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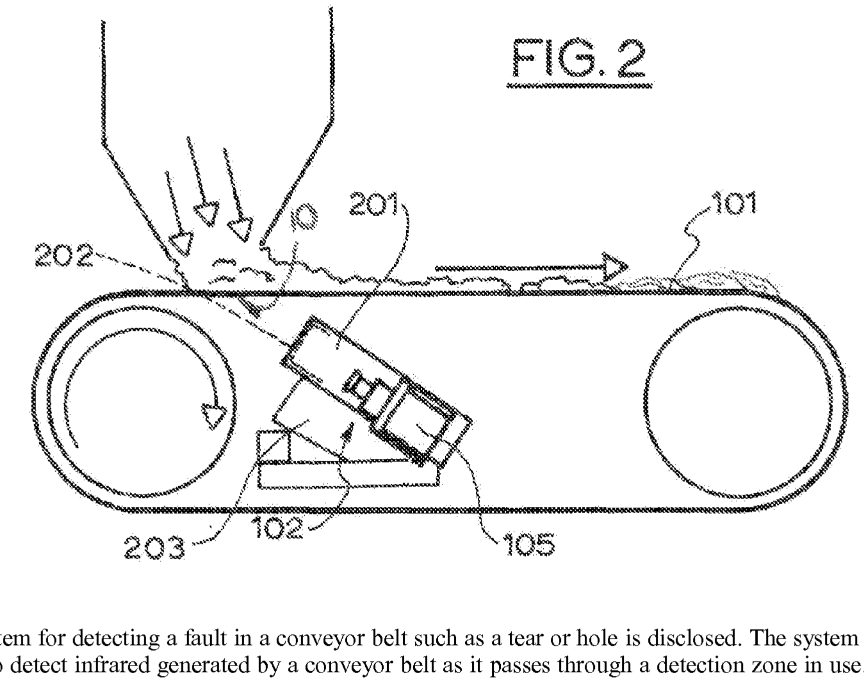
FIG. 2



(57) **Abstract**: A system for detecting a fault in a conveyor belt such as a tear or hole is disclosed. The system comprises an infrared detector positioned to detect infrared generated by a conveyor belt as it passes through a detection zone in use. The detector obtains infrared images of said conveyor belt which are processed by a processor for diagnosing a possible fault in the conveyor belt. The infrared detector is mounted beneath said conveyor belt and images a lower surface of the conveyor belt carrying material. The processor interprets the infrared images to determine whether there is a tear in the conveyor belt. A method for detecting a fault in a conveyor belt be sensing for heat generated by belt damage is also disclosed.

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INFRARED DETECTION OF CONVEYOR BELT FAULTS

FIELD OF DISCLOSURE

The present disclosure relates to a method and system for the detection of conveyor belt faults, such as tears or holes. In particular, the disclosure relates to methods and systems that employ the use of infrared detection of such faults in conveyor belts.

BACKGROUND ART

Conveyor belts play an important role in many manufacturing and mining processes. They see use in the transportation of raw materials and components to production and in the transportation of the finished products. Due to continual mining processes in use on many sites, there are generally substantial material flows which have to be handled. Conventional transport systems present issues and are not well-suited to managing such mass flows. Consequently, conveyor belts are the most common choice for companies with requirements of fast and steady delivery of goods with a high mass flow.

One issue facing companies using conveyor belts is linear rips in the belt from impact by sharp objects in the flow path. In general, rips are caused by different tramp materials unintentionally becoming part of the bulk material stream. The inventors have previously developed an optical rip detection system which combines an optical laser beam and a camera supported by particular software developed for the system. After initial trials it was determined that such systems are generally less effective or difficult to implement in dusty and moist environments. In particular, it is envisaged that such systems may require relatively expensive ventilation and air blowing systems to alleviate issues relating to dust within the working environment. Such systems may also require frequent maintenance of requisite filters and air blowing systems.

United States Patent No. 7,894,934 describes systems for the remote monitoring of conveyor belts. As part of the system, a rip detection system is described with reference to the SENSOR GUARD system. This system works on the premise of closed-circuit loops and RFID tags embedded in the belt, monitored by electromagnetic detectors placed at high potential damage points. As the conveyor moves, these loops and tags pass over the detectors which generate output pulses. If the belt begins to rip, a sensor loop is also cut. As this cut loop passes over a detector, no pulse is generated. The lack of pulse is recognized by the control unit, which signals the drive controls to shut the conveyor down to minimize further damage. The recorded tag information positively identifies the location of the damaged area. Such systems are also described in United States Patent Publication No. 2007/0278068, incorporated into United States Patent No. 7,894,934 by reference.

The subject matter claimed herein is not limited to embodiments that solve any disadvantages or that operate only in environments such as those described above. Rather, this background is only provided to illustrate one exemplary technology area where some embodiments described herein may be practice.

The reference to prior art in this specification is not and should not be taken as an acknowledgment or any form of suggestion that the referenced prior art forms part of the common general knowledge in Australia or in any other country.

SUMMARY OF DISCLOSURE

One aspect of the present disclosure provides a system for detection of faults in a conveyor belt comprising:

an infrared detector mounted to image at least a portion of said conveyor belt, thereby obtaining infrared images of said conveyor belt; and

a processor adapted to process said infrared images of said conveyor belt and thereby identify faults in said conveyor belt.

The processing of infrared images by the processor may comprise processing data generated from said infrared images.

The infrared detector may be mounted in any suitable location relative to the conveyor belt. For example, the infrared detector may be mounted above the conveyor belt, or may be mounted to indirectly image an underside of the conveyor belt (e.g. through reflective means). In one embodiment, the infrared detector is mounted beneath said conveyor belt to image an underside of said conveyor belt. This location of the infrared detector is thought to provide the best perspective for the early identification of faults as they appear in the conveyor belt.

The infrared detector may be arranged to image laterally across the width of the conveyor belt. The infrared detector may be arranged to image laterally across the entire width of the conveyor belt

Further the infrared detector may be orientated to image a longitudinal section of said conveyor belt along the travel path of said conveyor belt, e.g. image a longitudinal section across the entire width of said conveyor belt.

It is envisaged that the distance from the infrared detector to the conveyor belt is not particularly limited. The infrared detector may be located relatively close to the conveyor belt, for example either above or below the conveyor belt, or may be located some distance away from the conveyor belt.

The infrared detector may be arranged to obtain two-dimensional spatial infrared images of at least a portion of said conveyor belt. Generally the infrared detector comprises an infrared camera which is adapted to obtain two-dimensional infrared images.

The infrared detector may comprise at least one infrared camera. In particular the infrared detector may comprise an infrared camera which is adapted to obtain two-dimensional infrared images.

In that regard, it is envisaged that in some applications is may be advantageous for the infrared detector to comprise a plurality of infrared cameras arranged to image the conveyor belt from different perspectives. This may provide additional information for subsequent processing and analysis.

In order to protect the infrared detector from the working environment, the system may additionally comprise a housing which houses said infrared detector. Said housing may comprise a casing that receives said infrared detector and a screen through which a lens of said infrared detector is directed. The screen should be transparent to infrared radiation but need not necessarily be transparent to visible light infrared radiation.

The casing may be elongate, in which case the screen may be disposed on one end of said casing.

The processor is adapted to process said infrared images of said conveyor belt and thereby identify faults in said conveyor belt. The processor may also be adapted to process data generated from said infrared images. In certain embodiments, said processor is adapted to identify heat signatures, e.g. linear heat signatures, along the travel path of said conveyor belt, imaged by said infrared detector, and determine whether said linear heat signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt.

The processor may comprise software adapted to identify whether said linear heat signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt. The software may comprise an algorithm-based determination of whether said linear heat signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt. Alternatively, or in combination with the algorithm-based determination, the system may comprise a linear heat signature library, e.g. a linear heat signature library, and the software may be adapted to compare said heat signatures imaged by said infrared detector with said heat signature library to determine whether said heat signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt.

In certain embodiments, the processor may be adapted to identify cold spots in said conveyor belt, imaged by said infrared detector, and determine whether said cold spots are representative of a hole or tear in said conveyor belt. In that regard, the processor may comprise software to identify whether said cold spots are representative of a hole or tear in said conveyor belt, for example by means of an algorithm-based determination or when compared with a cold spot library of said system. It will be appreciated that such software may be an extension of the software described above.

In certain applications, it may be advantageous for the system to additionally comprise at least one optical camera mounted to image said portion of said conveyor belt. If so, the optical camera may provide real time images of said conveyor belt that are sent to an operator or controller of said system. It is envisaged that other scanning technology may also be employed to supplement the infrared imaging. For example, this may include laser scanning of the conveyor belt, although this may raise issues due to the harsh environment of the conveyor belt, which may not be conducive to adequate operation of the laser.

According to another aspect of the disclosure there is provided a method for detection of faults in a conveyor belt comprising:

imaging at least a portion of said conveyor belt with an infrared detector to obtain infrared images of said conveyor belt;

processing said infrared images; and

identifying faults in said conveyor belt based on said infrared images, or data generated from said infrared images.

The processing of infrared images may comprise processing data generated from said infrared images.

As with the system of the disclosure, imaging may comprise imaging a length of an underside of said conveyor belt along the travel path of said conveyor belt. Likewise, imaging may comprise imaging said conveyor belt across part of, and in some embodiments, the entire width of said conveyor belt.

Thus imaging may comprise obtaining a two-dimensional spatial image comprising a length of an underside of said conveyor belt along the travel path of said conveyor and a width across the entire width of said conveyor belt.

Processing may comprise identifying linear heat signatures along the travel path of said conveyor belt, imaged by said infrared detector, and determining whether said linear heat signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt. This may comprise an algorithm-based determination of whether said linear heat signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt. It may alternatively or additionally comprise comparing said linear heat signatures imaged by said infrared detector with a linear heat signature library to determine whether said linear heat signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt.

Processing may alternatively or additionally comprise identifying cold spots in said conveyor belt, imaged by said infrared detector, and determining whether said cold spots are representative of a hole or tear in said conveyor belt, for example by means of an algorithm-based determination or by comparison with a cold spot library.

As with the above described system, the method may additionally comprise optically imaging said portion of said conveyor belt and relaying optical images of said conveyor belt to an operator in real time.

The present disclosure comprises features and a combination of parts hereinafter fully described and illustrated in the accompanying drawings, it being understood that various changes in the details may be made without departing from the scope of the disclosure or sacrificing any of the advantages of the present disclosure.

According to another aspect there is provided a system for detecting a fault in a conveyor belt, the system including:

an infrared detector for obtaining infrared images of a portion of a conveyor belt in operation as it passes through a detection zone; and

a processor capable of receiving the infrared images from the infrared detector for processing the infrared images and based on this identifying a possible fault in the conveyor belt.

The term fault in a conveyor belt is to be interpreted broadly and may include damage to the belt caused by operation of the conveyor belt, e.g. a longitudinal split, a longitudinal tear or a longitudinal cut in the conveyor belt. It may also include a hole, a gouge, a puncture or a crater in the conveyor belt. It may also include a stress region or region of weakness in the material of the conveyor belt. It may also include a manufacturing flaw in the belt.

The infrared detector may be mounted on a stationary support beneath the conveyor belt with the infrared detector facing upwards towards the detection zone which extends across a downward facing surface of the belt.

The conveyor belt may include a transport leg for transporting material and a return leg for returning the belt to a start of the transport leg, and the infrared detector may be directed at an underside of the transport leg of the conveyor belt, e.g. which is carrying material thereon.

Further the infrared detector may be positioned adjacent to a feed point at which material is fed onto the conveyor belt.

The portion of the conveyor belt within the detection zone may include a longitudinal section of the belt and substantially a full width of the conveyor belt.

The infrared detector may comprise at least one infrared camera including a lens and the infrared camera may obtain two-dimensional infrared images of the detection zone, e.g. two dimensional spatial images.

Optionally the system may comprise more than one infrared camera with the cameras being arranged to collectively obtain infrared images of the detection zone.

The system may include an elongate casing having a screen, and the infrared detector may be received within the casing with the lens of the camera being directed through the screen.

The processor may process the infrared images detected by the infrared detector. The processor may compare these images with other stored images to identify the type of fault in the conveyor belt.

In at least one alternative form the processor may use a processing method other than comparison with stored images in order to identify a fault in the conveyor belt.

In particular the processor may identify certain heat signatures in the infrared signatures that are indicative of certain types of damage to the conveyor belt.

The processor may further determine whether the heat signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt.

The system may further include at least one optical camera directed at the detection zone which obtains optical images of the belt in the detection zone to assist in identifying faults in the conveyor belt.

The optical camera may optionally transfer the optical images, e.g. in real time, to an operator to enable the operator to assess faults in the conveyor belt.

According to another aspect there is provided a system for detecting a fault in a flexible conveyor belt made of a material including rubber, the system including:

a detector for detecting heat that is generated by belt damage and based on this identifying a possible fault in the belt, e.g. so that intervention can occur.

In particular the detector may detect heat that is infrared radiation, e.g. in the form of infrared images, generated by the belt when it is damaged.

The system may include any one or more of the features described above in preceding aspects of the disclosure.

According to another aspect of the disclosure there is provided a method for detecting a fault in a conveyor belt, the method including:

obtaining infrared images of a portion of a conveyor belt as the conveyor belt passes through a detection zone; and

processing the infrared images of the conveyor belt to identify a possible fault in the conveyor belt.

Obtaining infrared images of a portion of a conveyor belt may include obtaining two dimensional infrared images of the conveyor belt. Obtaining infrared images of the conveyor belt may include obtaining images of the belt on a continuous basis. For example the detector may generate a continuous stream of images which are then processed.

Processing the infrared images of the conveyor belt may include identifying certain faults in the conveyor belt based on the infrared images have been obtained and processed.

Obtaining infrared images of a portion of a conveyor belt may include obtaining images of a longitudinal length of a portion of the belt across part of the width of the belt. In some forms the images may extend across all of the width of the belt.

Processing the infrared images of the portion of the conveyor belt may further include identifying certain heat signatures within the detection zone that are indicative of certain types of fault in and/or damage to the conveyor belt.

Processing the infrared images may further include determining whether the heat signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt.

The method may further include using an optical camera to obtain optical images of the portion of the belt in the detection zone to assist in identifying damage to the conveyor belt.

The method may further include transferring the optical images to a controller, e.g. an operator, to enable them to assess the conveyor belt.

The method may include any of the method features defined in the preceding aspects of the disclosure directed to methods.

According to another aspect of the disclosure there is provided a method for detecting a fault in conveyor belt made of a material including rubber, the method including:

sensing heat that is generated as a result of belt damage and based on this identifying a possible fault in the belt.

Sensing heat that is generated when damage is done may include detecting infrared radiation that is generated by the belt.

Detecting infrared radiation may include obtaining infrared images and processing the images to detect the type of damage to the belt.

The method may include processing the infrared images of the conveyor belt to identify a possible flaw in the conveyor belt.

The method may include any of the method features defined in the preceding aspects of the disclosure directed to methods.

According to yet another aspect of the disclosure there is provided a conveyor belt installation comprising:

a support;

an endless belt mounted on the support for conveying material from one location to another, the endless belt including a transport leg for transporting material from one point to another and a return leg for returning the belt to said one point; and

a system for detecting a fault in the endless belt as defined in any of the preceding aspects of the invention.

The endless belt may be made of a flexible material that includes rubber and may be passed around two endless rollers that are spaced apart from each other.

One roller may a drive roller which actively drives the belt and the other roller may be an idler roller.

The infrared detector may be positioned beneath the transport leg of the belt and may be directed up at a downward facing underside of the transport leg of the belt.

Further the infrared detector may be positioned adjacent an upstream end of the transport section of the belt to enable the system to identify a fault shortly after material has been fed onto the belt.

The system may include any one or more of the features described above in preceding aspects of the disclosure.

An advantage of the system and method of the disclosure is that it utilises heat that is generated as a result of belt damage to diagnose or detect a potential fault in the belt. The heat that is generated when damage occurs is more easily detected than systems which rely on a visual indication of damage. This is particularly so in a particle laden and dusty environment of transferring a particulate material on a conveyor. Particles including dust within the environment have the same temperature as the surrounding environment but this does not affect functionality because the use of infrared utilizes differences in temperature and infrared radiation to diagnose faults.

BRIEF DESCRIPTION OF ACCOMPANYING DRAWINGS

To further clarify various aspects of some embodiments of the present disclosure, a more particular description of the disclosure will be rendered by references to specific embodiments thereof, which are illustrated in the appended drawings. It is appreciated that these drawings depict only typical embodiments of the disclosure and are therefore not to be considered limiting of its scope. The disclosure will be described and explained with additional specificity and detail through the accompanying drawings in which:

FIG. 1 illustrates a schematic drawing of a system in accordance with the disclosure (showing an underside of the conveyor belt).

FIG. 2 illustrates a schematic side view of conveyor belt fitted with the system of FIG. 1.

FIG. 3A illustrates a perspective view of an infrared camera mounted for use in a system of an embodiment of the disclosure of FIG 3A.

FIG. 3B illustrates another perspective view of the mounted infrared camera.

FIG. 4 illustrates an infrared camera image including a belt splice region of a conveyor belt.

FIGS. 5-7 illustrate an infrared camera image of a conveyor belt including linear hot spots.

FIG. 8 illustrates an infrared camera image after two months on site use of the infrared camera, before cleaning the lens surface.

FIG. 9 illustrates an infrared camera image after two months on site use of the infrared camera, after cleaning the lens surface.

FIG. 10 illustrates a flowchart of methodology according to an embodiment of the disclosure.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

The present disclosure provides a method and system for the detection of conveyor belt faults, such as tears or holes. In particular, the disclosure relates to methods and systems that employ the use of infrared detection of such faults in conveyor belts.

Hereinafter, the present disclosure will be described in more detail according to some example embodiments. It is to be understood that limiting the description to the example embodiments of the disclosure is merely to facilitate discussion of the present disclosure. Alternatives and modifications to the example embodiments may be understood and appreciated by those of skill in the art and are included within the ambit of the disclosure without departing from the scope of the appended claims.

Referring to Figure 1, a system 100 for detection of faults in a conveyor belt 101 is illustrated. The system 100 includes an infrared camera 102 mounted beneath the conveyor belt 101, or in a location where it can see an underside of the conveyor belt 101. For example, it is envisaged that it may be possible to mount the infrared camera 102 so that it is easily accessible (i.e. in a location that is not under the conveyor belt 101), but imaging the underside of the belt via a reflective surface. For convenience, though, the following discussion will generally relate to imaging from beneath the conveyor belt 101, although the disclosure is not so limited.

The infrared camera 102 is mounted such that its field of view includes a detect ion zone 10 that extends for a distance along the length of the conveyor belt 101 in the direction of travel of the conveyor belt 101. The detection zone 10 within the field of view of the infrared camera 102 extends across the entire width of the conveyor belt 101. As such, the field of view of the infrared camera 102 includes a length of the conveyor belt 101, generally about 0.5 to 2m in length. This ensures heat signatures or hot spots, e.g. linear heat signatures, may be identified, as discussed in more detail below. The infrared camera 102 is mounted at an angle of elevation of from 10 to 60 degrees relative to the plane of the conveyor belt 101.

Generally, the infrared camera 102 is positioned in a location where foreign objects have a higher probability of getting stuck in the ore stream and tearing the conveyor belt 101. For example, the location may be adjacent to a transfer station or a feed chute as shown in Figure 2. It is thought that when a thick piece of rubber is in the process of being torn, a substantial amount of heat will be generated. This heat should be clearly evident in the image taken by the infrared camera 102.

The images, or data collected from the detection zone 10 are communicated to a processor 103. The processor 103 is provided with software adapted to interpret the images and/or data. For example, the software may use an algorithm-based determination of whether or not a particular heat signature or cold spot imaged by the infrared camera 102 corresponds with a tear, potential tear or hole in the conveyor belt 101. The software may also rely on a library of heat signatures and/or cold spots that can be used for comparative purposes to determine whether a particular heat signature or cold spot imaged by the infrared camera 102 corresponds with a tear, potential tear or hole in the conveyor belt 101.

It is envisaged that an algorithm, for example, would look for a linear heat signature that is hot downstream (where the foreign object is pushing into the belt) and cool upstream. If a tear is initiated outside of the field of view and upstream, it is envisaged that the algorithm may detect the sudden appearance of a linear heat signature.

Once a determination has been made, this is reported to a controller 104, which may be manually operated or automated. The controller 104 controls the conveyor belt 101 and may shut down the conveyor belt 101 if it is deemed necessary based on the information reported by the processor 103. This enables necessary maintenance and repairs to be carried out.

An optical camera 105 may also be provided that communicates a visual image of the detection zone 10 to the processor 103 and/or control 104. As such, visual confirmation of a tear or hole may be possible at the processor 103 and/or control 104.

Referring to Figures 2 and 3, mounting of the infrared camera 102 is shown in more detail. As illustrated, the infrared camera 102 is housed in a casing 201 provided with a screen 202, through which the lens of the infrared camera 102 is directed. The infrared camera 102 is mounted on a mount 203 underneath a conveyor belt 101 and is directed up at the detection zone 10 on an underside of the conveyor belt 101.

The infrared camera 102 mounted and illustrated in Figures 2 and 3 was used to image a conveyor belt 101. Figures 4 to 7 are infrared camera images, e.g. screen shots from a video file, which we received from the infrared camera 102. Figure 4 includes a region

401 corresponding to a belt splice and shows some hot spots associated with the belt splice. Linear heat signatures 501, 601 and 701 are shown in Figures 5, 6 and 7 respectively. These linear heat signatures 501, 601 and 701 are indicative of damage or scratches in the conveyor belt 101 which are heating up during the conveying process and are represented in red on a coloured thermal image. The infrared camera 102 also identifies areas 502, 602 and 702 of conveyor belt 101 that are under higher stress by the transport, which are represented in yellow on a coloured thermal image.

During the experiments carried out on the conveyor belt no difficulties were identified with the images collected by the infrared camera 102 during a two month trial period. The surface of the screen 202, which covers the lens of the infrared camera 102, was not cleaned over the two month period and the image obtained showed no deterioration over two months. Figures 8 and 9 show images taken after the two month trial period before and after cleaning of the screen 202 respectively. The infrared camera 102 seemed to be less sensitive to the harsh environment, compared with other systems, such as optical systems based on visual images. This system is particularly effective because the dust has the same temperature as the surrounding environment and this does not affect the functionality of the infrared camera 102 which utilizes differences in temperature and infra-red radiation to diagnose faults.

Referring to Figure 10, a method 1000 of detection of faults in a conveyor belt of an embodiment of the disclosure is illustrated. According to the method 1000 the conveyor belt is imaged 1010 with an infrared camera. Generally this will involve continuous imaging of the detection zone 10 on the conveyor belt. The images and/or data retrieved from the images is transferred 1020 to a processor for processing 1030. As discussed above, processing 1030 of the images and/or data will generally involve an algorithm-based determination of whether or not heat signatures or cold spots identified by the infrared camera correlate with tears, potential tears or holes in the conveyor belt. Faults 1040 are thereby identified.

Once faults have been identified, they are reported 1050 to a control system. Optical imaging 1060 may be conducted to obtain visual confirmation of a tear or hole in the conveyor belt, although this may not be optimal. The conveyor belt may then be stopped 1070 for maintenance if needed.

Unless the context requires otherwise or specifically stated to the contrary, integers, steps or elements of the disclosure recited herein as singular integers, steps or elements clearly encompass both singular and plural forms of the recited integers, steps or elements.

Throughout this specification, unless the context requires otherwise, the word “comprise”, or variations such as “comprises” or “comprising”, will be understood to imply the inclusion of a stated step or element or integer or group of steps or elements or integers, but not the exclusion of any other step or element or integer or group of steps, elements or integers. Thus, in the context of this specification, the term “comprising” is used in an inclusive sense and thus should be understood as meaning “including principally, but not necessarily solely”.

It will be appreciated that the foregoing description has been given by way of illustrative example of the disclosure and that all such modifications and variations thereto as would be apparent to persons of skill in the art are deemed to fall within the broad scope and ambit of the disclosure as herein set forth.

CLAIMS:

1. A system for detection of faults in a conveyor belt comprising:

an infrared detector mounted to image at least a portion of said conveyor belt, thereby obtaining infrared images of said conveyor belt; and

a processor adapted to process said infrared images of said conveyor belt, and thereby identify faults in said conveyor belt.

2. A system according to claim 1, wherein the processor processes the infrared images by processing data generated from said infrared images.

3. A system according to claim 2, wherein said infrared detector is mounted beneath said conveyor belt to image an underside of said conveyor belt, and said infrared detector is arranged to image a longitudinal section of said conveyor belt along the travel path of said conveyor belt.

4. A system according to claim 2 or 3, wherein said infrared detector is arranged to image across the entire width of said conveyor belt.

5. A system according to any one of claims 1 to 4, wherein said infrared detector comprises at least one infrared camera.

6. A system according to any one of claims 1 to 5, additionally comprising a housing that houses said infrared detector, said housing comprising a casing that receives said infrared detector and a screen through which a lens of said infrared detector is directed.

7. A system according to claim 6, wherein said casing is elongate and wherein said screen is disposed on one end of said casing.

8. A system according to any one of claims 1 to 7, wherein said processor is adapted to identify linear heat signatures along the travel path of said conveyor belt, imaged by said infrared detector, and determine whether said linear heat signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt.

9. A system according to claim 8, wherein said processor comprises software to identify whether said linear heat signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt.

10. A system according to claim 9, wherein said software comprises an algorithm-based determination of whether said linear heat signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt.

11. A system according to claim 9, comprising a linear heat signature library, wherein said software is adapted to compare said linear heat signatures imaged by said infrared detector with said linear heat signature library to determine whether said linear heat signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt.

12. A system according to any one of claims 1 to 11, wherein said processor is adapted to identify cold spots in said conveyor belt that are imaged by said infrared detector, and determine whether said cold spots are representative of a hole or tear in said conveyor belt.

13. A system according to claim 12, wherein said processor comprises software to identify whether said cold spots are representative of a hole or tear in said conveyor belt, for example by means of an algorithm-based determination or when compared with a cold spot library of said system.

14. A system according to any one of claims 1 to 13, additionally comprising at least one optical camera mounted to image said portion of said conveyor belt.

15. A system according to claim 14, wherein said optical camera relays real time images of said conveyor belt to an operator of said system.

16. A method for detection of faults in a conveyor belt comprising:

imaging at least a portion of said conveyor belt with an infrared detector to obtain infrared images of said conveyor belt;

processing said infrared images; and

identifying faults in said conveyor belt based on said infrared images, or data generated from said infrared images.

17. A method according to claim 16, wherein processing said infrared images includes processing data generated from said infrared images.

18. A method according to claim 16 or claim 17, wherein said imaging comprises imaging a length of an underside of said conveyor belt along the travel path of said conveyor belt across the entire width of said conveyor belt.

19. A method according to any one of claims 16 to 18, wherein said processing comprises identifying linear heat signatures along the travel path of said conveyor belt, imaged by said infrared detector, and determining whether said linear heat

signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt.

20. A method according to claim 19, wherein said processing comprises an algorithm-based determination of whether said linear heat signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt.

21. A method according to claim 19, wherein said processing comprises comparing said linear heat signatures imaged by said infrared detector with a linear heat signature library to determine whether said linear heat signatures are representative of a tear in said conveyor belt, a potential tear in said conveyor belt, or a form of heating of said conveyor belt other than a tear or potential tear in said conveyor belt.

22. A method according to any one of claims 16 to 21, wherein said processing comprises identifying cold spots in said conveyor belt, imaged by said infrared detector, and determining whether said cold spots are representative of a hole or tear in said conveyor belt, for example by means of an algorithm-based determination or by comparison with a cold spot library.

23. A method according to any one of claims 16 to 22, additional comprising optically imaging said portion of said conveyor belt and relaying optical images of said conveyor belt to an operator in real time.

24. A system for detecting a fault in a conveyor belt, the system including:

an infrared detector for obtaining infrared images of a portion of a conveyor belt as it passes in use through a detection zone; and a processor capable of receiving the infrared images from the infrared detector for processing the infrared images and based on this identifying a possible fault in the conveyor belt.

25. A system for detecting a fault in a flexible conveyor belt made of a material including rubber, the system including:

a detector for detecting heat that is generated by belt damage and based on this identifying a possible fault in the belt.

26. A method for detecting a fault in a conveyor belt, the method including:

obtaining infrared images of a portion of a conveyor belt as the conveyor belt passes in use through a detection zone; and

processing the infrared images of the conveyor belt to identify a possible fault in the conveyor belt.

27. A method for detecting damage to a flexible conveyor belt made of a material including rubber, the method including:

sensing heat that is generated by belt damage and based on this identifying a possible fault in the belt.

28. A conveyor belt installation comprising:

a support;

an endless belt mounted on the support for conveying material from one location to another, the endless belt including a transport leg for transporting material from one point to another and a return leg for returning the belt to said one point; and

a system for detecting a fault in the endless belt as defined in any one of claims 1 to 25.

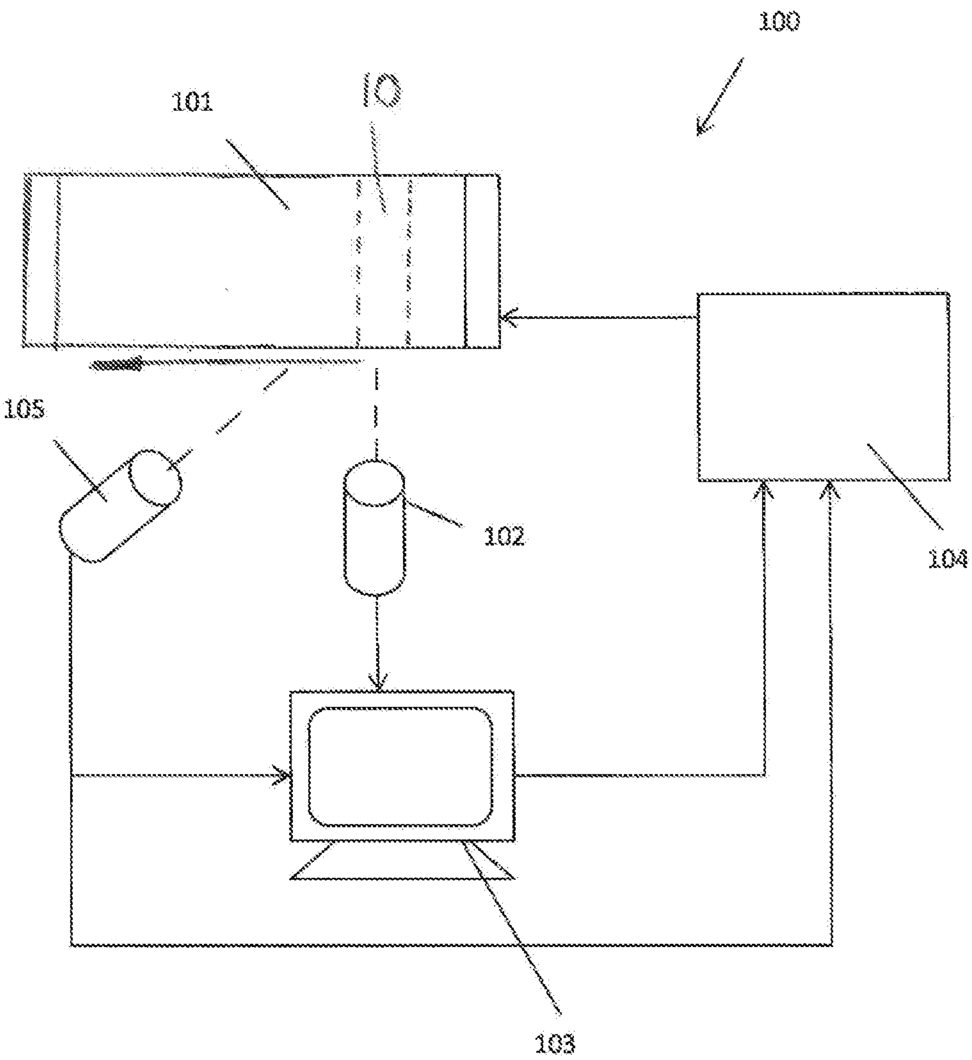

FIGURE 1

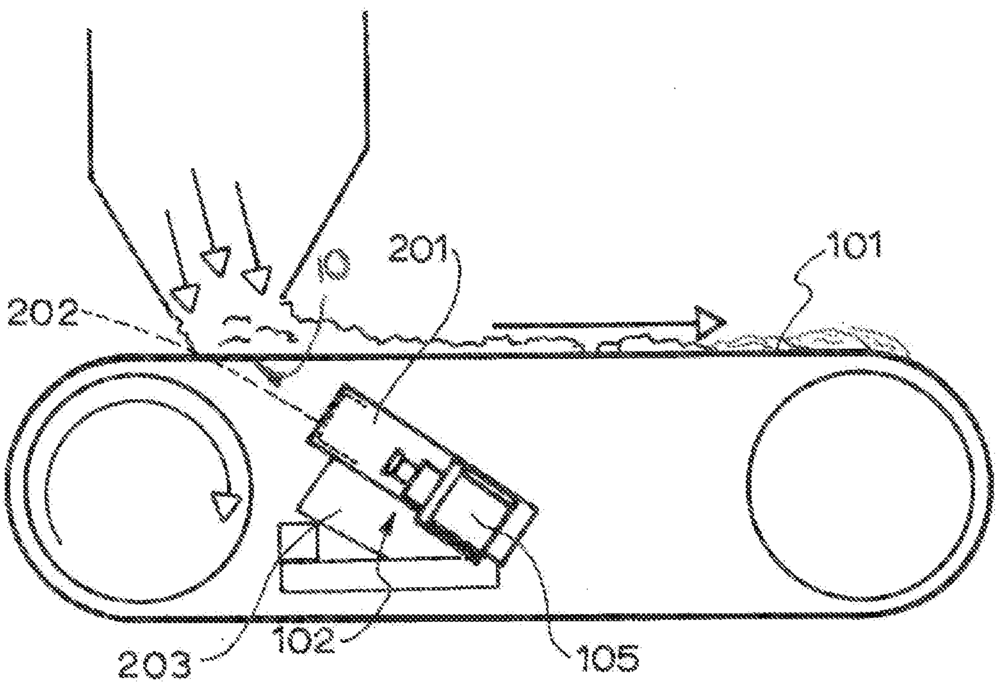

FIG. 2

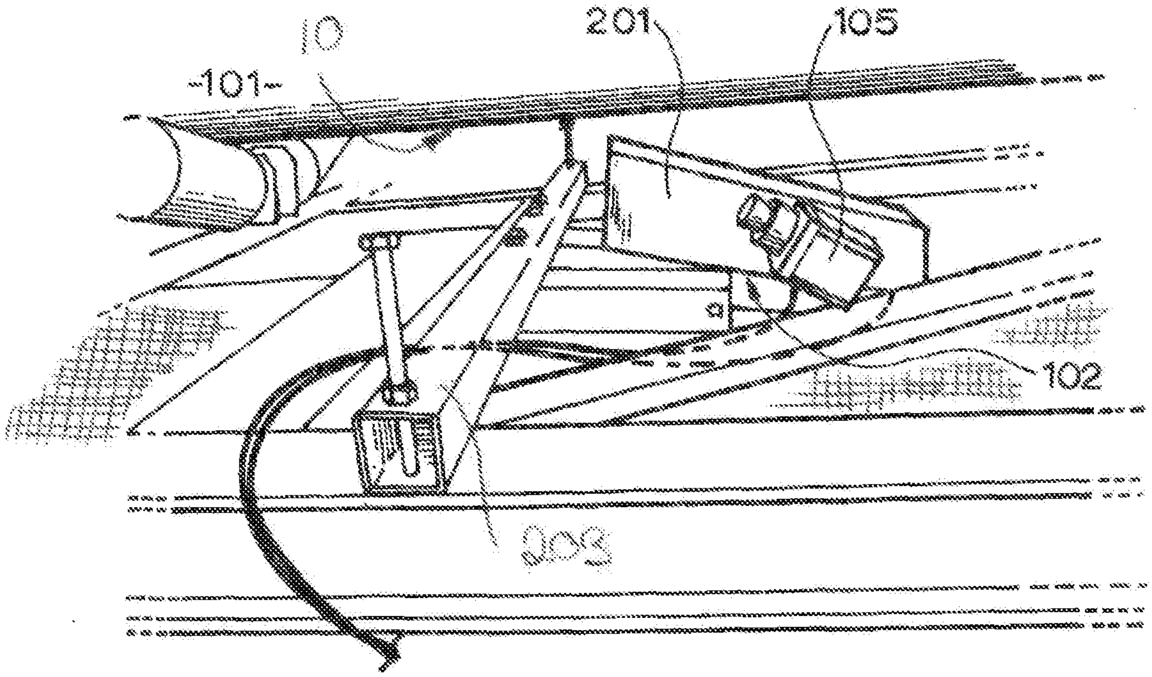

FIG.3A

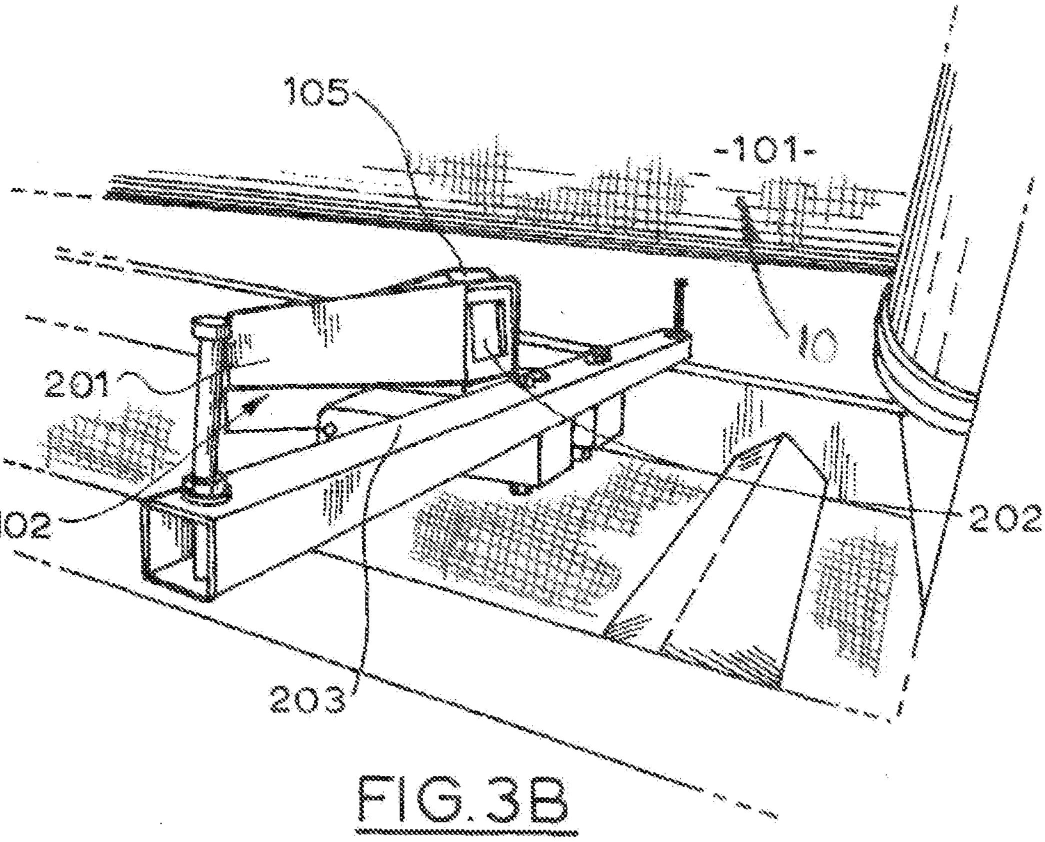

FIG.3B

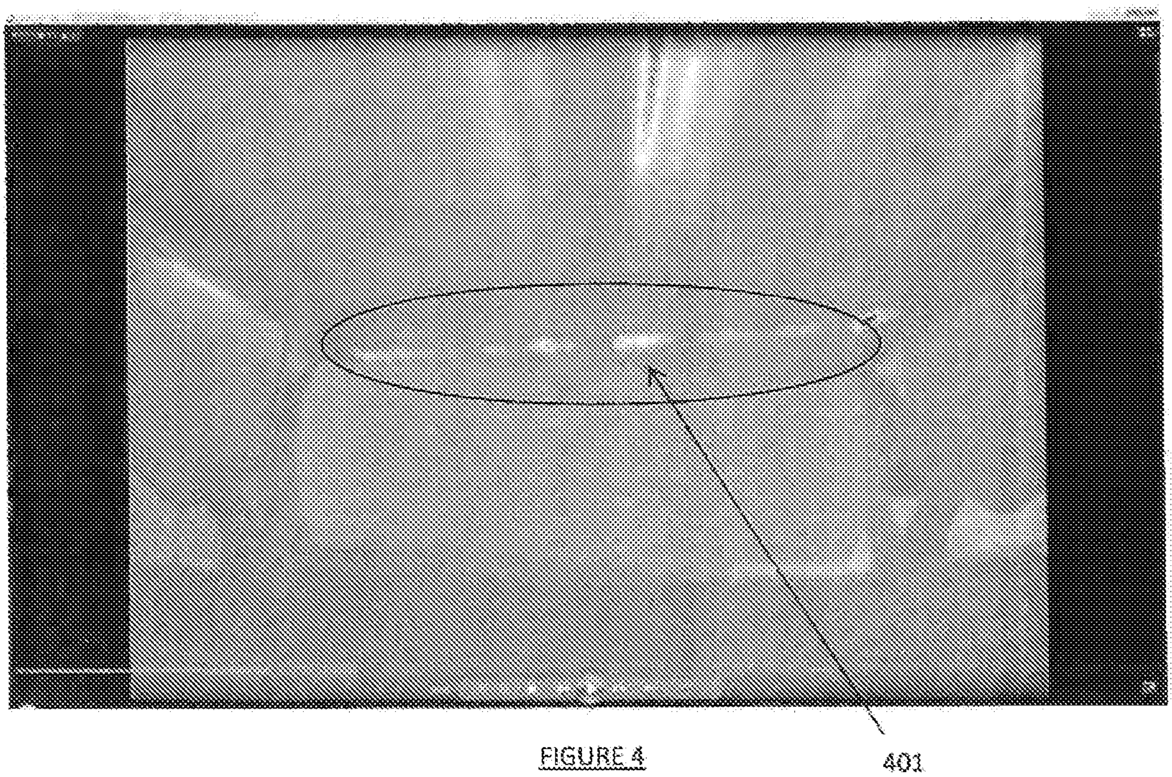

FIGURE 4

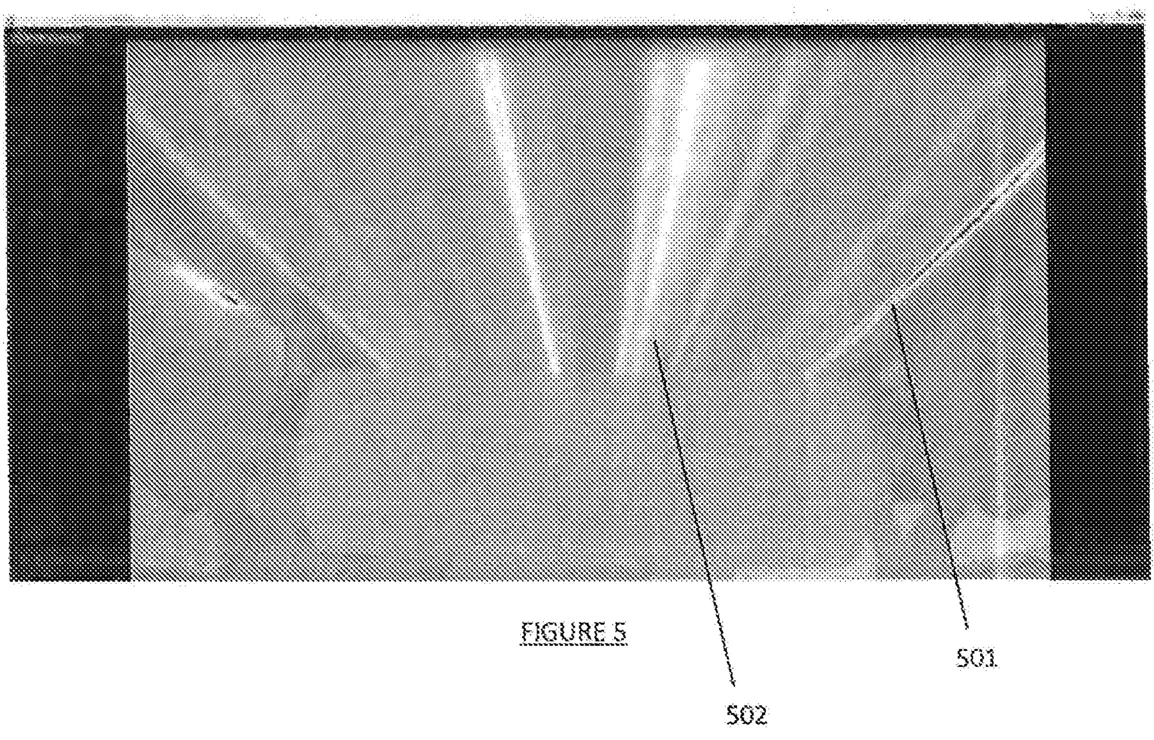

FIGURE 5

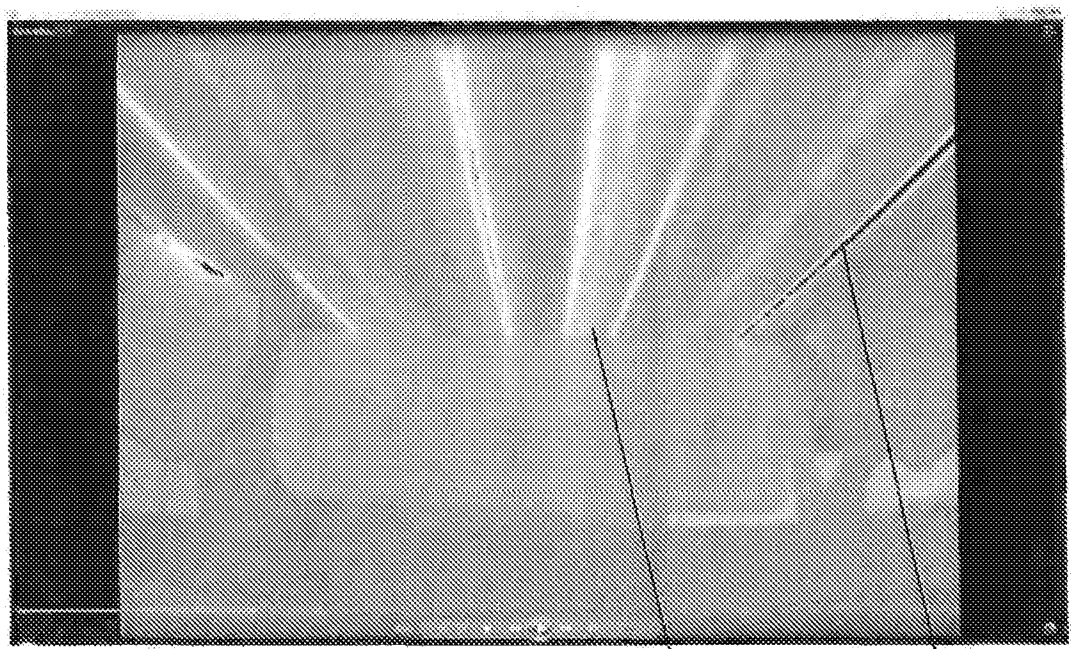

FIGURE 6

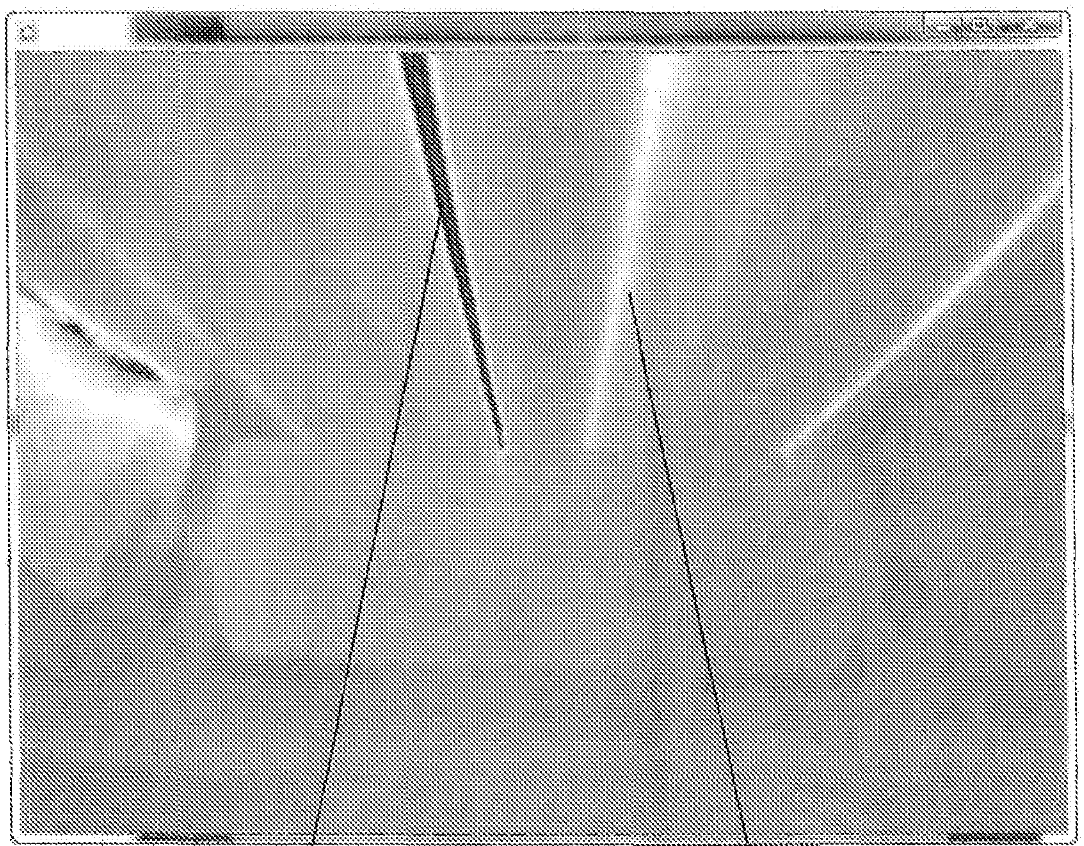

FIGURE 7

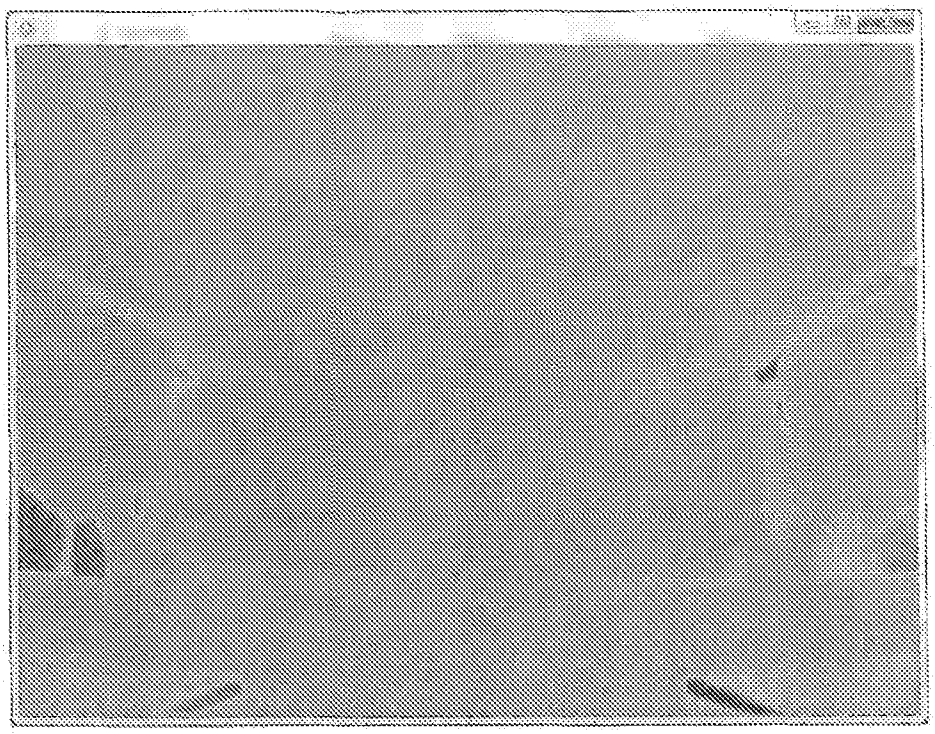

FIGURE 8

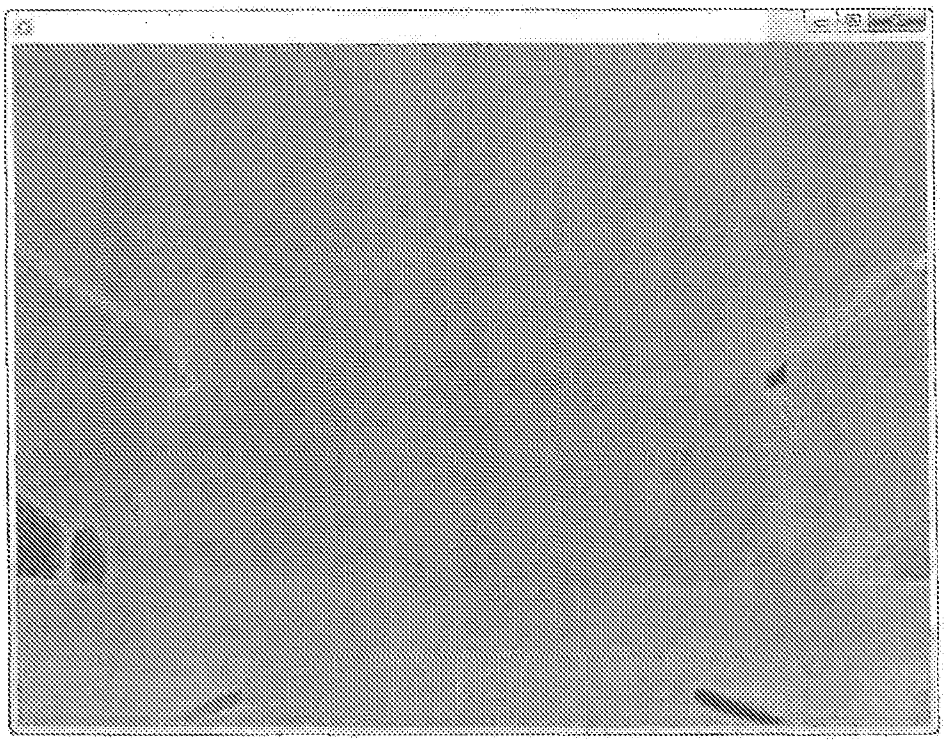

FIGURE 9

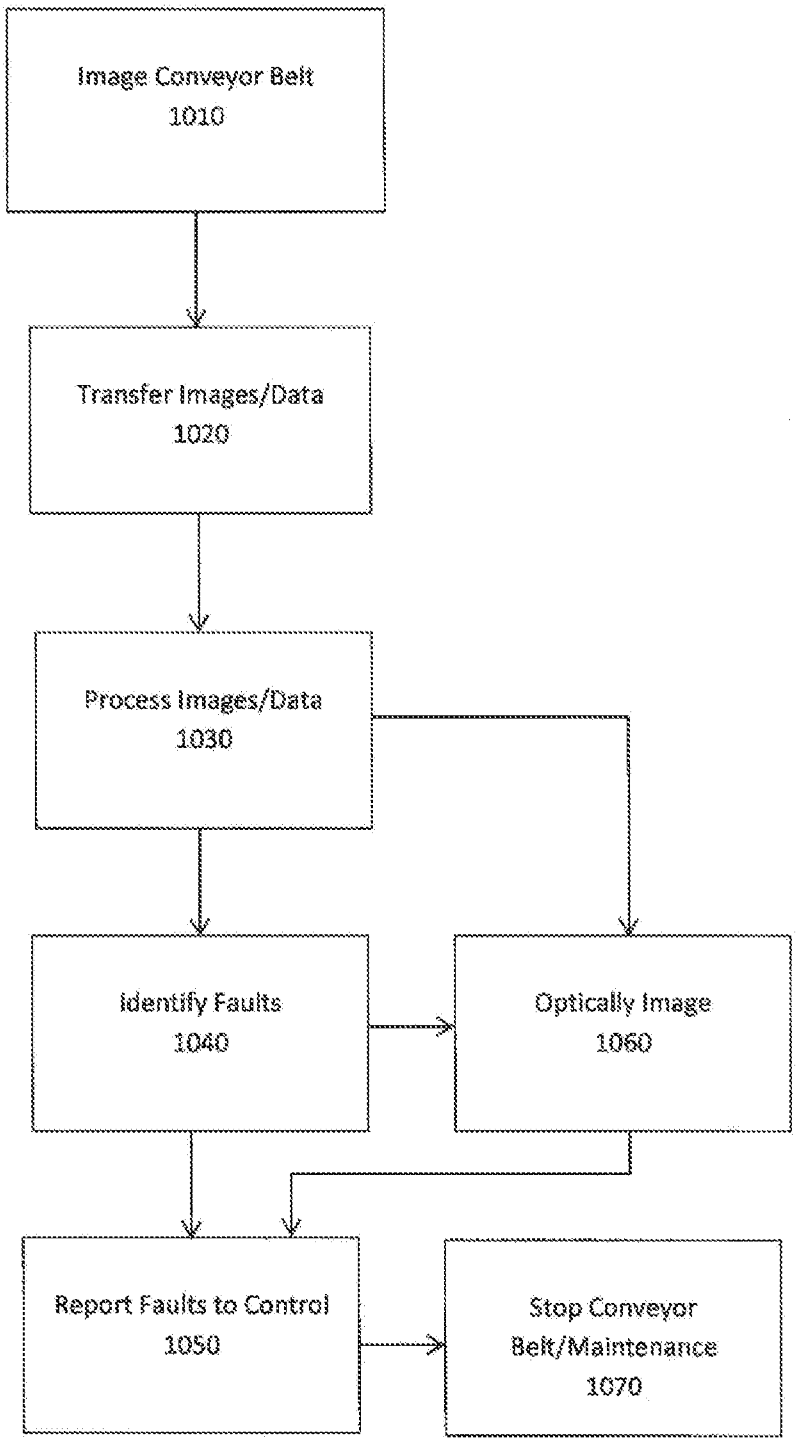
Image Conveyor Belt
1010
Transfer Images/Data
1020
Process Images/Data
1030
Identify Faults
1040
Optically Image
1060
Report Faults to Control
1050
Stop Conveyor
Belt/Maintenance
1070

FIGURE 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2014/000888

A. CLASSIFICATION OF SUBJECT MATTER

B65G 43/02 (2006.01) G05B 19/042 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI/EPODOC: IPC/CPC B65G43/00, 43/02, E21F13/08/low and Keywords (infrared, thermal, temperature, radiation, tear, wear, damage, process, detect, recognise, camera, image) & like terms; G05B19/042/low and Keywords (convey, belt, tear, wear, damage) & like terms.

Google Patents: Keywords (conveyor, belt, infrared, detect, thermal, damage, image, signature, profile, library) & like terms.

ESPACENET: CPC G05B 19/0425, 19/0428 and Keywords (conveyor) & like terms; IPC G05B19/042 and Keywords (conveyor) & like terms; G01N25/ic/cc and Keywords (image, cold, region) & like terms; Applicant/inventor name searches.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C   [X] See patent family annex

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 October 2014	14 October 2014

Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	Mark Smith AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262832573

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	CN 103213823 A (TAIYUAN UNIVERSITY OF TECHNOLOGY) 24 July 2013	
X	Abstract; pars [44], [56]; Figs 1-2	1-4, 6-10, 16-20, 24, 26, 28
Y	As above	14-15, 23
	CN 102951426 A (TAIYUAN UNIVERSITY OF TECHNOLOGY) 06 March 2013	
X	Abstract; Fig. 1	1-7, 16-18, 24
Y	As above	14-15, 23
	US 2008/0133051 A1 (WALLACE et al.) 05 June 2008	
X	Abstract; pars [42], [48]-[49]; Figs 2-3A	25, 27
Y	As above, and par. [52]	14-15, 23
	JP 2005-164471 A (BRIDGESTONE CORP) 23 June 2005	
X	AbstractFigs 1-3	25, 27-28
	WO 2003/059789 A2 (CARNEGIE MELLON UNIVERSITY) 24 July 2003	
A	Abstract; pars [007]-[009], [394]-[400]	12-13, 22
	US 5032727 A (COX, Jr. et al.) 16 July 1991	
A	Whole document, esp. col. 3 lines 8-17 and col. 5 lines 33-42	8-11, 19-21

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:
   the subject matter listed in Rule 39 on which, under Article 17(2)(a)(i), an international search is not required to be carried out, including

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box for Details

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Supplemental Box

Continuation of: Box III

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claims 1-15, 24 & 28 (when appended to either claim 1 or 24) and 16-23 are directed to a system and method for detecting a fault in a conveyor belt.. The feature of an infrared imaging detector obtaining images of a portion of the conveyor belt is specific to this group of claims.

- Claims 25, 27 and 28 (when appended to claim 25) are directed to a system and method for detecting a fault in a conveyor belt.. The feature of a detector for sensing heat generated by damage to a conveyor belt composed of rubber is specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. The only feature common to all of the claimed inventions and which provides a technical relationship among them is a heat detector associated with a conveyor belt arranged to detect a fault in the belt

However this feature does not make a contribution over the prior art because it is disclosed in:

D3: US 2008/0133051 A1 (WALLACE et al.) 05 June 2008; or

D4: JP 2005-164471 A (BRIDGESTONE CORP.) 23 June 2005

Therefore in the light of this document this common feature cannot be a special technical feature. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a posteriori*.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2014/000888**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
CN 103213823 A	24 July 2013	None	
CN 102951426 A	06 March 2013	CN 102951426 B	30 Jul 2014
US 2008/0133051 A1	05 June 2008	US 7894934 B2	22 Feb 2011
		BR PI0717127 A2	15 Oct 2013
		CA 2670794 A1	12 Jun 2008
		WO 2008070678 A2	12 Jun 2008
JP 2005-164471 A	23 June 2005	JP 3977323 B2	19 Sep 2007
		AU 2004255610 A1	20 Jan 2005
		AU 2004255610 B2	05 Mar 2009
		CN 1835881 A	20 Sep 2006
		CN 1835881 B	20 Apr 2011
		JP 2005106761 A	21 Apr 2005
		JP 2005138979 A	02 Jun 2005
		JP 2006156423 A	15 Jun 2006
		US 2006219528 A1	05 Oct 2006
		US 7347317 B2	25 Mar 2008
		WO 2005005292 A1	20 Jan 2005
WO 2003/059789 A2	24 July 2003	AU 2003235679 A1	30 Jul 2003
		GB 2402119 A	01 Dec 2004
		US 2003168317 A1	11 Sep 2003
		US 6988610 B2	24 Jan 2006
US 5032727 A	16 July 1991	AU 626146 B2	23 Jul 1992
		AU 7818991 A	19 Mar 1992
		CA 2047426 A1	15 Mar 1992
		EP 0475570 A2	18 Mar 1992
		JP H04282445 A	07 Oct 1992

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.