire member may, for example contain a small amount (e.g. up to 1% by weight) of Mn, Cr, Al, Si or the like in addition to Fe as the remaining portion.

Preferably, the Ni-Fe alloy wire member has a metal coating formed on the surface thereof.

The aforementioned and other objects, feature and advantages of the present invention will become more apparent from the following detailed description based on teh accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view showing a heat-generative electric wire of this invention;

Fig. 2 is a circuit diagram of an energization circuit used for energization testing of the heat-generative electric wire of Fig. 1;

Fig. 3 is a heat generation characteristic diagram in a case where the values of energizing current in the Ni-Fe alloy wire members containing different amounts of Ni are changed;

Fig. 4 is a side view of a heat-generative electric wire having a Ni-Fe alloy wire member wound in a direction different from that in the heat-generative electric wire shown in Fig. 1;

Fig. 5 is a cross sectional view of a heat-geneative electric wire having Ni-Fe alloy wire members stranded with strands on the outermost layer of an overhead electric wire;

Fig. 6 is a heat generation characteristic diagram of a Ni-Fe alloy wire member in a heat-generative electric wire in a case where a Zn coating is formed on the Ni-Fe alloy wire member wound on the overhead electric wire and in a case where such a Zn coating is not formed;

Fig. 7 is a side view showing a heat-generative electric wire having a Ni-Fe alloy wire member pre-formed in a spiral form and mounted thereon;

Fig. 8 is a heat generation characteristic curve diagram depending on the difference in the pitch of the Ni-Fe alloy wire member mounted in the heat-generative electric wire of Fig. 7;

Fig. 9 is a side view of a Ni-Fe alloy wire member pre-formed of three wires integrally formed in a spiral configuration;

Fig. 10 is a side cross sectional view showing the state in which a protection member is mounted on the end portion of a Ni-Fe alloy member wound on the overhead electric wire; and

Fig. 11 is a cross sectional view taken along the lines XI-XI of Fig. 10.

DETAILED DESCRIPTION

It has been found that Ni-Fe alloy wire members wound on or stranded with the outermost layer of an overhead electric wire tend to generate an excessive amount of heat at high power transmission levels when the amount of Ni contained therein is less than 45% by weight (which is hereinafter simply expressed by %). Furthermore, the amount of heat generated when the power transmitted is low tends to be inadequate if the amount of Ni is more than 80%, thereby preventing a sufficiently effective snow or ice melting effect from being attained. The content of Ni in alloys used in accordance with the invention is thus 45-80%, more preferably 47 to 54% and most preferably, 50 to 52%.

Since the Ni-Fe series alloy wire member has a large relative magnetic permeability, it generates a sufficient amount of heat to melt snow or ice even where the power transmitted along the overhead electric wire is small. Further, since the Ni-Fe alloy wire member may reach magnetic saturation (when the magnetic flux density B of the magnetic metal wire member is saturated) by a weak magnetic field H, the heat generated does not alter substantially even if the power transmitted becomes large. Thus it is unnecessary to limit the power transmitted to suppress excessive temperature rise in the overhead electric wire. Therefore, the heat-generative electric wire of this invention may provide a sufficiently large snow or ice melting effect even in the period of time from midnight to early morning during which the power transmitted is small and snow or ice adherence may easily occur. Further, in the daytime when the power transmitted is larger, it does not cause an accelerated temperature rise of the overhead electric wire.

EMBODIMENT 1

As shown in Fig. 1, one embodiment of a heat-generative electric wire 1 of this invention has a Ni-Fe alloy wire member 3 wound on the outermost layer of a overhead electric wire 2. Heat-generative electric wires 1 were formed by winding Ni-Fe alloy wire members 3 containing various amounts of Ni onto the overhead electric wire 2 formed of aluminum conductor steel reinforced (ACSR) having a cross sectional area of 610 mm^2 . The surface temperature of the alloy wire member 3 at the time of conducting current through the overhead electric wire 2 was measured.

The amount of Ni contained in the alloy wire member 3 was set to 35, 40, 46, 51, 60, 70 and 80 % producing seven cold-extended wire members with a diameter of 2.6 mm. These were sequentially would at regular intervals on the overhead electric wire 2 in a direction opposite to that of the stranding direction of the outermost layer thereof. Then, as shown in Fig. 2, the heat-generative electric wire 1 having seven kinds of alloy wire members 3 wound thereon was connected to a current supplying transformer 4. The surface temperatures of the alloy wire members 3 were measured when A.C. currents of 100 A and 800 A were supplied to the overhead electric wire 2 in a thermostatic laboratory kept at -4 °C.

In this case, the alloy wire members 3 were wound on the overhead electric wire 2 at a distance of more than 1 m from one another so as to prevent mutual thermal influence. In measuring the surface temperature, a thermocouple was used and the surface temperatures measured by the thermocouple were recorded by use of a chopper bar type recorder.

The result of the measurement is shown in Fig. 3. In Fig. 3, the abscissa indicates the content (%) of Ni and the ordinate indicates the surface temperature (°C) of each alloy wire member 3. As is clearly understood from Fig. 3, in the heat-generative electric wire 1 of this invention having the Ni-Fe series alloy wire member with the Ni content of 45 to 80 % wound thereon, the surface temperature of each alloy wire member 3 was raised to such a temperature as to melt snow, that is, to 10 to 18 °C even when the amount of current supply was as small as 100 A. Further, when the power transmission was as large as 800 A, the surface temperature of each alloy wire member 3 fell in a temperature range of 20 to 45 °C.

In contrast, in the heat-generative electric wire having a Ni-Fe alloy wire member with a Ni content of 35 or 40 % wound thereon, the temperature was excessively raised when the power transmission was large, and the surface temperature was extremely low when the power transmission was small. The surface temperatures of the alloy wire member 3 were respectively approx. 2 °C and 3 °C when the power transmission amount was 100 A, and respectively approximately 140 °C and 80 °C when the power transmission amount was 800 A.

Further, as shown in Fig. 4, each of the alloy wire members 3 was wound on the overhead electric wire 2 in a stranding direction of the outermost layer. The surface temperature of each alloy wire member 3 was measured in the same manner as in the former embodiment. Substantially the same result as in the former embodiment was obtained. There occurred no difference in the amount of generated heat even when the Ni-Fe series alloy wire member 3 was wound on the overhead electric wire in any direction with respect to the stranding direction of the outermost layer thereof.

In the above embodiment the heat-generative electric wire 1 has the Ni-Fe alloy wire member 3 wound on the outermost layer of the overhead electric wire 2, but similar snow melting effects may be obtained when the Ni-Fe series alloy wire members 3 are stranded with strands 2a constituting the outermost layer of the overhead electric wire 2 as shown in Fig. 5. In a case where the alloy wire members 3 are stranded with the strands 2a, it is preferable equally to distribute the Ni-Fe alloy wire members 3 amongst the strands 2a constituting the outermost layer in a ration of 1:3 to 1:2 by number.

Further, in the above embodiment, a circular-form wire having a circular section is illustrated as the Ni-Fe alloy wire member 3, but a wire of any other desired form, such as a wire having a rectangular section or a tape-like wire, can be used.

EMBODIMENT 2

Cold-drawing wire members containing 50.5 to 52%, of Ni, 0.20 to 0.35% of Mn, less than 0.20% of Si and Fe as the remaining portion and having a diameter of 2.6 mm were used as the alloy wire member 3, and a Zn coating was formed to a thickness of 0.035 mm on the alloy wire member 3 by plating. The alloy wire members 3 were wound on the overhead electric wire 2 constructed in the same manner as in the embodiment 1 in a direction opposite to that of the stranding direction of the outermost layer thereof. Then, the overhead electric wire 2 was connected to the current supplying transformer 4 shown in Fig. 2 under the same measurement condition as in the embodiment 1, and A.C. currents of 50 A, 80 A, 100 A, 150 A and 200 A were supplied thereto. Then, a temperature rise ΔT which is the difference between the room temperature (-4 °C) and the surface temperature of the alloy wire member 3 after the current supply was measured.

The result is shown in Fig. 6 together with the measurement result used as a comparison example and relating to a heat-generative electric wire having the alloy wire member 3 with no Zn coating but otherwise being of the same composition wound thereon. In Fig. 6, the abscissa indicates a current value (A), the ordinate indicates the temperature rise ΔT (°C), and the results of this invention and the comparison example are respectively indicated by Δ and O. As is clearly seen from Fig. 6, in the heat-generative electric wire, the heat generation amount increases by approx. 20 % maximum when a Zn coating is formed on the alloy wire members 3, and thus the snow or ice melting effect can be enhanced.

Further, antirust tests were effected in which salt water was sprayed for 1500 hours onto heat-generative electric wire 1 having either alloy wire members 3 with a Zn coating or alloy wire members 3 without a Zn coating while currents (100A) were supplied to them. As a result, the heat-generative electric wire 1 having alloy wire members without a Zn coating showed an electrolyte corrosion phenomenon between the overhead electric wire 2 and the alloy wire member, and mu rust occurred in the overhead electric wire 2, thus reducing the effective diameter. On the other hand, in the case of the heat-generative electric wire 1 having alloy wire members 3 with a Zn coating, the water repellency was enhanced and occurrence of rust due to the electrolyte corrosion was not observed.

EMBODIMENT 3

Fig. 7 shows an embodiment in which the alloy wire member 3 is pre-formed in a spiral form with a preset pitch, and this alloy wire member 3 is preferable since it can be rapidly mounted on an overhead electric wire 2 which has already been constructed, for example.

Alloy wire members 3 having various pitches from 1.5 up to five times the diameter D of the overhead electric wire 2 and previously formed in a spiral form were prepared. They were mounted on the respective overhead electric wires 2 having a cross sectional area of 610 mm^2 and formed in the same manner as in the embodiment 1 as shown in Fig. 7. The temperature rise ΔT caused when an A.C. current of 100 A was supplied was measured.

The heat generation characteristic curve obtained as the result is shown in Fig. 8. In Fig. 8, the abscissa indicates a winding pitch P (mm) expressed by the multiple of the diameter D (mm) and the ordinate indicates the temperature rise ΔT ($^\circ C$). The winding pitch P was set to 1.3D, 1.5D, 2.1D, 2.6D, 3.0D, 3.3D, 4.2D and 4.9D.

Assuming that the temperature rise ΔT due to current supply needs to be 9 $^\circ C$ in order to attain sufficient heat generation for melting snow or ice attached to the electric wire, then, as seen from Fig. 8, the pitch P (mm) at which the alloy wire member 3 is wound on the overhead electric wire 2 is preferably set in the range of 1.5 to 3 times the diameter D of the overhead electric wire 2 indicated by an arrow in Fig. 8.

However, in a case where the winding pitch P is less than 1.5 times the diameter D, it becomes difficult to mount it on the overhead electric wire 2. On the other hand, in a case where the pitch P exceeds three times the diameter D, the heat generation amount is abruptly reduced, causing an undesirable result. Further, if Zn or other metallic coatings are previously formed on the pre-formed alloy wire members 3, the water repellency and corrosion resistance thereof can be enhanced.

Further, a plurality of alloy wire members 3, for example, as shown in Fig. 9, three alloy wire members 3 can be integrally pre-formed in a spiral form with a pitch of 1.5 to 3 times the diameter D of the overhead electric wire 2. In addition, the three alloy wire members 3 integrally pre-formed in a spiral form can be coated with Zn or other metals on the surface thereof.

In each of the above embodiments, protection members 5 shown in Figs. 10 and 11 are preferably mounted on both ends of the alloy wire member 3 wound on the overhead electric wire 2 to protect the overhead electric wire 2.

The protection member 5 is formed of semispherical half-divided bodies 6 and 7 coupled by use of a hinge. The half-divided bodies 6 and 7 respectively have recesses 6a and 7a formed in the respective inner portions, and they are coupled by a bolt 8 and a nut 9 fixed in grooves 6b and 7b formed in the outer central portions thereof. The protection member 5 is disposed to shield the end of the alloy wire member 3 arranged as shown in Fig. 10 with the recesses 6a and 7a previously filled with filler 10 such as grease, silicone-series filler or the like.

Occurrence of corona discharge between the overhead electric wire 2 and the alloy wire member 3 can be prevented by mounting the protection member 5. Further, the alloy wire member 3 wound on the overhead electric wire 2 can be prevented from becoming loose.

Claims

1. A heat-generative electric wire comprising a Ni-Fe alloy wire member which contains 45 to 80% by weight of Ni with the remaining portion being substantially Fe and which is wound on or stranded with the outermost layer of an overhead electric wire.

2. A heat-generative electric wire according to claim 1, wherein said Ni-Fe alloy wire member contains 47 to 54% by weight of Ni.

3. A heat-generative electric wire according to claim 2, wherein said Ni-Fe alloy wire member contains 50 to 52% by weight of Ni.

4. A heat-generative electric wire according to any of claims 1 to 3, wherein said Ni-Fe alloy wire member is pre-formed in a spiral form with a preset pitch.

5. A heat-generative electric wire according to claim 4, wherein said pre-formed spiral comprises a plurality of wire members integrally formed.

6. A heat-generative electric wire according to claim 4 or claim 5, wherein the winding pitch of said pre-formed spiral is 1.5 to 3 times the diameter of said overhead electric wire.

7. A heat-generative electric wire according to any of claims 1 to 3, wherein said Ni-Fe alloy wire members are equally distributed amongst the

strands constituting the outermost layer of the overhead electric wire.

8. A heat-generative electric wire according to claim 7, wherein the ratio of said Ni-Fe alloy wire members to the strands constituting the outermost layer of the electric wire is 1:4 to 1:2 by number.

9. A heat-generative electric wire according to any of claims 1 to 8, wherein said Ni-Fe alloy wire member has a protection member mounted on the winding end of said heat-generative electric wire

10. A heat-generative electric wire according to any of claims 1 to 9, wherein said Ni-Fe alloy wire member has a metal coating on the surface thereof.

11. A heat-generative electric wire according to claim 10, wherein said metal coating is Zn.

12. A method for the manufacture of a heat-generative electric wire wherein a pre-formed spiral of Ni-Fe alloy wire as defined in any of claims 4 to 6 is applied to an overhead electric wire.

13. A process as claimed in claim 12 wherein one or more protection members are applied to said heat-generative electric wire.

Fig. 1

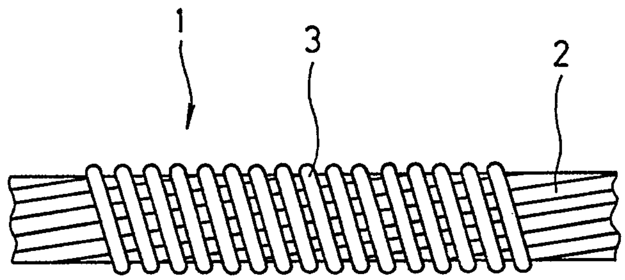


Fig. 2

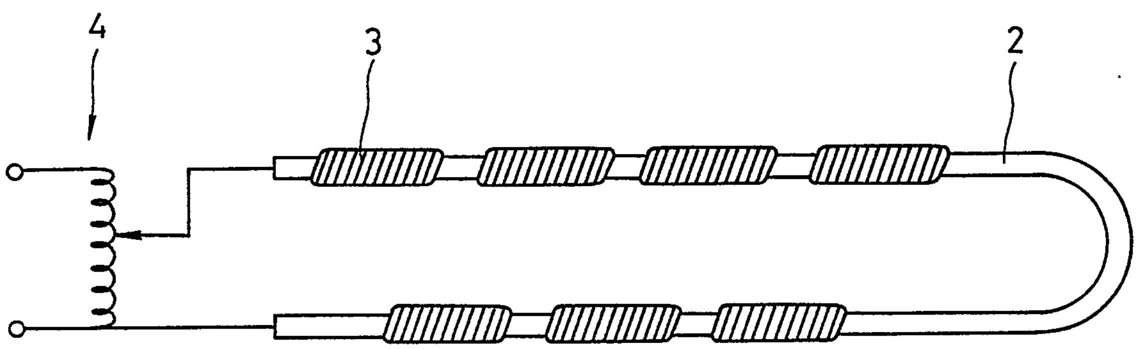


Fig. 3

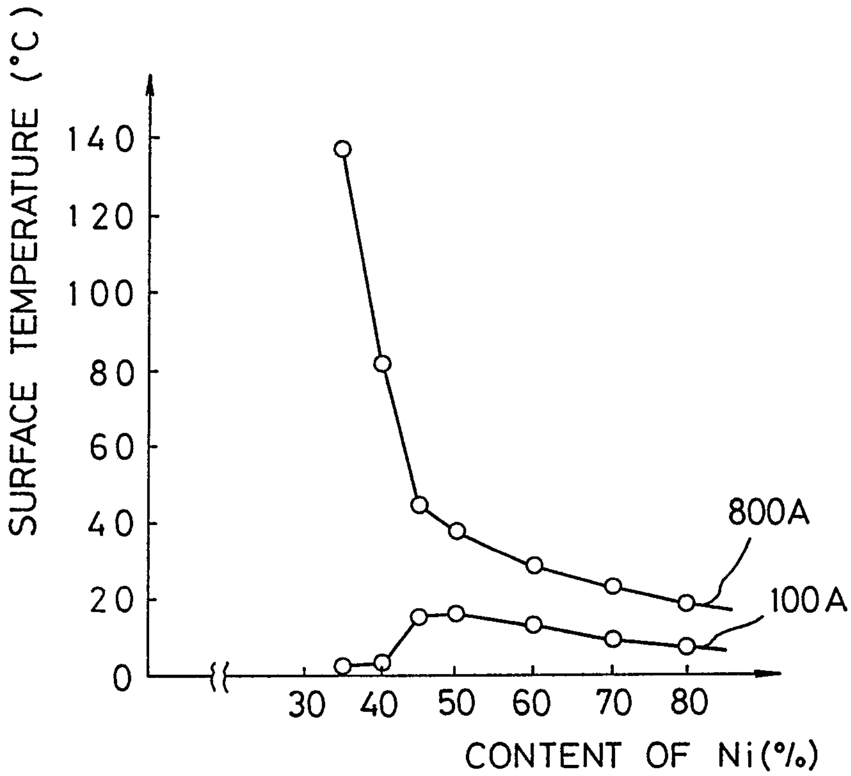

SURFACE TEMPERATURE (°C)
140
120
100
80
60
40
20
0
30
40
50
60
70
80
CONTENT OF Ni(%)
800A
100A

Fig. 4

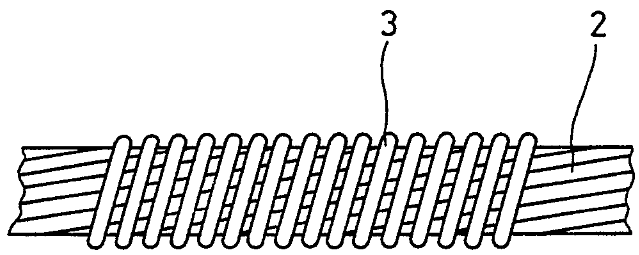

3
2

Fig. 5

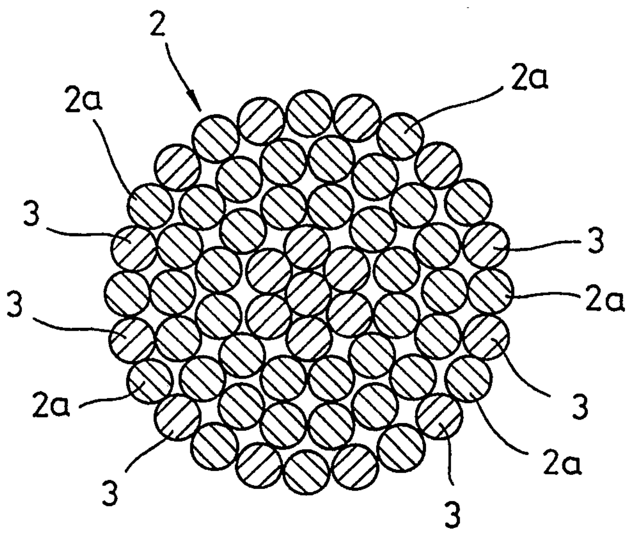

2
2a
2a
3
3
3
2a
3
2a
3
3
2a
3

Fig. 6

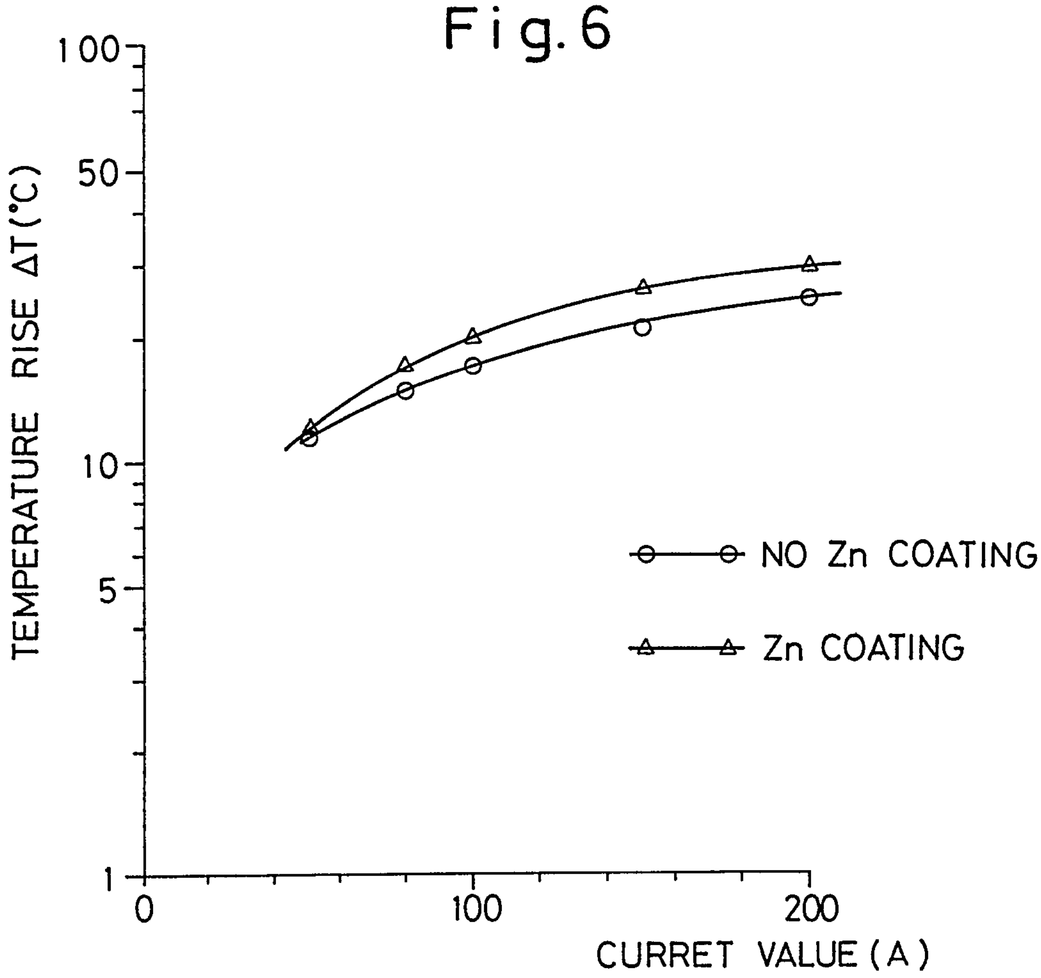

100
50
10
5
1
0
100
200
TEMPERATURE RISE ΔT(°C)
CURRET VALUE (A)
NO Zn COATING
Zn COATING

Fig. 7

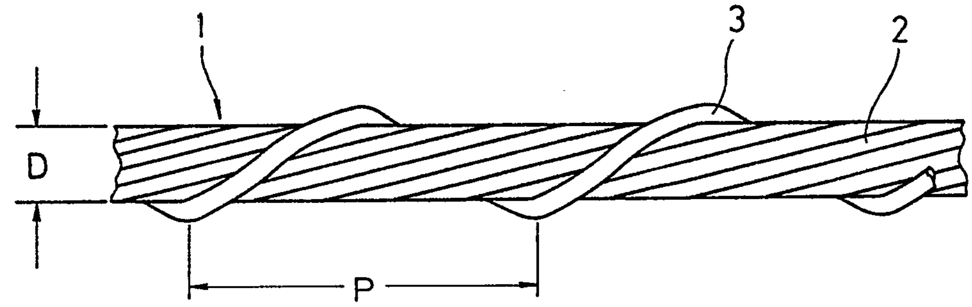

1
3
2
D
P

Fig. 8

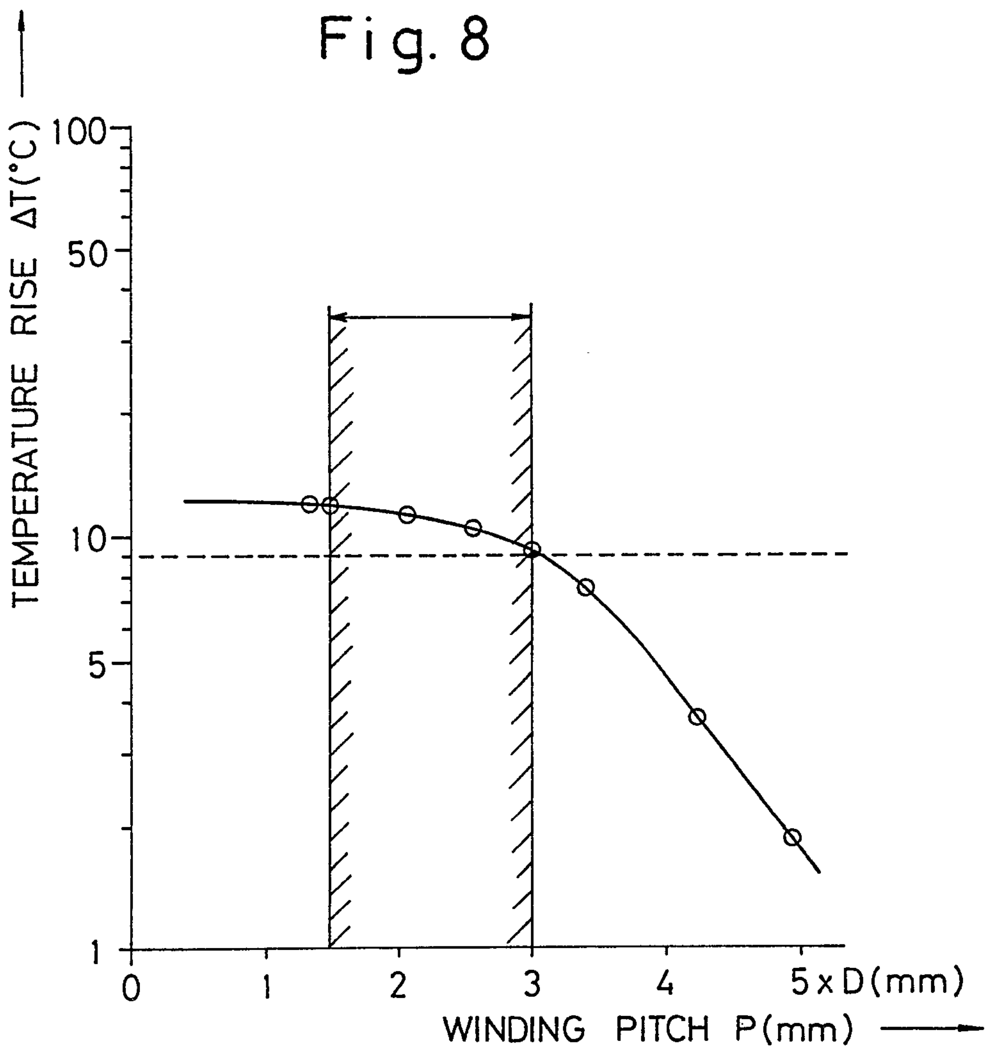

TEMPERATURE RISE ΔT(°C)
100
50
10
5
1
0
1
2
3
4
5 x D(mm)
WINDING PITCH P(mm)

Fig. 9

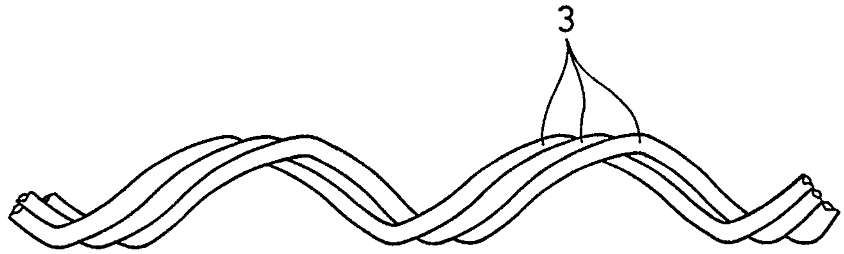


Fig. 10

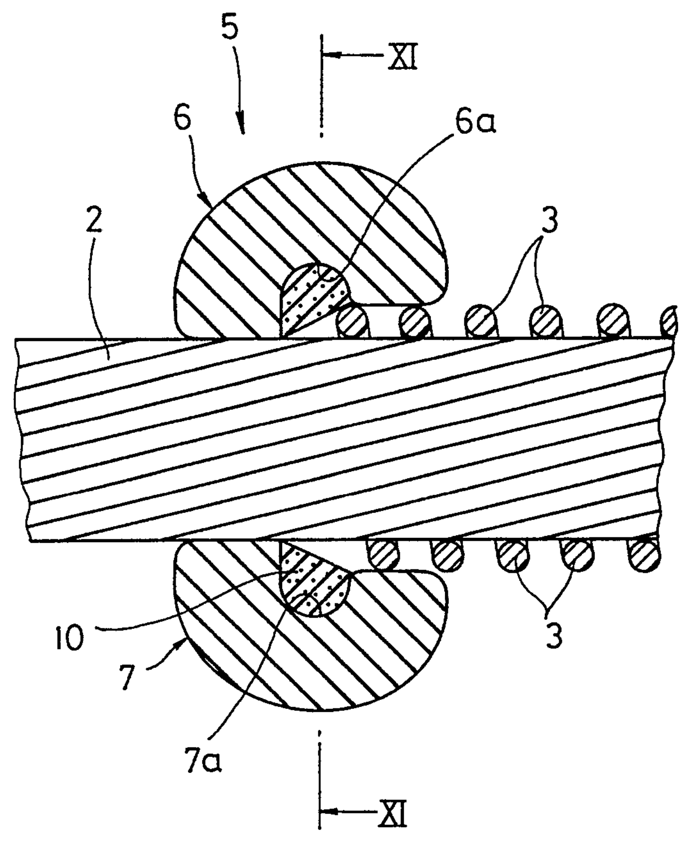
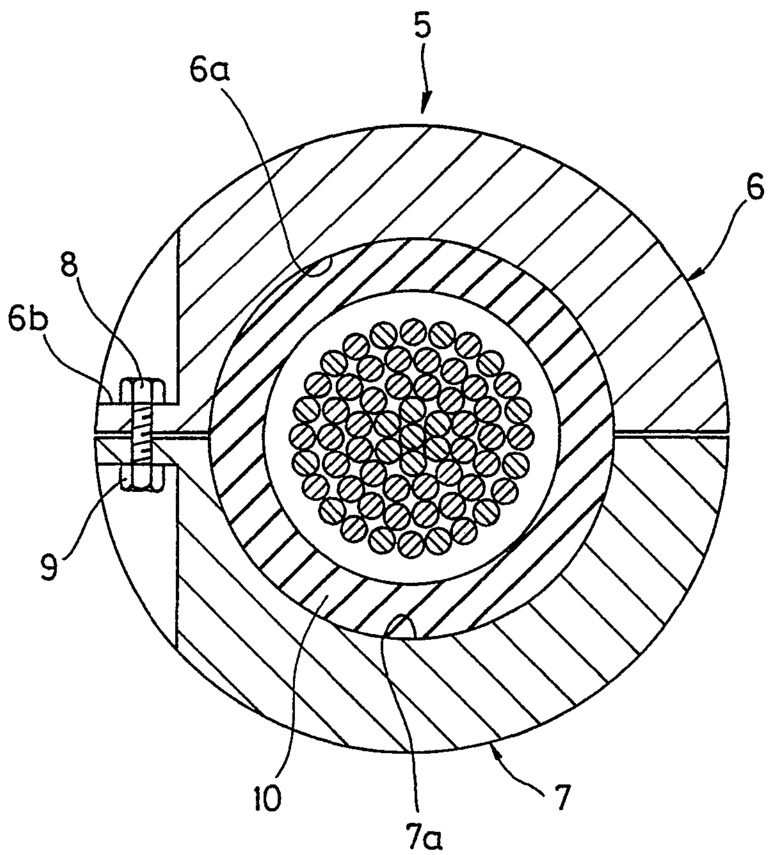


Fig. 11



European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 90303675.4

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US - A - 4 100 673 (LEAVINES) * Abstract; claim 1; fig. 4 * --	1	H 05 B 1/00 H 02 G 7/16
A	US - A - 4 605 819 (WARBURTON) * Abstract; column 3, lines 8-25; claims; fig. 1-3 * --	1	
A	FR - A1 - 2 332 674 (ACIM JOUANIN) * Claims; fig. * --	1	
A	DE - B2 - 2 206 138 (THE FURUKAWA ELECTRIC) * Column 5, lines 13-25; fig. 4 * ----	1	

TECHNICAL FIELDS SEARCHED (Int Cl.5)

H 01 B 5/00
H 02 G 7/00
H 05 B 1/00
H 05 B 3/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	11-07-1990	TSILIDIS

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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