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(54) **A device and a method for monitoring the operability of a signal connection**

(57) The invention relates to a device and a method for monitoring the operability of a signal connection between a control unit (5) and a balise (4), wherein the signal connection is provided at least partially by at least one connecting cable (7), wherein the device (9) comprises a monitoring signal generator (10), at least one means for determining a connecting cable current (I) and at least one evaluating unit (13), wherein a monitoring signal with a monitoring frequency is injectable into the connecting cable (7), wherein the connecting cable current (I) is determinable, wherein a current portion with the monitoring frequency is determinable, wherein an incorrect operability of the signal connection is detectable if a current value of the current portion is smaller than a predetermined threshold value.

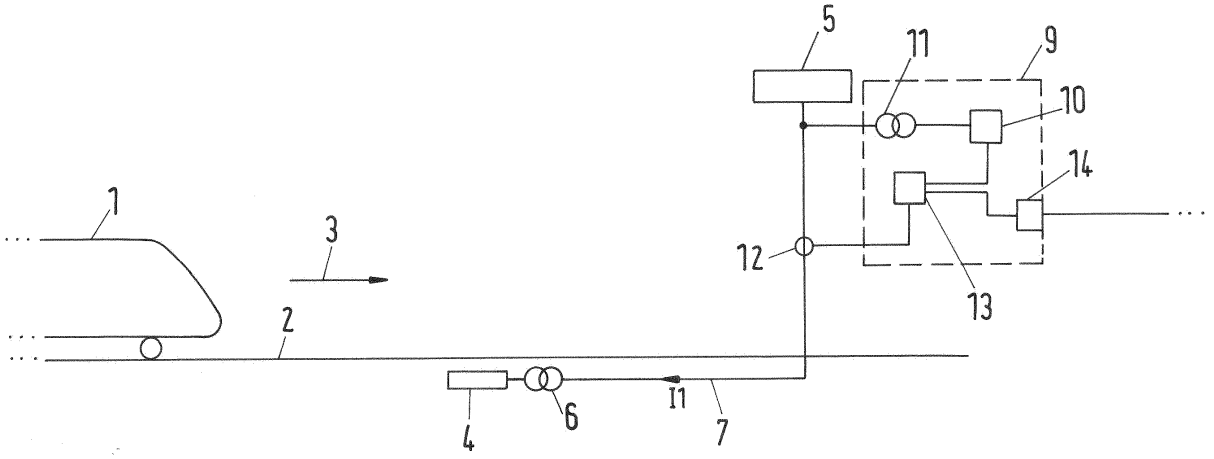

Fig.1

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Description

[0001] The invention relates to a device and a method for monitoring the operability of signal connection between a control unit and a balise.

[0002] It is known that an interlocking computer or interlocking control unit controls and monitors various devices along a railway line in modern railway signalling systems. Among the most important wayside objects are point machines and lamp signals. Traditionally, lamp signals have been monitored by the interlocking control unit by measuring the current which flows through the lamp and checking if said current is within predetermined limits. If the lamp fails, the failure will affect the current and can thus be detected by the interlocking control unit which, in turn, generates an alarm signal. Similarly, the current deliverance to a point machine can be measured and monitored and the status of the point machine can be monitored depending on said current. Should the point machine fail, the failure will be detected when the point machine is ordered to reverse and an alarm signal can be generated.

[0003] Track-sided transmitters, which can be also referred to as balises, which are used to send information to passing trains, cannot be monitored in this way. If, for instance, a cable connecting the balise and a balise-related control unit breaks, the failure is not automatically detected by the control unit. Similarly, if the balise should fail or be ripped off its sleeper, the control unit will not detect it. Furthermore, cable breakage or failure of the balise will result in restrictive action by the rail vehicles but it is not always clear that something is broken or missing. The driver of the rail vehicle is supposed to report failures of the balise but such reports are usually irregular.

[0004] The document DE 10 2009 012 986 A1 describes a method for operating a system for controlling a rail vehicle. A track-sided electronic control unit selects a data signal depending on a signal term and transmits said signal to a balise which is arranged on a track. Furthermore, the balise receives an activation signal which is sent by a vehicle-sided antenna.

[0005] The communication disclosed in DE 10 2009 012 986 A1 is, however, not compatible with the European Standard ERTMS/ECTS Class 1 FFFIS for Eurobalise, SUBSET-036. Said standard standardises a balise-based ATP-telegram (automatic train protection telegram) transmission between way-sided elements and train-sided elements and serves as a starting point for this invention.

[0006] EP 13193300.4 (application number) discloses a method for monitoring the operability of a balise for transmitting information to a rail vehicle, wherein a tele-powering signal emitted by the rail vehicle is received by the balise, wherein a telegram switch inhibit signal is generated by the balise and transmitted to a balise-related control unit upon reception of the tele-powering signal, wherein the operability of the balise is monitored depending on the telegram switch inhibit signal. The disadvantage of the method disclosed in said document is that the control unit needs to be switched on and a train has to pass the balise.

[0007] There is the technical problem to provide a device and a method for monitoring the operability of a signal connection between a control unit and a balise, wherein a time-related applicability of the method and the device is increased.

[0008] The technical solution to the problem is provided by the subject-matter with the features of claims 1 and 9. Further embodiments of the invention are provided by the subject-matter where the features of the remaining sub-claims.

[0009] A device for monitoring the operability of a signal connection between a control unit and a balise is proposed. A balise denotes a device by which a signal encoding or containing balise-related information can be transmitted to a vehicle passing the balise.

[0010] The balise-related information can e.g. comprise static information which are always transmitted to a vehicle passing the balise. Static information can thus be also transmitted if no data is provided to the balise by the control unit. Static information can be information on an identity of the balise, information on a geographical position of the balise and information on one or more consecutive balises along a track of the rail vehicle. Further, a physical representation of said information can be provided within the balise. For instance, data encoding the static information can be programmed into a non-volatile memory of the balise.

[0011] Further, the balise can transmit dynamic information. A dynamic information can e.g. be an information on a movement authorization. A movement authorization information can e.g. represent if vehicle passage of the balise is allowed or not permitted. As mentioned before, the movement authorization can be determined based on the state of a signal lamp and/or point machine which is/are assigned to the balise. If the signal lamp or point machine is in a first state, the vehicle passage is allowed. If the signal lamp or point machine is in a second state, the vehicle passage is not permitted. The control unit (which can also be referred to as balise-related control unit) can e.g. be connected to the signal lamp and/or to an interlocking control unit for controlling the operation of the signal lamp in order to determine the state of the signal lamp. For instance, the control unit can be connected to the signal lamp, wherein an operating current of the signal lamp is determinable by the control unit. Depending on said operating current, the control unit can determine whether the signal lamp is in the aforementioned first or second state and generate a corresponding operating signal which is than transmitted to the balise via the signal connection.

[0012] An information if a static and/or dynamic information and, if applicable, an information on which dynamic information is to be transmitted by the balise can be provided by the control unit and transmitted from the control unit to the balise via an operating signal. It is for

instance, possible that a physical representation of a dynamic information, e.g. if the signal lamp is in the first or in the second state, is provided within the balise, wherein the control unit provides an information on which of the first and the second signal is to be transmitted to a passing vehicle.

[0013] The signal connection is provided at least partially by at least one connecting cable. It is possible that an operating signal output terminal of the control unit is connected to the connecting cable non-galvanically. In particular, the at least one operating signal output terminal can be connected to the connecting cable via transformer. It is further possible that an operating signal input terminal of the balise is connected to the connecting cable non-galvanically, in particular via another transformer.

[0014] Monitoring the operability of the signal connection comprises in particular monitoring the presence of the connecting cable, the presence of the balise and monitoring the integrity of the connecting cable. The control unit can in particular be provided by a so-called lineside electronic unit (LEU).

[0015] The proposed device comprises a monitoring signal generator. The monitoring signal generator can be an alternating current (AC) signal generator. Further, the device comprises at least one means for determining a connecting cable current. For example, the at least one means for determining the connecting cable current can be a means for measuring the current, in particular a current sensor.

[0016] Further, the device comprises at least one evaluating unit. The evaluating unit can be connected to the at least one means for determining the connecting cable current.

[0017] A monitoring signal with a monitoring frequency is injectable into the connecting cable. In the context of this invention, the term "able" is used in the sense of "can be". This means that the proposed device is arranged and/or designed such that it is capable of performing the corresponding action.

[0018] As will be explained later in more detail, the monitoring signal can be injected simultaneously to an operating signal. Alternatively or in addition, the monitoring signal can be injected in a time period during which no operating signal is transmitted via the connecting cable. It is possible that the monitoring signal can be exclusively injected simultaneously to an operating signal or exclusively injected in a time period during which no operating signal is transmitted via the connecting cable. Preferably, the monitoring signal is injectable independent of the transmission of an operating signal. The monitoring signal can be injected by the aforementioned monitoring signal generator or an injection means.

[0019] Further, the connecting cable current is determinable, in particular by the aforementioned means for determining the connecting cable current.

[0020] Further, a current portion with the monitoring frequency is determinable, in particular by the at least one evaluating unit. The current portion with the monitoring frequency can e.g. denote a spectral portion of the cable current spectrum which comprises (only) the monitoring frequency or frequencies within an (small) interval around the monitoring frequency.

[0021] Further, an incorrect operability of the signal connection is detectable if a current value of the current portion is smaller than a predetermined threshold value. The current value can e.g. be a root mean square (RMS) value or an amplitude of the current portion. Also, the current value can be an intensity of the aforementioned spectral portion. The predetermined threshold value can be determined application-dependent by a skilled person. In particular the predetermined threshold value is small, preferably close to zero. A correct operability of the signal connection is detectable if the current value of the current portion is higher than or equal to the predetermined threshold value.

[0022] In a case where the current value is smaller than the predetermined threshold value, the monitoring signal is most likely not received by the balise. This can be the case if the connecting cable is stolen, broken and/or if the balise is not connected to the connecting cable. As the injection of the monitoring signal is theoretically possible at all-time instances, a time-related applicability of the monitoring method is increased.

[0023] In another embodiment, the device further comprises at least one means for injecting the monitoring signal non-galvanically into the connecting cable. This means that there is no galvanic connection between the connecting cable and the monitoring signal generator. This advantageously reduces the risk of a cross-talk between two balises and further increases an EMI-robustness of the connecting cable, the monitoring signal generator and the corresponding signal connection.

[0024] Further described is an embodiment, wherein the at least one means for injecting monitoring signal is a transformer. The transformer can be the same transformer by which the aforementioned at least one operating signal output terminal of the control unit is connected to the connecting cable. It is, however, also possible that the transformer is provided separately from said transformer connecting the at least one monitoring signal output terminal to the connecting cable. The use of a transformer advantageously allows a reliable injection of the monitoring signal.

[0025] In a preferred embodiment, the monitoring frequency is lower than an operating frequency of an operating signal which is transmitted from the control unit to the balise via the signal connection. The operating signal has been explained before. The operating signal is an AC signal typically comprises a frequency of a range from 10 kHz to 1000 kHz, in particular from 50 kHz to 600 kHz. An impedance of the signal connection, in particular of the connecting cable, for the operating frequency is high. In particular, there is no/or only a small current flow within the connecting cable generated by the injection of the operating signal into the connecting cable. A current-based monitoring of the operability therefore requires a

monitoring frequency of the injected monitoring signal which is chosen depending on an impedance of the signal connection such that a non-zero current can flow throw through the connecting cable. Preferably, the monitoring frequency can be chosen from a range of 90 Hz to 110 Hz. This advantageously increases a reliability of the monitoring process.

[0026] In another preferred embodiment, the monitoring frequency is chosen unequal to 50 Hz. Alternatively or in addition, the monitoring frequency is chosen unequal to 60 Hz. Alternatively or in addition, the monitoring frequency is chosen unequal to 1 or more corresponding overtones of 50 Hz and/or 60 Hz. Alternatively or in addition, the monitoring frequency is chosen unequal to 1 or more corresponding undertones of 50 Hz and/or 60 Hz, e.g. unequal to 50/3 Hz (16 2/3 Hz). As the stated frequencies are often use in devices arranged in the vicinity of the signal connection, a monitoring signal with one of said frequencies can be disturbed. Thus, the described embodiment further increases a reliability of the monitoring process.

[0027] In another embodiment, the monitoring signal is injectable during an operating signal is transmitted via the signal connection. This means, that both, the operating signal and the monitoring signal are applied to the signal connection. This, of course, does not exclude the case where only the monitoring signal and no operating signal is applied to the signal connection. In particular, the proposed device can be used during time periods where no operating signal is applied to the signal connection and also in time periods during which an operating signal is applied to the signal connection.

[0028] In another embodiment, the monitoring signal is superimposable onto the operating signal. The aforementioned monitoring signal generator and/or the at least one means for injecting the monitoring signal can be designed and/or arranged such that the monitoring signal can be superimposed onto the operating signal. This advantageously simplifies a simultaneous transmission of the operating and monitoring signal.

[0029] In another embodiment, an alarm signal is generable if an incorrect operability is detected. The alarm signal can e.g. be generated by the aforementioned evaluating unit. The alarm signal can be transmitted to an external control unit, e.g. the interlocking control unit. In this case, the proposed device can comprise at least one signal transmission means. The alarm signal can be transmitted using a predetermined communication protocol, in particular in form of a data stream.

[0030] Alternatively or in addition, a supervised switch is activatable if an incorrect operability is detected. The switch can e.g. be supervised by a supervising unit. A supervising unit can e.g. be provided by the aforementioned interlocking control unit. In this case, the alarm signal can be generated by the supervising unit.

[0031] The alarm signal can also be provided to operating personal via adequate means. In this case, the operating personal can be immediately informed in the case that the connecting cable is stolen, broken and/or a balise is not connected to the connecting cable anymore. Then, adequate counter measures can be taken.

[0032] Further described is an embodiment, wherein the determined connecting cable current is filterable in order to determine the current portion with the monitoring frequency. In this case, the device can comprise at least one filter means. Filter means can e.g. be designed as a low-pass filter or a band-pass filter or a notch filter. This advantageously allows a reliable determination of the current portion with a monitoring frequency in particular in the case if an operating signal is transmitted via the signal connection simultaneously.

[0033] In another embodiment, the monitoring signal generator and/or the at least one means for measuring a connecting cable current and/or the at least one evaluating unit is provided by the control unit. Alternatively, the monitoring signal generator and/or the at least one means for measuring a connecting cable current and/or the at least one evaluating unit is provided by at least one unit which is build separate from the control unit.

[0034] Further proposed is a method for monitoring the operability of a signal connection between a control unit and a balise. The method can be performed by the device according to one of the embodiments described in this invention.

[0035] A signal connection is provided at least partially by at least one connecting cable. A monitoring signal with a monitoring frequency is injected into the connecting cable. Further, a connecting cable current is determined, in particular measured. Further, a current portion with a monitoring frequency is determined. An incorrect operability of this signal connection is detected if a current value of the current portion is smaller than a predetermined threshold value. A correct operability of the signal connection can be detected if the current value of the current portion is higher than or equal to the predetermined threshold value.

[0036] By performing the proposed method, a reliable monitoring of the operability is possible, wherein a time-related applicability of the method is increased. In particular, the method can be performed at all times.

[0037] In another embodiment, the monitoring signal is injected non-galvanically. This has been explained before.

[0038] Further described is an embodiment, wherein the monitoring signal is injected via a transformer. This has been also explained before.

[0039] In another embodiment, the monitoring frequency is lower than an operating frequency of an operating signal which is transmitted from the control unit to the balise via the signal connection.

[0040] In another embodiment, the monitoring frequency is chosen unequal to 50 Hz and/or unequal to 60 Hz and/or unequal to 1 or more corresponding overtones and/or undertones.

[0041] In another embodiment, the monitoring signal is injected during an operating signal is transmitted via

the signal connection.

[0042] In another embodiment, the monitoring signal is superimposed onto the operating signal.

[0043] In another embodiment, an alarm signal is generated and/or a supervised switch is activated if an incorrect operability is detected.

[0044] Further described is an embodiment, wherein the determined connecting cable current is filtered in order to determine the current portion with the monitoring frequency.

[0045] The invention will be described with reference to the attached figure. The only figure shows schematic block diagram of a device for monitoring an operability of a signal connection according to the invention.

[0046] Figure 1 shows a rail vehicle 1 travelling along a rail track 2, wherein a direction of travel indicated by an arrow 3. Further shown is a balise 4 for transmitting a signal which is received by the rail vehicle 1. The balise 4 is connected to a lineside electronic unit 5 (LEU 5) via a balise-sided transformer 6, a connecting cable 7 and a LEU-sided transformer (not shown). The LEU-sided transformer can be part of the LEU 5. A connecting cable current I is also indicated in figure 1.

[0047] Further shown is a device 9 according to the invention. The device 9 comprises a monitoring signal generator 10. The monitoring signal generator 10 generates a monitoring signal with a monitoring frequency which is lower than an operating frequency of an operating signal generated by the control unit 5. The monitoring signal is injected into the connecting cable 7 via a generator-sited transformer 11.

[0048] Further, the device comprises a current sensor 12 for measuring the connecting cable current I. The current sensor 12 is connected to an evaluating unit 13, wherein an evaluating unit 13 of the device 9 can determine a current value of the current portion of the connecting cable current I with the monitoring frequency. The current portion with the monitoring frequency denotes a portion of the cable current I which is generated due to the injected monitoring signal.

[0049] The evaluating unit 13 can be connected to the signal generator 10.

[0050] Further, the device 9 comprises a signal communication means 14 which also connected to the evaluating unit 13. An incorrect operability of the signal connection is detectable if current value of a current portion of the measured cable current I is smaller than a predetermined threshold value. In this case, an alarm signal can be generated by the evaluating unit 13 and transmitted via the transmitting means to an external higher-level system, e.g. an interlocking control unit.

Claims

1. A device for monitoring the operability of a signal connection between a control unit (5) and a balise (4), wherein the signal connection is provided at least partially by at least one connecting cable (7), **characterized in that**
the device (9) comprises a monitoring signal generator (10), at least one means for determining a connecting cable current (I) and at least one evaluating unit (13), wherein a monitoring signal with a monitoring frequency is injectable into the connecting cable (7), wherein the connecting cable current (I) is determinable, wherein a current portion with the monitoring frequency is determinable, wherein an incorrect operability of the signal connection is detectable if a current value of the current portion is smaller than a predetermined threshold value.

2. The device according to claim 1, **characterized in that** the device (9) further comprises at least one means for injecting the monitoring signal non-galvanically into the connecting cable (7).

3. The device according to one of the claims 1 to 2, **characterized in that** the monitoring frequency is lower than an operating frequency of an operating signal which is transmitted from the control unit to the balise (4) via the signal connection.

4. The device according to one of the claims 1 to 3, **characterized in that** the monitoring frequency is chosen unequal to 50 Hz and/or unequal to 60 Hz and/or unequal to one or more corresponding overtones and/or undertones.

5. The device according to one of the claims 1 to 4, **characterized in that** the monitoring signal is injectable during an operating signal is transmitted via the signal connection.

6. The device according to claim 5, **characterized in that** the monitoring signal is superimposable onto the operating signal.

7. The device according to one of the claims 1 to 6, **characterized in that** an alarm signal is generable and/or a supervised switch is activatable if an incorrect operability is detected.

8. The device according to one of the claims 1 to 7, **characterized in that** the monitoring signal generator (10) and/or the at least one means for measuring a connecting cable current (I) and/or the at least one evaluating unit (9) is/are provided by the control unit (5) or separate from the control unit (5).

9. A method for monitoring the operability of a signal connection between a control unit (5) and a balise (4), wherein the signal connection is provided at least partially by at least one connecting cable (7), wherein a monitoring signal with a monitoring frequency is injected into the connecting cable (7), wherein a con-

necting cable current (I) is determined, wherein a current portion with a monitoring frequency is determined, wherein an incorrect operability of this signal connection is detected if a current value of the current portion is smaller than a predetermined threshold value.

10. The method according to claim 9, **characterized in that** the monitoring signal is injected non-galvanically.

11. The method according to one of the claims 9 to 10, **characterized in that** the monitoring frequency is lower than an operating frequency of an operating signal which is transmitted from the control unit to the balise (4) via the signal connection.

12. The method according to one of the claims 9 to 11, **characterized in that** the monitoring frequency is chosen unequal to 50 Hz and/or unequal to 60 Hz and/or unequal to one or more corresponding overtones and/or undertones.

13. The method according to one of the claims 9 to 12, **characterized in that** the monitoring signal is injected during an operating signal is transmitted via the signal connection.

14. The method according to claim 13, **characterized in that** the monitoring signal is superimposed onto the operating signal.

15. The method according to one of the claims 9 to 14, **characterized in that** an alarm signal is generated and/or a supervised switch is activated if an incorrect operability is detected.

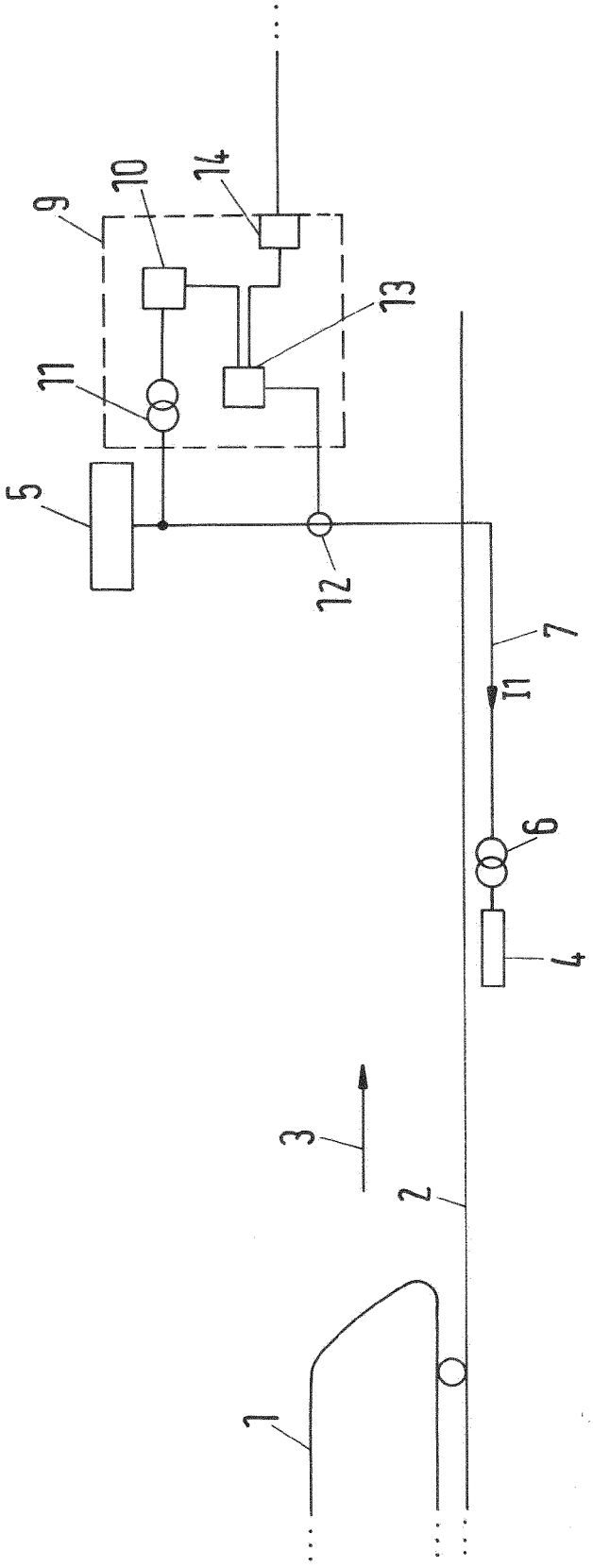

Fig.1

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EUROPEAN SEARCH REPORT

Application Number
EP 15 15 8135

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CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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