

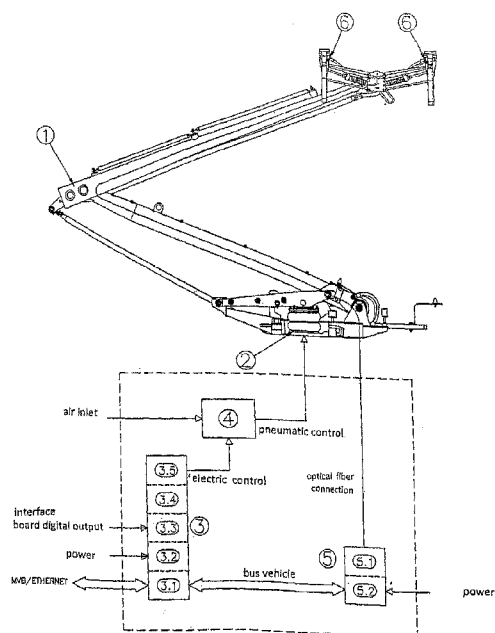


- (51) International Patent Classification:  
*B60L 5/28* (2006.01) *B60L 5/32* (2006.01)
- (21) International Application Number: PCT/IT2011/000378
- (22) International Filing Date: 17 November 2011 (17.11.2011)
- (25) Filing Language: Italian
- (26) Publication Language: English
- (30) Priority Data:  
NA2010A0000058 30 November 2010 (30.11.2010) IT
- (71) Applicant (for all designated States except US): **CONTACT S.R.L.** [IT/IT]; Via G. Porzio IS E/3, 80143 Napoli (IT).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **BORRIELLO, Gianfranco** [IT/IT]; Via Alcide de Gasperi n° 88, 81020 San Nicola La Strada (CE) (IT). **DIANA, Giorgio** [IT/IT]; Via dell'Ontano 4 A, 20090 Mille Pini di Rodano (MI) (IT). **COLLINA, Andrea** [IT/IT]; Via Moltoni n. 3, 20010 Milano (IT).
- (74) Agent: **CIRILLO, Gennaro**; Brevetti Ing. Cirillo G. & C. s.a.s., Via Santa Lucia n°15, 80132 Napoli (IT).
- (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, 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, 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, MD, 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).

**Published:**

— with international search report (Art. 21(3))

(54) Title: COMMAND SYSTEM FOR THE ACTIVE AND DIAGNOSTIC CONTROL OF A RAILWAY PANTOGRAPH



(57) Abstract: Command system for the active and diagnostic control of a railway pantograph that continuously controls the pressure in the pneumatic actuator and, thus, the contact force on the catenary. The system also realizes the diagnostic and the maintenance under condition of the pantograph and of the contact line by using optical sensors.

WO 2012/073266 A1

**COMMAND SYSTEM FOR THE ACTIVE AND DIAGNOSTIC CONTROL OF A RAILWAY PANTOGRAPH.**

The pantograph is the device that picks up in trains the current from the overhead feeder line.

For most of the vehicles in use, the thrust of the pantograph on the overhead supply line is determined by electropneumatic motor systems and by  
5 aerodynamic forces.

The users' demand for picking up systems more and more reliable and able to guarantee a suitable level in the quality of the picking up, in particular for high-speed trains, has brought about the necessity to develop a command system for the active and diagnostic control of railway pantographs.

10 The system, that constitutes the object of the present patent for industrial invention, allows the continuous control of the pantograph thrust as a function of the running parameters of the railway vehicle and realizes a diagnostic system able to detect and to prevent the faultiness of the pantograph and that of the contact line.

15 This continuous control of the pantograph thrust is carried out by operating on the pneumatic actuator which, in the case of a railway pantograph, consists of an air spring.

By continually controlling the pressure of the air spring it is possible to obtain, through the transfer function of the pantograph, the continuous  
20 control of its thrust.

Furthermore, it is possible to realize a diagnostic of the pantograph and of the contact line.

On the enclosed table a pantograph (1) is shown, with a diagram of the command system for the active and diagnostic control.

25 In particular, the active control of the pressure of the spring air (2) is realized by means of a proportional valve (4) that, under the command signal coming from the electronic control unit (3), governs, in a continuous way, the outgoing

pressure.

The command signal processed by the electronic control unit (3) is a function of the running parameters of the vehicle on which the pantograph is installed.

5 These running parameters of the train are transferred to the electronic control unit by the vehicle bus (MVB or ethernet) or by wired signals.

The running parameters of the train transmitted to the electronic control unit (3) and necessary to realize the continuous control function of the thrust are:

- lifting and lowering control of the pantograph,
- supply voltage of the overhead contact line,
- 10 • train speed,
- train direction,
- single or multiple picking up,
- train localization.

Under these input signals the control unit (3) processes a command current signal (typical value 4÷20mA) for the proportional valve (4).

The values of the command signals of the proportional valve, as a function of the train speed, characterize therefore the overhead contact line, the train direction and the single or multiple picking up.

It is also possible to process the command signal of the proportional valve (4) as a function of the train localization.

The proportional valve (4), as a function of the command of the control unit (3), supplies a continuous outgoing pressure (typical value 0÷5 bar) controlled by a pressure sensor placed on the outgoing pneumatic pipe of the valve itself.

25 Finally, the system composed by the control unit (3) and the proportional valve (4) supplies, as a function of the running parameters, a continuous pressure which is controlled as input by the pantograph air spring that brings about a continuous and controlled thrust of the pantograph on the catenary.

The standard configuration of the control unit (3) consists of the following boards:

- Micro board (3.1) with electric/optic interface MVB or electric interface Ethernet (bus-vehicle dialogue) and connection with diagnostic board (5).
- Board with analogue interface (3.5) (proportional valve command).
- 5 • Interface board digital input (3.3) (interface for digital input signals of the vehicle).
- Interface board digital output (3.4) (interface for digital output signals of the vehicle).
- Stabilized power supply (3.2).

10 The standard configuration of the proportional valve (4) consists of:

- a mechanic component to reduce the supply pressure to the outgoing pressure required by the control unit (3) for the selected pantograph;
- an electronic pilot system for the command and control of the mechanic component;
- 15 • a pressure sensor for the feedback on the outgoing pressure.

Apart from the continuous control of the thrust, the system includes a diagnostic (5) to register the failures of both the pantograph and the overhead contact line, bringing about their maintenance under condition.

20 The picking up systems nowadays in use do not include diagnostic systems able to measure the acceleration of the pantograph slidings and the dynamic parameters of the board.

The absence of this kind of diagnostic system on traditional pantographs is due to the fact that the pantograph is in tension (1,5-3-15-25kV), so that the use of traditional sensors that are electrically supplied is particularly onerous  
25 in terms of electric safety and installation costs.

With the new technologies it has been possible to use sensors that are completely optical and directly connected to the pantograph. These sensors solve all the problems of galvanic insulation and safety.

30 In particular, by using sensors that are completely optical, without electric supply and directly connected to the pantograph, it is possible to process, in

the domain of time and frequency, signals that are measured to evaluate the correct working of both the pantograph and the contact line.

The control unit (5), by processing the analogue signals coming from the optical sensors and interrelating them with the train speed and its geographic location, may transmit any information to the train diagnostic system, by means of a bus MVB/Ethernet, concerning possible faultiness of:

- picking up head,
- mobile frame,
- pantograph motor system (air spring),
- 10 • overhead supply line.

In its standard configuration, the diagnostic system measures and processes the acceleration signals of the pantograph single sliding bow.

The passband required for optical accelerometers is 0,5÷200 Hz and the sampling rate is equal to 2 Hz.

15 The processings required for the acceleration signals of each single sliding bow, interrelated to the train direction, location and speed are, for each km of line:

- total effective value,
- peak (max 10),
- 20 • effective value (typical) in 4 frequency bands (0,5÷4 Hz); (4÷20 Hz); (20÷100 Hz); (55÷65 Hz).

Furthermore, regarding the acceleration values measured for each km of line, a statistical processing of the registered accelerations is carried out by calculating the:

- 25 • mean,
- root-mean-square deviation,
- skewness,
- kurtosis.

If the processed values overcome the limit values, the relative data, combined with the train speed and location, are transmitted to the train diagnostic

30

through the bus vehicle.

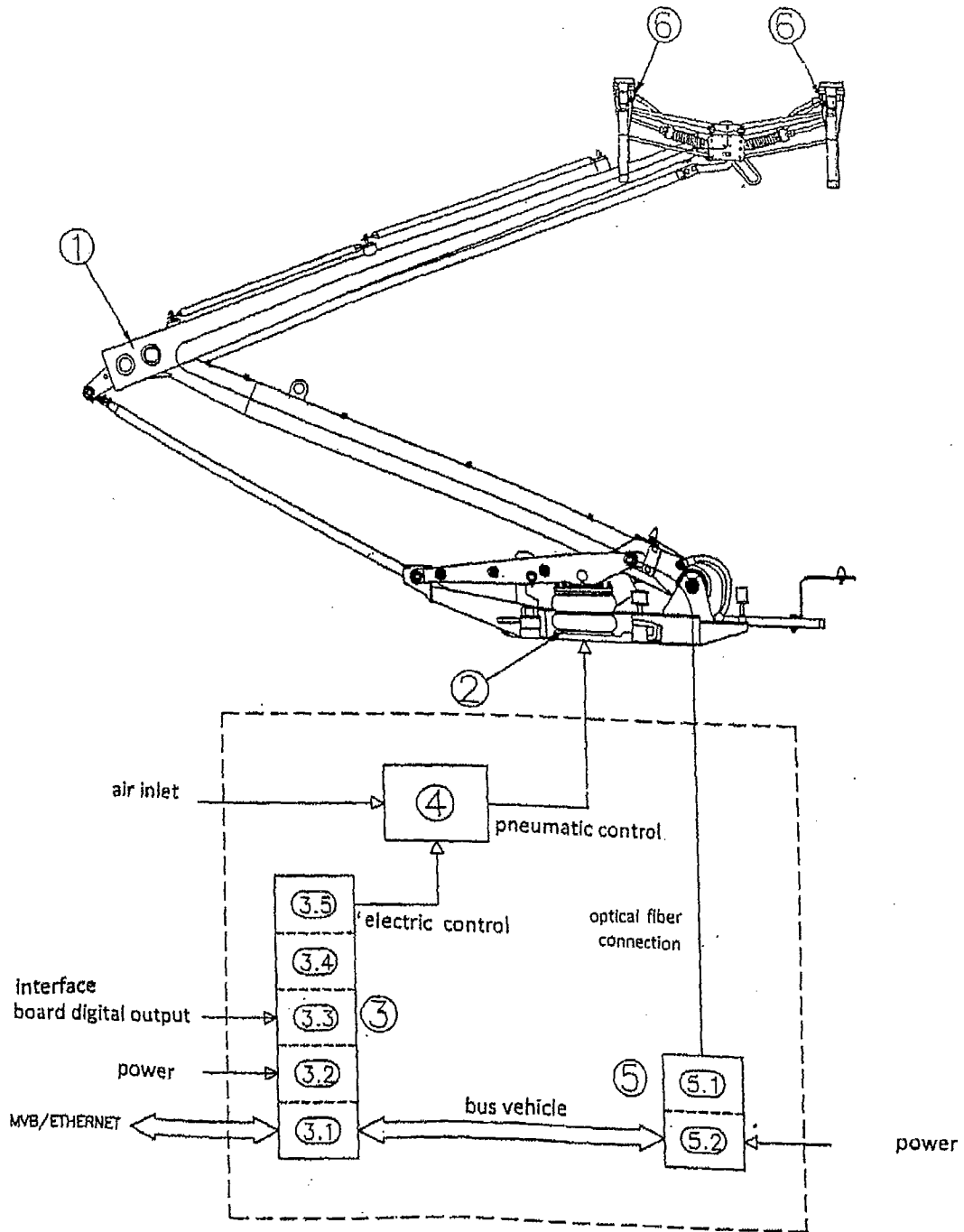
The standard configuration of the diagnostic system consists of:

- optical sensors (6) with fibre optics and connectors (standard configuration optical accelerometers),
  - 5 • board for the management of optical sensors (5.1) and the conversion in analogue electric signal (typical value 100mV/g),
  - board for the processing of analogue electric signal, data storage, connection to the central unit (5.2) and interface to the bus vehicle (option).
- 10 The main advantages of the command system for the active and diagnostic control are:
- improvement in the quality of the pantograph picking up, both in single and multiple picking up,
  - lower wear of the slidings,
  - 15 • lower aggression of the pantograph on the contact line,
  - diagnostic aimed at the maintenance under condition of the pantograph and contact line.

Formal and structural changes may be made to the patent, without departing from the solution idea that is defined by the following claims.

## CLAIMS

- 1) Active monitoring and diagnostics control system for railway pantograph characterized by the fact that it continuously monitors the pressure in the pneumatic actuator, and then, using the transfer function of the pantograph, the contact force on the catenary. This monitoring takes place through two sub-systems consisting of a special electronic control unit and proportional valve.
- 2) System, like the previous claim, characterized by the fact that it creates a device for detecting the pantograph and catenary defects thanks the use of optical sensors and special electronic diagnostic check control unit.
- 3) System, like the previous claims, characterized in that the electronic control units specified in claims 1) and 2) are the railway type and dialogue with the vehicle's BUS and each other.
- 4) System, like the previous claims, characterized in that the pantograph thrust monitoring control unit processes starting from the vehicle operation parameters such as speed, single or multi-tapping, the direction of train travel and a supply voltage of the contact line and location, the control signal to power the proportional valve continuously to regulate the pressure of the pneumatic actuator of the pantograph.
- 5) System, like the previous claims, characterized in that the diagnostic control unit sees to the processing from the optical sensors in the time and frequency domain.  
On the basis of such signals, related to the location of the convoy, the diagnostic system reports any faults of the pantograph or contact line and provides information for the maintenance on the condition of the pantograph and contact line.



# INTERNATIONAL SEARCH REPORT

International application No PCT/IT2011/000378
---

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> INV. B60L5/28                      B60L5/32 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) B60L		
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		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 605 214 A2 (HITACHI LTD [JP] HITACHI LTD [IE]; HITACHI LTD [JP]) 6 July 1994 (1994-07-06) figures 25, 29-32 -----	1-5
X	US 5 954 171 A (GRAMATKE KLAUS-DIETER [DE] ET AL) 21 September 1999 (1999-09-21) the whole document -----	1
X	DE 43 34 716 A1 (ABB PATENT GMBH [DE]) 13 April 1995 (1995-04-13) abstract column 4, line 28 - line 44 -----	1,2,5
X	FR 2 552 244 A1 (MONTAGNAT FRANCOIS [FR]) 22 March 1985 (1985-03-22) figure 2 -----	1
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> 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 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	
17 February 2012	23/02/2012	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Overdijk, Jaco	

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IT2011/000378

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0605214	A2	CN 1090538 A	10-08-1994
		DE 69315316 D1	02-01-1998
		EP 0605214 A2	06-07-1994
		US 5531301 A	02-07-1996
-----			
US 5954171	A	NONE	
-----			
DE 4334716	A1	NONE	
-----			
FR 2552244	A1	NONE	
-----			