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(71) Applicant (*for all designated States except US*): **E.V. OFFSHORE LIMITED** [GB/GB]; Alexander House, 7-13 Rose Lane, Norwich, Norfolk NR1 1PL (GB).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **STEBBINGS, Terence**; 79 Lee Crescent, Bridge of Don, Aberdeen, Aberdeenshire AB22 8FG (GB). **THURSBY, Jonathan**; Keswick Barn, Intwood Road, Norwich, Norfolk NR 4 6TG (GB).

(74) Agents: **JACKSON, Nicholas** et al.; 25 The Square, Martlesham Heath, Ipswich, Suffolk IP5 3SL (GB).

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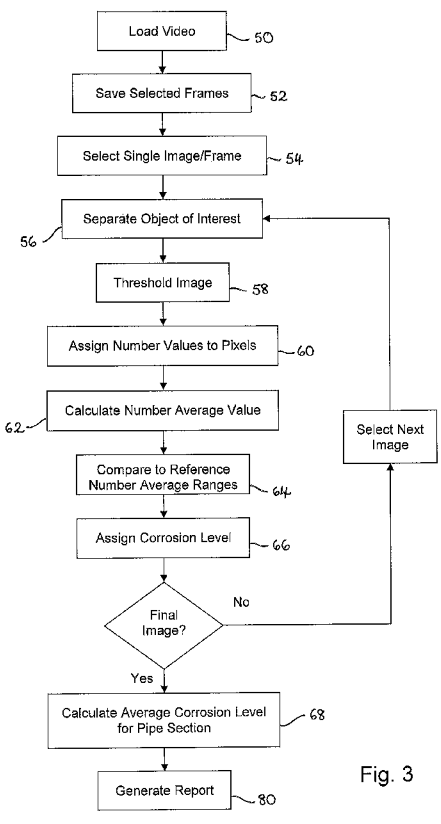

Fig. 3

(57) Abstract: This invention relates to an apparatus and a method for assessing corrosion. In particular this invention relates to the assessment of corrosion levels on pipework in offshore environments. A method of analysing the corrosion levels on a surface of a structure comprises the steps of capturing a plurality of digital images including the surface of the structure, the images comprising individual frames of a continuous video, and analysing each of said plurality of images. The step of analysing each image comprises selecting an area of interest within an image, assigning a number value to each pixel within the area of interest, the number value corresponding to the colour of that pixel, calculating, from the number values of the pixels, a number average for the image, and comparing the number average for the image to a set of reference number averages corresponding to a set of standard corrosion levels to determine a corrosion level for the image.

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Corrosion Assessment Apparatus and Method

BACKGROUND

a. Field of the Invention

This invention relates to an apparatus and a method for assessing corrosion. In particular this invention relates to the assessment of corrosion levels on pipework in offshore environments.

b. Related Art

External corrosion assessment of pipelines and piping is carried out on both onshore and offshore installations to determine the level of surface corrosion present. This information is used to inform maintenance schedules and assess the fitness for purpose of the structure or asset. This is typically known in the trade as fabric maintenance.

The operating companies, of the offshore installations for example, are known to have standard corrosion categories which are set by integrity teams within the organisation. Inspected piping is compared with these standard categories to give a measure of the current corrosion state of the pipe. Often this involves comparing photographs of the current state of the pipes with reference photographs corresponding to each of the categories. It is known that there is a variation in the categories used by different companies but as an example there may be four categories corresponding to: (1) no corrosion or surface coating breakdown, only paint visible, (2) pockets of corrosion visible, limited surface coating breakdown (3) connected areas of corrosion and/or surface coating breakdown, (4) majority of surface covered in corrosion, severe coating breakdown.

The comparison is typically carried out manually by inspectors and as such can often be a subjective process. Firstly it is generally necessary for the inspectors to capture photos at selected points of interest around the pipework being inspected. This necessarily means that the inspector must choose which parts of the pipework require further analysis and also must record the location at which the photo was taken as well as note any additional information, for example about the surrounding pipework or environment. Secondly, the inspector must analyse the photographs against the category standards in order to produce a maintenance or repair report.

This process is both time consuming and subjective, and can therefore be both expensive and inaccurate.

In addition, many areas of an offshore installation are difficult to access and therefore, the requirement to carry and use a camera as well as means to record locations and other relevant information, poses a safety risk to the inspector as he or she walks and climbs around the installation.

As such it is an object of the present invention to provide a corrosion assessment method and system that overcomes the above disadvantages.

SUMMARY OF THE INVENTION

According to the invention there is provided a method of analysing the corrosion levels on a surface of a structure, the method comprising the steps of:

- capturing a plurality of digital images including the surface of the structure, the images comprising individual frames of a continuous video; and
- analysing each of said plurality of images;

  wherein the step of analysing each image comprises:

  - selecting an area of interest within an image;
  - assigning a number value to each pixel within the area of interest, the number value corresponding to the colour of that pixel;
  - calculating, from the number values of the pixels, a number average for the image; and
  - comparing the number average for the image to a set of reference

number averages corresponding to a set of standard corrosion levels to determine a corrosion level for the image.

In order to permit objective comparisons to be made between different parts of the structure it is advantageous if the image is thresholded to divide the image into regions falling within distinct thresholded limits. Preferably only the area of interest is thresholded and then a number value is associated with a range of colours within the thresholded limits, so as to assign a specific number value to each pixel.

Typically the area of interest comprises a region of the image comprising the surface of said structure being analysed, for example the external surface of a pipe.

Generally the structure being inspected and analysed comprises more than one section, for example discrete lengths of pipe between corners or joins. Preferably each section is captured in a series of images or frames in the video, and the method further includes determining a corrosion level for a section of the structure by averaging the corrosion levels determined for each image of the series of images.

The method preferably further comprises the step of generating a report comprising information about corrosion levels of the structure. The report will generally include summaries of the corrosion levels found, including for example areas of greatest corrosion.

In a preferred embodiment once the corrosion level for an image has been determined, the method further comprises the step of displaying an edited image of the area of interest. In the edited image the area of interest is coloured according to the calculated corrosion level. For example, in the inspection of offshore pipes, the pipe surface in the image may be shaded red to indicate a high corrosion level.

In order to allow the video, images and data to be reviewed and analysed quickly and easily, in preferred embodiments the method further includes the step of tagging the video to indicate points of interest while the video is being captured. Preferably the method further comprises a step of recording an audio message while the video is being captured, to enable additional information to be captured to aid in the analysis stages.

Preferably the method further comprises transmitting said plurality of digital images to a computer, and this will typically be achieved by transmitting the continuous video to a computer.

In preferred embodiments of the invention the standard corrosion levels are provided by reference images corresponding to each of the levels, and preferably the method comprises uploading a set of reference digital images to the computer.

The set of reference digital images are analysed to determine a set of reference number averages, and preferably the step of analysing comprises selecting an area of interest within said reference image, assigning a number value to each pixel within the area of interest, the number value corresponding to the colour of that pixel, and calculating, from the number values of the pixels, a reference number average for the reference image.

The invention further provides a method of analysing the corrosion levels on the external surfaces of pipes in an offshore installation, using a method according to the invention.

In these cases, once the digital video images have been captured offshore, the method preferably includes transmitting the continuous video to an onshore computer for analysis, in order to minimise the time spent offshore.

The invention further provides a camera system for use in the method according to the invention, the system comprising:

- a digital video camera for capturing digital video data;
- a memory, for storing said digital video data;

- transmitting means, for transmitting said digital video data to a computer; and
- video marking means to enable a user of the system to place indicators at specific places in the digital video during capture by the camera.

Preferably the system further comprises a pointer for aligning the camera so that the surface of the structure being analysed remains within a field of view of the camera. The pointer may be in the form of a light source which also acts to illuminate the surface of the structure.

Preferably the camera is mounted on a piece of headgear to be worn by the inspector or user of the camera system. This means that the images can be captured hands free while the user moves around the structure. In other embodiments the camera is fixed to a strap to be worn by the user of the system, for example over the shoulder of the user.

Preferably the video camera is a 3D video camera to aid in locating areas of corrosion in relation to other parts of the structure.

In some cases it may also be advantageous for the system to further include audio recording means, to allow the user of the system to provide a commentary, at least during parts of the video.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be further described, by way of example only and with reference to the accompanying drawings in which:

Figure 1 is a flowchart showing the method steps involved in capturing video data according to an embodiment of the present invention;

Figure 2 is a flowchart showing the method steps involved in establishing reference data against which to analyse the captured video data, according to an embodiment of the present invention;

Figure 3 is a flowchart showing the method steps involved in assessing the captured video data according to an embodiment of the present invention;

Figures 4a to 4c illustrate three areas of captured images comprising 64 pixels and showing different levels of corrosion;

Figures 4d to 4f illustrate the number values assigned to each of the pixels of the three areas of Figures 4a to 4c;

Figure 4g shows the thresholding scale used to assign the number values in Figures 4d to 4f;

Figure 5 illustrates a region of pipework that is being assessed using the method of the present invention; and

Figure 6 illustrates an output of an embodiment of the method of the present invention, the output including a representation of the region of pipework of Figure 5 including shaded or coloured sections indicating sections of greater corrosion.

DETAILED DESCRIPTION

The method of the present invention is used to determine the state of corrosion or surface coating breakdown of a structure or installation. In particular, and as described in the following example, this method may be used to examine pipework on an offshore installation such as an oil platform or in an onshore installation such as a refinery.

Due to the harsh environmental conditions, a regular maintenance program is often needed to deal with corrosion or surface coating breakdown on the external surfaces of the pipes in these locations. This maintenance program may consist of re-coating or re-painting the pipes or even replacing sections of pipe if the corrosion is particularly severe. In order to determine which sections of the pipework require attention the method of the present invention allows the extent of the corrosion of the pipe to be accurately and objectively assessed and compared with reference corrosion limits typically used to monitor the maintenance requirements.

Figures 1 to 3 show flowcharts illustrating the steps involved in analysing the corrosion state of a pipework structure according to the present method. Briefly the method comprises capturing image data of the structure of interest, establishing reference corrosion levels from reference image data, and then analysing the captured image data and comparing it to the reference data.

In the following description references to corrosion of a structure, for example pipework, includes both true corrosion such as rust as well as more general surface coating breakdown or deterioration.

Figure 1 shows the steps involved in capturing image data of the pipework of interest. In a first part of the method 10 an inspector, or user of the method, uses a digital video camera to record continuous images of the complete pipework structure under investigation. The digital video camera is preferably a colour digital camera having a resolution of 1080p and a frame rate of 25 frames per second. In a preferred embodiment the camera has a fixed focal length, however, in other embodiments the camera may be an auto-focussing camera, or may include means to allow the inspector to manually focus the camera.

Continuous video data is captured in real time as the inspector walks around the area of interest. Because the location of pipework is often inaccessible and exposed, in particular in offshore environments, it is preferable if the video camera is hands-free. For example the camera may be mounted on some form of headgear such as a hard hat or headband, or the camera may be mounted on a strap or piece of clothing worn by the inspector. It is desirable to mount the camera in this way so that the inspector's hands are free to enable the inspector to move more safely around the installation.

Mounting the camera on a piece of headgear that is worn by the inspector has the additional advantage that the camera will point in approximately the same direction as the inspector is looking. As such, in order to record a complete video of the pipework the inspector simply walks around the installation looking at each piece of pipe included in the inspection. Preferably the inspector's line of sight travels along each pipe of interest so that the surface of the pipe falls within the camera's field of view.

To aid the inspector in this process the camera may include a laser pointer or other suitable device to enable the inspector to know in which direction the camera is pointing. In embodiments including a laser pointer, the camera and pointer are aligned so that when the beam of the laser pointer falls on an object, that object is central within the field of view of the camera. In other embodiments, the system may include a monitor to allow the inspector to see the images that the camera is collecting, to ensure that the pipe surface of interest remains in the field of view of the camera, even if the pointer is not directed at the pipe.

If a laser pointer is used, it is desirable to include means to switch off the pointer during video capture. This prevents the laser light being captured by and recorded on the video, especially where the laser beam strikes an object of interest. In this respect, the laser pointer may be used in a first step 12 of the method at the start of the inspection process to set up and align the camera system before video capture is started 14.

In other embodiments the system may include light emitting means, for example light emitting diodes (LEDs) that illuminate the field of view of the camera. In this way, the light source firstly acts as a pointer to allow the user of the system to see where the camera is pointing and secondly the light source provides even illumination of the pipe's surface to enable improved analysis of the resulting images.

Alternatively or additionally some embodiments of the invention may include an ultra violet light source. When using the system to inspect pipework, the ultra violet light may be combined with the use of fluorescent dyes applied to the surface of the pipes to detect leaks in the pipework using a method known in the art.

The camera system may further include means for marking or ‘tagging’ the video at particular time points. These means preferably allow the inspector to ‘tag’ 16 the video while it is being recorded in order to indicate a particular section of interest 18. These sections of interest may be related, for example, to a change in the type of pipe, a region of severe corrosion, or a region above or near to an inlet or outlet where corrosion conditions may change. The means for tagging the video may be used to mark the video at each joint of the pipework to enable the resulting images to be divided during the subsequent analysis into different sections of pipe that may be treated or replaced independently after the inspection. In particular, the means for tagging the video may comprise a push button that, when pressed, creates a time-coded event that relates to the absolute video reference. As such, the means for tagging the video at certain points enables specific locations of interest to be found quickly and easily when reviewing the video footage.

The camera system may also include a microphone and audio recording means to enable speech to be recorded 20 while the inspection is carried out and the video is being recorded. The speech recording may be saved as part of the video, so that the inspector provides an audio commentary during the inspection process, or alternatively audio recordings may be saved in separate audio files in a memory of the camera system. The video may then be tagged 22 to indicate the section of the video corresponding to the particular audio recording.

The ability to record speech allows the inspector or user of the system to record information such as the names of the sections of pipe being inspected, the deck level on which the inspection is being carried out, or when the inspection moves from one module to another. The recordings may also be used to give additional and/or more specific information about possible causes of increased corrosion or surface coating breakdown in certain areas, for example, the existence of damaged module coverings that may have caused increased exposure in a localised area.

The continuous video captured by the camera may be saved 24 to a memory contained within the camera system or to an external or removable memory device such as a memory card. Preferably the camera system further comprises transmitting means to enable the video data to be transmitted 26 to a computer, on which the analysis software is loaded. The computer may be located on the offshore installation and accessed by the inspector, for example the computer may be a portable laptop computer used by the inspector, or the computer may be located in an onshore location remote from the inspection site. In some embodiments, the camera system may be arranged to stream live video to the computer to enable a second user of the system to monitor the progress of the inspection. A means for tagging the video may additionally be located in the computer such that, as the inspector walks around the installation, the second user is able to tag the video to indicate points of interest. In systems not including a transmitting means, video data is uploaded to a computer from the memory of the camera system once capturing is completed, ready for subsequent analysis.

The first step in the analysis of the video is to ‘teach’ the analysis software the corrosion levels of interest to the company for which the inspection is being carried out. Each level corresponds to a different degree and extent of corrosion or surface coating breakdown on the surface of the pipes. What maintenance, if any, is carried out, and on what timescale, for a particular section of pipe will depend on which corrosion level that particular section of pipe is categorised in. Different companies use different corrosion level categories, and even within a single company the specific corrosion levels may vary between different sites, and will depend on factors such as the speed of corrosion, the material from which the pipes are made, and the company's particular maintenance routine.

Figure 2 illustrates the steps followed to establish reference data corresponding to the corrosion levels. First, a set of digital images corresponding to the different levels of corrosion are uploaded into the analysis software 30. For each image 32 an area of interest in the image is selected 34. In this example the area or object of interest is the surface of a pipe. This is separated from the background of the image and any surrounding parts of the image, so that only the area of interest is included in the subsequent analysis. This separation step may be accomplished using any known method, and may involve an edge detection program.

An area of interest selection step may not always be necessary, as the reference images may comprise only an area of the surface of a pipe, for example, in which case the whole area of the image is processed as described below.

Each pixel of the resulting area of interest or object image is given a number value corresponding to the colour of that pixel 38. Typically each image is thresholded 36 so that each number value corresponds to a range of colours in the image. For each image the number values assigned to individual pixels are then averaged 40 over the whole of the image. This results in a number average value for that image and correspondingly for that corrosion level. This process of thresholding and calculating a number average value is repeated 42 for each of the set of digital images to produce a set of reference number average values corresponding to the corrosion levels. An example of a set of number average values for four corrosion levels is shown in the table below:

Table 1

Corrosion Level	Number Average Value	Number Average Range
1	1.3	≤ 1.55
2	1.8	1.56 – 2.00
3	2.2	2.01 – 2.40
4	2.6	≥ 2.41

For each corrosion level a number average range is then calculated 44. The ranges are established by setting the number average value calculated for that corrosion level as the median value of the range. The extent of the range is then determined by the difference between subsequent number average values so that the ranges for each of the levels do not overlap. As such, for example, the upper value for the range for corrosion level 1 is 1.55 which lies halfway between 1.3 and 1.8, which are the number average values for corrosion levels 1 and 2 respectively.

Once the reference number average ranges for the corrosion levels have been established, the captured video data can be analysed and compared with the reference data to determine corrosion levels in different regions of the pipework structure under investigation.

Figure 3 shows the steps involved in analysing the data in a preferred embodiment of the method of the invention. At a first step the video is loaded into the software 50 on a computer. The analytical software then saves 52 each selected frame of the video as a separate image. It may be desirable to analyse every frame of the video, however, in most cases it is more practical to set the software to select only every fifth or every fiftieth frame as an image, for example. The number of frames selected and saved as images may depend on the length of pipe being analysed, the frame rate of the video, or the available computing time and file space, for example.

For each saved image 54, corresponding to an individual frame of the video, the same analytical steps are then carried out. These steps will be described in relation to a single image (frame) but it will be understood that the same process is repeated for each of the saved images.

The image is first processed to separate the area or object of interest 56, which in this example is the surface of a section of pipe, from the background of the image, which may include other pipes in the installation or may be the surrounding landscape. This object isolation step can be carried out by any method known in the art, and will not be described further here.

The next step is to threshold 58 the image so that a given number value is assigned to a particular range of colours. The thresholding step allows the different images to be compared directly by compensating for differences between each image, the differences including light level, shadow and angle of the image with respect to the surface of the object of interest.

Taking as an example the analysis of images of the surfaces of pipes, if the surfaces of the pipes are painted a particular shade of blue, then the images can be thresholded so that the painted surface of a pipe in each of the images falls within a particular colour range, i.e. a particular range of shades of blue, and is therefore assigned the same number value, even if one image was taken in direct sunlight and therefore brighter, and another image was taken in shadow and therefore darker.

Once the image has been thresholded 58, each pixel of the image is assigned 60 a number value corresponding to the colour of the pixel. This is shown for a series of examples in Figures 4a-4g. In this embodiment, pixels corresponding to the colour of the paint are given low values and pixels corresponding to areas of rust or corrosion are given high values.

A number average value for the frame is then calculated 62 by adding together the number values of each pixel and dividing by the number of pixels in the image. In this example, the greater the number average value the more rust or corrosion is present in that image. The calculated number average value is compared 64 to the reference number average ranges calculated for each of the corrosion levels and a corrosion level is assigned 66 to this image.

A simplified example of three ‘images’ 70, 72, 74 is shown in Figures 4a to 4c which represent surfaces having increasing amounts of corrosion, indicated by the darker pixels or squares. The thresholding scale 76 used to analyse these images 70-74 is shown in Figure 4g, in which lighter pixels are assigned lower numbers. Figures 4d-4f show the results of assigning number values to each of the pixels of the images 70-74 based on this threshold scale 76. The number average value is then calculated for each of the images 70-74 and compared to reference number average ranges, for example those shown in Table 1. It can be seen that the first image 70, which has a number average value of 1.50 would be assigned to corrosion level 1. The second image 72 (number average value = 1.75) would be assigned to corrosion level 2, and the third image 74 (number average value = 2.14) would be assigned to corrosion level 3. In other embodiments this assignment of values may be reversed so that areas of paint, or non-corroded surface, are assigned high values and areas of rust or corrosion are assigned low values.

It may also be advantageous in some cases to record the number of pixels in an image having a number value above a corrosion threshold value. This data could be used to establish or assess the extent of the corrosion over the surface of the pipe, as a greater number of pixels having high values would suggest a larger area of rust or corrosion on the pipe. Furthermore, an image containing only a few pixels having high values would indicate minimal or localised corrosion.

In addition, by using a system including means for marking or tagging the video, it is possible for the inspector (or user of the system) to additionally mark the video to indicate a small area of significant corrosion or surface breakdown contained within a larger area of satisfactory surface coating. This may be useful in instances in which the area of corrosion is so localised or is of such a small size that the assigned corrosion level would be low, however the corrosion or surface coating breakdown is in a critical location in the structure.

The corrosion level for each image is saved in relation to that frame of the video. By associating a series or range of frames with a particular section of the pipe, an average corrosion level for that pipe section can then be determined 68. The frame numbers corresponding to discrete sections of pipe may be determined by the inclusion of markers or tags inserted into the video by the inspector as the data was being collected, at the bends or joins in the pipe for example.

In some embodiments, rather than calculating an average corrosion level for a given section of pipe, the highest corrosion level within that section may be associated with the section so as to provide a ‘worst case’ picture of the corrosion levels of the pipework.

The software may be used to output 80 a report that summarises the extent of corrosion over the pipework of interest. In particular, the report may list the different sections of the pipe that have different corrosion levels. The report may also highlight the particular regions of the pipe corresponding to the highest corrosion level.

In some embodiments the report may include data in spreadsheet or tabular format such that it is easily integrated with the operator’s existing data. For example the data may be incorporated into the company’s Risk Based Inspection (RBI) system.

In a preferred embodiment of the invention, the corrosion level data is used to produce an edited video visually highlighting areas of the pipework having severe or extensive corrosion. In a particular example the edited video comprises shaded or coloured pipework, with each of the corrosion levels being associated with a particular colour. For example, corrosion level one may be blue, corrosion level two green, corrosion level three yellow and corrosion level four red. Once a corrosion level has been assigned to an image, the image is then manipulated or edited so that the pipe surface in the image is coloured or shaded according to the assigned corrosion level and the colour edited image is then saved.

This colour editing step is carried out for each of the selected frames in the video, and a second edited video is then generated using each of the colour edited frames. In this way, when the edited video is played or viewed, a video of the pipework is seen with the sections of pipes coloured corresponding to the assessed corrosion level of that section. For example, Figure 5 is a schematic diagram of a region of pipework that is being assessed and Figure 6 shows the same region of pipework but this image has been edited so that regions of higher corrosion levels are shaded. This allows the locations and extent of the corroded sections of pipe to be visualised quickly and easily in relation to the rest of the pipework.

In a further embodiment of the present invention, the captured video data is a three dimensional (3D) video. In this case, the resulting report generated following the assessment steps described above preferably includes a rotatable 3D image highlighting the areas of the pipework in which corrosion has been detected.

The use of 3D images also allows depth measurements to be made which may be used to enhance the corrosion assessment. The 3D views can be used to confirm the location of particular areas of the pipework with respect to the surrounding structure and can give a clear indication of distances between neighbouring pipes or the geometries of bends and joins in the pipework for example. The identification of the location of specific areas of pipework may be further enhanced by the addition of global positioning system (GPS) data and Gyro inputs. In this regard, it may be preferable if the system of the present invention further comprises means for receiving GPS data.

The present invention, therefore, provides a method of assessing the surface condition of a structure, and in particular surface corrosion on pipework in harsh, aggressive and corrosive environments such as offshore installations. By using digital video capture and interpreting software to assess the captured data, the results are more objective in comparison to the more subjective interpretation given by individual inspectors using prior art methods. The method of the present invention allows a single standard of corrosion assessment to be applied across different inspection sites for example, even if different inspectors capture the raw video data. The software is also easily adapted to assess the data in relation to different corrosion standards in order to fulfil the inspection requirements of different companies.

A further advantage of the present system, especially in offshore locations, is that the video can be captured hands free thereby improving safety by keeping the inspector's hands free to aid in negotiating his or her way around the structure.

The method is also cost effective because by continuously recording a video throughout the inspection, rather than needing to stop and capture specific photographs at different locations, as well as record separately the location at which each photograph was taken, the data collection process is significantly shortened and simplified.

In addition, in offshore applications there is a significant financial cost associated with sending an inspector offshore to collect the data. Therefore, by simplifying the data collection process through the use of video, the time for which an inspector needs to be offshore is significantly reduced. Furthermore, all of the analysis can be completed onshore, including locating specific areas of corrosion within the network of pipes, because the use of continuous video data of the entire pipe network makes it easy to determine specific locations in relation to the surrounding pipes and other structures.

Although the foregoing description has focussed on the use of the method of the present invention to analyse the corrosion and/or surface coating breakdown on pipework in offshore environments, it will be obvious to a person skilled in the art that this method may be used in any situation in which there is a requirement to assess the surface condition of a structure or asset in relation to a set of reference conditions.

The method and system of the present invention, therefore, provides a corrosion assessment and analysis tool that overcomes the disadvantages of prior art systems and methods.

CLAIMS

1. A method of analysing the corrosion levels on a surface of a structure, the method comprising the steps of:

- capturing a plurality of digital images including the surface of the structure, the images comprising individual frames of a continuous video; and
- analysing each of said plurality of images;

  wherein the step of analysing each image comprises:

  - selecting an area of interest within an image;
  - assigning a number value to each pixel within the area of interest, the number value corresponding to the colour of that pixel;
  - calculating, from the number values of the pixels, a number average for the image; and
  - comparing the number average for the image to a set of reference number averages corresponding to a set of standard corrosion levels to determine a corrosion level for the image.

2. A method as claimed in claim 1, wherein the step of assigning a number value to each pixel further includes the steps of:

- thresholding the area of interest; and
- associating number values with ranges of colours within thresholded limits.

3. A method as claimed in Claim 1 or Claim 2, wherein the step of selecting an area of interest comprises selecting a region of the image comprising the surface of said structure being analysed.

4. A method as claimed in any preceding claim, wherein the structure comprises more than one section and each section is captured in a series of images, and wherein the method further includes determining a corrosion level for a section of the structure by averaging the corrosion levels determined for each image of said series of images.

5. A method as claimed in any preceding claim, wherein the method further

comprises the step of generating a report comprising information about corrosion levels of the structure.

6. A method as claimed in any preceding claim, wherein, after the corrosion level for the image has been determined, the method further comprises the step of displaying an edited image of the area of interest, in which the area of interest has been coloured according to the calculated corrosion level.

7. A method as claimed in any preceding claim, wherein the method further includes the step of tagging said video to indicate points of interest while the video is being captured.

8. A method as claimed in any preceding claim, wherein the method further comprises the step of recording an audio message while the video is being captured.

9. A method as claimed in any preceding claim, wherein the method further comprises transmitting said plurality of digital images to a computer.

10. A method as claimed in Claim 9, wherein the method comprises transmitting said continuous video to a computer.

11. A method as claimed in Claim 9 or Claim 10, wherein the method comprises uploading a set of reference digital images to the computer, the reference images corresponding to the standard corrosion levels.

12. A method as claimed in Claim 11, wherein the method comprises analysing the set of reference digital images to determine a set of reference number averages, the step of analysing comprising:

- selecting an area of interest within said reference image;
- assigning a number value to each pixel within the area of interest, the number value corresponding to the colour of that pixel;
- calculating, from the number values of the pixels, a reference number

average for the reference image.

13. A method of analysing the corrosion levels on the external surfaces of pipes in an offshore installation, the method being as claimed in any previous claim.

14. A method as claimed in Claim 13, wherein the method includes transmitting continuous video to an onshore computer for analysis.

15. A camera system for use in the method as claimed in Claims 1 to 14, the system comprising:

- a digital video camera for capturing digital video data;
- a memory, for storing said digital video data;
- transmitting means, for transmitting said digital video data to a computer; and
- video marking means to enable a user of the system to place indicators at specific places in the digital video during capture by the camera.

16. A camera system as claimed in Claim 15, wherein the system comprises a pointer for aligning the camera so that the surface of the structure being analysed remains within a field of view of the camera.

17. A camera system as claimed in Claim 15 or Claim 16, wherein the camera is mounted on a piece of headgear.

18. A camera system as claimed in any of Claims 15 to 17, wherein the camera is fixed to a strap to be worn by the user of the system

19. A camera system as claimed in any of Claims 15 to 18, wherein the video camera is a 3D video camera.

20. A camera system as claimed in any of Claims 15 to 19, wherein the system further includes audio recording means.

21. A method substantially as herein described with reference to the accompanying drawings.

22. A camera system substantially as herein described.

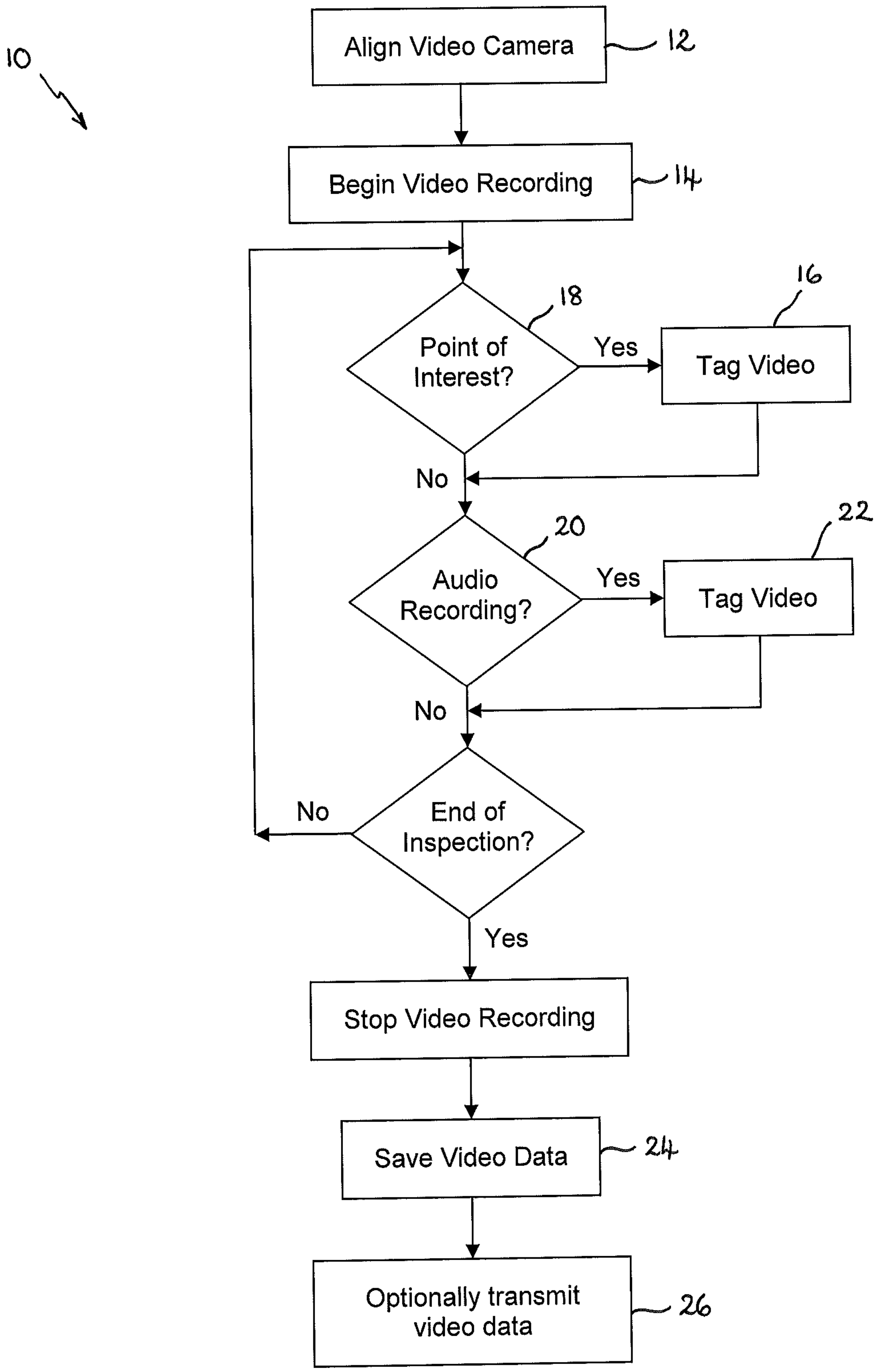
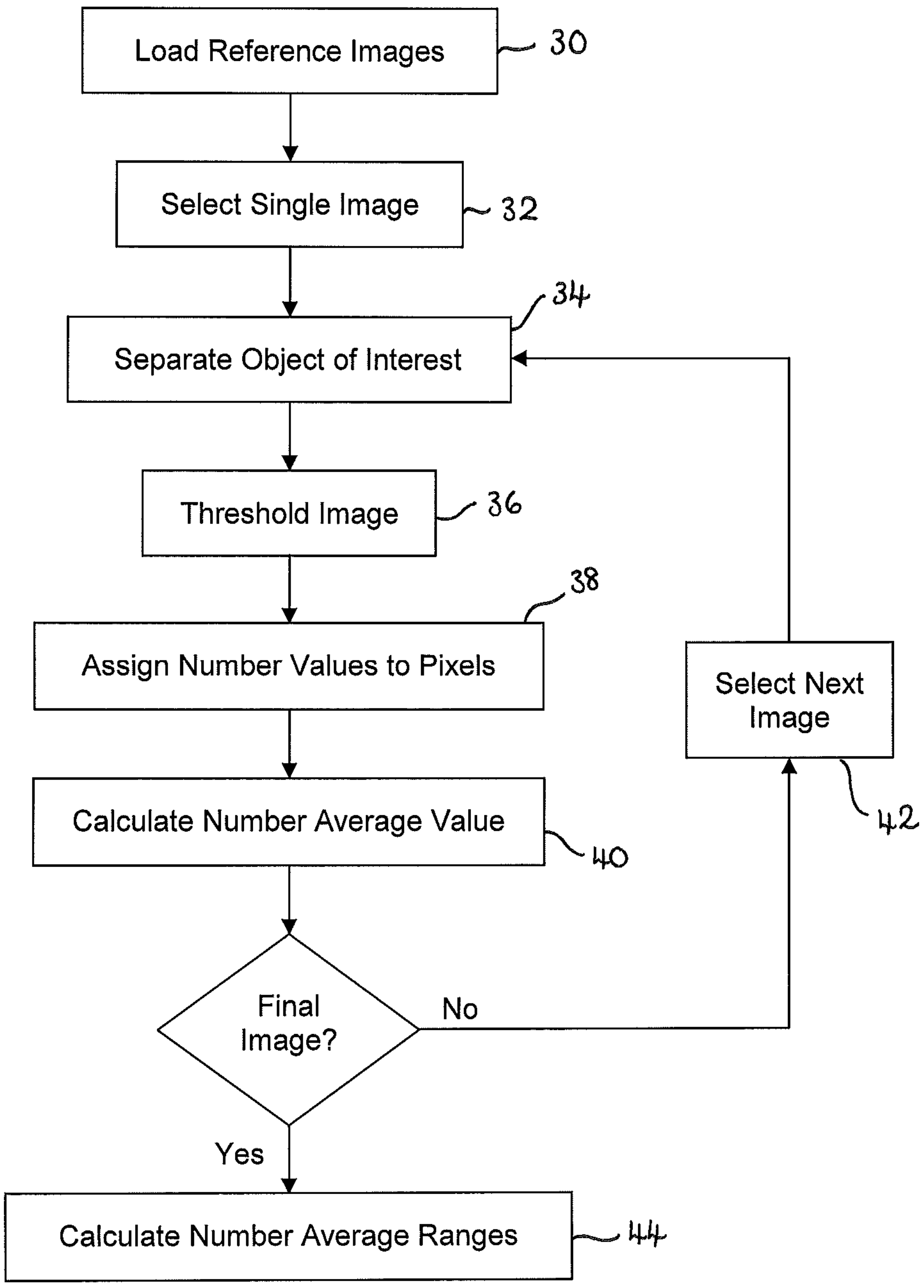
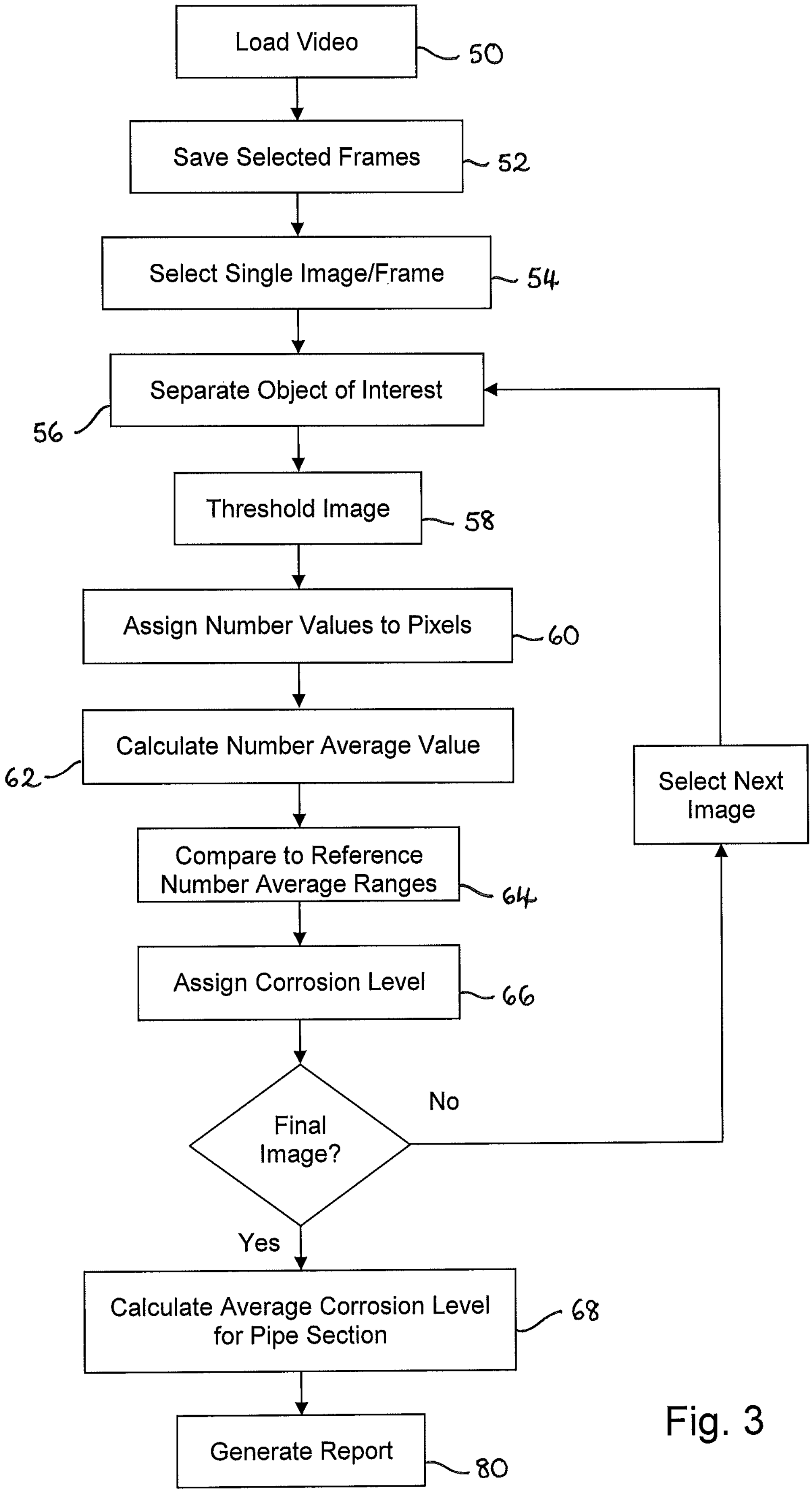

10
Align Video Camera
12
Begin Video Recording
14
Point of Interest?
18
Yes
Tag Video
16
No
Audio Recording?
20
Yes
Tag Video
22
No
End of Inspection?
No
Yes
Stop Video Recording
Save Video Data
24
Optionally transmit video data
26

Fig. 1



Load Reference Images
30
Select Single Image
32
Separate Object of Interest
34
Threshold Image
36
Assign Number Values to Pixels
38
Calculate Number Average Value
40
Final Image?
No
Select Next Image
42
Yes
Calculate Number Average Ranges
44

Fig. 2



Load Video
50
Save Selected Frames
52
Select Single Image/Frame
54
Separate Object of Interest
56
Threshold Image
58
Assign Number Values to Pixels
60
Calculate Number Average Value
62
Compare to Reference Number Average Ranges
64
Assign Corrosion Level
66
Final Image?
No
Select Next Image
Yes
Calculate Average Corrosion Level for Pipe Section
68
Generate Report
80

Fig. 3

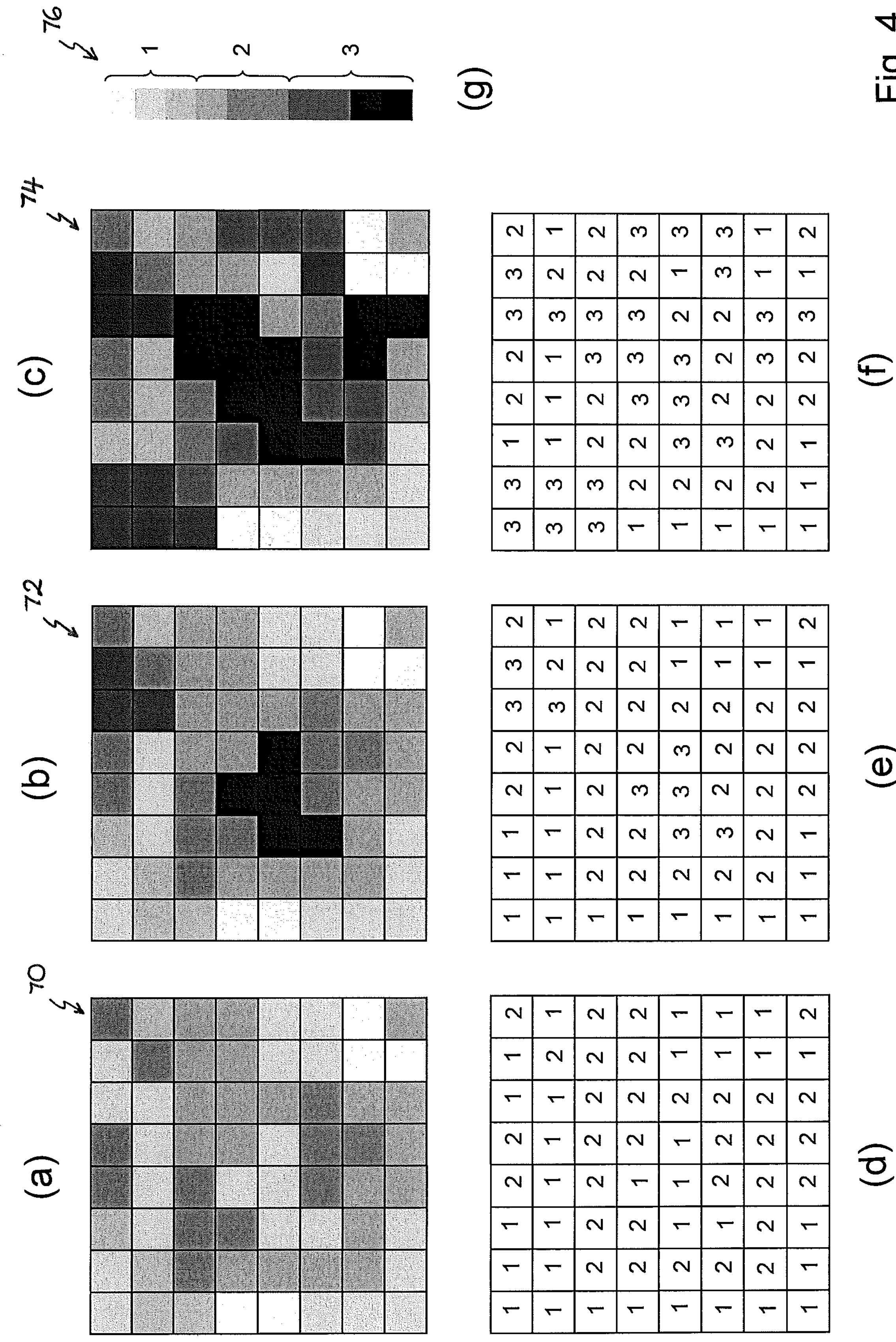


Fig. 4

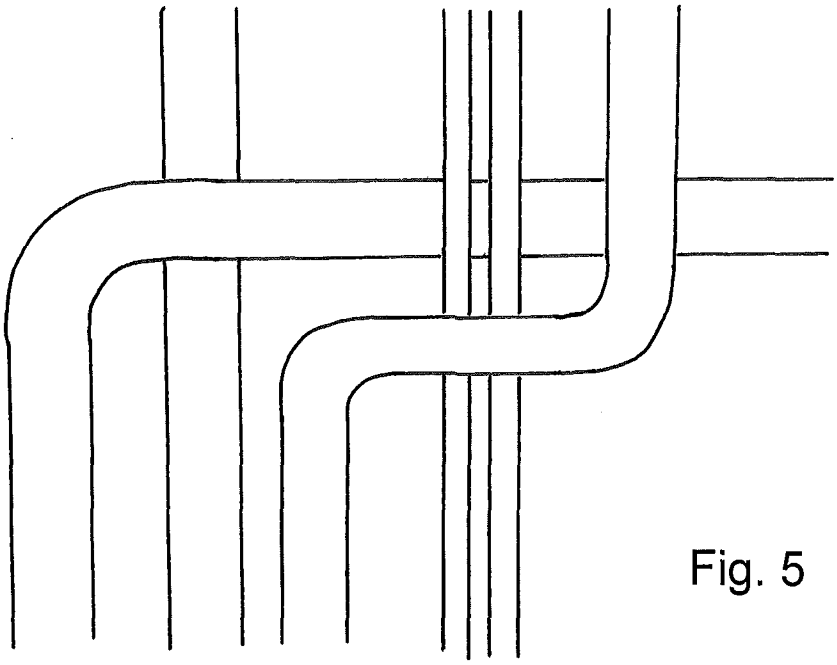


Fig. 5

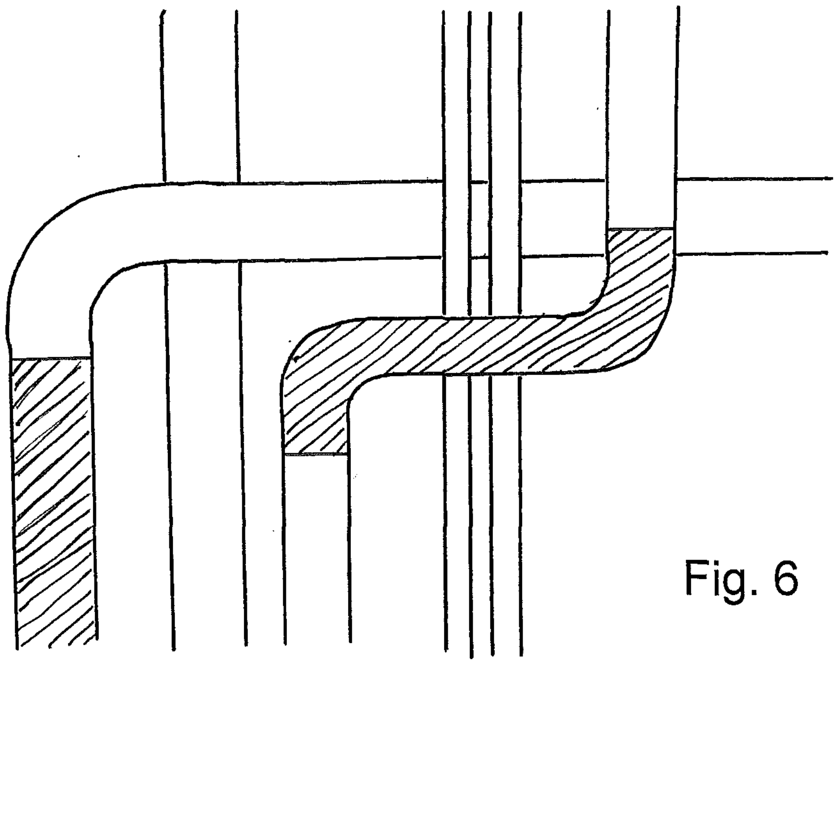


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2012/050497

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N21/88 G01N21/952 G06T7/00
ADD.

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)
G01N G06T A42B

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)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2005/151841 A1 (NELSON BRUCE N [US] ET AL) 14 July 2005 (2005-07-14) paragraphs [0003], [0005], [0013], [0014], [0029], [0033], [0054], [0056], [0062], [0069], [0070], [0074], [0084] - [0101] -----	1-14
Y	US 4 647 220 A (ADAMS MARK J [US] ET AL) 3 March 1987 (1987-03-03) column 10, lines 3-10 -----	16
X	US 6 704 044 B1 (FOSTER RONALD R [US] ET AL) 9 March 2004 (2004-03-09)	15,17-19
Y	the whole document -----	16,20
A	JP 11 132962 A (TOKYO ELECTRIC POWER CO; TOMOE CORP) 21 May 1999 (1999-05-21) abstract -----	1,15
	-/--	

[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
19 July 2012	30/07/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Brison, Olivier

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2012/050497

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2006/079787 A1 (3 D SCANNERS LTD [GB]; CRAMPTON STEPHEN [GB]; RADNOV JURIY [BG]) 3 August 2006 (2006-08-03) page 16, paragraph 2nd	13,14
X	US 2010/313335 A1 (WATERS MICHAEL [US]) 16 December 2010 (2010-12-16)	15
Y	paragraphs [0075] - [0081]	20
Y	JP 2009 115528 A (NAKANIHON HIGHWAY ENGINEERING) 28 May 2009 (2009-05-28) abstract	1-14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB2012/050497

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:

2. ☒ Claims Nos.: 21, 22
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:
see FURTHER INFORMATION sheet PCT/ISA/210

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:

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 an 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.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 21, 22

Claims shall not rely on references to the description or drawings, Article 6 and Rule 6.2(a) PCT.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2012/050497

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005151841 A1	14-07-2005	US 2005151841 A1 WO 03083460 A1	14-07-2005 09-10-2003
US 4647220 A	03-03-1987	NONE	
US 6704044 B1	09-03-2004	NONE	
JP 11132962 A	21-05-1999	JP 3181543 B2 JP 11132962 A	03-07-2001 21-05-1999
WO 2006079787 A1	03-08-2006	NONE	
US 2010313335 A1	16-12-2010	US 2010313335 A1 WO 2011137406 A2	16-12-2010 03-11-2011
JP 2009115528 A	28-05-2009	NONE	