(12) STANDARD PATENT (11) Application No. **AU 2016336151 B2**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Traction and braking control system for a railway train set

(51) International Patent Classification(s)
B60T 13/66 (2006.01) ***B60T 17/22*** (2006.01)

(21) Application No: **2016336151** (22) Date of Filing: **2016.10.07**

(87) WIPO No: **WO17/060858**

(30) Priority Data

(31) Number	(32) Date	(33) Country
102015000059848	**2015.10.09**	**IT**

(43) Publication Date: **2017.04.13**
(44) Accepted Journal Date: **2021.05.27**

(71) Applicant(s)
Faiveley Transport Italia S.p.A.

(72) Inventor(s)
Tione, Roberto;Grasso, Angelo

(74) Agent / Attorney
Phillips Ormonde Fitzpatrick, PO Box 323, COLLINS STREET WEST, VIC, 8007, AU

(56) Related Art
US 2010/0235022 A1
US 2016/0009304 A1
DE 102012108395 A1
DE 10249714 A1
US 5950967 A

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

CORRECTED VERSION

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
13 April 2017 (13.04.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/060858 A8

(51) International Patent Classification:
B60T 13/66 (2006.01) *B60T 17/22* (2006.01)

(21) International Application Number:
PCT/IB2016/056004

(22) International Filing Date:
7 October 2016 (07.10.2016)

(25) Filing Language: Italian

(26) Publication Language: English

(30) Priority Data:
102015000059848 9 October 2015 (09.10.2015) IT

(71) Applicant: **FAIVELEY TRANSPORT ITALIA S.P.A.** [IT/IT]; Via Volvera 51, I-10045 Piossasco (Torino) (IT).

(72) Inventors: **TIONE, Roberto**; Via Garibaldi 4, I-10020 Lauriano (Torino) (IT). **GRASSO, Angelo**; Via Saracco 36, I-14053 Canelli (Asti) (IT).

(74) Agents: **QUINTERNO, Giuseppe** et al.; c/o Jacobacci & Partners S.p.A., Corso Emilia 8, I-10152 Torino (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, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, 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, SA, 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, ST, 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, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

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

— *of inventorship (Rule 4.17(iv))*

Published:

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

(48) Date of publication of this corrected version:
17 August 2017

[Continued on next page]

(54) Title: TRACTION AND BRAKING CONTROL SYSTEM FOR A RAILWAY TRAIN SET

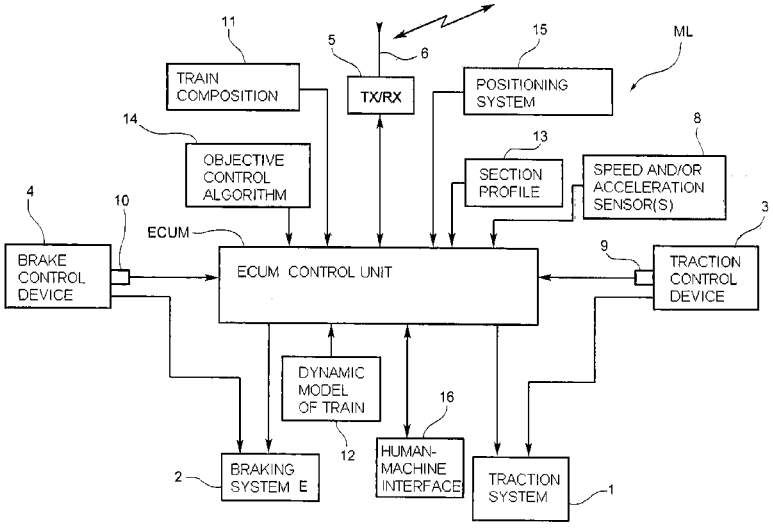

FIG. 2

(57) Abstract: Traction and braking control system for a train set (T) comprising a master locomotive (ML), at least one slave locomotive (SL) and a plurality of carriages (C), in which each of the locomotives (ML, SL) includes traction apparatus (1) and braking apparatus (2) associated with respective manually actuated control devices (3; 4) and a respective electronic control unit (ECUM; ECUS). The system is characterized that the control unit (ECUM) in the master locomotive (ML) is designed to check the consistency of the commands given by the driver using at least one operational device and to provide the driver with instructions on how to operate said control devices (3; 4) to achieve said operational objective; generate traction and/or braking control signals as a function of the stored data, and send said control signals to the control unit (ECUS) of the slave locomotive (SL).

WO 2017/060858 A8

(15) Information about Correction:
see Notice of 17 August 2017

Traction and braking control system for a railway train set

The present invention relates to a traction and braking control system for a railway train set.

More specifically, the present invention relates to a traction and braking control system for a railway train set comprising a leading master locomotive, at least one trailing or intermediate slave locomotive and a plurality of carriages or cars, and provided with a pneumatic braking system, in which each of said locomotives comprises braking and traction apparatus associated with respective manual control devices and a respective electronic control unit and related transceiver means through which the electronic control unit of the master locomotive is able to communicate with the control unit of said at least one slave locomotive; the arrangement being such that the traction and braking apparatus of the at least one slave locomotive can be controlled by the master locomotive.

In existing railway train sets, all of the locomotives operate synchronously, i.e. the slave locomotive or locomotives execute all of the traction and braking control commands given by the driver of the leading master train set.

This control system has the advantage of being extremely simple to operate, and the driver of the leading locomotive drives the train set as if it were a head-end train.

However, such systems have a limited capacity to control slack action. Indeed, on certain section profiles, such control systems may not be able to limit the occurrence of significant longitudinal forces between the vehicles that make up the train set, in extension or in compression, resulting in dangerous stresses and accident risks.

Devices to help with driving and event recording that are designed to "predict" the future state of a train set on the basis of the traction and braking commands given by the driver are known. However, such systems are based on the ability of the driver to use personal experience to "interpret" the predictive information provided and to subsequently give commands.

Such systems also fail to address the problem of controlling slack action of the train set in track sections with "difficult" route profiles.

A reference herein to a patent document or any other matter identified as prior art, is not to be taken as an admission that the document or other matter was known or that the information it contains was part of the common general knowledge as at the priority date of any of the claims.

One aspect of the present invention is to propose a traction and braking control system for a railway train set of the type defined above that has been improved to enable a more effective management of the issues set out above.

According to an aspect of the present invention, there is provided a traction and braking control system for a railway train set comprising a leading master locomotive, at least one trailing or intermediate slave locomotive and a plurality of carriages or cars wherein the railway train set is provided with a pneumatic braking system, said leading master locomotive and said at least one trailing or intermediate slave locomotive comprise traction apparatus and braking apparatus, the traction apparatus and the braking apparatus being associated with respective manual control devices a respective electronic control unit and signal transceivers through which the electronic control unit of the leading master locomotive is able to communicate with the electronic control unit of said at least one trailing or intermediate slave locomotive; the traction apparatus and the braking apparatus of the at least one trailing or intermediate slave locomotive being controlled by the leading master locomotive, wherein the control unit in the master locomotive is associated with:

- one or more sensor means designed to provide said electronic control unit in the leading master locomotive with signals indicating the speed and/or acceleration of the leading master locomotive and the commands given by the driver to the traction braking control devices,
- memory modules storing data indicating composition of the railway train set, data defining a mathematical model of the longitudinal dynamics of the railway train set, as well as data defining a profile of a section on which the railway train set is travelling, and data defining at least one predetermined operational objective;

- a positioning system providing signals indicating an instantaneous position of the railway train set along said section; and
- a human-machine interface for providing information to the driver;

the electronic control unit of the leading master locomotive being designed to

check whether the instructions given by the driver using the traction control devices and the braking control devices are consistent with said operational objective, and to use the human-machine interface to provide the driver with instructions on how to operate said traction control devices and said braking control devices to achieve said at least operational objective; and

- generate, in a predetermined manner and as a function of the data stored in said memory modules and information provided by said one or more sensors and said positioning system, signals for controlling traction and/or braking, and to transmit said control signals to the electronic control unit of said at least one trailing or intermediate slave locomotive through said signal transceiver means.

In one embodiment, the control unit of the master locomotive is also designed to generate, in a predetermined manner and as a function of the data stored in said memory module and the information provided by the one or more sensors and said positioning system, signals for controlling traction and braking, and to use said signals to control the traction apparatus and the braking apparatus of the leading master locomotive.

Further characteristics and advantages of the system according to the invention are set out in the detailed description below, provided purely as a non-limiting example and with reference to the attached drawings, in which:

Figure 1 is a partial schematic side view of a railway train set provided with a traction and braking control system according to the present invention;

Figure 2 is a block diagram showing the equipment of the leading master locomotive of a railway train set provided with a control system according to the present invention; and

Figure 3 is a similar block diagram showing the control equipment of each slave locomotive of a railway train set provided with a control system according to the present invention.

In Figure 1, reference sign T indicates the railway train set as a whole, including a leading master locomotive ML and at least one intermediate or trailing slave locomotive SL, as well as a plurality of cars or carriages C.

In the embodiment shown schematically in Figure 1, the locomotives ML and SL are electric locomotives powered by and overhead conductor CC via respective pantographs P. However, the invention is not limited to application to train sets including such locomotives.

The train set T is provided with a pneumatic braking system of a known type, in which all of the vehicles in the train set are connected together pneumatically by a brake pipe that is kept at a predetermined pressure, for example 5 bar, and keeps the brakes of all of the vehicles open.

A pressure drop in the brake pipe, caused by actuating a brake cock in the driving cab of the master locomotive ML, is propagated throughout the entire train set and reaches the braking equipment on the individual vehicles. A distributor in said vehicles, which is

usually associated with a control cylinder and an auxiliary cylinder, causes air to enter the brake cylinders, thereby braking the train set.

A subsequent pressure increase in the brake pipe again releases the brakes on the train set.

The block diagrams in Figures 2 and 3 illustrate the key elements of the equipment on the leading master locomotive ML and respectively a slave locomotive SL of the train set T.

As shown in said figures each of the locomotives ML and SL have respective traction apparatus 1 and braking apparatus 2, which are associated with corresponding control devices 3 and 4 that can be actuated manually in the cab by a driver.

Each locomotive ML and SL is also provided with a respective electronic control unit ECUM and ECUS and with related transceiver devices 5 to enable said electronic units to communicate with one another.

In the embodiment shown by way of example, the transceiver devices are able to communicate with one another by radio, using a respective antenna 6. However, this solution is not mandatory, and communication between said transceiver devices may be achieved using other channels, such as cables or optical fibres.

In the traction and braking control system according to the invention, the control unit ECUM of the master locomotive ML is associated with sensor devices 8 designed to provide same with electrical signals indicating the speed and/or acceleration of said locomotive.

The control unit ECUM of the master locomotive ML is also linked to detector devices 9 and 10 designed to provide signals indicating the commands given by the driver of said locomotive using the traction control devices 3 and, respectively, the braking control devices 4.

The control unit ECUM is also associated with memory devices 11 storing data describing

the composition of the train set T, and other memory devices 12 containing data used to define a mathematical model of the longitudinal dynamics of the train set T.

Other memory devices 13, which are also associated with the unit ECUM, store data that are used to define the profile of the section on which the train set T is travelling.

Other memory devices 14 associated with the control unit ECUM are used to store data defining a control algorithm and at least one predetermined operational objective.

Although the block diagrams in Figures 2 and 3 show the memory devices 11–14 as external to the control units ECUM and ECUS, said memory devices may also be built into said control units.

With reference to Figure 2, the control unit ECUM of the master locomotive ML is also associated with positioning devices 15 that are designed to provide signals indicating the instantaneous position of said locomotive, and therefore of the train set T, along the aforementioned section. The positioning devices may be inertial and/or satellite platforms (GPS and similar), or other systems.

The unit ECUM is also linked to a human-machine interface 16 that is designed to provide information/instructions to the driver of the master locomotive ML.

This control unit ECUM is designed to control the traction and braking of the train set T in the manner described below.

Said unit ECUM is in particular designed to check that the commands given by the driver of the master locomotive ML (and therefore of the train set T) are consistent with a predetermined operational objective stored in the memory devices 14.

This operational objective may for example be to reduce the dynamic stresses exchanged between the different vehicles that make up the train set T during train movement.

An alternative or additional operational objective may for example be maintaining a constant assigned speed in a track section subject to a speed limit.

The consistency of the commands given by the driver using the traction and braking control devices 3, 4 with the aforementioned operational objectives is checked using the information contained in the memory devices 11–14 (composition of the train set T, mathematical model of the dynamic behaviour of the train set T, section profile, control algorithm and operational objectives), the information provided by the positioning system 15, and the information provided by the detector devices 9 and 10 associated with the traction and braking control devices 3, 4.

The control unit ECUM is also designed to use the information received from the devices 8–15 to generate traction and/or braking control signals for the slave locomotive or locomotives SL. Said control signals are sent to the control unit ECUS of at least one slave locomotive SL using the transceiver devices 5, 6.

In each slave locomotive SL, the traction and braking control signals from the control unit ECUM of the master locomotive ML are received by the local control unit ECUS, which then controls the traction system 1 and the braking system 2 of the corresponding slave locomotive SL accordingly.

In the embodiment described thus far, control of the traction and braking of the master locomotive ML is left completely to the driver, and the control unit ECUM can be arranged appropriately to provide said driver, by means of the human-machine interface 16, with information/recommendations regarding the consistency of the commands given by the driver with the operational objective or objectives assigned.

Conversely, the traction and braking of each of the slave locomotives SL is entirely dependent on the commands provided by the control unit ECUM of the master locomotive ML and sent to the control unit ECUS of the corresponding slave locomotive SL.

In another embodiment, traction and control of the master locomotive ML is controlled in

part using the commands given manually by the driver using the control devices 3 and 4, and in part using control signals generated by the unit ECUM on the basis of information provided to said unit by the devices 8–15.

This "mixed" traction and braking control method for the master locomotive ML helps to optimize management of the movement of the train set.

The control and decision algorithm implemented by the control unit ECUM can be implemented using artificial-intelligence techniques, for example using neural networks or Petri nets.

The control system according to the present invention helps to optimize management of the longitudinal dynamics of the train set T as a function of the profile of the section being travelled, and to improve the performance of such a train set under specific circumstances (starting, braking, skid conditions, etc.).

Comparison of the block diagrams in Figures 2 and 3 shows how the equipment architecture in each slave locomotive SL is similar to the equipment architecture in the master locomotive ML.

In general, to implement the aforementioned control methods, each slave locomotive SL only strictly requires the devices shown in Figure 3 using an unbroken line.

Nonetheless, it may be beneficial for all of the locomotives, ML and SL, to be fitted with the same equipment that can be operated selectively as master locomotive equipment or slave locomotive equipment, such that each locomotive can, as required, be used as a leading master locomotive or an intermediate or trailing slave locomotive. Accordingly, the equipment architecture shown in Figure 3 can therefore be augmented by adding the devices shown in said figure using a dotted line, which are indicated using the same reference signs as used in Figure 2.

Naturally, notwithstanding the principle of the invention, the means of implementation and

the specific embodiments may vary greatly from that described and illustrated purely by way of a non-limiting example, without thereby moving outside the scope of the invention as defined in the attached claims.

Where any or all of the terms "comprise", "comprises", "comprised" or "comprising" are used in this specification (including the claims) they are to be interpreted as specifying the presence of the stated features, integers, steps or components, but not precluding the presence of one or more other features, integers, steps or components.

The claims defining the invention are as follows:

1. A traction and braking control system for a railway train set comprising a leading master locomotive, at least one trailing or intermediate slave locomotive and a plurality of carriages or cars, wherein the railway train set is provided with a pneumatic braking system, said leading master locomotive and said at least one trailing or intermediate slave locomotive comprise traction apparatus and braking apparatus, the traction apparatus and the braking apparatus being associated with respective manual control devices a respective electronic control unit and signal transceivers through which the electronic control unit of the leading master locomotive is able to communicate with the electronic control unit of said at least one trailing or intermediate slave locomotive; the traction apparatus and the braking apparatus of the at least one trailing or intermediate slave locomotive (SL) being controlled by the leading master locomotive,

and wherein the electronic control unit in the leading master locomotive is associated with:

- one or more sensors designed to provide said electronic control unit in the leading master locomotive with signals indicating the speed and/or the acceleration of the leading master locomotive and the commands given by a driver to traction control devices and braking control devices;

- memory modules storing data indicating composition of the railway train set, data defining a mathematical model of the longitudinal dynamics of the railway train set, data defining a profile of a section on which the railway train set is travelling, and data defining at least one operational objective;

- a positioning system providing signals indicating an instantaneous position of the railway train set along said section; and

- a human-machine interface for providing information to the driver;

the electronic control unit of the leading master locomotive being designed to

- check whether the commands given by the driver using the traction control devices and the braking control devices are consistent with said at least one operational objective, and to use the human-machine interface to provide the driver with instructions on how to operate said traction control devices and said braking control devices to achieve said at least operational objective; and

2016336151 23 Apr 2021

- generate, in a predetermined manner and as a function of the data stored in said memory modules and information provided by said one or more sensors and said positioning system, signals for controlling traction and/or braking, and to transmit said control signals to the electronic control unit of said at least one trailing or intermediate slave locomotive through said signal transceivers.

2. The control system according to Claim 1, wherein the electronic control unit (ECUM) of the leading master locomotive is also designed to generate, in a predetermined manner and as a function of the data stored in said memory modules and the information provided by said one or more sensors and said positioning system, signals for controlling traction and braking, and to use said signals to control the traction apparatus and the braking apparatus of the leading master locomotive.

3. Control system according to Claim 1 or 2, wherein each electronic control unit of the at least one trailing or intermediate slave locomotive is associated with the same one or more sensors, memory modules, positioning system and human-machine interface that are also associated with the electronic control unit of the leading master locomotive; the electronic control units of the leading master locomotive and of the at least trailing or intermediate slave locomotive being designed to operate selectively as a master control unit or as a slave control unit.

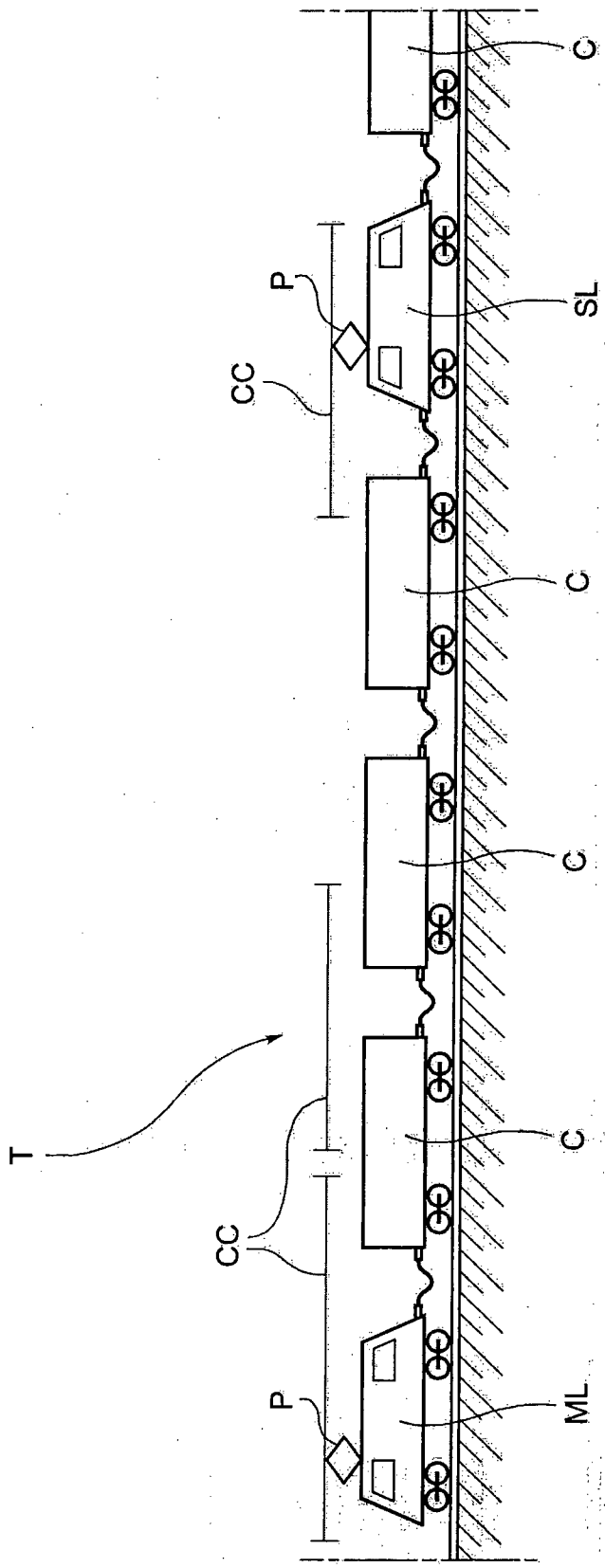

FIG. 1

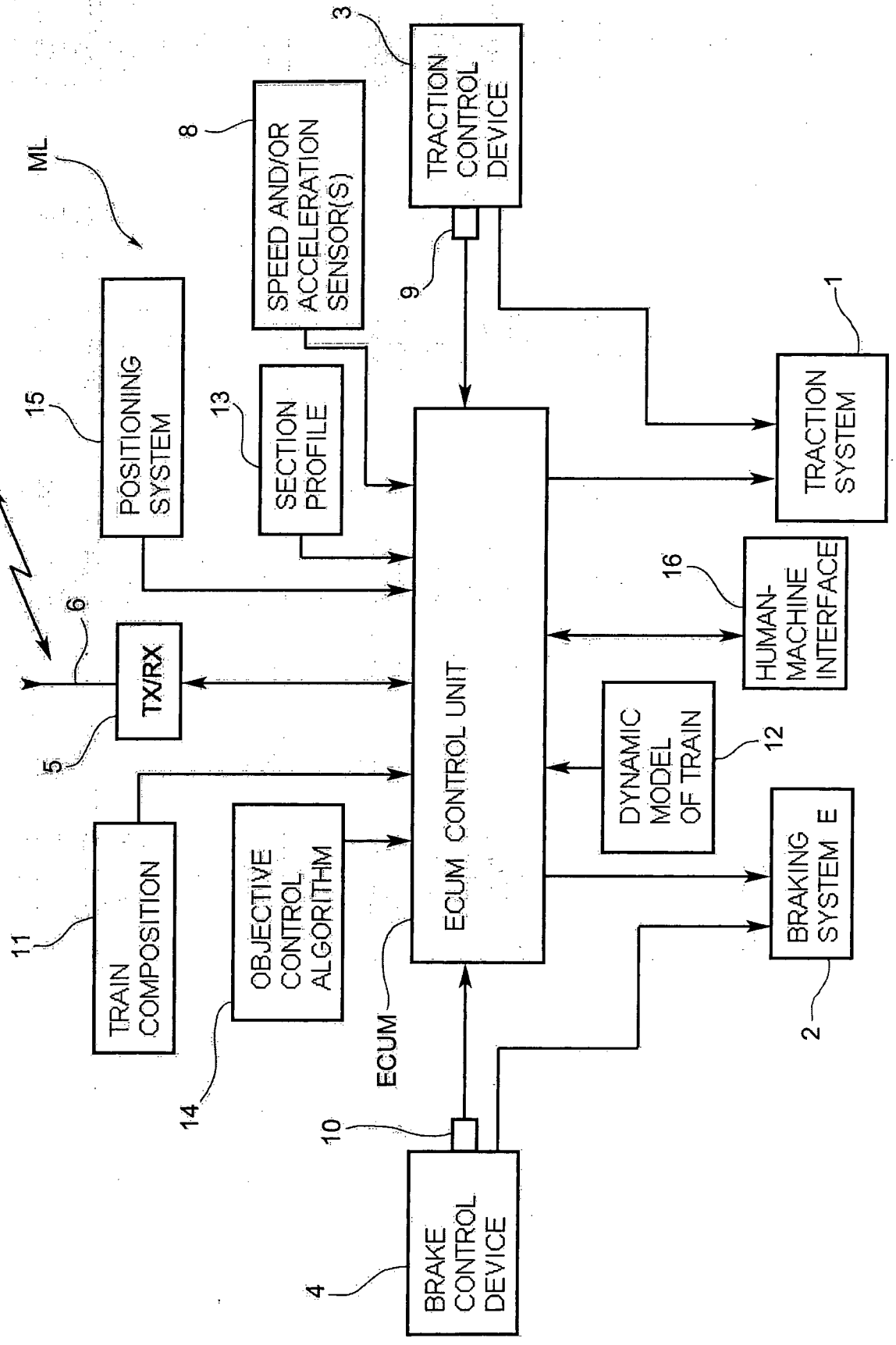
ML
TRACTION CONTROL DEVICE
3
SPEED AND/OR ACCELERATION SENSOR(S)
8
9
POSITIONING SYSTEM
15
SECTION PROFILE
13
TRACTION SYSTEM
1
6
TX/RX
5
ECUM CONTROL UNIT
HUMAN-MACHINE INTERFACE
16
DYNAMIC MODEL OF TRAIN
12
TRAIN COMPOSITION
11
OBJECTIVE CONTROL ALGORITHM
14
ECUM
BRAKING SYSTEM E
2
10
BRAKE CONTROL DEVICE
4

FIG. 2

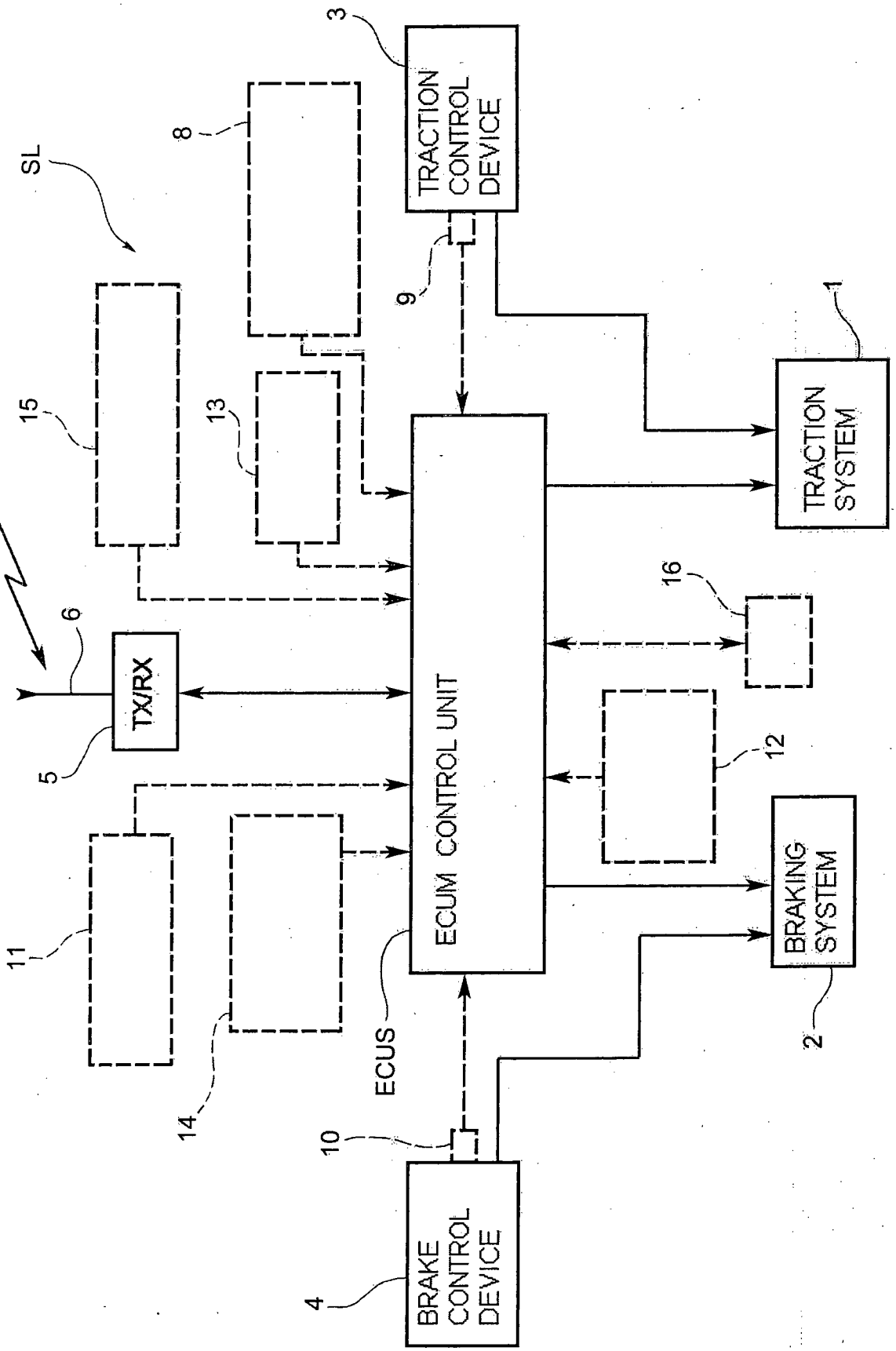
TRACTION CONTROL DEVICE
3
8
SL
9
1
TRACTION SYSTEM
15
13
16
6
TX/RX
5
ECUM CONTROL UNIT
12
11
BRAKING SYSTEM
2
ECUS
14
10
BRAKE CONTROL DEVICE
4

FIG. 3