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H02H 9/02 (2006.01) *H01F 6/02* (2006.01)

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(54) Title: HIGH TEMPERATURE SUPERCONDUCTOR TAPE FOR QUENCH DETECTION IN SUPERCONDUCTING MAGNETS

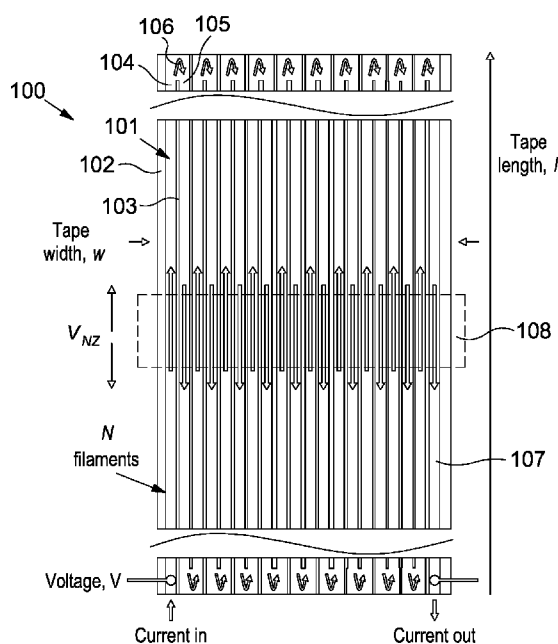


Figure 1

(57) Abstract: A high temperature superconductor, HTS, tape (100) for detecting a quench in a superconducting magnet. The HTS tape comprises an HTS layer (101) of HTS material supported by a substrate (102). The HTS layer is divided into a plurality of strips (104, 105, 107). The strips are connected (106) in series along an open path.

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- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

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INTERNATIONAL SEARCH REPORT

International application No

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A. CLASSIFICATION OF SUBJECT MATTER

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H01F6/02

ADD.

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)

H01B H01L H02H 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 practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015/148236 A1 (WANG CONNIE P [US] ET AL) 28 May 2015 (2015-05-28)	1-5
A	abstract paragraphs [0001] - [0002], [0013] - [0034]; figures 1-3	26,27
X	EP 1 622 209 A1 (NEXANS [FR]) 1 February 2006 (2006-02-01) abstract paragraphs [0017] - [0031], [0037] - [0067]; claim 7; figures 1,2	1-4,9,20
X	WO 2015/116289 A2 (VARIAN SEMICONDUCTOR EQUIPMENT [US]) 6 August 2015 (2015-08-06) abstract paragraphs [0021] - [0049]; figures 1-3	1-9,18
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Further documents are listed in the continuation of Box C.



See patent family 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 application or patent but published on or after the international filing date

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"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

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB2018/050800

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2018/050800

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2001/015880 A1 (HEISMANN BJORN [DE]) 23 August 2001 (2001-08-23) paragraphs [0022] - [0029]; figures 1-3 -----	1-4,9,19
A	JP 2014 229753 A (CHUBU ELECTRIC POWER; UNIV WASEDA) 8 December 2014 (2014-12-08) abstract paragraphs [0022] - [0032]; figures 1-4 -----	10-17, 21-25
A	US 2010/254047 A1 (MARTCHEVSKII MAXIM [US]) 7 October 2010 (2010-10-07) abstract figure 1 -----	10,13, 21,22
A	JP H05 327042 A (HITACHI LTD) 10 December 1993 (1993-12-10) abstract figure 1 -----	10,13, 21,22
A	KR 2011 0001214 A (KOREA BASIC SCIENCE INST [KR]) 6 January 2011 (2011-01-06) abstract figures 1,2 -----	17

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2018/050800

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015148236 A1	28-05-2015	US 2015148236 A1	28-05-2015
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KR 20110001214 A	06-01-2011	NONE	

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-9, 18-20

A high temperature superconductor, HTS, tape for detecting a quench in a superconducting magnet, the HTS tape comprising an HTS layer of HTS material supported by a substrate, the HTS layer being divided into a plurality of strips, the strips being connected in series along an open path (claim 1), wherein the strips are connected within the HTS layer by the HTS material (claim 3), wherein the plurality of strips are separated by non-superconducting barriers of the HTS material (claim 5), wherein the non-superconducting barriers are non-superconducting as a result of thermal damage to the HTS material (claim 6).

2. claims: 10-17, 21-25

A Wheatstone bridge circuit for detecting a quench in a superconducting magnet, the circuit comprising a current supply; two half-bridge sections connected across the current supply in parallel, each half-bridge section comprising an HTS tape according to claim 1 arranged as two non-overlapping arms connected in series at a node, each arm comprising a continuous section of the open path of the HTS tape; and a voltage sensor connected between the nodes of each half-bridge section (claims 10-12,21); or a quench protection system for use with a superconducting magnet having at least one primary coil comprising high temperature superconductor, HTS, material, the system comprising a secondary HTS tape according to claim 1; a detection unit configured to detect onset of a loss of superconductivity in the secondary HTS tape; and a quench protection unit configured to cause energy to be dumped from the primary coil to an external resistive load in response to said detection (claims 13-17); or a method of protecting a superconducting magnet from quenches, the superconducting magnet having at least one primary coil comprising high temperature superconductor, HTS, material, the method comprising providing a secondary HTS tape according to claim 1; detecting onset of a loss of superconductivity in the secondary HTS tape by detecting a voltage difference in excess of a predetermined value between two points of the secondary HTS tape; and in response to said detection, dumping energy from the primary coil into an external resistive load (claims 22-25).

3. claims: 26, 27

A method of producing a high temperature superconductor, HTS, tape for detecting a quench in a superconducting

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

magnet, the HTS tape comprising an HTS layer of HTS material supported by a substrate, the HTS material being coated with a stabiliser layer comprising stabiliser material, the method comprising selectively directing laser radiation on to the stabiliser layer to form non-superconducting barriers of the HTS material which divide the HTS layer into a plurality of strips connected in series along an open path.
