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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
2 May 2013 (02.05.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/062428 A1

(51) International Patent Classification:
G01N 27/83 (2006.01) *B66B 7/12* (2006.01)
G01N 27/90 (2006.01)

(21) International Application Number:
PCT/PL2012/000110

(22) International Filing Date:
22 October 2012 (22.10.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
P.396732 24 October 2011 (24.10.2011) PL

(71) Applicant: **AKADEMIA GÓRNICZO-HUTNICZA IM. STANISŁAWA STASZICA** [PL/PL]; Al. Mickiewicza 30, PL-30-059 Kraków (PL).

(74) Agent: **WOŹNIAK, Jolanta**; Kancelaria Rzecznikowska Patent, ul. Bobrzyńskiego 31a/1, PL-30-348 Kraków (PL).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*

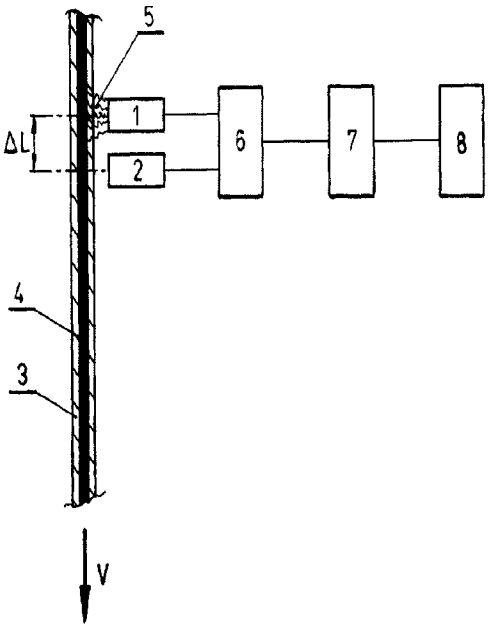
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

— *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))*

(54) Title: SYSTEM FOR CONTINUOUS DETECTION OF CORD DEFECTS IN FLAT STEEL-PLASTIC ELEVATOR ROPES



(57) Abstract: A system for continuous detection of cord defects in flat steel-plastic elevator ropes comprises an integrated measuring head with pulsed inductor (1) of variable magnetic field and detector (2) of stray field (5), a signal processing block (6), a signal analyser (7) and a data carrier (8). The inductor (1) and the detector (2) are situated over the surface of the rope (3), deployed along cords (4) and along direction of motion (V) of the rope (3) one by one at a small distance (AL) from each other.

WO 2013/062428 A1

System for continuos detection of cord defects in flat steel-plastic elevator ropes

The present invention relates to a diagnostic system for continuous detection of cord defects in flat steel-plastic ropes to be used particularly for the purpose of operating inspection of passenger elevators and goods lifts as well as conveyor belts reinforced with steel cords and circular cross-section cables used in cableway transport systems.

Recent development in the vertical transport technology resulted in introduction of systems eliminating the upper machinery room and employing ropes in the form of flat bands made of steel cords arranged in parallel and fixed with respect to each other by means of covering them with an elastic plastic, typically polyurethane. In the year 200, OTIS company has introduced an new solution for passenger elevator drive systems known as Gen2, using a gearless power winch and steel-polyurethane ropes in the form of 3 mm-thick tension bands with 12 cords, each 1.5 mm in diameter and made of 7 strands spliced in turn of 7 zinc-plated steel wires with diameter of 0.175 mm and embedded in polyurethane. Safety regulations applicable to rope-based transport systems impose special requirements in scope of particularly careful inspection concerning condition of their load-carrying components. The solution revealed in the European patent application EP2299251 uses the magnetic energy for diagnosing degradation of cords in flat steel-plastic ropes. The measuring head has permanent magnets that generate continuously, as the belt-shaped rope moves, a constant magnetic field with its circuit being closed through steel cords along the rope section between longitudinally deployed N–S poles. The measurement of variations in the magnetic field intensity taken by the detector directly over the N–S region provides a picture of homogeneity and continuity of the rope's internal ferromagnetic structure through which the magnetic field lines are being closed. The head comprises a number of measuring systems assigned to each of the cords such that signals from detectors of those individual systems are electronically processed, successively, in a signal processing block and an analyser, and then registered in a data carrier. The results allows to determine technical condition of the rope with possibility to identify, by means of an encoder, the location in which the tension strength of the rope is deteriorated. Similar measuring system is employed in solution presented in description of Polish patent application PL207764 designed for on-line monitoring and location of defects in a reinforced belt lapping joints of a long conveyor composed of a large number of

sections connected to each other with their ends by means of vulcanisation or adhesive bonding. Solutions with heads generating permanent magnetic field and the circuit being closed along the rope are difficult to integrate in conditions where a belt-shaped rope's width is in the range 30–60 mm with small distance typically maintained between them.

The system for continuos detection of cord defects in flat steel-plastic elevator ropes according to the present invention is provided, just like as in the solution described above, with an integrated measuring head comprising a magnetic filed source and a field intensity sensor, a signal processing block, a signal analyser, and a data storage. The essence of the solution consists in that the measuring head comprises a variable magnetic field pulse inductor and a stray field detector situated over the surface and deployed along the cords along direction of motion of the rope one by one at a small distance from each other.

The measuring head encompasses preferably the whole width of the rope, giving thus, in the above-described operating conditions, a result representing the local tension strength for the whole rope length.

In particularly difficult operation conditions, wireless transmission of data between the signal processing block and the analyser, and possibly also between the analyser and the data carrier may turn out to be a preferable solution.

In the system according to the present invention, a defect is represented by a variation of intensity of stray field induced around the cords in the zone directly adjacent to the location where pulsed magnetic field variations occur. The assumed small distance between the stray field detector and the inductor is a guarantee for high damage detectability. At the same time, analysis of the detector's signal converted into information on field pulsation resulting from periodic structure of strands allows to determine the rope velocity thus eliminating the need of using an encoder.

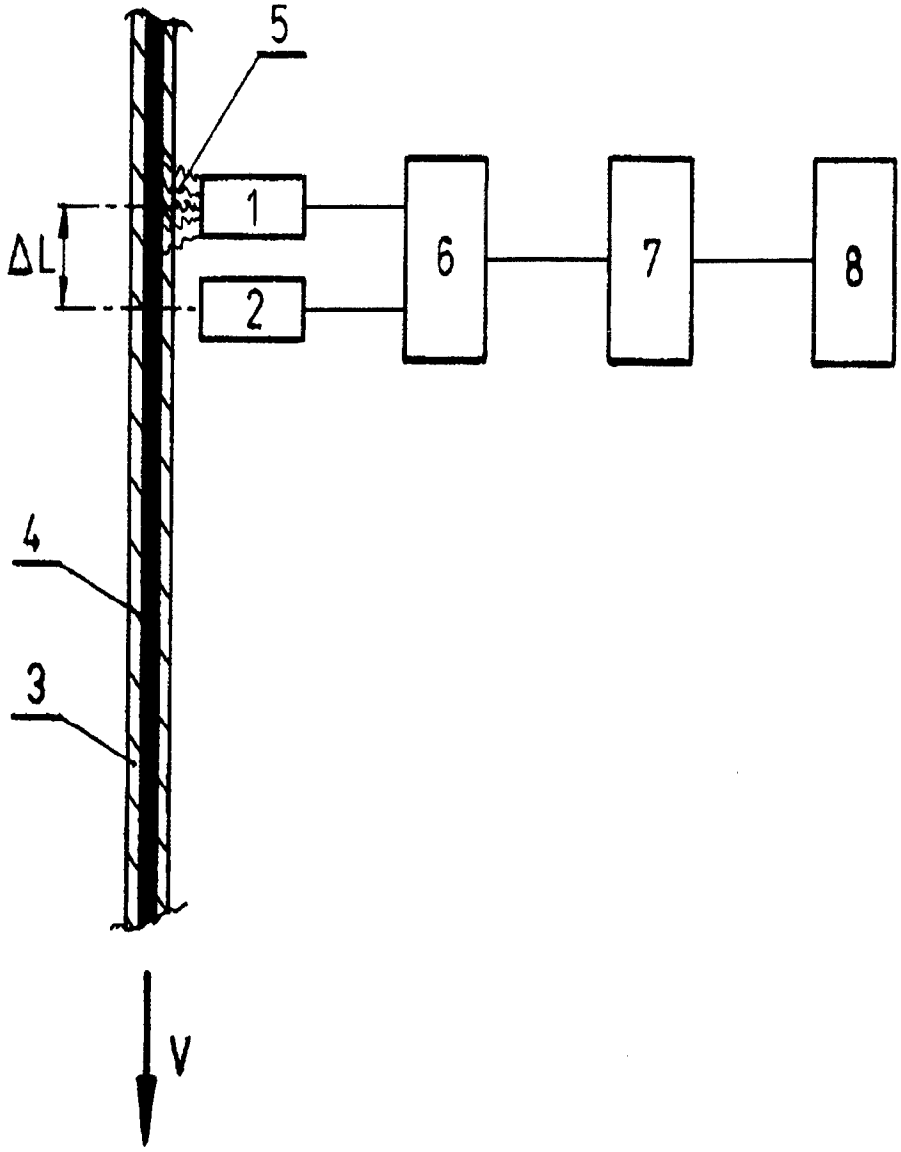
The invention is illustrated below by an example embodiment of the system for continuos detection of cord defects in flat steel-polyurethane rope presented schematically in the figure.

The system comprises a measuring head with a pulse inductor (1) of variable magnetic field and the detector (2) of stray field (5) mounted directly one by one at a small distance (ΔL) from each other along cords (4) and along direction of motion (V) of rope (3). The inductor (1) may be of eddy current or induction type, while the detector (2) contains measuring elements reacting to magnetic field intensity variations, preferably a Hall effect sensor or a thin film element. At a small distance (ΔL), magnetic field generated by inductor

(1) maintains intensity guaranteeing effective operation of detector (2) resulting in detection of flaws in cords (4) constituting the steel structure of rope (3). The signal from detector (2) representing variations of stray field (5) generated by a decrease of cross-section area of cords (4) is transferred to the signal processing block (6) and, after filtration, further to the signal analyser (7). Measuring zone of the head covers the whole width of rope (3), and the result defining indirectly the local tension strength of rope (3) is compared to a nominal reference level value. Results of inspection concerning technical condition of rope (3) are registered in a database stored in data carrier (9) and may be presented graphically if necessary.

Patent Claims

1. A system for continuos detection of cord defects in flat steel-plastic elevator ropes comprising an integrated measuring head with a magnetic field source and a field intensity sensor, signal processing block, signal analyser and data carrier, characterised in that its measuring head is composed of pulsed inductor (1) generating variable magnetic field and detector (2) of stray field (5) situated over the surface and deployed along cords (4) and along direction of motion (V) of rope (3) one by one at a small distance (ΔL) from each other.
2. A system according to claim 1 characterised in that the measuring head (1, 2) encompasses the whole width of rope (3).
3. A system according claim 1 characterised in that the signal processing block (6) is connected wirelessly with analyser (7).
4. A system according to any of claims 1 or 2 characterised in that the analyser (7) is connected wirelessly with data carrier (8).


5
1
2
ΔL
6
7
8
4
3
V

INTERNATIONAL SEARCH REPORT

International application No
PCT/PL2012/000110

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N27/83 G01N27/90 B66B7/12
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)
G01N B66B

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)

EPO-Internal, WPI Data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 253 954 A2 (BUSCH DIETER & CO PRUEFTECH [DE]) 24 November 2010 (2010-11-24) Figure 2 and description thereof	1-4
X	US 2005/285588 A1 (KATRAGADDA GOPICHAND [IN] ET AL) 29 December 2005 (2005-12-29) Figures 1,4,6 and description thereof	1-4
A	EP 2 299 251 A1 (OTIS ELEVATOR CO [US]) 23 March 2011 (2011-03-23) cited in the application the whole document	1-4
A	GB 2 152 218 A (AKAD GORNICZO HUTNICZA) 31 July 1985 (1985-07-31) Figure 3 and description thereof	1

☐ 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

"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
19 March 2013	02/04/2013

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, Fax: (+31-70) 340-3016	Meyer, Fred

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/PL2012/000110

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2253954 A2	24-11-2010	CN 101893601 A	24-11-2010
		DE 102009022138 A1	25-11-2010
		EP 2253954 A2	24-11-2010
		JP 2010271318 A	02-12-2010
		RU 2010119331 A	27-11-2011
		US 2010295545 A1	25-11-2010
US 2005285588 A1	29-12-2005	NONE	
EP 2299251 A1	23-03-2011	BR 0009371 A	26-12-2001
		CN 1351710 A	29-05-2002
		EP 1173740 A2	23-01-2002
		EP 2299251 A1	23-03-2011
		JP 4741734 B2	10-08-2011
		JP 2002540419 A	26-11-2002
		JP 2010204113 A	16-09-2010
		KR 20060097072 A	13-09-2006
		US 6633159 B1	14-10-2003
		US 2004046540 A1	11-03-2004
		WO 0058706 A2	05-10-2000
GB 2152218 A	31-07-1985	DE 3446667 A1	11-07-1985
		GB 2152218 A	31-07-1985
		PL 245502 A1	02-07-1985