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- (71) Applicant: **JRB ENGINEERING PTY LTD** [AU/AU];
24 Drummond Place, West Perth, Western Australia 6005 (AU).
- (72) Inventor: **BLAIR, Stewart**; 24 Drummond Place, West Perth, Western Australia 6005 (AU).
- (74) Agent: **GRIFFITH HACK**; Level 19, 109 St George Terrace, Perth, Western Australia 6000 (AU).
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(54) Title: A METHOD AND SYSTEM FOR DETECTING A MATERIAL DISCONTINUITY IN A MAGNETISABLE ARTICLE

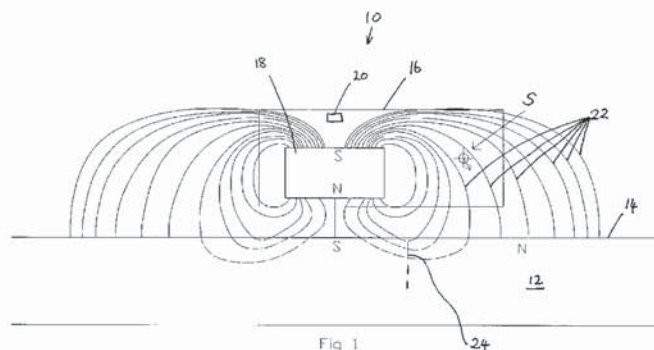


Fig 1

(57) Abstract: A system (10) and associated method for detecting a material discontinuity in a magnetisable article (12) has a sensor unit (16) which includes a magnet 18 and at least one magnetic field coupling sensor S. The magnet (18) is supported a distance above the rail (12) so that the lines of magnetic flux (22) loop through the rail (12). The magnetic field of the magnet (18) causes the surface (14) of the rail (12) directly below the magnet (18) to become polarised opposite to the facing pole of the magnet (18) and the regions distant from the magnet (18) to become inversely polarised. The coupling sensor S is placed and held at a fixed position relative to and in the active magnetic field of the magnet (18). The coupling sensor S measures the flux coupling between the rail (12) and the magnet (18).

PATENT COOPERATION TREATY
PCT
INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY
(Chapter II of the Patent Cooperation Treaty)
(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P100711.PCT	FOR FURTHER ACTION See Form PCT/IPEA/416																	
International application No. PCT/AU2016/050821	International filing date (<i>day/month/year</i>) 31 August 2016	Priority date (<i>day/month/year</i>) 31 August 2015																
International Patent Classification (IPC) or national classification and IPC G01N 27/72 (2006.01) G01N 27/82 (2006.01)																		
Applicant JRB ENGINEERING PTY LTD																		
1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36. 2. This REPORT consists of a total of 4 sheets, including this cover sheet. 3. This report is also accompanied by ANNEXES, comprising: a. ☒ (<i>sent to the applicant and to the International Bureau</i>) a total of 13 sheets, as follows: ☒ sheets of the description, claims and/or drawings which have been amended and/or sheets containing rectifications authorized by this Authority, unless those sheets were superseded or cancelled, and any accompanying letters (see Rules 46.5, 66.8, 70.16, 91.2, and Section 607 of the Administrative Instructions). ☐ sheets containing rectifications not taken into account by this Authority because they were not available at the time when this Authority began to draw up this report, and any accompanying letters (Rules 66.4<i>bis</i>, 70.2(e), 70.16 and 91.2). ☐ Superseded sheets and any accompanying letters, where this Authority either considers that the superseding sheets contain an amendment that goes beyond the disclosure in the international application as filed, or the superseding sheets were not accompanied by a letter indicating the basis for the amendments in the application filed, as indicated in item 4 of Box No. I and the Supplemental Box (see Rule 70.16(b)). b. ☐ (<i>sent to the International Bureau only</i>) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see paragraph 3<i>bis</i> of Annex C of the Administrative Instructions). 4. This report contains indications relating to the following items: <table style="width: 100%; margin-left: 20px;"> <tr><td>☒ Box No. I</td><td>Basis of the report</td></tr> <tr><td>☐ Box No. II</td><td>Priority</td></tr> <tr><td>☐ Box No. III</td><td>Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</td></tr> <tr><td>☐ Box No. IV</td><td>Lack of unity of invention</td></tr> <tr><td>☒ Box No. V</td><td>Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement</td></tr> <tr><td>☐ Box No. VI</td><td>Certain documents cited</td></tr> <tr><td>☐ Box No. VII</td><td>Certain defects in the international application</td></tr> <tr><td>☐ Box No. VIII</td><td>Certain observations on the international application</td></tr> </table>			☒ Box No. I	Basis of the report	☐ Box No. II	Priority	☐ Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability	☐ Box No. IV	Lack of unity of invention	☒ Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement	☐ Box No. VI	Certain documents cited	☐ Box No. VII	Certain defects in the international application	☐ Box No. VIII	Certain observations on the international application
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Date of submission of the demand 23 May 2017	Date of completion of this report 28 September 2017																	
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaaustralia.gov.au		Authorised officer Eugene Koh AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. +61262832580																

Box No. I

Basis of the report

1. With regard to the **language**, this report has been established on the basis of:
- ☒ The international application in the language in which it was filed:
- ☐ A translation of the international application into , which is the language of a translation furnished for the purposes of :
- ☐ international search (under Rules 12.3(a) and 23.1 (b)).
- ☐ publication of the international application (under Rule 12.4(a)).
- ☐ international preliminary examination (Rules 55.2(a) and/or 55.3(a) and (b)).
2. With regard to the **elements** of the international application, this report is based on (*replacement sheets which have been furnished to the receiving office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):
- ☐ the international application as originally filed/furnished, or
- ☒ the description: pages **1-14** , as originally filed/furnished
pages , received by this Authority on with the letter of
- ☒ the claims: pages , as originally filed/furnished
pages , as amended (together with any statement) under Article 19,
pages **15** , received by this Authority on **16 August 2017** with the letter of **16 August 2017**
pages **16-18** , received by this Authority on **23 May 2017** with the letter of **23 May 2017**
- ☒ the drawings: pages **1/12-12/12** , as originally filed/furnished
pages , received by this Authority on with the letter of
- ☐ a sequence listing - see Supplemental Box Relating to Sequence Listing.
3. ☐ The amendments have resulted in the cancellation of:
- ☐ the description, pages
- ☐ the claims, Nos.
- ☐ the drawings, sheets/figs
- ☐ the sequence listing (specify):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since either they are considered to go beyond the disclosure as filed, or they were not accompanied by a letter indicating the basis for the amendments in the application as filed, as indicated in the Supplemental Box (Rules 70.2(c) and (c-bis)):
- ☐ the description, pages
- ☐ the claims, Nos.
- ☐ the drawings, sheets/figs
- ☐ the sequence listing (specify):
5. ☐ This report has been established:
- ☐ taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rules 66.1(d-bis) and 70.2(e)).
- ☐ without taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rules 66.4bis and 70.2(e)).
6. With regard to top-up searches (Rules 66.1ter and 70.2(f)):
- ☒ A top-up search was carried out by this Authority on 20 June 2017.
- ☐ Additional relevant documents have been discovered during the top-up search.
- ☐ No top-up search was carried out by this Authority because it would serve no useful purpose.
7. ☐ Supplementary international search report(s) from Authority(ies)
has/have been received and taken into account in establishing this report (Rule 45bis.8(b) and (c)).

* If item 4 applies, some or all of those sheets may be marked "superseded."

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims 1-18	YES
	Claims NONE	NO
Inventive step (IS)	Claims 1-18	YES
	Claims NONE	NO
Industrial applicability (IA)	Claims 1-18	YES
	Claims NONE	NO

2. CITATIONS AND EXPLANATIONS:**CITATIONS**

D1: US 2013/0113472 A1 (BLAIR et al.) 09 May 2013
D2: US 2003/0020469 A1 (KATRAGADDA et al.) 30 January 2003
D3: US 2005/0285588 A1 (KATRAGADDA et al.) 29 December 2005

NOVELTY (N)

The subject matter of claims 1-18 is new and meets the requirements of Article 33(2) of the PCT with regard to novelty.

Claims 1, 9, 13, 14, 17 and 18

Claims 1, 9, 13, 14, 17 and 18 require features which variously relate to the analysis, measurement or acquisition of a magnetic coupling between a magnet and an article.

Claim 1 requires a step of analysing a measured magnetic coupling in an active magnetic field for a change in the magnetic coupling, claim 9 requires a sensor which traverses along the article with the magnet to measure magnetic coupling between the magnet and the article, claims 13 and 14 require a step of acquiring multiple samples of magnetic field coupling between an article and a magnet at a known sampling frequency, claim 17 requires a step of acquiring one or more samples of magnetic field coupling between a magnet and a rail in a railway track, and claim 18 requires a defect that causes a detectable change in natural polarization boundary of an active magnetic field couple with the article.

These features are not explicitly disclosed in the above cited prior art documents.

D2 is regarded to be the prior art document that is closest to the present invention. Whilst D2 discloses embodiments with Hall sensors in Fig. 10 and para. [0051], these sensors 100 however are understood to be not placed in the active magnetic field as required by the claims and therefore cannot measure magnetic coupling between the magnet and the article. It is understood from a skilled reading that these sensors 1000 instead measure magnetic flux leakage.

Therefore, the subject matter of claims 1, 9, 13, 14, 17 and 18 is new and meets the requirements of Article 33(2) of the PCT with regard to novelty

Claims 2-8, 10-12 and 15-16

Claims 2-8 ultimately depend on claim 1, claims 10-12 ultimately depend on claim 9 and claims 15-16 ultimately depend on claims 13 or 14. These claims define further features to those defined in the respective independent claims.

Therefore, the subject matter of claims 2-8, 10-12 and 15-16 is also new and meets the requirements of Article 33(2) of the PCT with regard to novelty.

INVENTIVE STEP (IS)

The subject matter of all of claims 1-18 is not obvious and meets the requirements of Article 33(3) of the PCT with regard to inventive step.

None of the above prior art documents either individually or in combination obviously suggests to a person skilled in the art the inclusion of features variously relating to the analysis, measurement or acquisition of a magnetic coupling between a magnet and an article.

Therefore, the subject matter of claims 1, 9, 13, 14, 17 and 18 is not obvious and meets the requirements of Article 33(3) of the PCT with regard to inventive step.

Claims 2-8 ultimately depend on claim 1, claims 10-12 ultimately depend on claim 9 and claims 15-16 ultimately depend on claims 13 or 14. These claims add further aspects of the inventive concept.

Therefore, the subject matter of claims 2-8, 10-12 and 15-16 is also not obvious and meets the requirements of Article 33(3) of the PCT with regard to inventive step.

INDUSTRIAL APPLICABILITY (IA)

The invention defined in the claims 1-18 is considered to meet the requirements of Industrial Applicability under Article 33(4) of the PCT because it can be made by, or used in, industry.

The Receiving Office

16 August 2017

Sir

**IN THE MATTER OF International (PCT) Patent Application No. PCT/AU2016/050821
in the name of JRB ENGINEERING PTY LTD
entitled A METHOD AND SYSTEM FOR DETECTING A MATERIAL DISCONTINUITY IN A
MAGNETISABLE ARTICLE
Our Ref: P100711.PCT**

We refer to the Written Opinion issued on 23 June 2017 in relation to the above application.

We request that claim page 15 be cancelled and replaced with the fresh corresponding claim page attached. The effect of this is to amend claim 6 to remove the clarity issue noted in Box No. VIII of the Written Opinion.

We acknowledge but respectfully disagree with the opinion of the IPEA that the current invention lacks novelty and/or inventive step in light of the reference D2.

The Hall sensors 1000 refer to in D2 and relied upon for the basis of the novelty and inventive step objections are not placed in the active magnetic field as required by the claims and therefore do not and cannot measure magnetic coupling between the magnet and the article.

In D2 the Hall sensors 1000 are outside of the active magnetic field and measure magnetic flux leakage rather than coupling. In D2 the toroidal magnet 140 is provided with brushes 160 that physically contact the underlying rail 10. This is readily apparent from paragraphs [0036] and [0037] which state:

- “The brushes 160 longer than the spacing 450 and each brush 160 contains 5 mil diameter carbon steel bristles.”[0036]
- “The bristles 160 also act to clean the surface 12 of the rail head 10 to remove dust or grease before the probe 150 slides over. “

In order for the sensors 1000 to be in the active magnetic field and thus measure magnetic field coupling they must be between the poles of the electromagnetic 140 and the rail 10. But this isn't possible in the arrangement of D2 because of the existence of the brushes 160.

The difference between measuring flux coupling and measuring leakage is described in the current specification at page 9 lines 3-12 which reads:

Level 10, 161 Collins Street
Melbourne VIC 3000 Australia
GPO Box 1285
Melbourne VIC 3001 Australia
T +61 3 9213 8300

Level 29 Northpoint
100 Miller Street
North Sydney NSW 2060 Australia
GPO Box 4164
Sydney NSW 2001 Australia
T +61 2 9925 5900

Level 19
109 St Georges Terrace
Perth WA 6000 Australia
T +61 8 9213 8300

Level 15, 300 Queen Street
Brisbane QLD 4000 Australia
GPO Box 3125
Brisbane QLD 4001 Australia
T +61 7 3232 1700

“The sensing or measurement of flux coupling or changes in flux coupling in the disclosed method and system is different to and distinguishable from measurement of flux leakage which is common in non-destructive testing (NDT). Figure 10 illustrates a general arrangement for measuring flux leakage. Here lines of flux 40 circulate through magnet M1, the article/rail 12, magnet M2, and free air 42. The rail has a surface defect, e.g. a spall 30a causing a leakage path 45 of flux from and back to the rail 12. The flux leaked from the rail is sensed by a sensor 44. This is to be contrast with the embodiment of the current system 10 where it is the flux coupling though the air between the rail 12 and the magnet 18 that is being ended(sic) and used to determine the existence of a material discontinuity.”

Each of independent claims 1, 9, 13, 14 and 17 is limited by the feature of acquiring samples of magnetic field coupling between the magnet and an article/rail. Given that the reference D2 does not disclose or suggest this feature and indeed following the teachings of D2 can never enable a realisation of this feature we request that the novelty and inventive step objections based on D2 to these claims be withdrawn.

This deficiency in D2 is not made good by combination with D1 also does not disclose the magnetic coupling feature.

The reliance of D2 relation to the invention defined by claim 18 is also misplaced. D2 has no description whatsoever of estimating spatial displacement by sensing magnetic field strength and subsequently processing the sense magnetic field strength at successive sampling instance to provide an estimate displacement.

Paragraph [0058] of D2 relied upon to support subsection is referring to the measurement of eddy currents not magnetic field strength. Further, on reading it as a whole it is readily apparent that D2 relies on the use of velocity and GPS to locate defects on a track in stage 1360 (also referred to in paragraph [0058]).

We therefore requested the objection to claim 18 also be withdrawn.

Yours faithfully
GRIFFITH HACK



A. P. (Tony) Mizzi

Principal

tony.mizzi@griffithhack.com

The Receiving Office

23 May 2017

Sir

**IN THE MATTER OF International (PCT) Patent Application No. PCT/AU2016/050821
in the name of JRB ENGINEERING PTY LTD
- and -
IN THE MATTER OF Demand for International Preliminary Examination
Our Ref: P100711.PCT**

We enclose a Demand for International Preliminary Examination together with the prescribed fee of \$858.00.

We request that pages 15-18 of the specification as filed be cancelled and replaced with fresh pages 15-18 attached. The effect of this replacement of pages is to amend claims 6 and 13 to address the observations in Box No. VIII of the Written Opinion.

We respectfully disagree with the opinion of the ISR regarding novelty and inventive step of the claimed invention.

The reference D1 is totally irrelevant to the present invention for the purposes of assessing novelty and inventive step.

It appears the ISA has not understood or has disregarded the difference between an active field and remnant field and their associated magnetic field measuring process.

The reference D1 pertains to predicting the existence of a crack by measuring a remnant magnetic field. The present invention as claimed relates to detecting a material discontinuity (which may indeed be a crack) but does so by measuring magnetic coupling in an active magnetic field. Remnant magnetic fields and active magnetic fields are different. A remnant magnetic field is one which is induced by another magnetic field and remains after the inducing magnetic field has been removed. The active magnetic field can be considered to be the magnet field that induces the remnant magnetic field.

In comparing present claim 1 with the disclosure in D1 the ISA correctly notes that D1 teaches the traversing of a magnet along an article. This will indeed result in lines of magnetic flux looping through the article and magnetically coupling the magnet to the article. However the ISA is incorrect in stating that D1 discloses placing a magnetic field coupling sensor at a fixed position relative to the magnet in the active field of the magnet.

Level 10, 161 Collins Street
Melbourne VIC 3000 Australia
GPO Box 1285
Melbourne VIC 3001 Australia
T +61 3 9213 8300

Level 29 Northpoint
100 Miller Street
North Sydney NSW 2060 Australia
GPO Box 4164
Sydney NSW 2001 Australia
T +61 2 9925 5900

Level 19
109 St Georges Terrace
Perth WA 6000 Australia
T +61 8 9213 8300

Level 15, 300 Queen Street
Brisbane QLD 4000 Australia
GPO Box 3125
Brisbane QLD 4001 Australia
T +61 7 3232 1700

Figures 3a and 3b and paragraph [0057] which are cited by the ISA to support this contention only describe the location of the sensors. Neither these Figures nor the referenced paragraph make any disclosure whatsoever of the magnet (with the active field) which initially induced the remnant magnetic field measured by the sensors.

In D1 a measurement is made of the flux leakage from the remnant magnetic field. This measurement is made after the active magnetic field which caused the remnant magnetic field has passed and no longer has effect. It would not be possible for the method and system of D1 to operate in accordance the present invention because the active magnetic field would totally swamp the remnant magnetic field such that the sensors in D1 would not be able to discern the remnant magnetic field. We direct attention to paragraph [0047] of D1 which states:

“ Thus the magnetising and the sensing are conducted at different times. The permanent magnet and the senses are not supported on the same structure and run along the rail section at the same time.”

We further point out that independent claims 1 and 9 of the current application include the limitations of traversing a magnet along an article so that lines of magnetic flux from an active magnetic field of the magnet loop through the article and, placing a magnetic field coupling sensor in the active magnetic field of the magnet where the sensor traverses along the article with the magnet.

This is not disclosed in the reference D1. Accordingly the invention defined by present independent claims 1 and 9 and their dependent claims is novel over the disclosure. It further follows from the above that the invention defined by these claims is inventive over D1 as D1 teaches the exact opposite of the claimed invention by stipulating initially magnetising an article to induce a remnant magnetic field and subsequently, as a separate action, sensing the remnant magnetic field when the magnetising active field is not present.

For similar reasons the objections in relation to independent claims 13, 14, and 17 are without foundation. Each of these claims requires the acquisition of samples of magnetic field coupling between an article and a magnet. As previously explained this is not disclosed in D1 which only measures remnant magnetic field after an inducing magnetic field has passed. Accordingly in D1 is not possible to measure the magnetic coupling between an active magnetic field and the article because the magnet with the active magnetic field is not present when the sensors of D1 are sensing the remnant magnetic field.

In relation to independent claim 18 the reference D1 does not anywhere disclose or describe a system for estimating spatial displacement along an article. Indeed the word “displacement” does not appear in the text of the reference D1. The sections of D1 relied upon by the ISA to support the disclosure of the features of claim 18 have no relevance. It is abundantly clear from [0065] of D1 that sampling is conducted at fixed distances. But this is not a disclosure that D1 teaches a method for estimating the fixed distance or any spatial displacement. All D1 says is that samples are taken every 0.25mm (or some other fixed distance). But D1 does not use the



sensors 26, or describe any other sensors or system, for measuring this distance. This absence would lead a person of ordinary skill in the art to assume that the distance measurement is made by an extraneous system or device such as a wheel tacho or GPS.

For the above reasons we request that all of the novelty and inventive step objections be withdrawn.

Yours faithfully
GRIFFITH HACK

A handwritten signature in black ink, appearing to read "A. P. Mizzi", written over the printed name.

A. P. (Tony) Mizzi
Principal
tony.mizzi@griffithhack.com

CLAIMS

1. A method of detecting a material discontinuity in a magnetisable article comprising:
 - 5 traversing a magnet along the article so that lines of magnetic flux from an active magnetic field of the magnet loop through the article and magnetically couple the magnet to the article;
 - placing at least one magnetic field coupling sensor at a fixed position relative to the magnet and in the active magnetic field of the magnet
 - 10 wherein the at least one coupling sensor traverses along the article with the magnet to sample magnetic coupling between the magnet and the article;
 - and
 - analysing the measured magnetic coupling in the active magnetic field for a change in the magnetic coupling during the traversing of the magnet and
 - 15 using the change in magnetic coupling to detect a discontinuity in the article.
2. The method according to claim 1 wherein analysing information comprises making a determination of a size of the discontinuity.
- 20 3. The method according to claim 1 or 2 wherein the at least one coupling sensor is arranged to sense at least direction of the magnetic flux looping through the article.
- 25 4. The method according to any one of claims 1 to 3 wherein the at least one coupling sensor is arranged to sense at least density of the magnetic flux looping through the article.
5. The method according to any one of claims 1 to 4 wherein the article is a rail for a rail transport vehicle.
- 30 6. The method according to any one of claims 1 to 5 further comprising acquiring longitudinal samples of the magnetic field along the article using one or more displacement sensors simultaneously with acquisition of samples of magnetic coupling from the one or more coupling sensors;
- 35 between instants at which the samples are acquired, moving: the magnet, the coupling sensors and the displacement sensors in a fixed juxtaposition relative to

CLAIMS

1. A method of detecting a material discontinuity in a magnetisable article comprising:
 - 5 traversing a magnet along the article so that lines of magnetic flux from an active magnetic field of the magnet loop through the article and magnetically couple the magnet to the article;
 - placing at least one magnetic field coupling sensor at a fixed position relative to the magnet and in the active magnetic field of the magnet
 - 10 wherein the at least one coupling sensor traverses along the article with the magnet to sample magnetic coupling between the magnet and the article;
 - and
 - analysing the measured magnetic coupling in the active magnetic field for a change in the magnetic coupling during the traversing of the magnet and
 - 15 using the change in magnetic coupling to detect a discontinuity in the article.
2. The method according to claim 1 wherein analysing information comprises making a determination of a size of the discontinuity.
- 20 3. The method according to claim 1 or 2 wherein the at least one coupling sensor is arranged to sense at least direction of the magnetic flux looping through the article.
- 25 4. The method according to any one of claims 1 to 3 wherein the at least one coupling sensor is arranged to sense at least density of the magnetic flux looping through the article.
5. The method according to any one of claims 1 to 4 wherein the article is a rail for a rail transport vehicle.
- 30 6. The method according to any one of claims 1 to 5 further comprising acquiring longitudinal samples of the magnetic field along the article using one or more displacement sensors simultaneously with acquisition of samples of magnetic coupling from the one or more coupling sensors;
- 35 between instants at which the samples are acquired, moving: the magnet, the coupling sensors and the displacement sensors in a fixed juxtaposition relative to

each other along the article; and
using the samples from the displacement sensors to provide an estimate of the
displacement of the magnet along the article between successive sampling
instants.

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7. The method according to claim 6 wherein using the samples from the
displacement sensors to provide an estimate of the displacement of the magnet
comprises cross correlating the samples acquired from the displacement
sensors at successive sampling instants.

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8. The method according to claim 7 comprising combining the samples from the
coupling sensors and the displacement sensors to provide an indication of
magnetic field coupling across a discontinuity in the displacement domain.

15

9. A system for detecting a material discontinuity in a magnetisable article
comprising:

a magnet capable of being traversed along the article so that lines of
magnetic flux from an active magnetic field of the magnet loop through the
article and magnetically couple the magnet to the article; and
at least one magnetic field sensor located at a fixed position relative to the
magnetic and in the active magnetic field of the magnet wherein the at
least one sensor traverses along the article with the magnet and is
arranged to measure magnetic coupling between the magnet and the
article.

25

10. The system according to claim 9 further comprising a magnetic flux analysis
system arranged to analyse information pertaining to the magnetic flux provided
by the at least one sensor to provide an indication of a characteristic of the
surface penetrating discontinuity.

30

11. The system according to claim 9 or 10 wherein the at least one magnetic field
coupling sensor is one of a plurality of coupling sensor arranged in an array in a
direction transverse to a direction of traverse of the magnet along the article.

35

12. The system according to anyone of claims 9-11 comprising a displacement
sensor acquiring samples of the magnetic field at multiple locations spaced
longitudinally along the rail simultaneously with acquisition of samples of

magnetic coupling from the one or more coupling sensors.

13. A method of estimating spatial displacement with respect to a magnetic field response of an article comprising:

5 acquiring multiple samples of magnetic field coupling between an article and a magnet at a known sampling frequency wherein the magnet is capable of being moved in a direction to traverse a length of the article and wherein the multiple samples are simultaneously acquires at each of a plurality of locations that are spaced from each other in the direction of the
10 length of the article;
 in a period between successive sampling instants moving the magnet and the an apparatus capable of acquiring the samples in a fixed spatial relationship with each other along the article; and
 processing the acquired multiple samples to provide an estimate of the
15 displacement of the magnetic along the article between successive sampling instants.

14. A method of facilitating characterization of a material discontinuity in a ferromagnetic article comprising:

20 applying a magnetic field to the article;
 acquiring multiple samples of magnetic field coupling between the magnet and the article at a known sampling frequency;
 in a period between the successive sampling instants moving an apparatus capable of applying the magnetic field and acquiring the samples in a fixed
25 spatial relationship with each other along the article;
 processing the acquired multiple samples to provide an estimate of the displacement of the apparatus along the article between successive sampling instants;
 using the estimates of displacement to facilitate characterization of the
30 feature in the article.

15. The method according to claim 14 wherein acquiring multiple samples of magnetic field coupling comprises acquiring a first multiple of samples at each of a plurality of locations that are spaced from each other in the direction of motion of the
35 article; and a second multiple of sample at each of a plurality of locations that are spaced from each other transverse to the direction of motion of the article.

16. The method according to claim 13 or 15 wherein processing the acquired multiple samples to provide an estimate of the displacement comprises cross correlating the samples acquired at successive sampling instants from the plurality of locations that are spaced from each other in the direction of the length of the article or the direction of motion of the article.
17. A method of detecting a break in a railway track, the method comprising:
acquiring one or more samples of magnetic field coupling between a magnet and a rail in a railway track to facilitate an estimation of depth of a crack in the rail;
simultaneously acquiring longitudinal samples of the magnetic field coupling along the rail;
between instants at which the samples are acquired, moving an apparatus capable of acquiring the samples along the rail;
using the longitudinal samples to provide an estimate of the displacement of the apparatus along the rail between successive sampling instants to facilitate an estimation of width of the crack; and
processing the depth and width estimations to enable the surface penetrating feature to be characterised as one of a plurality of features including a break in the rail.
18. A system for estimating spatial displacement along a magnetisable article with respect to a defect sufficient to cause a detectable change in natural polarization boundary of an active magnetic field couple with the article comprising:
an apparatus supporting a magnetic field measuring system arranged to sense magnetic field strength at multiple spaced locations in a length direction of the article at each sampling instant of a known sampling frequency, the apparatus being capable of being moved in the length direction along the article; and
a processor arranged to process the measured magnetic field strength at the multiple locations at successive sampling instants to provide an estimate of displacement of the apparatus at each sampling instant along the article in the vicinity of the defect.

each other along the article; and
using the samples from the displacement sensors to provide an estimate of the displacement of the magnet along the article between successive sampling instants.

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7. The method according to claim 6 wherein using the samples from the displacement sensors to provide an estimate of the displacement of the magnet comprises cross correlating the samples acquired from the displacement sensors at successive sampling instants.

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8. The method according to claim 7 comprising combining the samples from the coupling sensors and the displacement sensors to provide an indication of magnetic field coupling across a discontinuity in the displacement domain.

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9. A system for detecting a material discontinuity in a magnetisable article comprising:

a magnet capable of being traversed along the article so that lines of magnetic flux from an active magnetic field of the magnet loop through the article and magnetically couple the magnet to the article; and
at least one magnetic field sensor located at a fixed position relative to the magnetic and in the active magnetic field of the magnet wherein the at least one sensor traverses along the article with the magnet and is arranged to measure magnetic coupling between the magnet and the article.

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10. The system according to claim 9 further comprising a magnetic flux analysis system arranged to analyse information pertaining to the magnetic flux provided by the at least one sensor to provide an indication of a characteristic of the surface penetrating discontinuity.

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11. The system according to claim 9 or 10 wherein the at least one magnetic field coupling sensor is one of a plurality of coupling sensor arranged in an array in a direction transverse to a direction of traverse of the magnet along the article.

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12. The system according to anyone of claims 9-11 comprising a displacement sensor acquiring samples of the magnetic field at multiple locations spaced longitudinally along the rail simultaneously with acquisition of samples of

magnetic coupling from the one or more coupling sensors.

13. A method of estimating spatial displacement with respect to a magnetic field response of an article comprising:

5 acquiring multiple samples of magnetic field coupling between an article
and a magnet at a known sampling frequency wherein the magnet is
capable of being moved in a direction to traverse a length of the article the
and wherein the multiple samples are simultaneously acquires at each of a
plurality of locations that are spaced from each other in the direction of the
10 length of the article;
in a period between successive sampling instants moving the magnet and
the an apparatus capable of acquiring the samples in a fixed spatial
relationship with each other along the article; and
processing the acquired multiple samples to provide an estimate of the
15 displacement of the magnetic along the article between successive
sampling instants.

14. A method of facilitating characterization of a material discontinuity in a ferromagnetic article comprising:

20 applying a magnetic field to the article;
acquiring multiple samples of magnetic field coupling between the magnet
and the article at a known sampling frequency;
in a period between the successive sampling instants moving an apparatus
capable of applying the magnetic field and acquiring the samples in a fixed
25 spatial relationship with each other along the article;
processing the acquired multiple samples to provide an estimate of the
displacement of the apparatus along the article between successive
sampling instants;
using the estimates of displacement to facilitate characterization of the
30 feature in the article.

15. The method according to claim 14 wherein acquiring multiple samples of magnetic field coupling comprises acquiring a first multiple of samples at each of a plurality of locations that are spaced from each other in the direction of motion of the
35 article; and a second multiple of sample at each of a plurality of locations that are spaced from each other transverse to the direction of motion of the article.

16. The method according to claim 13 or 15 wherein processing the acquired multiple samples to provide an estimate of the displacement comprises cross correlating the samples acquired at successive sampling instants from the plurality of locations that are spaced from each other in the direction of the length of the article or the direction of motion of the article.
17. A method of detecting a break in a railway track, the method comprising:
acquiring one or more samples of magnetic field coupling between a magnet and a rail in a railway track to facilitate an estimation of depth of a crack in the rail;
simultaneously acquiring longitudinal samples of the magnetic field coupling along the rail;
between instants at which the samples are acquired, moving an apparatus capable of acquiring the samples along the rail;
using the longitudinal samples to provide an estimate of the displacement of the apparatus along the rail between successive sampling instants to facilitate an estimation of width of the crack; and
processing the depth and width estimations to enable the surface penetrating feature to be characterised as one of a plurality of features including a break in the rail.
18. A system for estimating spatial displacement along a magnetisable article with respect to a defect sufficient to cause a detectable change in natural polarization boundary of an active magnetic field couple with the article comprising:
an apparatus supporting a magnetic field measuring system arranged to sense magnetic field strength at multiple spaced locations in a length direction of the article at each sampling instant of a known sampling frequency, the apparatus being capable of being moved in the length direction along the article; and
a processor arranged to process the measured magnetic field strength at the multiple locations at successive sampling instants to provide an estimate of displacement of the apparatus at each sampling instant along the article in the vicinity of the defect.