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(54) Title: METHODS AND SYSTEMS FOR ANALYZING EQUIPMENT

(57) Abstract: Systems and methods for analyzing status of equipment are described. In an embodiment, a method of analyzing equipment, comprises: receiving equipment data comprising indications of measured attribute values of the equipment; looking up an equipment analysis template corresponding to the equipment in a database, the equipment analysis template comprising indications of equipment analysis calculations to be carried out using the measured attribute values of the equipment; analyzing the equipment data according to the equipment template to determine a status of the equipment; and generating an output indication indicating the status of the equipment.

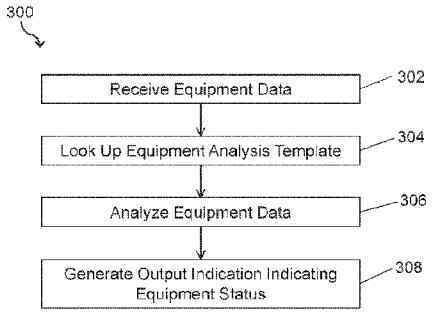

FIG.3

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METHODS AND SYSTEMS FOR ANALYZING EQUIPMENT

TECHNICAL FIELD

The present disclosure relates to equipment monitoring and status analysis. In particular, the present disclosure relates to methods and systems for analyzing status of rotating equipment such as compressors and turbines.

BACKGROUND

Rotating equipment such as compressors and turbines require regular maintenance and in addition to this may develop faults between scheduled maintenance events. Faults in such equipment can lead to costly downtime of production such as the extraction of oil and gas resources from subsurface reservoirs.

Thus, the predication of occurrences of faults in such equipment can lead to large cost savings and more efficient regular maintenance.

SUMMARY

According to a first aspect of the present disclosure a method of analyzing equipment is provided. The method comprises: receiving equipment data comprising indications of measured attribute values of the equipment; looking up an equipment analysis template corresponding to the equipment in a database, the equipment analysis template comprising indications of equipment analysis calculations to be carried out using the measured attribute values of the equipment; analyzing the equipment data according to the equipment template to determine a status of the equipment; and generating an output indication indicating the status of the equipment.

In an embodiment, the equipment analysis template comprises an indication of an analytics template, and the analytics template comprises an indication of expected values for attributes of the equipment and an indication of a deviation calculation.

In an embodiment, the deviation calculation is a calculation of an average deviation over a time period.

In an embodiment, the analytics template comprises an indication of an alert and the output indicating the status of the equipment comprises the alert.

In an embodiment, the alert is an email.

In an embodiment, the output indication comprises updating an indication on a dashboard.

In an embodiment, the indication on the dashboard indicates whether an attribute of the equipment is within an expected range of values.

In an embodiment, the method further comprises comparing a result of the deviation calculation with a failure mode library corresponding to the equipment and generating an indication of a possible failure mode for the equipment based on the result of the comparison.

In an embodiment, the failure mode library stores historical data for failures of failed equipment and measured attribute values for the failed equipment preceding the failures.

According to a second aspect of the present disclosure a computer readable medium storing processor executable instructions which when executed on a processor cause the processor to carry out a method as set out above is provided.

According to a third aspect of the present disclosure, an equipment analysis system for analyzing equipment is provided. The system comprises a processor and a data storage device storing computer program instructions operable to cause the processor to: receive equipment data comprising indications of measured attribute values of the equipment; look up an equipment analysis template corresponding to the equipment in a database, the equipment analysis template comprising indications of equipment analysis calculations to be carried out using the measured

attribute values of the equipment; analyze the equipment data according to the equipment template to determine a status of the equipment; and generate an output indication indicating the status of the equipment.

In an embodiment, the equipment analysis template comprises an indication of an analytics template, and the analytics template comprises an indication of expected values for attributes of the equipment and an indication of a deviation calculation.

In an embodiment, the deviation calculation is a calculation of an average deviation over a time period.

In an embodiment, wherein the analytics template comprises an indication of an alert and the output indicating the status of the equipment comprises the alert.

In an embodiment, the alert is an email.

In an embodiment, the data storage device further stores computer program instructions operative by the processor to: update an indication on a dashboard according to the output indication.

In an embodiment, the dashboard indicates whether an attribute of the equipment is within an expected range of values.

In an embodiment, the data storage device further stores computer program instructions operative by the processor to: compare a result of the deviation calculation with a failure mode library corresponding to the equipment and generate an indication of a possible failure mode for the equipment based on the result of the comparison.

In an embodiment, the failure mode library stores historical data for failures of failed equipment and measured attribute values for the failed equipment preceding the failures.

Further embodiments of the present invention are set out in the following clauses:

1. A method of analyzing equipment, the method comprising:

receiving equipment data comprising indications of measured attribute values of the equipment;

looking up an equipment analysis template corresponding to the equipment in a database, the equipment analysis template comprising indications of equipment analysis calculations to be carried out using the measured attribute values of the equipment;

analyzing the equipment data according to the equipment template to determine a status of the equipment; and

generating an output indication indicating the status of the equipment.

2. A method according to clause 1, wherein the equipment analysis template comprises an indication of an analytics template, and the analytics template comprises an indication of expected values for attributes of the equipment and an indication of a deviation calculation.

3. A method according to clause, wherein the deviation calculation is a calculation of an average deviation over a time period.

4. A method according to any of clauses 2 or 3, wherein the analytics template comprises an indication of an alert and the output indicating the status of the equipment comprises the alert.

5. A method according to clause 4, wherein the alert is an email.

6. A method according to any preceding clause, wherein the output indication comprises updating an indication on a dashboard.

7. A method according to clause 7, wherein the indication on the dashboard indicates whether an attribute of the equipment is within an expected range of values.

8. A method according to clause 2, further comprising comparing a result of the deviation calculation with a failure mode library corresponding to the equipment and

generating an indication of a possible failure mode for the equipment based on the result of the comparison.

9. A method according to clause 8, wherein the failure mode library stores historical data for failures of failed equipment and measured attribute values for the failed equipment preceding the failures.

10. A computer readable medium storing processor executable instructions which when executed on a processor cause the processor to carry out a method according to any one of clauses 1 to 9.

11. An equipment analysis system for analyzing equipment, the system comprising a processor and a data storage device storing computer program instructions operable to cause the processor to:

receive equipment data comprising indications of measured attribute values of the equipment;

look up an equipment analysis template corresponding to the equipment in a database, the equipment analysis template comprising indications of equipment analysis calculations to be carried out using the measured attribute values of the equipment;

analyze the equipment data according to the equipment template to determine a status of the equipment; and

generate an output indication indicating the status of the equipment.

12. An equipment analysis system according to clause 11, wherein the equipment analysis template comprises an indication of an analytics template, and the analytics template comprises an indication of expected values for attributes of the equipment and an indication of a deviation calculation.

13. An equipment analysis system according to clause 12, wherein the deviation calculation is a calculation of an average deviation over a time period.

14. An equipment analysis system according to clause 12 or clause 13, wherein the analytics template comprises an indication of an alert and the output indicating the status of the equipment comprises the alert.

15. An equipment analysis system according to clause 14, wherein the alert is an email.

16. An equipment analysis system according to any one of clauses 10 to 15, wherein the data storage device further stores computer program instructions operative by the processor to: update an indication on a dashboard according to the output indication.

17. An equipment analysis system according to clause 16, wherein the dashboard indicates whether an attribute of the equipment is within an expected range of values.

18. An equipment analysis system according to clause 11, wherein the data storage device further stores computer program instructions operative by the processor to: compare a result of the deviation calculation with a failure mode library corresponding to the equipment and generate an indication of a possible failure mode for the equipment based on the result of the comparison.

19. An equipment analysis system according to clause 18, wherein the failure mode library stores historical data for failures of failed equipment and measured attribute values for the failed equipment preceding the failures.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, embodiments of the present invention will be described as non-limiting examples with reference to the accompanying drawings in which:

FIG.1 is a block diagram showing an environment comprising an equipment analysis system according to an embodiment of the present invention;

FIG.2 is a block diagram showing an equipment analysis system according to an embodiment of the present invention;

FIG.3 is a flowchart showing a method of equipment analysis according to an embodiment of the present invention;

FIG.4 is a block diagram showing an equipment analysis template according to an embodiment of the present invention;

FIG.5 is a block diagram showing an analytics template according to an embodiment of the present invention;

FIG.6 is screen view of a dashboard showing selected critical parameters and equipment detail page according to an embodiment of the present invention;

FIG.7 is screen view of a dashboard showing an equipment analytic monitoring page according to an embodiment of the present invention;

FIG.8 is screen view of a dashboard showing an equipment attributes trending page according to an embodiment of the present invention; and

FIG.9 is screen view of a dashboard showing an equipment performance and efficiency page according to an embodiment of the present invention.

DETAILED DESCRIPTION

The present disclosure relates to methods and systems for monitoring and analyzing equipment such as compressors and turbines. Embodiments of the present invention allow the monitoring of assets from a central location and provide predictive capabilities with analytic functions that allow small anomalies in monitoring data of the equipment into actionable early warnings of potential failure. Further, the systems and methods allow the monitoring of expensive equipment which may be deployed in disparate locations that are challenging to reach and may have difficult operating conditions. This monitoring can feed into diagnosis systems so that the critical

operation of the equipment can continue without interruption. Trend analysis and can be extremely valuable as an early warning indicator of potential problems and issues.

FIG.1 is a block diagram showing an environment comprising an equipment analysis system according to an embodiment of the present invention. As shown in FIG.1, the environment 100 comprises a plurality of rotating equipment items 110. The rotating equipment items may be for example, compressors or turbines. The rotating equipment items 110 are connected to a monitoring network 120. The monitoring network 120 monitors attribute values of the rotating equipment items 110 and generates equipment data which comprises indications of measured attribute values and timestamps indicating the time at which the attribute values were measured. The monitoring network 120 is connected to an equipment analysis system 150, which receives the equipment data and performs analysis of the rotating equipment items 110 based on the received equipment data using algorithm templates. The equipment analysis system 150 is coupled to a template database 180 which stores algorithm templates. The algorithm templates may comprise equipment analysis templates and analytics templates. The template database 180 may also store user preferences for creating dashboard display pages and alerts based on the analysis. These user preferences may form part of the algorithm templates. The equipment analysis system 150 is coupled to a failure mode library. The failure mode library 185 is a database which stores historical data on failures of the rotating equipment 110. This historical data comprises indications of a type and component which failed and also historical data attribute data from the time period preceding the failure. The equipment analysis system 150 generates a dashboard display 192 and alerts 194 as a result of the analysis.

Examples of the monitored attributes of the rotating equipment include: measurements of vibration, turbine control combustion temperatures, positioning of fuel actuators, suction pressure and temperature of fuel actuators, discharge pressure and temperature of fuel actuators, generator power, generator voltage, generator frequency, generator current, seal system flow, temperature and pressure of lubrication oil, generator winding temperature, pressure change across filters, turbine compressor temperature and pressure, fuel system pressure and temperature, and bearing temperature. It will be appreciated that the attributes listed here are exemplary

and the values of other attributes may be analyzed by the methods and systems described herein.

FIG.2 is a block diagram showing an equipment analysis system according to an embodiment of the present invention. The equipment analysis system 150 comprises a processor 152, a working memory 154, a network interface 156 and program storage 160. The processor 152 may be implemented as one or more central processing unit (CPU) chips. The program storage 160 is a non-volatile storage device such as a hard disk drive which stores computer program modules. The computer program modules are loaded into the working memory 154 for execution by the processor 152. The network interface 156 is an interface that allows the equipment analysis system 150 to communicate with the monitoring network 120 shown in FIG.1 to receive the equipment data.

The program storage 160 stores a template look up module 162, an analysis module 164, a dashboard display module 165 an alert generation module 166 and a failure mode module 168. The computer program modules cause the processor 152 to execute various equipment analysis methods which are described in more detail below. The program storage 160 may be referred to in some contexts as computer readable storage media and/or non-transitory computer readable media. As depicted in FIG.2, the computer program modules are distinct modules which perform respective functions implemented by the equipment analysis system 150. It will be appreciated that the boundaries between these modules are exemplary only, and that alternative embodiments may merge modules or impose an alternative decomposition of functionality of modules. For example, the modules discussed herein may be decomposed into sub-modules to be executed as multiple computer processes, and, optionally, on multiple computers. Moreover, alternative embodiments may combine multiple instances of a particular module or sub-module. It will also be appreciated that, while a software implementation of the computer program modules is described herein, these may alternatively be implemented as one or more hardware modules (such as field-programmable gate array(s) or application-specific integrated circuit(s)) comprising circuitry which implements equivalent functionality to that implemented in software.

Although the equipment analysis system 150 is described with reference to a computer, it should be appreciated that the equipment analysis system 150 may be formed by two or more computers in communication with each other that collaborate to perform a task. For example, but not by way of limitation, an application may be partitioned in such a way as to permit concurrent and/or parallel processing of the instructions of the application. Alternatively, the data processed by the application may be partitioned in such a way as to permit concurrent and/or parallel processing of different portions of a data set by the two or more computers. In an embodiment, virtualization software may be employed by the equipment status analysis system 150 to provide the functionality of a number of servers that is not directly bound to the number of computers in the equipment analysis system 150. In an embodiment, the functionality disclosed above may be provided by executing the application and/or applications in a cloud computing environment. Cloud computing may comprise providing computing services via a network connection using dynamically scalable computing resources. A cloud computing environment may be established by an enterprise and/or may be hired on an as-needed basis from a third-party provider.

FIG.3 is a flowchart showing a method of equipment analysis according to an embodiment of the present invention. The method 300 shown in FIG.3 is carried out by the equipment analysis system 150 shown in FIG.2.

In step 302, the network interface 156 of the equipment status analysis system 160 receives equipment data from the monitoring network 120. The equipment data comprises indications of measured attribute values of the rotating equipment items 110 and corresponding timestamps.

In step 304, the template look up module 162 is executed by the processor 152 to look up an equipment analysis template corresponding to the rotating equipment 110 in the template database 180.

FIG.4 is a block diagram showing an equipment analysis template according to an embodiment of the present invention. As shown in FIG.4, the equipment analysis template 400 comprises an indication of an equipment type 410, an indication of

equipment attributes 420, an indication of a first analytics template 430 and an indication of a second analytics template 440. The equipment analysis template 400 is a data object or algorithm template which is stored in the template database 180.

The indication of the equipment type 410 indicates a type of rotating equipment and is used by the template look up module 162 to look up the equipment analysis template corresponding to the rotating equipment 110.

The indication of equipment attributes 420 indicates attributes which will be displayed on a dashboard or which may be used during the analysis of equipment status.

The indication of a first analytics template 430 and the indication of the second analytics template 440 indication analytics templates which are stored in the template database 180. An example of an analytics template is shown in FIG.5.

FIG.5 is a block diagram showing an analytics template according to an embodiment of the present invention. As shown in FIG.5, the analytics template 500 comprises an indication of an analytic type 510, an indication of variables 520 used in the analysis carried out by the analytic, an indication of thresholds 530 for the variables and an indication of alerts 540. The analytics template 500 is a data object or algorithm template which is stored in the template database 180.

The analytic type 510 may be, for example an average deviation assessment over a time period. This involves calculating the deviation of the value of a variable from its average value over a time period. The time period may be, for example 1 hour, 30 days or another period over which the analysis is to be carried out. The variable or variables over which this analysis is to be carried out are specified in the variables. The threshold variables 530 specify thresholds for the analysis. For example, in an average deviation assessment, the threshold variables may specify thresholds for the deviation from the average and indications of an action or label for value of an attribute when depending of the value relative to the threshold. The threshold variables may specify a normal range of values, an upper alert value, a lower alert value, a range of bad values and / or that the equipment is shutdown. The alerts 540 indicate alerts to be generated depending on the value of the variables relative to the threshold

variables 530. For example, the alerts may specify that an alert is to be generated if the deviation from the average exceeds the upper or lower threshold specified in the threshold variables 530.

As described above, the analysis carried out by the equipment analysis system 150 uses algorithm templates which define how the analysis is carried out. The use of algorithm templates allows the modification and updating of analysis in a efficient manner. For example, if a user wishes to add a new equipment type, a new equipment analysis template can be added which references existing analytics templates. Thus, the user does not have to recreate or re-program all of the analysis methodology that has already been created for other equipment. Further, if changes are to be made to the analysis, these can be made to the necessary templates and complete updates for all equipment types are not required.

Returning now to FIG.3, in step 306, the analysis module 164 is executed by the processor 152 to carry out analysis as specified by the algorithm templates.

Examples of the analysis carried out in step 306 include calculation of a health bar for one of the rotating equipment items 110, calculation of a deviation of an attribute over a period of, for example rolling 1 hour, calculation of a deviation of a mean value of an attribute over a period of, for example rolling 30 days. The result of the calculation of the deviation of the attribute may be compared with a threshold. This threshold may be set by a user and stored as a template in the database 180. The analysis may comprise determining a duration over which an attribute is above or below a threshold, and the threshold may be stored as a template in the database 180.

The analysis may also comprise determining an anomaly indication for a rotating equipment item 110 based on the result of the calculation. For example, the duration over which the attribute is above or below a threshold may be used to calculate an anomaly. For example, if the attribute is above the threshold for a predetermined period, an anomaly indicator may be updated on the display dashboard and an alert will be generated.

In step 308, the dashboard display module 165and / or the alert generation module 166 are executed by the processor 152 to generate an output indication indicating the equipment status and anomalies. The output indication comprises an update to the display dashboard indicating the equipment status and anomalies alternatively, or additionally, the output indication comprises an alert generated by the alert generation module 166. The alert comprises an alert email sent to a user by the equipment analysis system 150.

In some embodiments, the failure mode module 168 is executed by the processor 152 when anomalous attribute values are detected. The failure mode module 168 accessed the failure mode library 185 to determine possible failures that may result from the anomalous attribute values.

The information displayed on the dashboard display 192 will now be described in more detail with reference to FIG.6 to FIG.9. The purpose of the dashboard display 192 is to show the relevant information related to attributes of the rotating equipment items and how these attributes exceed or/and deviate from threshold values. This allows users such as rotating specialists and engineers to focus on the problems that may be shown the deviations and may cause performance problems in the rotating equipment. Further the dashboard display 192 allows the users to diagnose problems in a prioritized and time efficient manner.

FIG.6 is screen view of a dashboard showing selected critical parameters and equipment detail page according to an embodiment of the present invention. As shown in FIG.6, the dashboard page 600 shows equipment information 610, selected parameters for monitoring 620, selected parameter trending 630, an indication of equipment running hours 640, equipment yearly availability and reliability values 650, equipment yearly unplanned deferment values 660, and equipment deviation analysis 670.

The equipment information 610 comprises an indication of the equipment type, make and model. The selected parameters for monitoring 620 show values of parameters as analog displays. The selection of parameters for display may be determined from the equipment analysis template for the equipment. The selected parameter trending

630 is shown as a graph of the parameter attribute values against time. This allows a user to identify how the parameter is changing over time. Again, the selection of parameters for display as the selected parameter trending 630 may be determined from the equipment analysis template for the equipment. The equipment running hours 640 indicates the number of hours that the equipment has been active. The equipment yearly availability and reliability values 650 indicate as a percentage the availability and reliability of the equipment over the current and previous years. The yearly unplanned deferment (UPD) values 660 indicate the number times the equipment has been taken offline for an unplanned reason in the current and previous years. The equipment deviation analysis 670 indicates the deviation of an equipment attribute from an expected performance curve. This analysis may be carried out by an analytics template stored in the template database 180.

FIG.7 is screen view of a dashboard showing an equipment analytic monitoring page according to an embodiment of the present invention. As shown in FIG.7, the equipment analytic monitoring page 700 shows an equipment overall health indicator 710 and equipment attribute individual health status indictors 720. The equipment overall health indicator 710 and the equipment attribute individual health status indictors 720 take the form of traffic light indicators which display different color to indicate the health status of the equipment. The equipment attribute individual health status indictors 720 are calculated according to analytics templates which may specify the thresholds for different health statuses, for example, normal, alert and critical alert. The equipment overall health indicator 710 is based on an algorithm template. As described above, the templates for the equipment analytic monitoring page allow a user to redefine and modify the variables, and thresholds related to the indicator displays in an efficient manner.

FIG.8 is screen view of a dashboard showing an equipment attributes trending page according to an embodiment of the present invention. As shown in FIG.8, the equipment attributes trending page 800 shows equipment attribute graphs 810. The equipment attribute graphs 810 show upper and lower limits which are based on an algorithm template.

FIG.9 is screen view of a dashboard showing an equipment performance and efficiency page according to an embodiment of the present invention. As shown in FIG.9, the equipment performance and efficiency page 900 shows equipment performance curves 910. The equipment performance curves 910 show the performance of the equipment and are based on an algorithm template.

Whilst the foregoing description has described exemplary embodiments, it will be understood by those skilled in the art that many variations of the embodiments can be made within the scope and spirit of the present invention.

CLAIMS

1. A method of analyzing equipment, the method comprising:

receiving equipment data comprising indications of measured attribute values of the equipment;

looking up an equipment analysis template corresponding to the equipment in a database, the equipment analysis template comprising indications of equipment analysis calculations to be carried out using the measured attribute values of the equipment;

analyzing the equipment data according to the equipment template to determine a status of the equipment; and

generating an output indication indicating the status of the equipment.

2. A method according to claim 1, wherein the equipment analysis template comprises an indication of an analytics template, and the analytics template comprises an indication of expected values for attributes of the equipment and an indication of a deviation calculation.

3. A method according to claim 2, wherein the deviation calculation is a calculation of an average deviation over a time period.

4. A method according to claim 2, wherein the analytics template comprises an indication of an alert and the output indicating the status of the equipment comprises the alert.

5. A method according to claim 4, wherein the alert is an email.

6. A method according to claim 1, wherein the output indication comprises updating an indication on a dashboard.

7. A method according to claim 7, wherein the indication on the dashboard indicates whether an attribute of the equipment is within an expected range of values.

8. A method according to claim 2, further comprising comparing a result of the deviation calculation with a failure mode library corresponding to the equipment and generating an indication of a possible failure mode for the equipment based on the result of the comparison.

9. A method according to claim 8, wherein the failure mode library stores historical data for failures of failed equipment and measured attribute values for the failed equipment preceding the failures.

10. A computer readable medium storing processor executable instructions which when executed on a processor cause the processor to carry out a method according to claim 1.

11. An equipment analysis system for analyzing equipment, the system comprising a processor and a data storage device storing computer program instructions operable to cause the processor to:

receive equipment data comprising indications of measured attribute values of the equipment;

look up an equipment analysis template corresponding to the equipment in a database, the equipment analysis template comprising indications of equipment analysis calculations to be carried out using the measured attribute values of the equipment;

analyze the equipment data according to the equipment template to determine a status of the equipment; and

generate an output indication indicating the status of the equipment.

12. An equipment analysis system according to claim 11, wherein the equipment analysis template comprises an indication of an analytics template, and the analytics template comprises an indication of expected values for attributes of the equipment and an indication of a deviation calculation.

13. An equipment analysis system according to claim 12, wherein the deviation calculation is a calculation of an average deviation over a time period.

14. An equipment analysis system according to claim 12, wherein the analytics template comprises an indication of an alert and the output indicating the status of the equipment comprises the alert.

15. An equipment analysis system according to claim 14, wherein the alert is an email.

16. An equipment analysis system according to claim 10, wherein the data storage device further stores computer program instructions operative by the processor to: update an indication on a dashboard according to the output indication.

17. An equipment analysis system according to claim 16, wherein the dashboard indicates whether an attribute of the equipment is within an expected range of values.

18. An equipment analysis system according to claim 11, wherein the data storage device further stores computer program instructions operative by the processor to: compare a result of the deviation calculation with a failure mode library corresponding to the equipment and generate an indication of a possible failure mode for the equipment based on the result of the comparison.

19. An equipment analysis system according to claim 18, wherein the failure mode library stores historical data for failures of failed equipment and measured attribute values for the failed equipment preceding the failures.

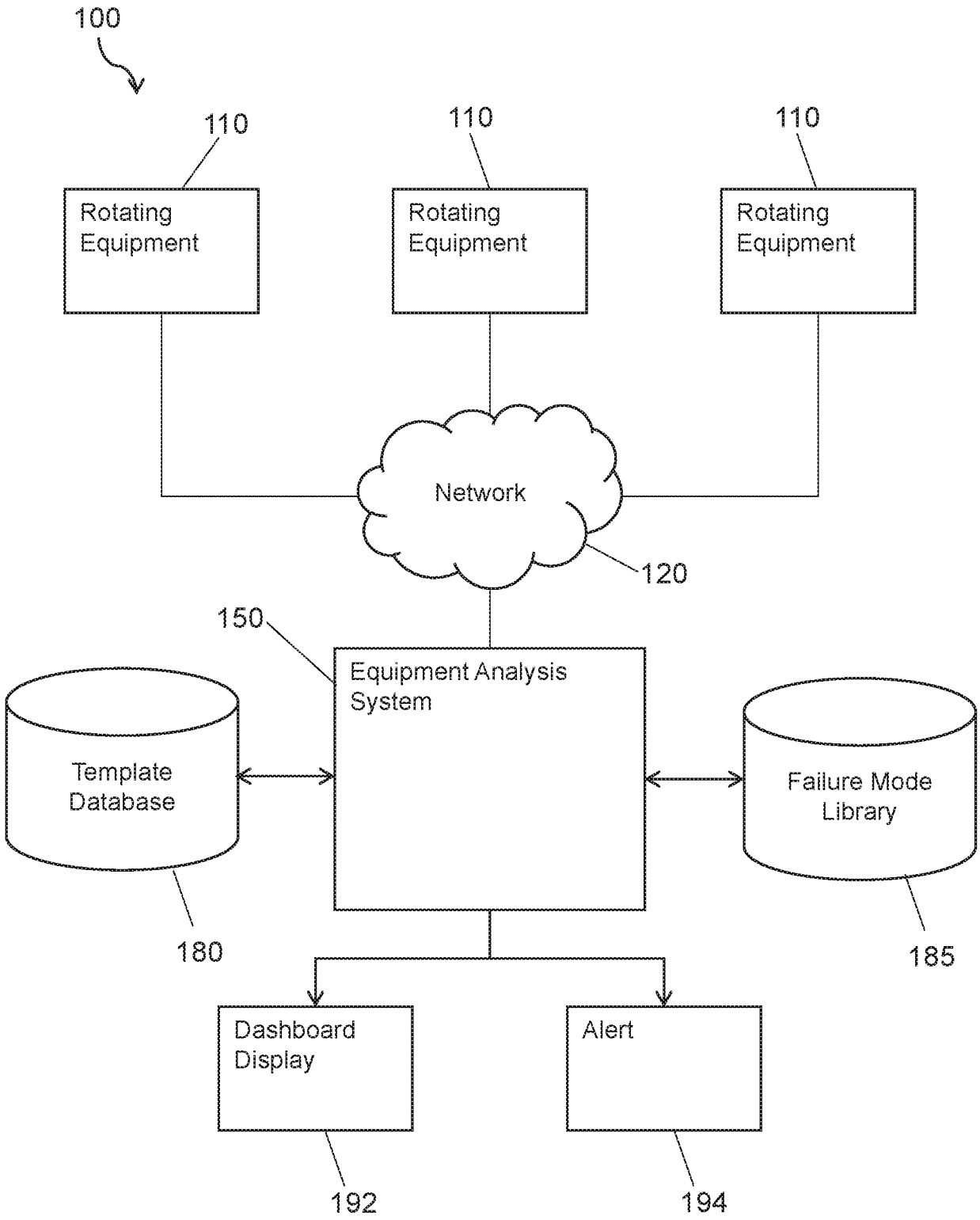
100
110
110
110
Rotating Equipment
Rotating Equipment
Rotating Equipment
Network
120
150
Equipment Analysis System
Template Database
Failure Mode Library
180
185
Dashboard Display
Alert
192
194

FIG.1

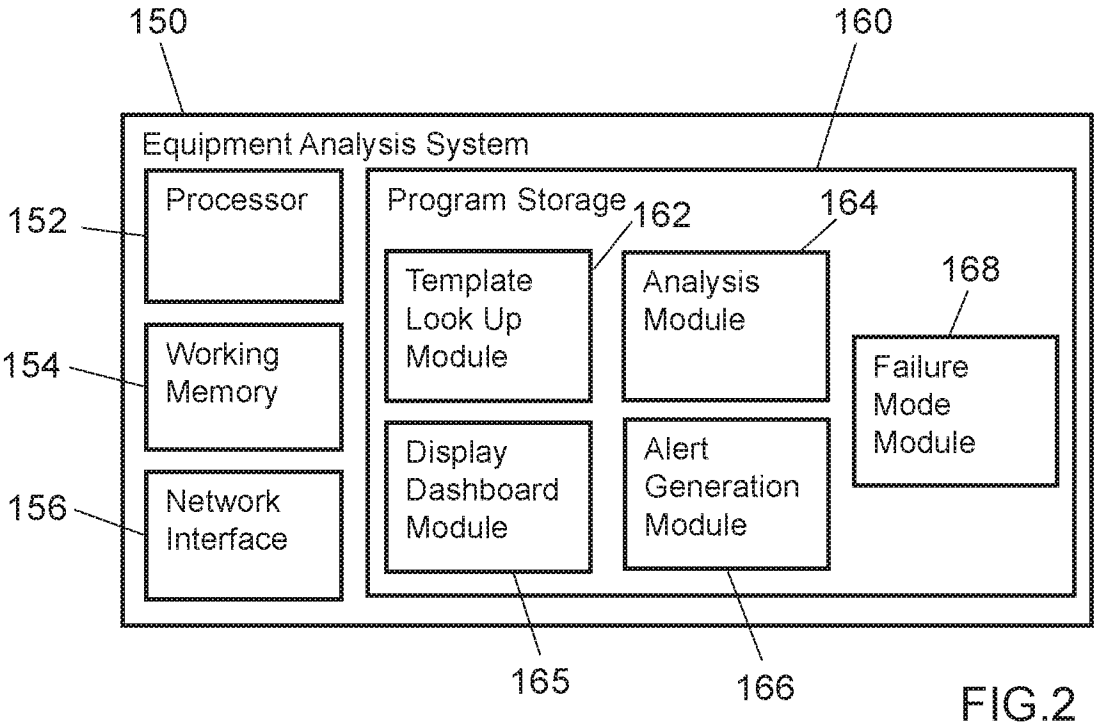
150
160
Equipment Analysis System
Processor
152
Working Memory
154
Network Interface
156
Program Storage
162
164
168
Template Look Up Module
Analysis Module
Failure Mode Module
Display Dashboard Module
Alert Generation Module
165
166

FIG.2

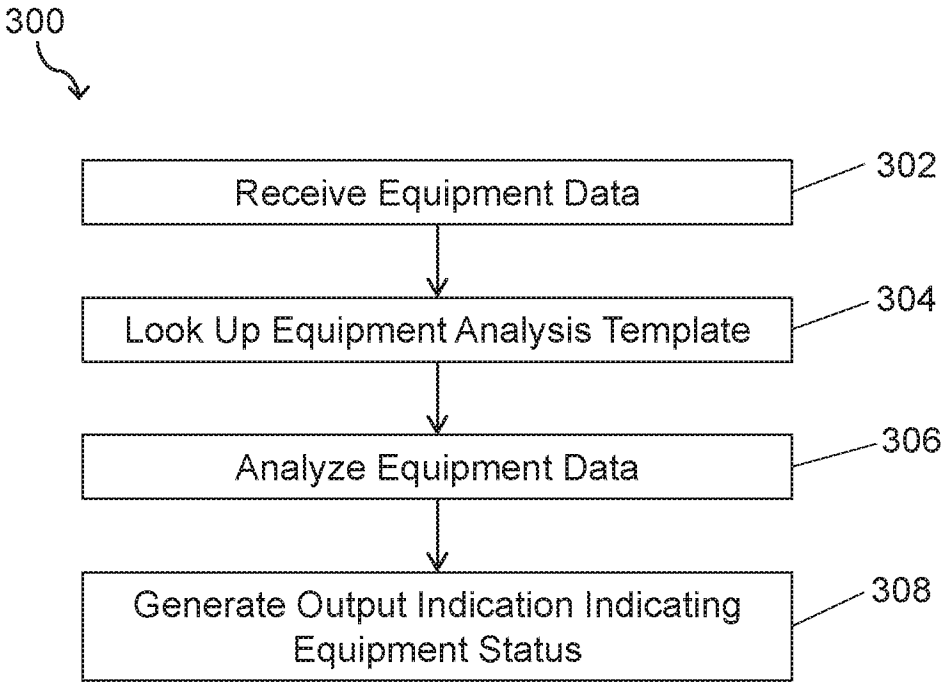
300
Receive Equipment Data
302
Look Up Equipment Analysis Template
304
Analyze Equipment Data
306
Generate Output Indication Indicating Equipment Status
308

FIG.3

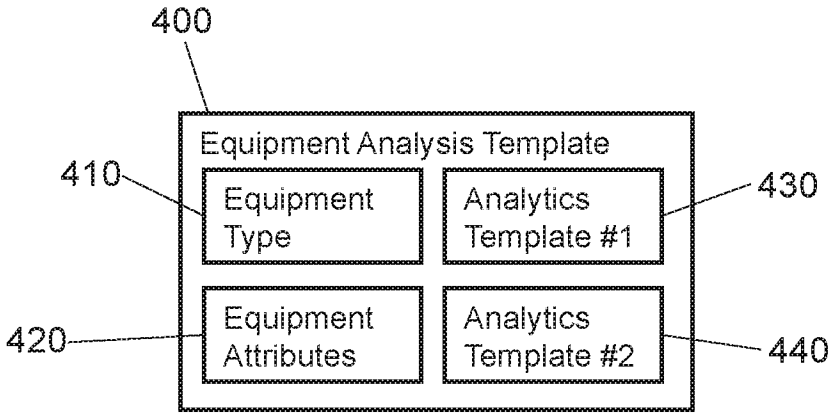
400
Equipment Analysis Template
410
Equipment Type
Analytics Template #1
430
420
Equipment Attributes
Analytics Template #2
440

FIG.4

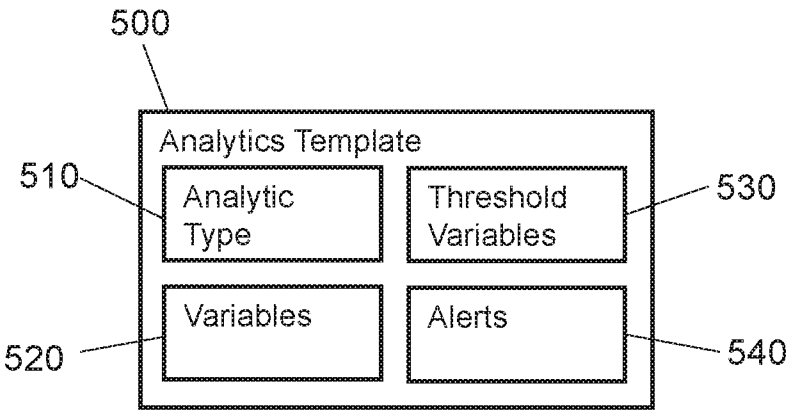
500
Analytics Template
510
Analytic Type
Threshold Variables
530
Variables
Alerts
520
540

FIG.5

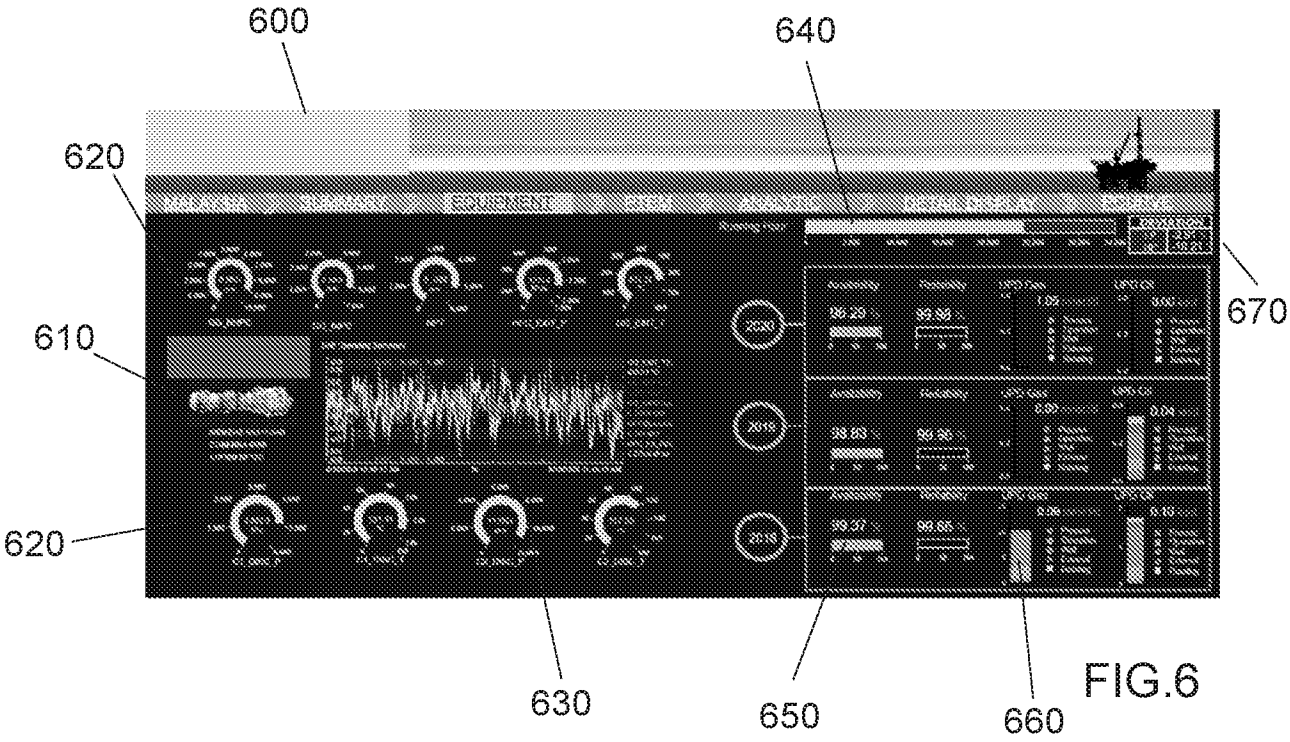

FIG.6

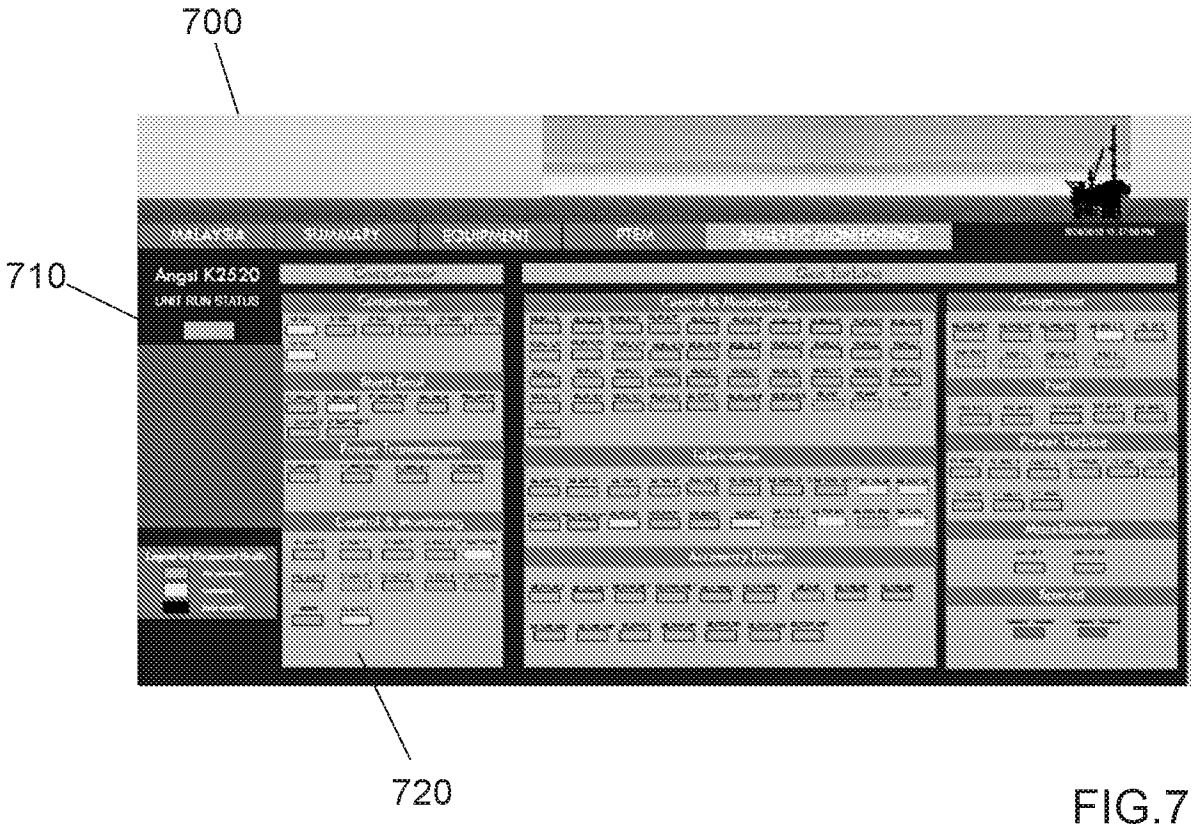

FIG.7

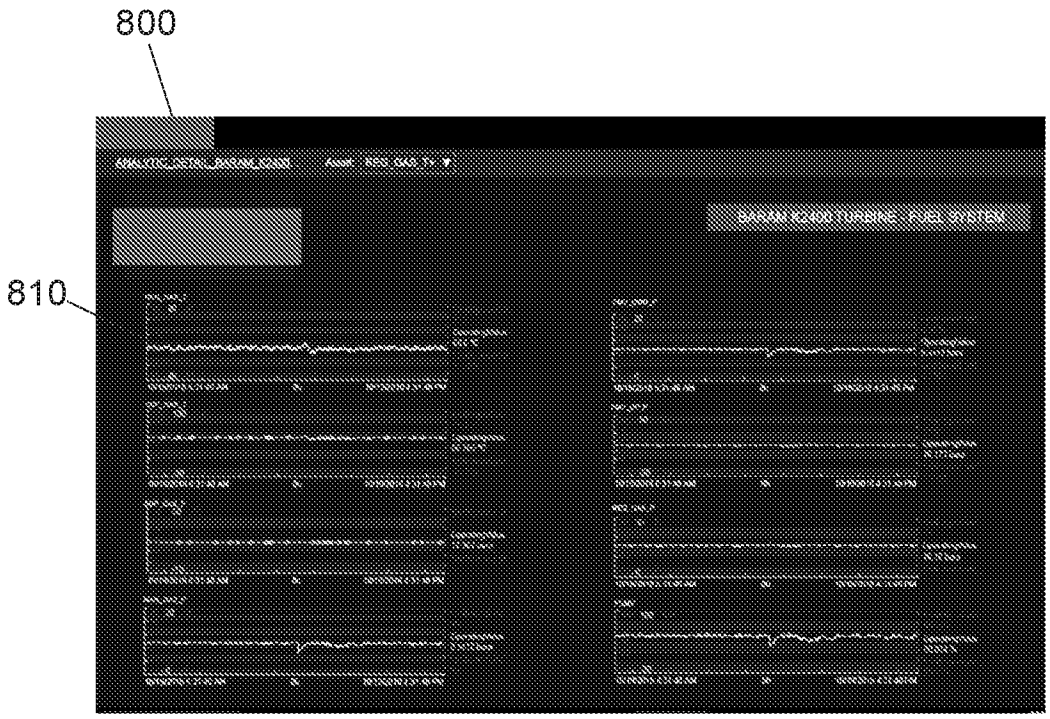
800
810

FIG.8

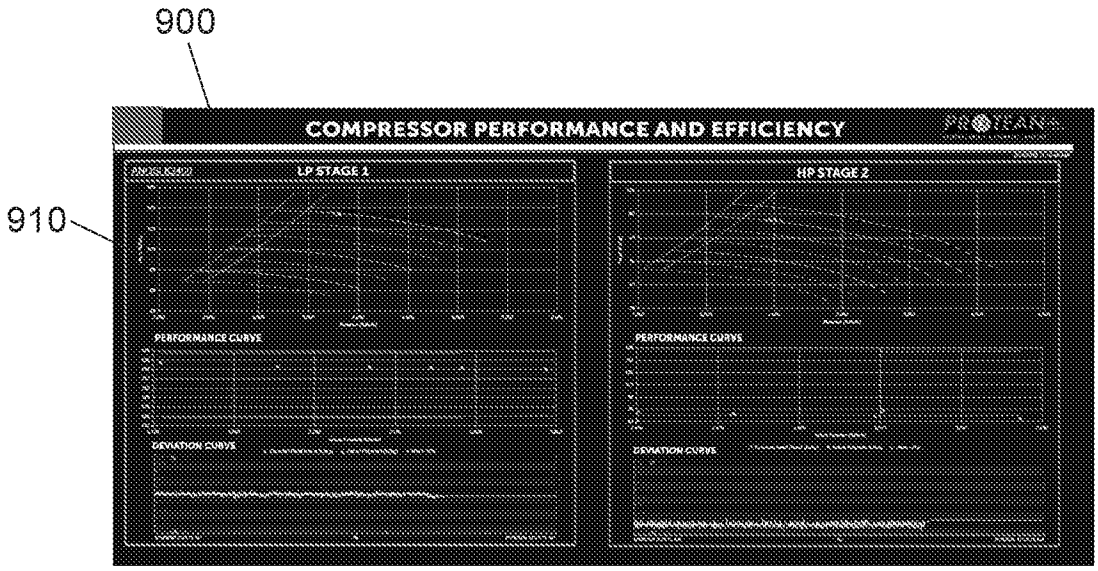
900
910
COMPRESSOR PERFORMANCE AND EFFICIENCY
LP STAGE 1
HP STAGE 2
PERFORMANCE CURVE
DEVIATION CURVE

FIG.9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/MY2021/050106

A. CLASSIFICATION OF SUBJECT MATTER

G01M 99/00(2011.01)i; **G06Q 50/10**(2012.01)i; **G08B 21/18**(2006.01)i

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)

G01M 99/00(2011.01); G05B 19/418(2006.01); G05B 23/00(2006.01); G05B 23/02(2006.01); G06F 11/07(2006.01); G06F 7/00(2006.01); G06Q 50/00(2006.01)

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

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: equipment, analysis, template, maintenance, attribute, status, deviation, failure, library

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2020-0201311 A1 (SHENZHEN JINGJIANG YUNCHUANG TECHNOLOGY CO., LTD.) 25 June 2020 (2020-06-25) paragraphs [0014]-[0042], claims 1, 3, and figures 1-3	1-19
A	US 2001-0001851 A1 (PIETY et al.) 24 May 2001 (2001-05-24) paragraphs [0076]-[0096], claim 1, and figures 1, 2	1-19
A	US 2013-0245883 A1 (HUMPHREY, JAMES D.) 19 September 2013 (2013-09-19) paragraphs [0041]-[0067] and figures 1-5	1-19
A	US 10387237 B2 (GENERAL ELECTRIC COMPANY) 20 August 2019 (2019-08-20) column 33, line 44 - column 36, line 33 and figures 1, 20, 21	1-19
A	JP 2007-079758 A (MITSUBISHI ELECTRIC CORP.) 29 March 2007 (2007-03-29) claim 1 and figures 1-6	1-19

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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"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
25 March 2022	**25 March 2022**

Name and mailing address of the ISA/KR	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/MY2021/050106

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