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(54) **METHODS FOR PREDICTING AND PREVENTING FAILURE OF IN VITRO DIAGNOSTIC INSTRUMENTS**

VERFAHREN ZUR VORHERSAGE UND VERHINDERUNG VON DEFEKTEN BEI INSTRUMENTEN FÜR DIE IN-VITRO-DIAGNOSE

PROCÉDÉS DE PRÉDICTION ET DE PRÉVENTION DE LA DÉFAILLANCE D'INSTRUMENTS DE DIAGNOSTIC IN VITRO

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Description

RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Application Serial Number 62/366,360 entitled "METHODS AND APPARATUS FOR PREDICTING AND PREVENTING FAILURE OF IN VITRO DIAGNOSTIC INSTRUMENTS" filed on July 25, 2016.

FIELD

[0002] The present disclosure relates to methods adapted to predict failures in in vitro diagnostic instruments.

BACKGROUND

[0003] US 2008/040152 and US 2008/312783 disclose a health-management system for aircraft, watercraft or land-based vehicles. WO 2015/179370 discloses methods for dynamically identifying solutions for troubleshooting issues related to in-vitro diagnostic instruments. In medical testing and processing, automated apparatus such as in vitro diagnostic instruments may include the use of robotics and are used to test and/or process biological liquids (otherwise referred to herein as "specimens"). Such automated apparatus are complex and from time-to-time may experience failures (e.g., malfunctions). Certain types of recurring malfunctions are relative easy to diagnose and the apparatus themselves may generate an "error code," which will lead the user to a set of instructions that provide a solution to rectify the malfunction. However, these types of solutions may be problematic.

[0004] Accordingly, methods that may improve upon malfunction solutions in such in vitro diagnostic instruments are sought after.

SUMMARY

[0005] The method according to the invention is defined by the features of claim 1.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

FIG. 1 illustrates a schematic diagram of an in vitro diagnostic instrument maintenance apparatus for multiple instruments at a location according to one or more examples not being part of the invention.

FIG. 2 illustrates a schematic functional diagram of an in vitro diagnostic instrument maintenance apparatus according to one or more examples not being part of the invention.

FIG. 3 illustrates a schematic diagram of an in vitro diagnostic instrument maintenance apparatus for a single instrument at a location according to one or more examples not being part of the invention.

FIG. 4 illustrates a flowchart of a method of predicting failures of an in vitro diagnostic instrument according one or more embodiments of the invention.

DETAILED DESCRIPTION

[0007] Failures in automated medical testing and processing equipment (e.g., in vitro diagnostic instruments) are typically diagnosed after they occur, such as by the operator receiving an equipment-generated error code indicating that a malfunction has occurred, and providing instructions on how to rectify the identified malfunction. This after-the-fact, reactionary approach, although adequate for malfunction diagnosis in the in vitro diagnostic instruments, may result in excessive repair downtime, and possibly extra labor costs due to overtime for unnecessarily-urgent repairs.

[0008] In one or more embodiments, an in vitro diagnostic instrument maintenance apparatus and method helps to detect upcoming or impending failures. The method and apparatus measures performance of one or more specific condition-based maintenance parameters (hereinafter "CBM parameters") in order to make predictions about impending malfunctions.

[0009] Knowing the performance of one or more specific CBM parameters, a failure prediction engine may compare the one or more measured CBM parameters against a pattern library of "normal" parameters that are indicative of normal behavior. If the measured value of the CBM parameter over time is deviating from the "normal" as identified by a CBM failure prediction engine, appropriate actions can be undertaken to address the deviation. The identification of a deviating CBM parameter may be indicative of deterioration (e.g., wear or impending failure) of a component (motor, heating unit, carousel, pump, valve, aspiration/dispense system, interfaces between subsystems, processors, power supplies, or the like). When a CBM parameter deviation of a predefined magnitude (e.g., slope above a predetermined magnitude) is measured, the component can be fixed by a customer service engineer before the instrument stops working.

[0010] Such in vitro diagnostic instrument maintenance apparatus and methods may provide one or more benefits and/or advantages, such as: 1) reduced instrument down-time by knowing upfront what the root-cause and what needs to be fixed, 2) reduced mean time to repair by having the right set of components (spare parts) available (in advance) to replace the defective ones, 3) ability to schedule repairs at opportune times, 4) increased first time repair rates, and/or 5) reduction in service spare parts by knowing upfront which components are most likely to fail.

[0011] In view of the foregoing, one or more embodiments of the disclosure provides methods configured and operable to rapidly identify and notify an operator of an impending malfunction of an in vitro diagnostic instrument.

[0012] These and other aspects and features of embodiments of the disclosure will be described with reference to FIGs. 1-4 herein.

[0013] In accordance with one or more apparatus examples referring to FIGs. 1 and 2, an in vitro instrument maintenance apparatus 100 is shown and described. The in vitro instrument maintenance apparatus 100 includes one or more monitoring devices 102A, 102B configured to monitor condition-based parameters of one or more instrument components of one or more instruments 104A-104N. One or more than one instrument 104-104N may be monitored. The one or more instruments 104A-104N may comprise one or more testing and/or processing apparatus, such as clinical chemistry testing apparatus, immuno-assay testing apparatus, vessel mover, sample handler, and/or the like. One or more than one of the components of the testing and/or processing apparatus of one or more of the instruments 104A-104N may be monitored. The components of the instruments 104A-104N being monitored may be one or more motors, pumps, probes, aspiration/dispense systems, valves, reservoirs, lines, moving components, and/or the like.

[0014] Monitoring by the monitoring devices 102A, 102B may be by way of sensors or current and/or voltage sensors/taps on electrical circuits, or other suitable devices. Sensors may be used, for example, to monitor time, distance, position, strain, drift, load, resistance (friction or electrical), speed, acceleration, temperature, # of cycles, component level, light presence, intensity, and/or gradients, pressure and/or vacuum levels, fluid level, flow, leaks, or fluid presence or absence, fluid constituent concentration or condition, bubbles, vibration, noise, capacitance, contamination, contact, closure, state, proximity, or the like of various subcomponents. Condition of pumps, motors, or other electrical components may be monitored by current and/or voltage taps on electrical circuits that are coupled to the motors, pumps, and/or other electrical components. Backlash or other types of degradation may be monitored. In other embodiments, software-related CBM parameters may be monitored, such as bar code reader cycles (or reads and/or failures), component connectivity, processor crashes, restarts, CPU utilization, memory usage, or the like. Derivatives and/or integrals, or other manipulations of measured values of any of the above may be obtained and monitored.

[0015] The in vitro instrument maintenance apparatus 100 may include a local data server 106 coupled to the one or more monitoring devices 102A, 102B. For example, the coupling may be by way of a network 108, such as a suitable wired or wireless network. Each of the monitoring devices 102A, 102B may include a conditioning/communication circuit (e.g., CC circuit 103) that is operable to processes the signal from the monitoring device 102A, 102B and provide it in proper form for communication to the local data server 106 through the network 108. Network 108 may be a local area network (LAN), wireless local area network (WLAN), power line communication (PLC) network, or the like. Other suitable networks may be used.

[0016] The local data server 106 may be any suitable computer device including a processor 110, memory 112, and communication interface 114. Communication interface 114 may include any suitable device or devices enabling communication with the network 108 and the internet 116, such as Ethernet adapter, and a router and/or modem, or the like.

[0017] Local data server 106 may include a checking module 118 (otherwise referred to as an instrument check/device check component), which may be configured to: test functionality of the one or more components of one or more devices included in the instruments 104A-104N. For example, the one or more devices may be one or more analyzers, a sample handler, vessel mover, pre-analytic module (e.g., centrifuge), post-analytic module, decapper, recapper, or the like of an in vitro diagnostic instrument 104A-104N. Functionality may be tested by any suitable means, such as reading digital inputs and/or outputs, reading analog inputs, and motor status signals, testing connectivity of motors and/or heaters, and/or verifying that signals are within a normal operating range therefor. In some embodiments, checking module 118 may obtain the condition-based parameters of the one or more instrument components such as a pressure signal value, an acceleration value, a motor anomaly such as backlash or slop, a velocity value (linear or rotational), a displacement value (linear or rotational), a current value, a voltage value, a power value, a state, a light (e.g., photometer) reading, a level reading, a noise reading, transducer or sensor noise level, a valve condition reading, a fluid condition reading (e.g., pH), and/or the like. Derivatives, integrals, or other manipulations of the above may be used as the end CBM parameter that is monitored.

[0018] Data on functionality and condition-based parameters of the one or more instrument components may be stored in memory 112 in a local database 120. Data may include time stamps as well as absolute values. Local database 120 may be configured to contain a compilation of the condition-based parameters for each instrument 104A-104N being thus monitored. The compilation may include the data sampled over time, and may include maximum value, minimum value, mean value, and/or standard deviation. In the depicted embodiment, the local database 120 may receive condition-based parameters from multiple instruments 104A-104N. Sampling may be taken at any suitable interval, such as every minute, day, week, upon startup, or any other time period.

[0019] The apparatus 100 may include a remote server, such as a CBM analysis server 122 shown, that may be configured to communicate with the local data server 106. Communication may be via communication inter-

face 123 communicating with local data server 106 through the internet 116, for example. Remote server (e.g., CBM analysis server 122), which may be at a different facility than local data server 106, may receive and store data on the CBM parameters and functionality data from the local data server 106 in memory 124, such as in a condition-based maintenance (CBM) parameter database 125. The data may include the previously-mentioned raw data, time stamps, and may include maximum, minimum, mean, and/or standard deviation data of the various instrument components. Other suitable related or associated data may be included.

[0020] The CBM analysis server 122 may also include a failure prediction engine module 126, and a failure rules model 128 configured as software or a combination of hardware and software. The failure prediction engine module 126 uses the data on CBM parameters from the one or more instruments 104A-104N to generate predictions of impending failures of components thereof.

[0021] For example, data over time may be collected for condition-based parameters such as pump backlash of multiple pumps of an aliquotter, IMT Probe, reagent arm location, sample probe pressure and/or location, and/or other components. The collected condition-based parameters may be compared against failure patterns and/or normal patterns stored in a failure pattern library 130. If the collected condition-based parameters over time are determined to be dissimilar enough (from a normal pattern) or similar enough (as compared to a failure pattern) from a corresponding pattern stored in the failure pattern library 130, then the failure rules module 132 may be triggered. The degree of dissimilarity may be determined by exceeding one or more thresholds or any other pattern recognition method. In some embodiments, a deviation from normal of a suitable magnitude above one or more threshold magnitudes is noted as denoting a failure pattern, wherein normal patterns may be stored in the failure pattern library 130. A solver may also provide some indication of the confidence level in the failure prediction, based on the degree of similarity or difference. In other embodiments, failure patterns may be stored in the failure pattern library 130 and failure may be determined based on the degree of likeness of the measured to the stored failure pattern. Likeness may be determined by being above certain thresholds or within pre-established threshold bands. Other suitable means for determining the similarity or difference, as the case may be, may involve curve fitting and goodness of fit, multi- or linear regression analysis, non-linear regression analysis, Mahanobolis distance analysis, decision trees, or the like.

[0022] Based on the rule for the deviation of that type, a rule is collected from the rules database 133 and fired and a suitable action is launched by the failure rules module 132. For example, the actions may be as provided in block 234 of FIG. 2. In one example, the action may be an alert that provides a warning to the local operator 134 through the data server user interface 136. The warning may be provided through a visual warning (e.g., displayed on a visual display monitor) to the local operator 134 and/or a remote operator 140 that a component of an instrument 104A-104N is about to malfunction. An audible warning may also be initiated. Optionally or additionally, a service call (e.g., service ticket) may be initiated to an instrument manufacture or servicer, wherein a service technician is sent to the location of the instrument 104A-104N to repair the component that has been flagged as being subject to an impending failure on the instrument 104A-104N. Suitable spare parts may be taken with the service technician based upon knowledge of the impending failure provided by failure rules module 132.

[0023] A CBM data manager 138 may be configured as software or a combination of software and hardware and may facilitate exchange of data between the failure prediction engine module 126 and the CBM Parameter database 125. Further, CBM data manager 138 may initiate pull of CBM parameters from the local database 120 through communication interface 123 as commanded via input from the remote operator 140 through analysis server user interface 142.

[0024] In other embodiments, the CBM data manager 138 may initiate pull of the CBM parameter data from the local database 120 at preprogrammed intervals, such as hourly, daily, or other suitable intervals. In other embodiments, the checking module 118 may be preprogrammed to push the data to the CBM analysis server 122 via the communication interface 114 at preprogramed intervals, such as hourly, daily, or other suitable intervals. In other embodiments, the local operator 134 may initiate, via suitable commands, a push of the CBM data to the CBM analysis server 122 via the communication interface 114.

[0025] Other instruments (not shown) coupled to other local servers (not shown) may also provide CBM parameters and functionality data through the internet 116 (as indicated by arrow 144) to communication interface 123 such that failure prediction thereof may also occur in the manner described herein. A communication monitor 145 may be included to identify the identity of the local data server (e.g., local data server 106) and respond as to the completeness of respective communications and data transmission therefrom.

[0026] In accordance with another example of the disclosure, an in vitro diagnostic instrument maintenance apparatus 300 is shown and described with reference to FIG. 3. The in vitro diagnostic instrument maintenance apparatus 300 includes monitoring devices 102A-102N configured to monitor condition-based parameters of instrument components 104_1-104_N of an in vitro diagnostic instrument 104A. Monitoring devices 102A-102N may be as discussed herein above. Multiple components of the in vitro diagnostic instrument 104A may be monitored.

[0027] The in vitro diagnostic instrument 104A may include a local workstation server 306 of the in vitro diagnostic instrument 104A coupled to the monitoring devices

102A-102N. The local workstation server 306 is configured to operate the components 104_1-104_N and one or more devices of the in vitro diagnostic instrument 104A. The local workstation server 306 may include, as previously described, a checking module 118 configured to: test functionality of the instrument components 104_1-104_N, and obtain the condition-based parameters of the instrument components 104_1-104_N, which are stored in memory 112. The local workstation server 306 may include a local database 120 configured to contain a compilation of the condition-based parameters.

[0028] The in vitro diagnostic instrument maintenance apparatus 300 may include a remote server (e.g., a CBM analysis server 122) as previously described. CBM analysis server 122 may be configured to communicate with the local server (e.g., local workstation server 306) and configured to receive and store the condition-based parameters in the CBM parameter database 125, wherein the remote server (e.g., a CBM analysis server 122) includes a failure prediction engine module 126, and a failure rules module 132, which function to predict impending failure and issue corrective actions. CBM parameters and data from other in vitro diagnostic instruments (not shown) may also be provided to the remote server (e.g., CBM Analysis server 122) through communication through the internet 116 as indicated by arrow 344.

[0029] According to the invention, a method 400 of predicting failures of an in vitro diagnostic instrument (e.g., in vitro diagnostic instrument 104A-104N) is provided. The method 400 includes, in 402, monitoring, via one or more monitoring devices (e.g., 102A-102N) associated with one or more components (e.g., components 104_1-104_N) of the in vitro diagnostic instrument, one or more condition-based maintenance parameters of the in vitro diagnostic instrument. Data on functionality of the (e.g., instrument components 104_1-104_N) may also be monitored. In 404, the method includes providing the one or more condition-based maintenance parameters of the in vitro diagnostic instrument to a local database (e.g., to local database 120). Any suitable sampling routine may be used. In 406, the condition-based maintenance data is transmitted to a remote server (e.g., CBM analysis server 122). Transmission may be automatic at any suitable interval or initiated by local operator 134 or remote operator 140. In 408, the method 400 includes storing the condition-based maintenance data at the remote server (e.g., in CBM parameter database 125), such as in a CBM parameter database 125 in memory 124.

[0030] The method 400 further includes, in 410, analyzing the condition-based maintenance data according to a failure prediction engine (e.g., failure prediction engine module 126) including failure prediction criteria. The failure prediction criteria may be a pattern wherein a pattern of the condition-based maintenance data is compared against known (previously collected) patterns in the failure pattern library 130 for that component. Any suitable method for comparison may be used, such as threshold based comparisons, wherein if a preselected threshold is exceeded, then a failure may be predicted to occur. The method 400 further includes, in 412, performing an action based on predefined deviation from the failure prediction criteria. For example, if the deviation is above a defined threshold amount then an action may be undertaken; otherwise, the CBM analysis server 122 continues to monitor the component. Actions may include alerts (e.g., warnings, request for additional information, such as input from the local operator 134, requests for further functionality data or condition-based maintenance data by either the local operator 134 or remote operator 140, or scheduling of maintenance including possibly ordering replacement parts for worn or parts that have been flagged by the method for impending failure.

[0031] While specific apparatus and methods have been shown by way of example embodiments herein, it should be understood that other and different embodiments are possible. It is intended that the disclosure is to cover all modifications, equivalents, and alternatives falling within the scope of the claims.

Claims

1. A method of predicting failures of an in vitro diagnostic instrument (104), comprising:

monitoring, via one or more monitoring devices (102) associated with one or more components of the in vitro diagnostic instrument (104), one or more condition-based maintenance (CBM) parameters of the in vitro diagnostic instrument (104);

providing the one or more condition-based maintenance parameters of the in vitro diagnostic instrument (104) to a local database (120) of a local data server (106) storing data on the functionality and condition-based maintenance parameters of the one or more components of the in vitro diagnostic instrument (104) in memory (112) in the local database (120);

transmitting the condition-based maintenance data to a remote server which is a CBM analysis server (122);

characterized in that

the transmitting of the condition-based maintenance data to the remote server comprises

- a conditional push operation where a condition must be met before the transmitting takes place;

storing the condition-based maintenance data at the CBM analysis server (122) which includes a failure prediction engine module (126), and a failure rules module (132);

generating predictions of impending failures of components of the in vitro diagnostic instrument

(104) by the failure prediction engine module (126) including failure prediction criteria, wherein a pattern of the condition-based maintenance data is compared against known patterns in a failure pattern library (130) for that component wherein the comparison comprises threshold based comparisons, wherein if a preselected threshold is exceeded, then a failure is predicted to occur;
and
launching a suitable action by the failure rules module (132) if the deviation from the failure prediction criteria is above a defined threshold amount, wherein
the one or more condition-based maintenance parameters of the in vitro diagnostic instrument (104) comprises one or more of:

a temperature of a component of the in vitro diagnostic instrument (104);
a pressure in a component of the in vitro diagnostic instrument (104);
a liquid level in a component of the in vitro diagnostic instrument (104);
a current drawn by a component of the in vitro diagnostic instrument (104);
a flow rate through a component of the in vitro diagnostic instrument (104); and
a backlash in a pump component of the in vitro diagnostic instrument (104).

2. The method of claim 1, comprising processing the one or more condition-based maintenance parameters to provide processed condition-based maintenance data,
wherein preferably the processed condition-based maintenance data comprises a maximum, minimum, mean, and standard deviation of the one or more condition-based maintenance parameters over a predefined period of time.

3. The method of claim 1, comprising setting a collection frequency of the one or more condition-based maintenance parameters of the in vitro diagnostic instrument (104).

4. The method of claim 1, comprising setting an upload frequency of the condition-based maintenance data of the in vitro diagnostic instrument (104).

5. The method of claim 1, wherein the transmitting of the condition-based maintenance data to the remote server comprises a pull operation where the transmitting is requested by the remote server.

6. The method of claim 1, wherein generating predictions of impending failures of components of the in vitro diagnostic instrument (104) by the failure prediction engine module (126) comprises determining a failure pattern match,
wherein the failure pattern match comprises exceeding a predetermined slope of the condition-based maintenance data over a predetermined period of time.

7. The method of claim 1, wherein the action comprises triggering one or more predefined rules from the failure rules module (132),
wherein preferably the predefined rules comprise one or more of:

provide a notice or warning to an instrument operator;
create report;
request more condition-based maintenance data from the instrument;
automatic instrument shutdown; and
schedule service of the instrument.

Patentansprüche

1. Verfahren zur Vorhersage von Ausfällen eines Instruments (104) für die in vitro-Diagnostik, umfassend:

Überwachen von einem oder mehreren Parametern der zustandsorientierten Instanthaltung (CBM) des Instruments (104) für die in vitro-Diagnostik mittels einer oder mehreren Überwachungsvorrichtungen (102), die mit einer oder mehreren Komponenten des Instruments (104) für die in vitro-Diagnostik assoziiert sind;
Bereitstellen des einen oder der mehreren Parameter der zustandsorientierten Instanthaltung des Instruments (104) für die in vitro-Diagnostik an eine lokale Datenbank (120) eines lokalen Datenservers (106), der Daten zur Funktionalität und Parameter zur zustandsorientierten Instanthaltung der einen oder mehreren Komponenten des Instruments (104) für die in vitro-Diagnostik im Speicher (112) in der lokalen Datenbank (120) speichert;
Übertragen der Daten zur zustandsorientierten Instandhaltung an einen Fernserver, der ein CBM-Analyseserver (122) ist;
dadurch gekennzeichnet, dass
das Übertragen der Daten zur zustandsorientierten Instandhaltung an den Fernserver umfasst:

- einen konditionalen Push-Vorgang, wobei eine Bedingung erfüllt sein muss, bevor das Übertragen stattfindet;

Speichern der Daten zur zustandsorientierten

Instandhaltung auf dem CBM-Analyseserver (122), der ein Ausfallvorhersage-Engine-Modul (126) und ein Ausfallregelnmodul (132) einschließt;
Generieren von Vorhersagen von drohenden Ausfällen von Komponenten des Instruments (104) für die in vitro-Diagnostik durch das Ausfallvorhersage-Engine-Modul (126) einschließlich Ausfallvorhersagekriterien, wobei ein Muster der zustandsorientierten Instandhaltungsdaten mit bekannten Mustern in einer Ausfallmusterbibliothek (130) für jene Komponente verglichen wird, wobei der Vergleich schwellenwertbasierte Vergleiche umfasst, wobei, falls ein vorgewählter Schwellenwert überschritten wird, dann das Auftreten eines Ausfalls vorhergesagt wird; und
Starten einer geeigneten Aktion durch das Ausfallregelnmodul (132), falls die Abweichung von den Ausfallvorhersagekriterien oberhalb einer definierten Schwellenwertmenge liegt, wobei der eine oder die mehreren Parameter zur zustandsorientierten Instandhaltung des Instruments (104) für die in vitro-Diagnostik ein oder mehrere der Folgenden umfassen:

eine Temperatur einer Komponente des Instruments (104) zur in vitro-Diagnostik;
einen Druck in einer Komponente des Instruments (104) zur in vitro-Diagnostik;
einen Flüssigkeitspegel in einer Komponente des Instruments (104) zur in vitro-Diagnostik;
einen Strom, der von einer Komponente des Instruments (104) zur in vitro-Diagnostik gezogen wird;
eine Flussrate durch eine Komponente des Instruments (104) zur in vitro-Diagnostik hindurch; und
einen Rückschlag in einer Pumpenkomponente des Instruments (104) zur in vitro-Diagnostik.

2. Verfahren nach Anspruch 1, umfassend Verarbeiten des einen oder der mehreren Parameter zur zustandsorientierten Instandhaltung, um verarbeitete zustandsorientierte Instandhaltungsdaten bereitzustellen,
wobei die verarbeiteten zustandsorientierten Instandhaltungsdaten vorzugsweise ein Maximum, ein Minimum, einen Mittelwert und die Standardabweichung des einen oder der mehreren Parameter zur zustandsorientierten Instandhaltung über einen vordefinierten Zeitraum umfassen.

3. Verfahren nach Anspruch 1, umfassend Einstellen einer Sammelhäufigkeit des einen oder der mehreren Parameter zur zustandsorientierten Instandhaltung des Instruments (104) für die in vitro-Diagnostik.

4. Verfahren nach Anspruch 1, umfassend Einstellen einer Hochladungshäufigkeit der zustandsorientierten Instandhaltungsdaten des Instruments (104) für die in vitro-Diagnostik.

5. Verfahren nach Anspruch 1, wobei das Übertragen der zustandsorientierten Instandhaltungsdaten an den Fernserver einen Pull-Vorgang umfasst, wobei das Übertragen durch den Fernserver angefordert wird.

6. Verfahren nach Anspruch 1, wobei das Generieren von Vorhersagen von drohenden Ausfällen von Komponenten des Instruments (104) für die in vitro-Diagnostik durch das Ausfallvorhersage-Engine-Modul (126) Ermitteln einer Ausfallmusterübereinstimmung umfasst,
wobei die Ausfallmusterübereinstimmung Überschreiten einer vorbestimmten Neigung der zustandsorientierten Instandhaltungsdaten über einen vorbestimmten Zeitraum umfasst.

7. Verfahren nach Anspruch 1, wobei die Aktion Auslösen von einer oder mehreren vordefinierten Regeln aus dem Ausfallregelnmodul (132) umfasst,
wobei die vordefinierten Regeln vorzugsweise ein oder mehrere der Folgenden umfassen:

Bereitstellen eines Hinweises oder einer Warnung an einen Bediener des Instruments;
Erstellen eines Berichts;
Anfordern von mehr zustandsorientierten Instandhaltungsdaten von dem Instrument;
automatisches Herunterfahren des Instruments; und
Anberaumen eines Servicetermins für das Instrument.

Revendications

1. Procédé de prévision de défaillances d'un instrument de diagnostic in vitro (104), comprenant les étapes consistant à :

surveiller, via un ou plusieurs dispositifs de surveillance (102) associés à un ou plusieurs composants de l'instrument de diagnostic in vitro (104), un ou plusieurs paramètres de maintenance conditionnelle (CBM) de l'instrument de diagnostic in vitro (104) ;
fournir le ou les paramètres de maintenance conditionnelle de l'instrument de diagnostic in vitro (104) à une base de données locale (120) d'un serveur de données local (106) stockant des données sur la fonctionnalité et les paramè-

tres de maintenance conditionnelle du ou des composants de l'instrument de diagnostic in vitro (104) dans la mémoire (112) de la base de données locale (120) ;
transmettre les données de maintenance conditionnelle à un serveur distant qui est un serveur d'analyse de maintenance conditionnelle (122) ;
caractérisé en ce que
la transmission des données de maintenance conditionnelle au serveur distant comprend

- une opération de poussée conditionnelle où une condition doit être satisfaite avant que la transmission ait lieu ;

stocker les données de maintenance conditionnelle au niveau du serveur d'analyse de maintenance conditionnelle CBM (122) qui comprend un module de moteur de prédiction de défaillance (126), et un module de règles de défaillance (132) ;
générer des prédictions de défaillances imminentes de composants de l'instrument de diagnostic in vitro (104) par le module de moteur de prédiction de défaillance (126) comprenant des critères de prédiction de défaillance, dans lequel un modèle des données de maintenance conditionnelle est comparé à des modèles connus dans une bibliothèque de modèles de défaillance (130) pour ce composant, dans lequel la comparaison comprend des comparaisons basées sur un seuil, dans lequel si un seuil présélectionné est dépassé, alors une défaillance est prédite ;
et
lancer une action appropriée par le module de règles de défaillance (132) si l'écart par rapport aux critères de prédiction de défaillance est supérieur à une quantité de seuil définie, dans lequel le ou les paramètres de maintenance conditionnelle de l'instrument de diagnostic in vitro (104) comprennent un ou plusieurs des paramètres suivants :

une température d'un composant de l'instrument de diagnostic in vitro (104) ;
une pression dans un composant de l'instrument de diagnostic in vitro (104) ;
un niveau de liquide dans un composant de l'instrument de diagnostic in vitro (104) ;
un courant consommé par un composant de l'instrument de diagnostic in vitro (104);
un débit à travers un composant de l'instrument de diagnostic in vitro (104) ; et
un jeu dans un composant de pompe de l'instrument de diagnostic in vitro (104).

2. Procédé selon la revendication 1 comprenant le traitement du ou des paramètres de maintenance conditionnelle pour fournir des données de maintenance conditionnelle traitées,
dans lequel, de préférence, les données de maintenance conditionnelle traitées comprennent un maximum, un minimum, une moyenne et un écart type du ou des paramètres de maintenance conditionnelle sur une période de temps prédéfinie.

3. Procédé selon la revendication 1, comprenant le réglage d'une fréquence de collecte du ou des paramètres de maintenance conditionnelle de l'instrument de diagnostic in vitro (104).

4. Procédé selon la revendication 1, comprenant le réglage d'une fréquence de téléchargement des données de maintenance conditionnelle de l'instrument de diagnostic in vitro (104).

5. Procédé selon la revendication 1, dans lequel la transmission des données de maintenance conditionnelle au serveur distant comprend une opération de tirage où la transmission est demandée par le serveur distant.

6. Procédé selon la revendication 1, dans lequel la génération de prédictions de défaillances imminentes de composants de l'instrument de diagnostic in vitro (104) par le module de moteur de prédiction de défaillance (126) comprend la détermination d'une correspondance de modèle de défaillance,
dans lequel la correspondance de modèle de défaillance comprend le dépassement d'une pente prédéterminée des données de maintenance conditionnelle sur une période de temps prédéterminée.

7. Procédé selon la revendication 1, dans lequel l'action comprend le déclenchement d'une ou plusieurs règles prédéfinies à partir du module de règles de défaillance (132),
dans lequel, de préférence, les règles prédéfinies comprennent un ou plusieurs des éléments suivants :

fournir un avis ou un avertissement à un opérateur d'instrument;
créer un rapport;
demander plus de données de maintenance conditionnelle de l'instrument ;
arrêter automatiquement l'instrument ; et
programmer l'entretien de l'instrument.

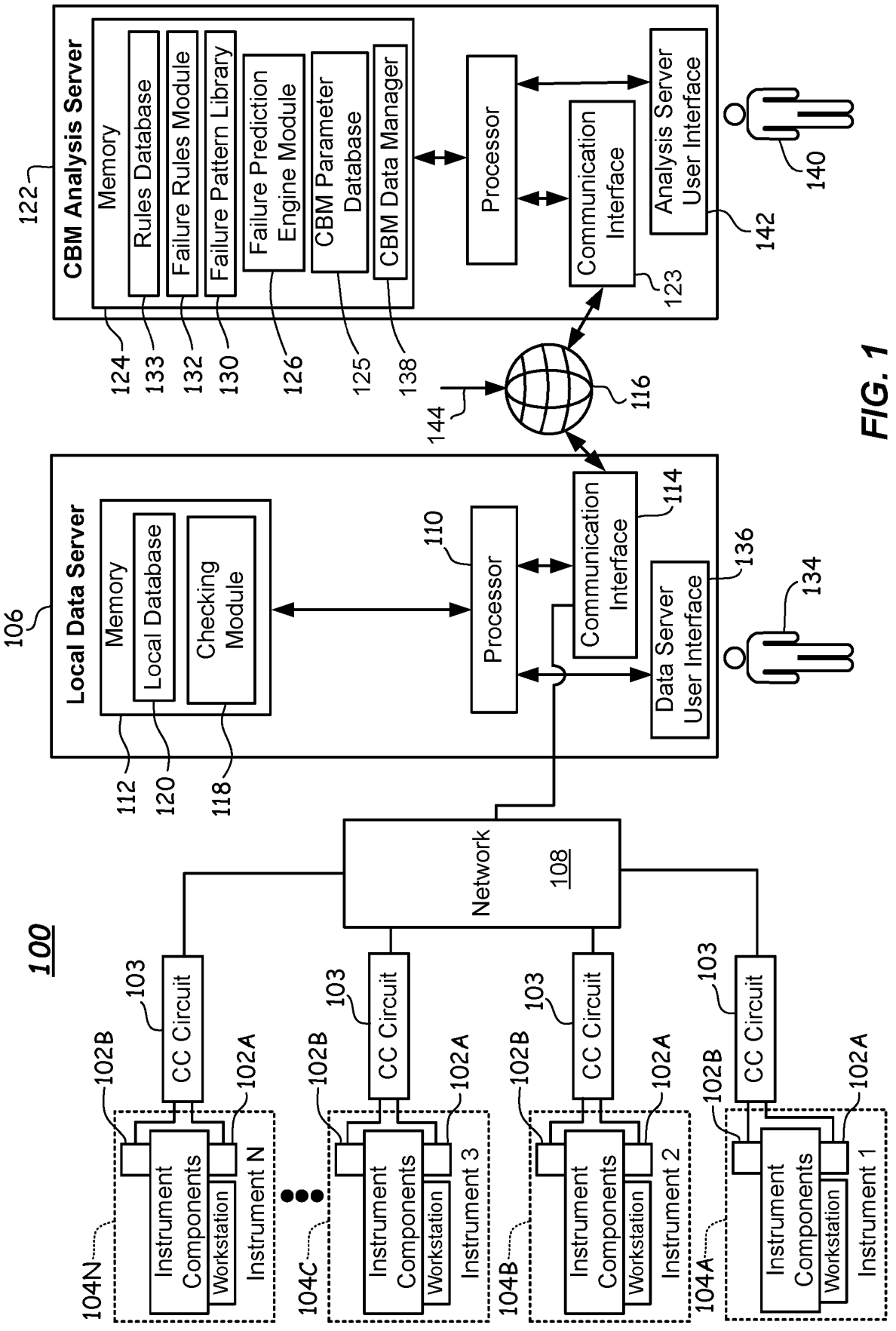
100
Network
108
Local Data Server
106
Memory
Local Database
Checking Module
112
120
118
Processor
110
Communication Interface
114
Data Server User Interface
136
134
CBM Analysis Server
122
Memory
Rules Database
Failure Rules Module
Failure Pattern Library
Failure Prediction Engine Module
CBM Parameter Database
CBM Data Manager
124
133
132
130
126
125
138
Processor
Communication Interface
123
Analysis Server User Interface
142
140
144
116
CC Circuit
103
102B
102A
Instrument Components
Workstation
Instrument N
104N
Instrument 3
104C
Instrument 2
104B
Instrument 1
104A

FIG. 1

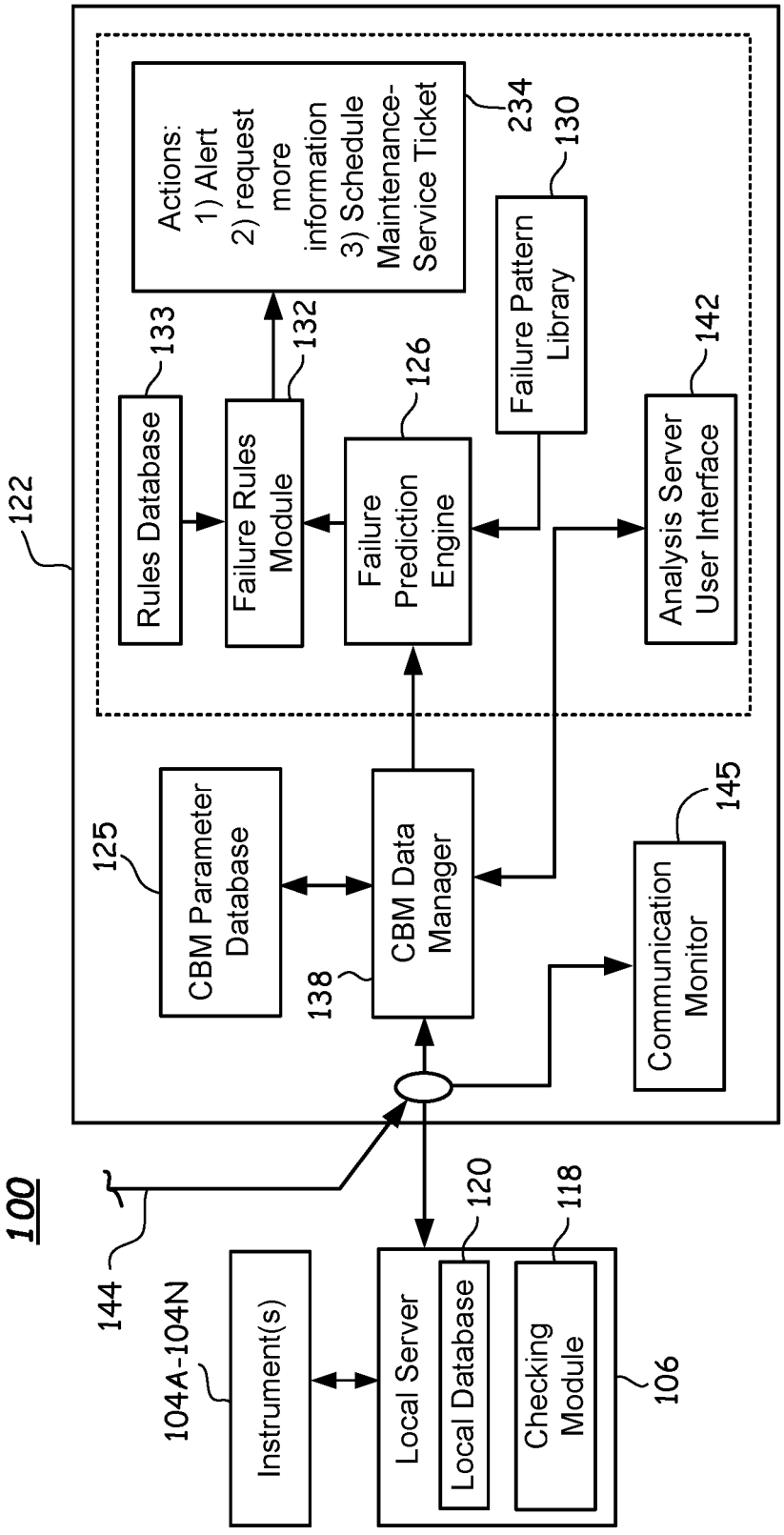
100
122
144
104A-104N
Instrument(s)
Local Server
120
Local Database
118
Checking Module
106
125
CBM Parameter Database
138
CBM Data Manager
145
Communication Monitor
Rules Database
133
Failure Rules Module
132
Failure Prediction Engine
126
Failure Pattern Library
130
Actions:
1) Alert
2) request more information
3) Schedule Maintenance-Service Ticket
234
Analysis Server User Interface
142

FIG. 2

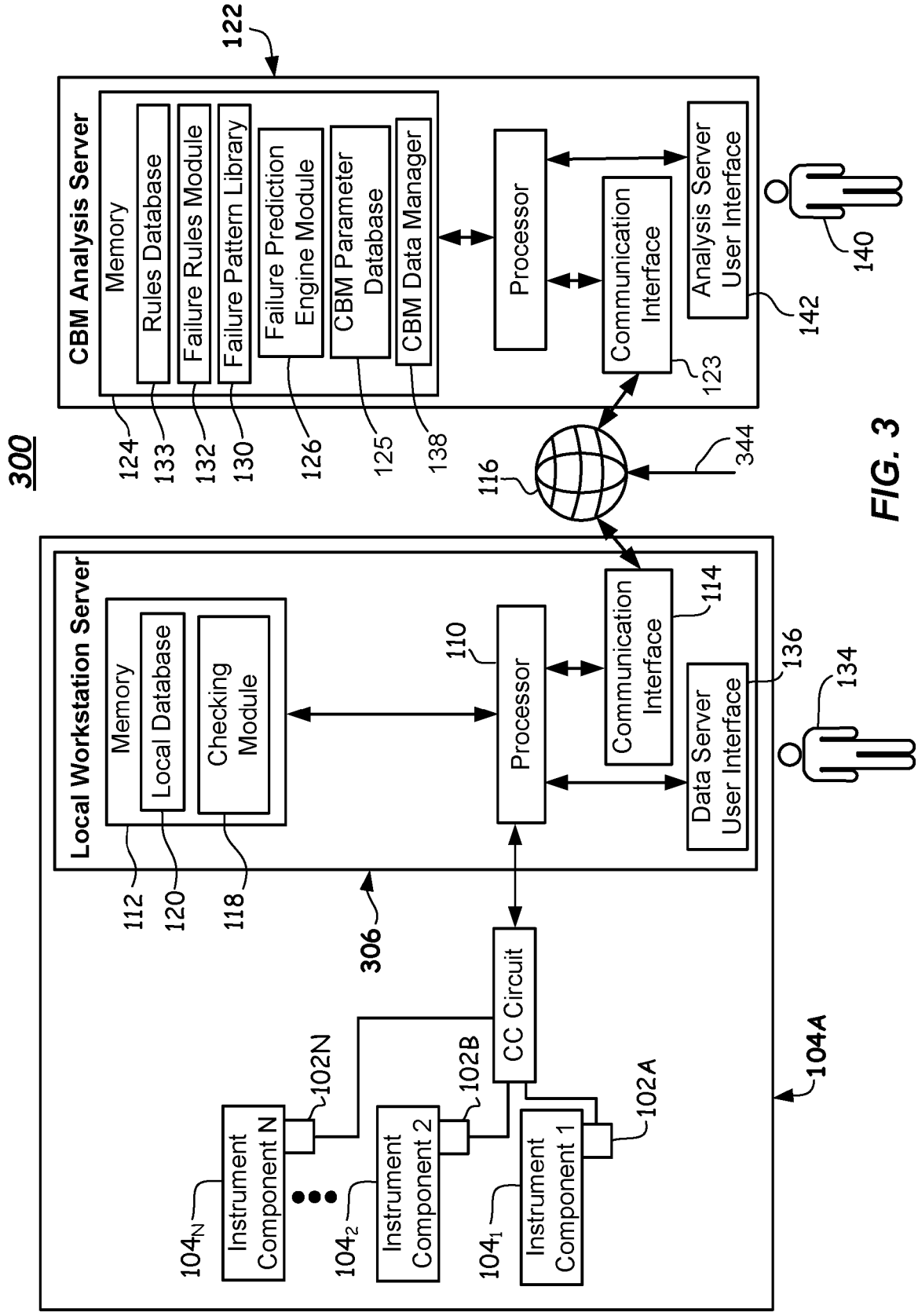
300
122
CBM Analysis Server
Memory
Rules Database
Failure Rules Module
Failure Pattern Library
Failure Prediction Engine Module
CBM Parameter Database
CBM Data Manager
Processor
Communication Interface
Analysis Server User Interface
124
133
132
130
126
125
138
123
142
140
116
344
Local Workstation Server
Memory
Local Database
Checking Module
112
120
118
110
Processor
Communication Interface
114
Data Server User Interface
136
134
306
CC Circuit
102N
102B
102A
Instrument Component N
Instrument Component 2
Instrument Component 1
104_N
104_2
104_1
104A

FIG. 3

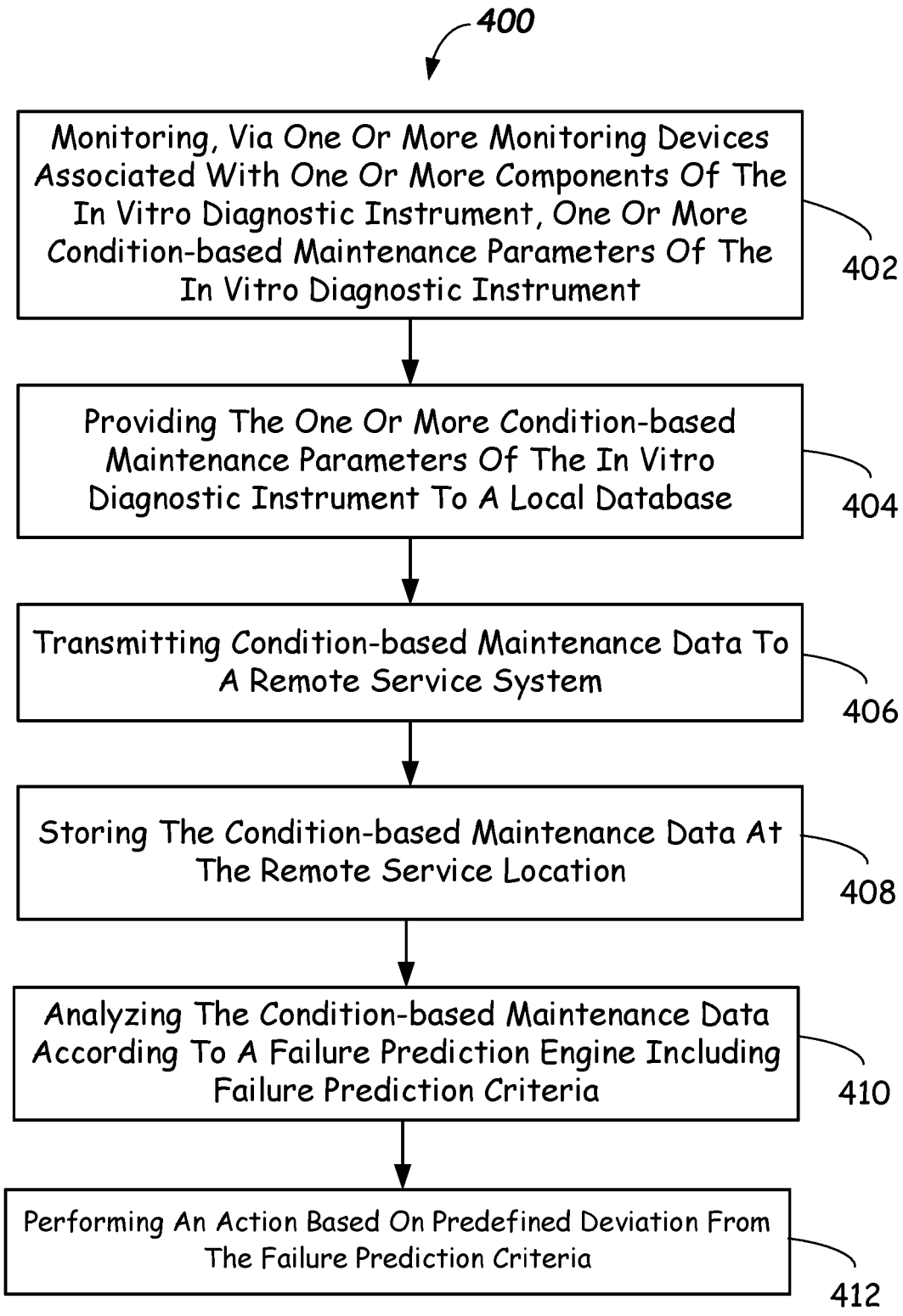
400
Monitoring, Via One Or More Monitoring Devices Associated With One Or More Components Of The In Vitro Diagnostic Instrument, One Or More Condition-based Maintenance Parameters Of The In Vitro Diagnostic Instrument
402
Providing The One Or More Condition-based Maintenance Parameters Of The In Vitro Diagnostic Instrument To A Local Database
404
Transmitting Condition-based Maintenance Data To A Remote Service System
406
Storing The Condition-based Maintenance Data At The Remote Service Location
408
Analyzing The Condition-based Maintenance Data According To A Failure Prediction Engine Including Failure Prediction Criteria
410
Performing An Action Based On Predefined Deviation From The Failure Prediction Criteria
412

FIG. 4

REFERENCES CITED IN THE DESCRIPTION

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