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(54) **ANALYSIS SYSTEM**

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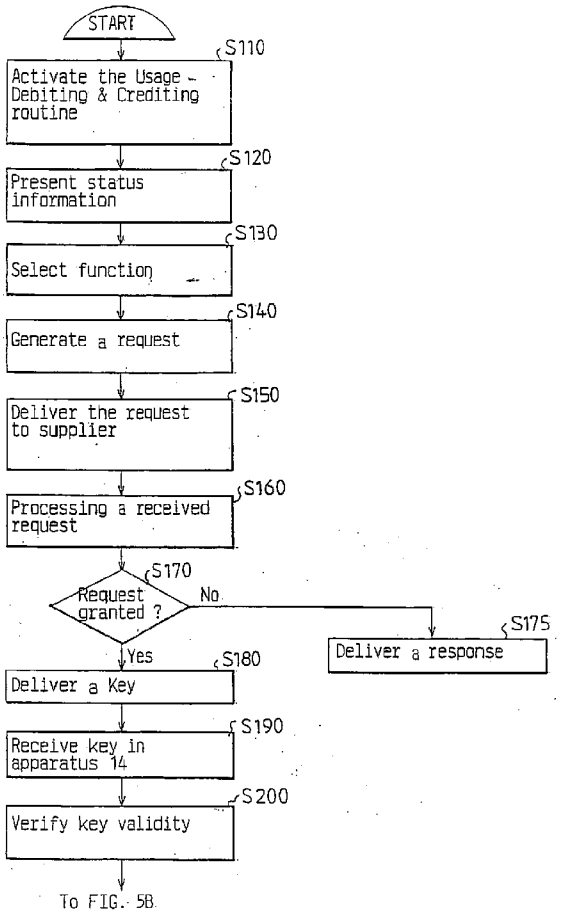
(57) **ABSTRACT**

An apparatus for analysing the condition of a machine having a rotating shaft, including:

at least one input for receiving measurement data from a sensor for surveying a measuring point of the machine; the measurement data being dependent on rotation of the shaft;

data processing element for processing condition data dependent on the measurement data; the data processing element including element for performing a plurality of condition monitoring functions (F1, F2, Fn), wherein

the data processing element includes a Field Programmable Gate Array circuit coupled to the at least one input.



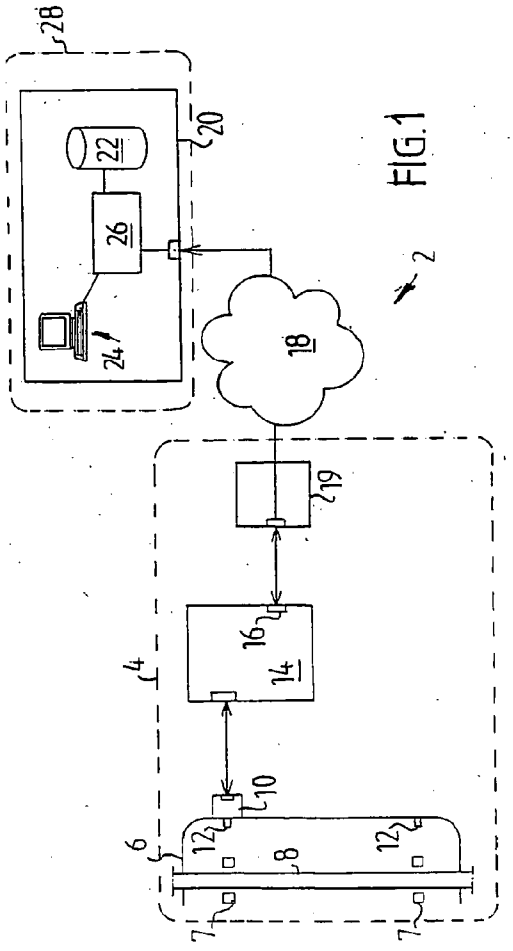

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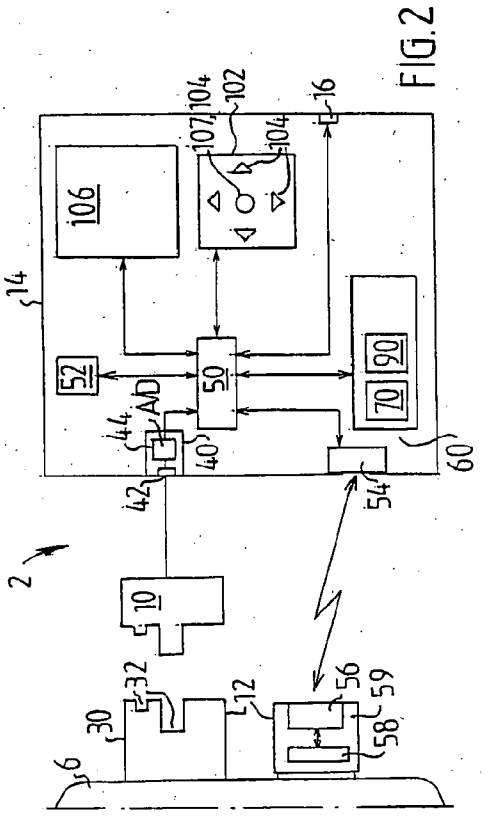
FIG.1


16
104
102
107
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106
14
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12
6

FIG.2

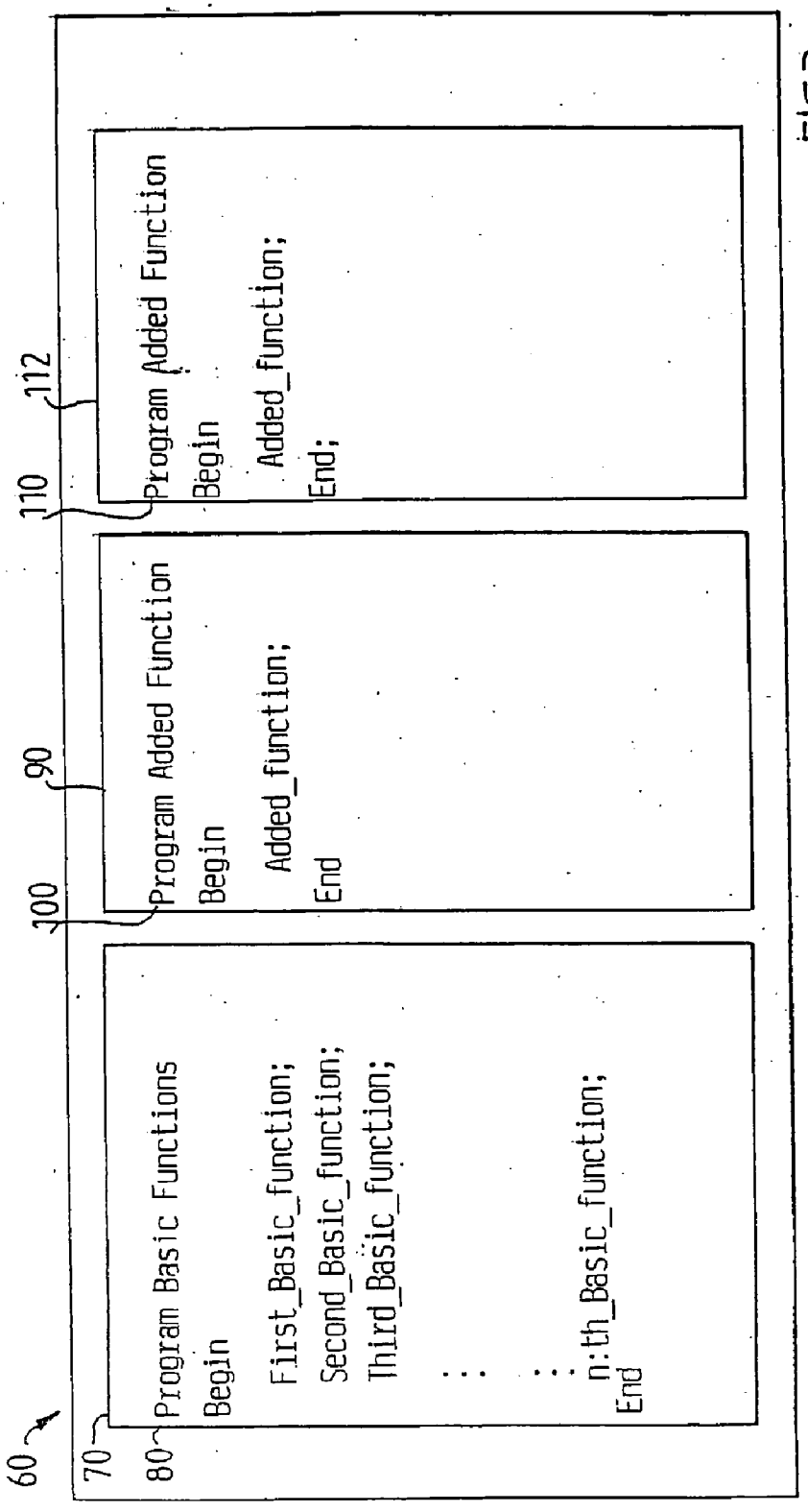
60
70
80
Program Basic Functions
Begin
First_Basic_function;
Second_Basic_function;
Third_Basic_function;
n:th_Basic_function;
End
100
90
Program Added Function
Begin
Added_function;
End
110
112
Program Added Function
Begin
Added_function;
End;

FIG.3

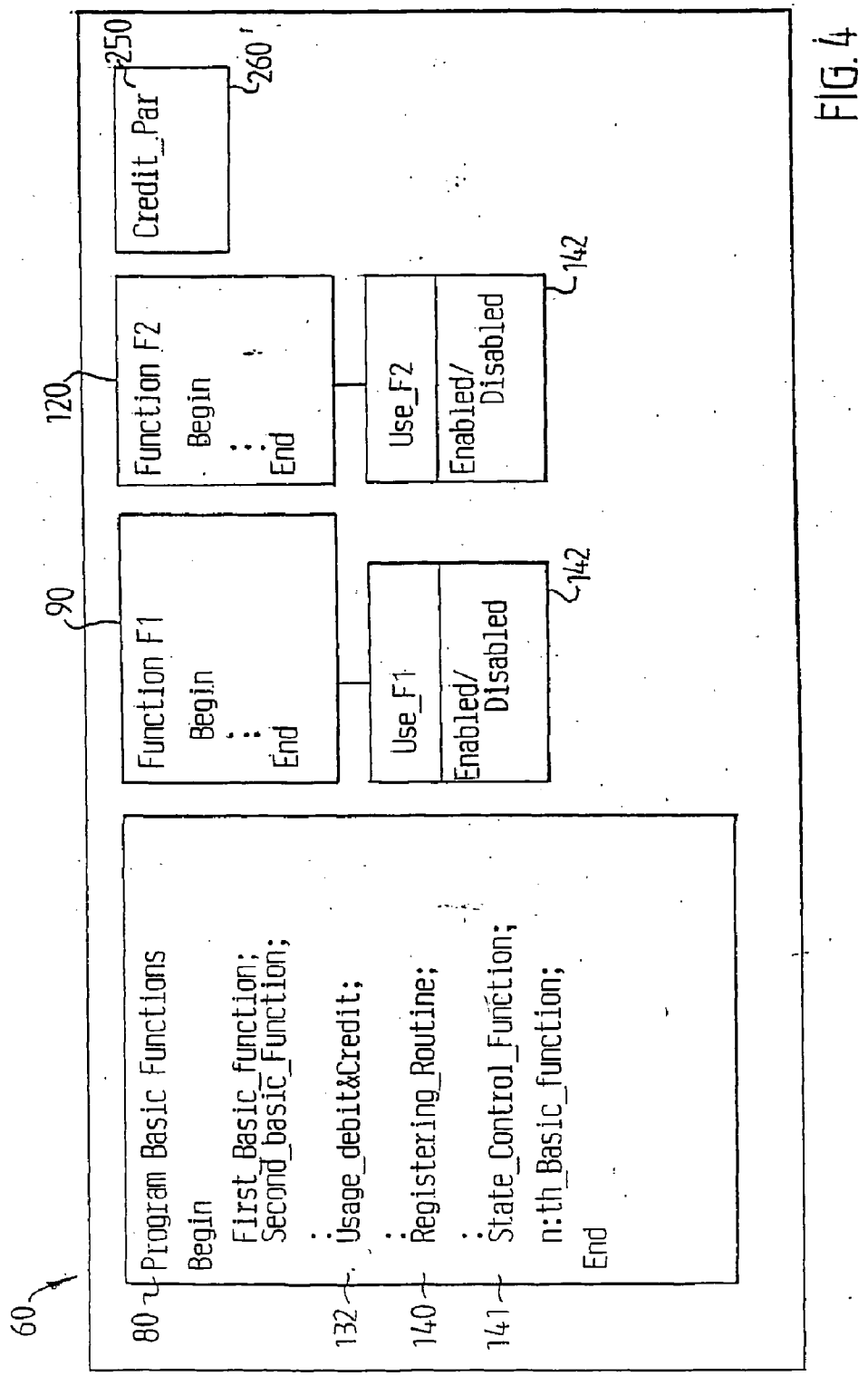
60
80
Program Basic Functions
Begin
First_Basic_function;
Second_basic_Function;
:
Usage_debit&Credit;
:
Registering_Routine;
:
State_Control_Function;
n:th_Basic_function;
End
132
140
141
90
Function F1
Begin
:
End
Use_F1
Enabled/
Disabled
142
120
Function F2
Begin
:
End
Use_F2
Enabled/
Disabled
142
250
Credit_Par
260'

FIG. 4

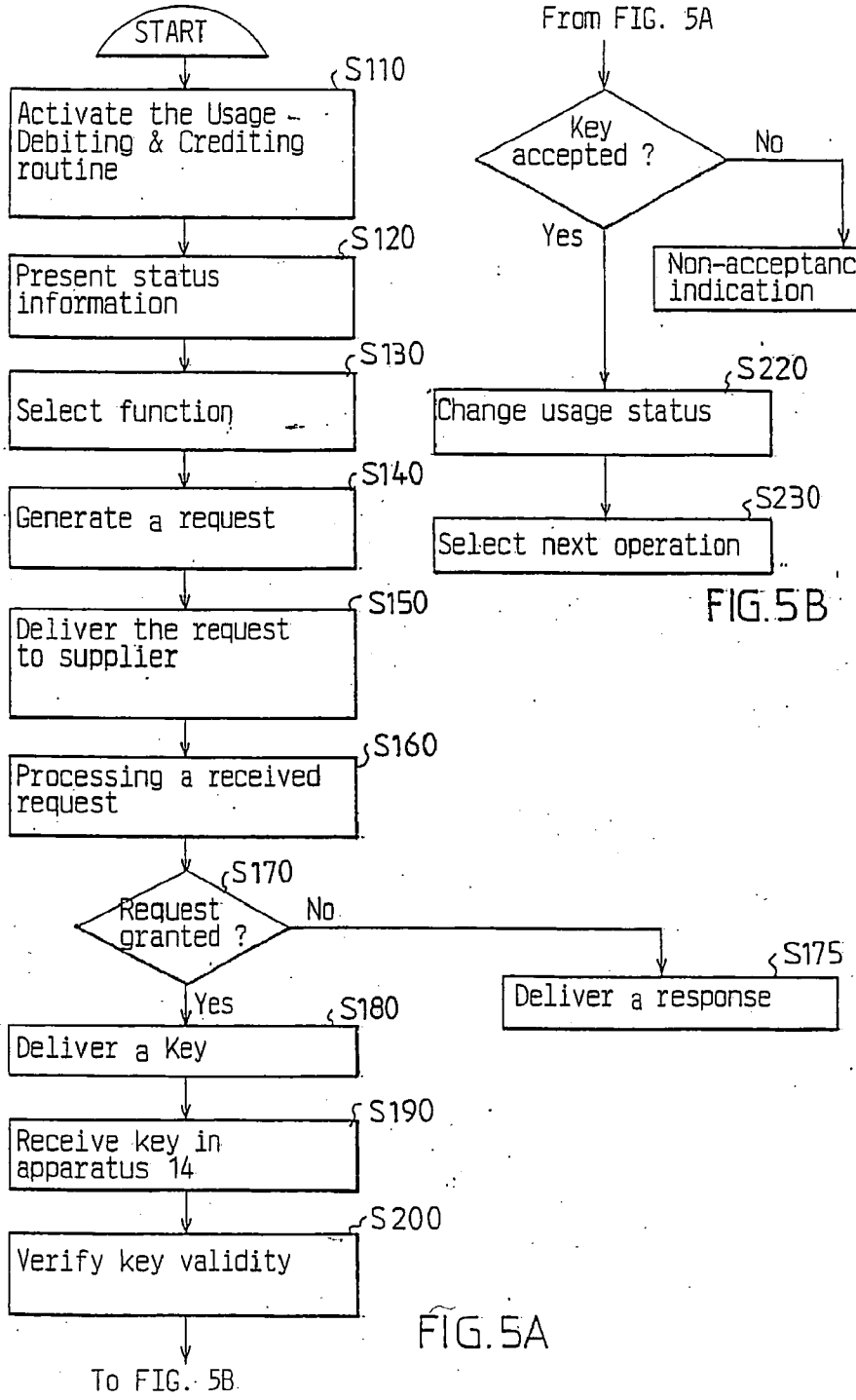
START
S110
Activate the Usage - Debiting & Crediting routine
S120
Present status information
S130
Select function
S140
Generate a request
S150
Deliver the request to supplier
S160
Processing a received request
S170
Request granted ?
No
S175
Deliver a response
Yes
S180
Deliver a Key
S190
Receive key in apparatus 14
S200
Verify key validity
To FIG. 5B
From FIG. 5A
Key accepted ?
No
S210
Non-acceptance indication
Yes
S220
Change usage status
S230
Select next operation

FIG. 5A

FIG. 5B

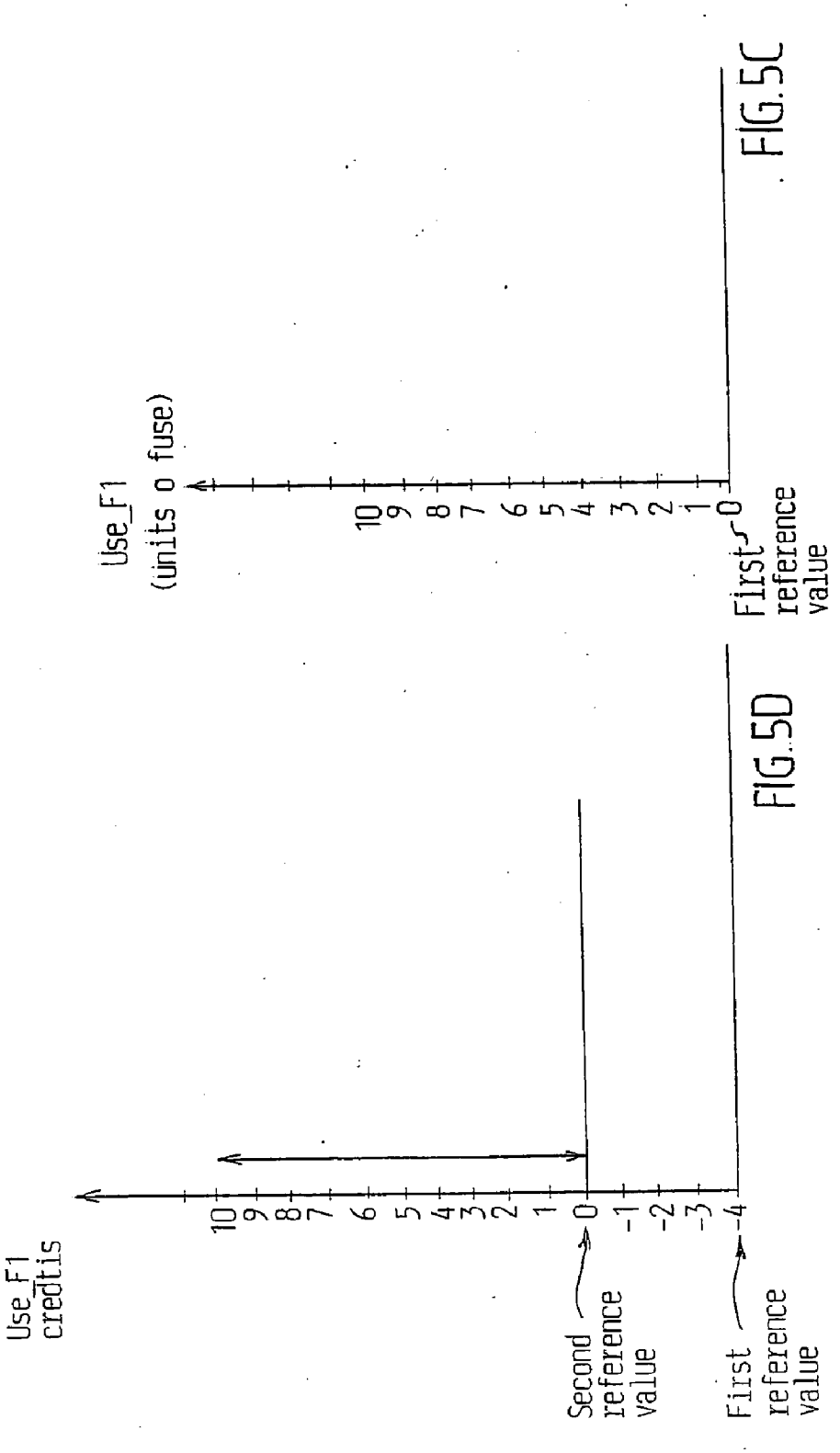
Use_F1
credtis
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
Second
reference
value
First
reference
value
Use_F1
(units o fuse)
10
9
8
7
6
5
4
3
2
1
0
First
reference
value

FIG.5D

FIG.5C

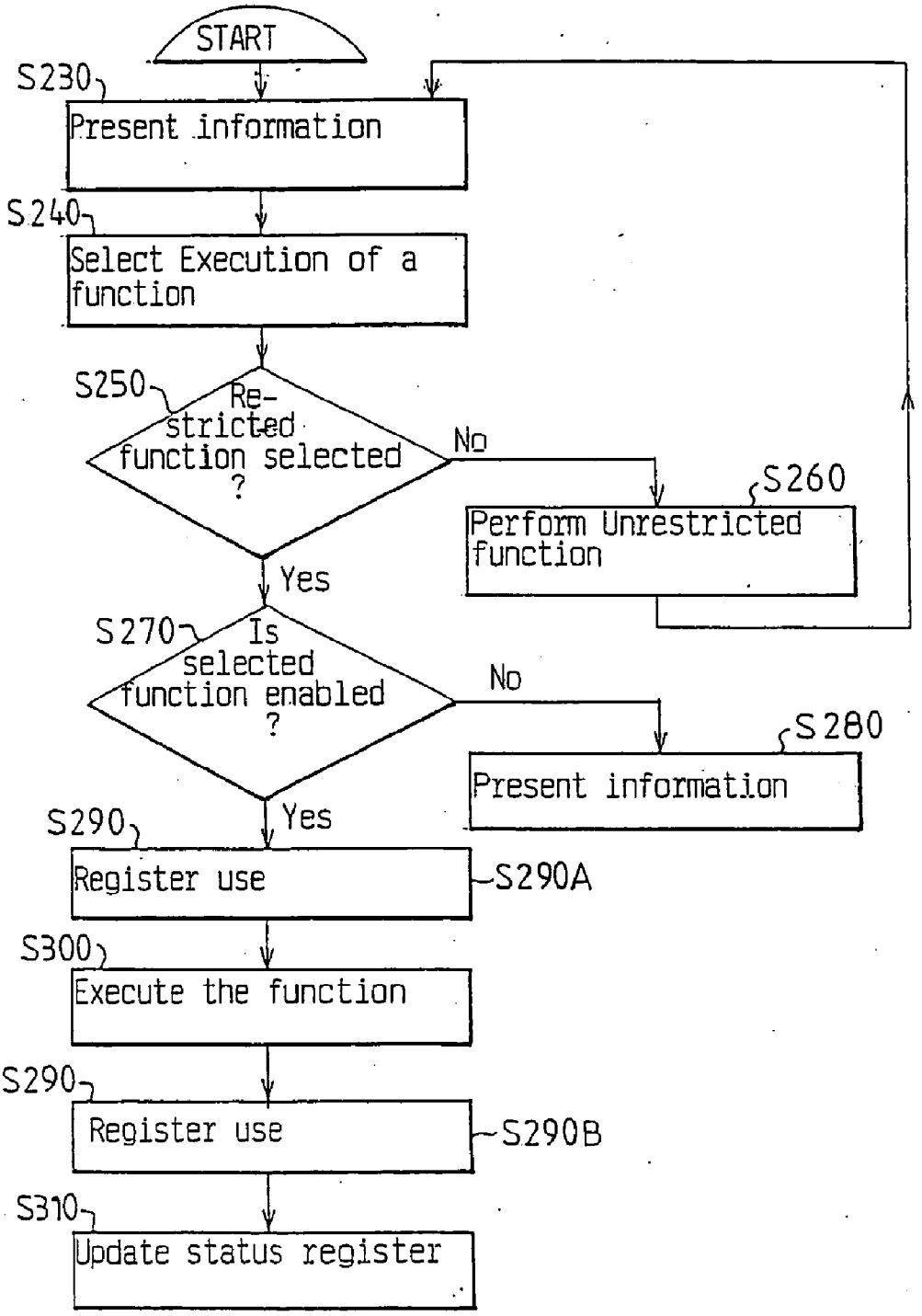
START
S230
Present information
S240
Select Execution of a function
S250
Re-stricted function selected ?
No
S260
Perform Unrestricted function
Yes
S270
Is selected function enabled ?
No
S280
Present information
Yes
S290
Register use
S290A
S300
Execute the function
S290
Register use
S290B
S310
Update status register

FIG.6

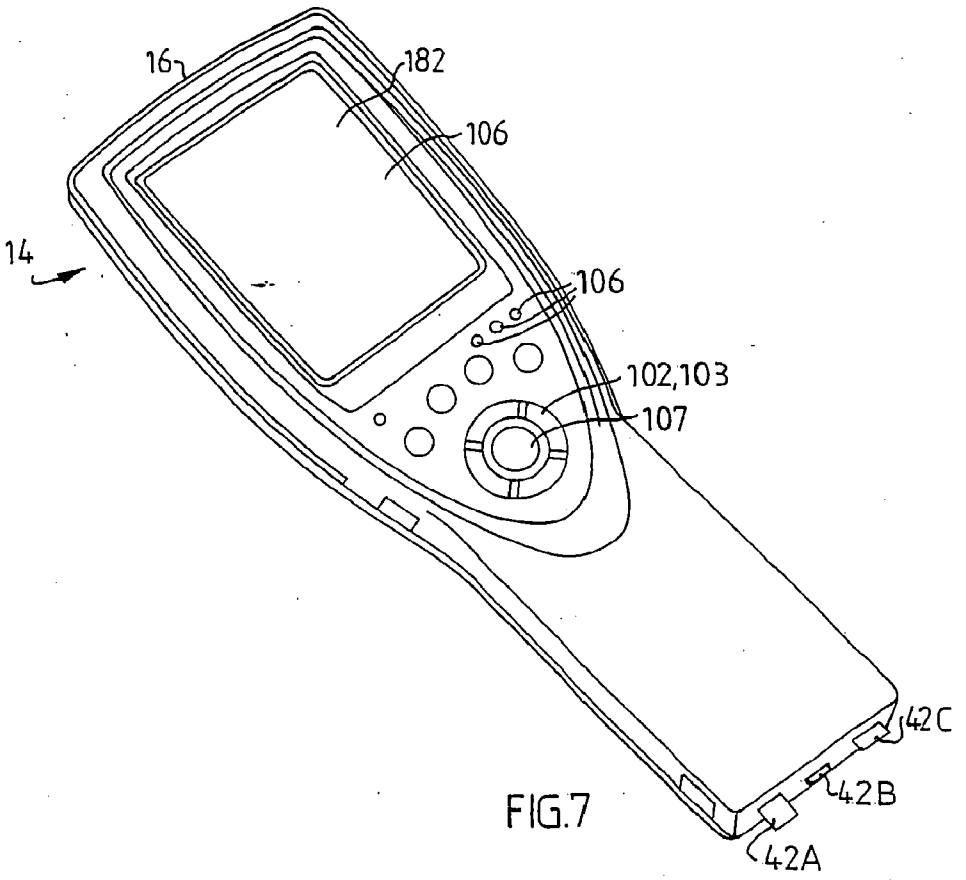

FIG.7

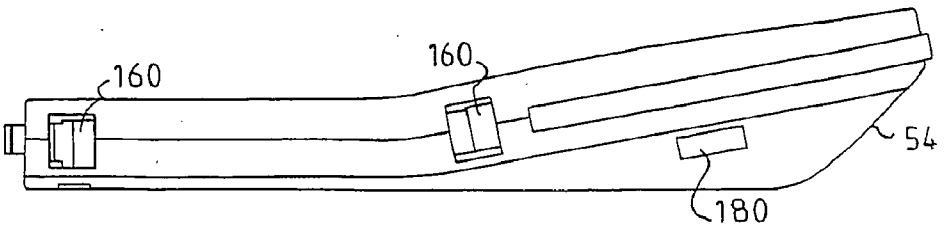

FIG.8

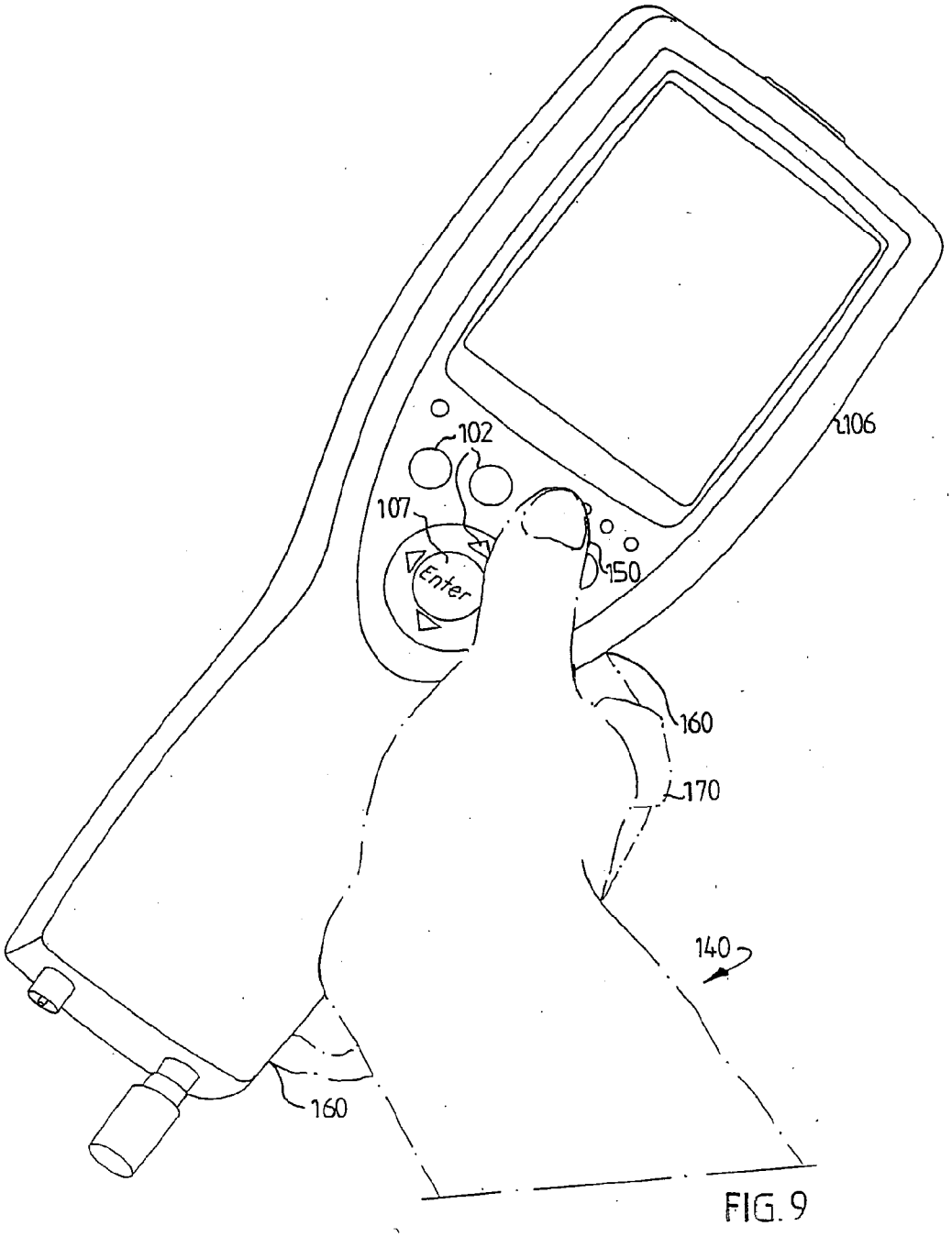

FIG. 9

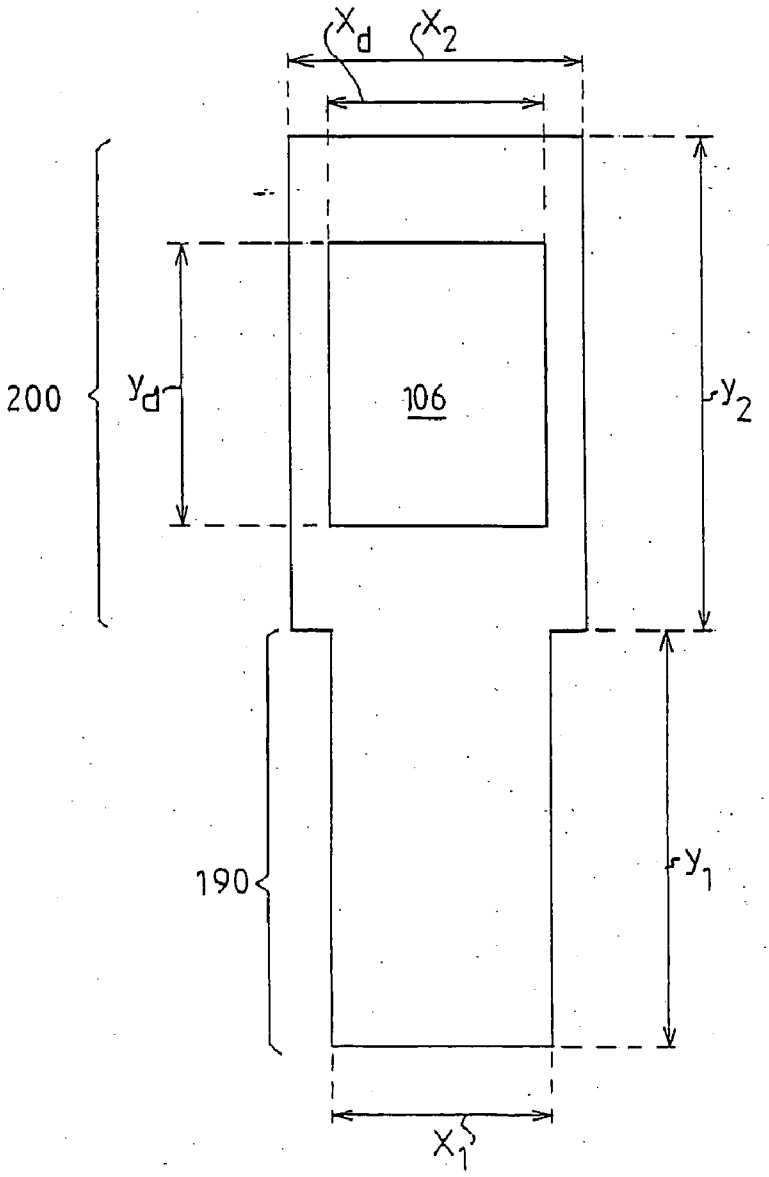

FIG.10

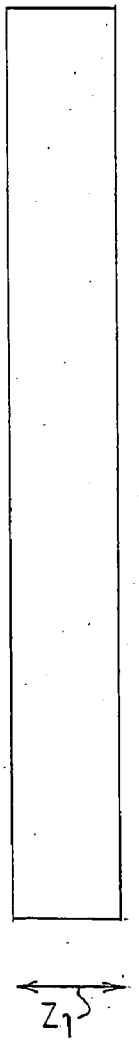

FIG.11

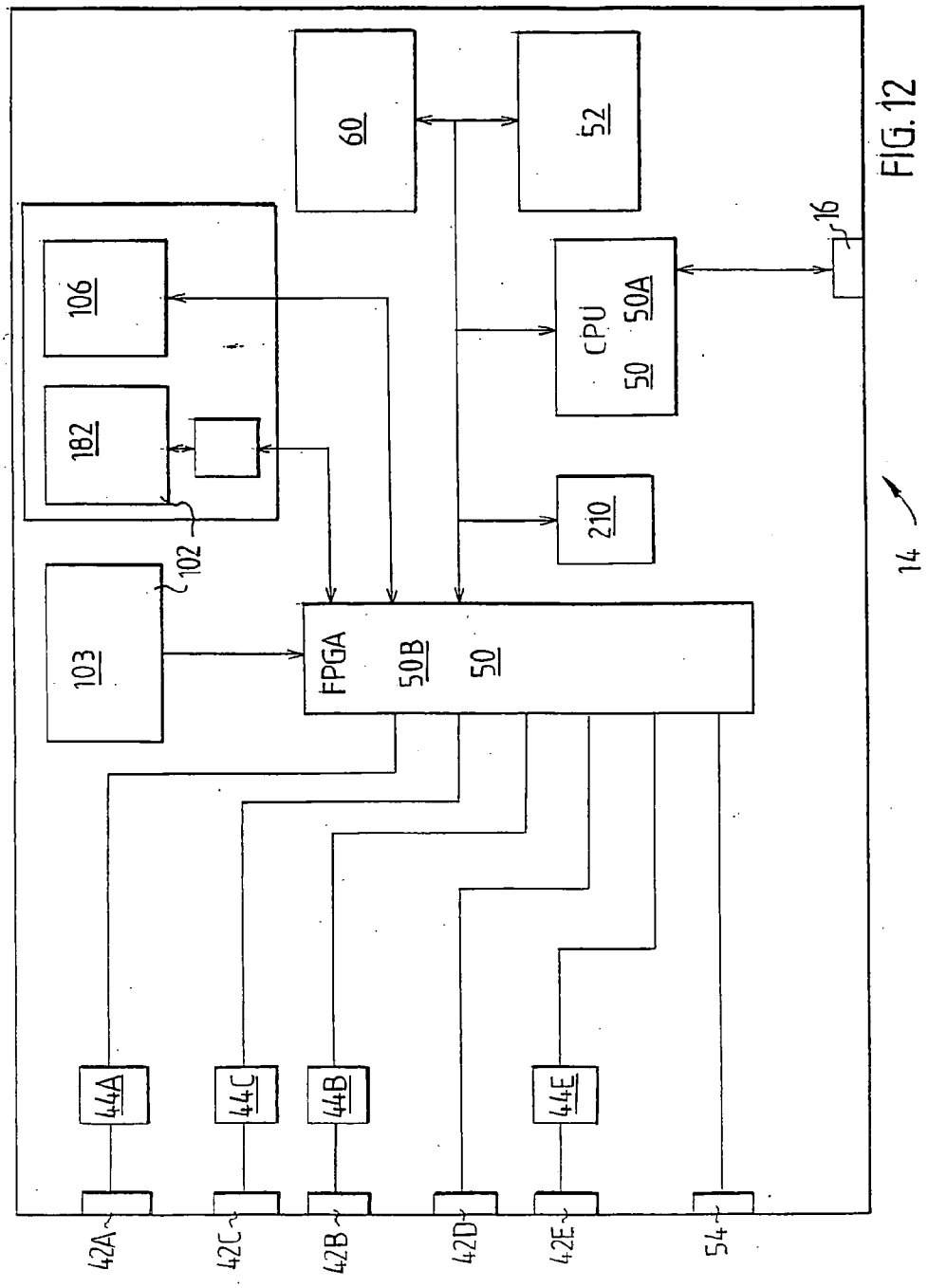
60
52
16
106
CPU
50
50A
182
210
102
14
103
FPGA
50B
50
44A
44C
44B
44E
42A
42C
42B
42D
42E
54

FIG. 12

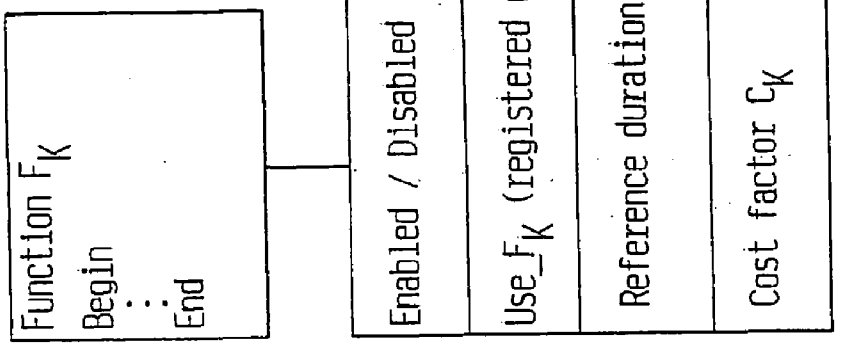

FIG.13B

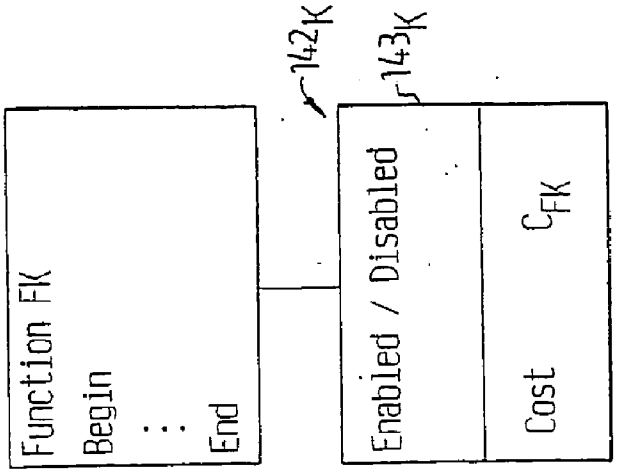

FIG. 13A

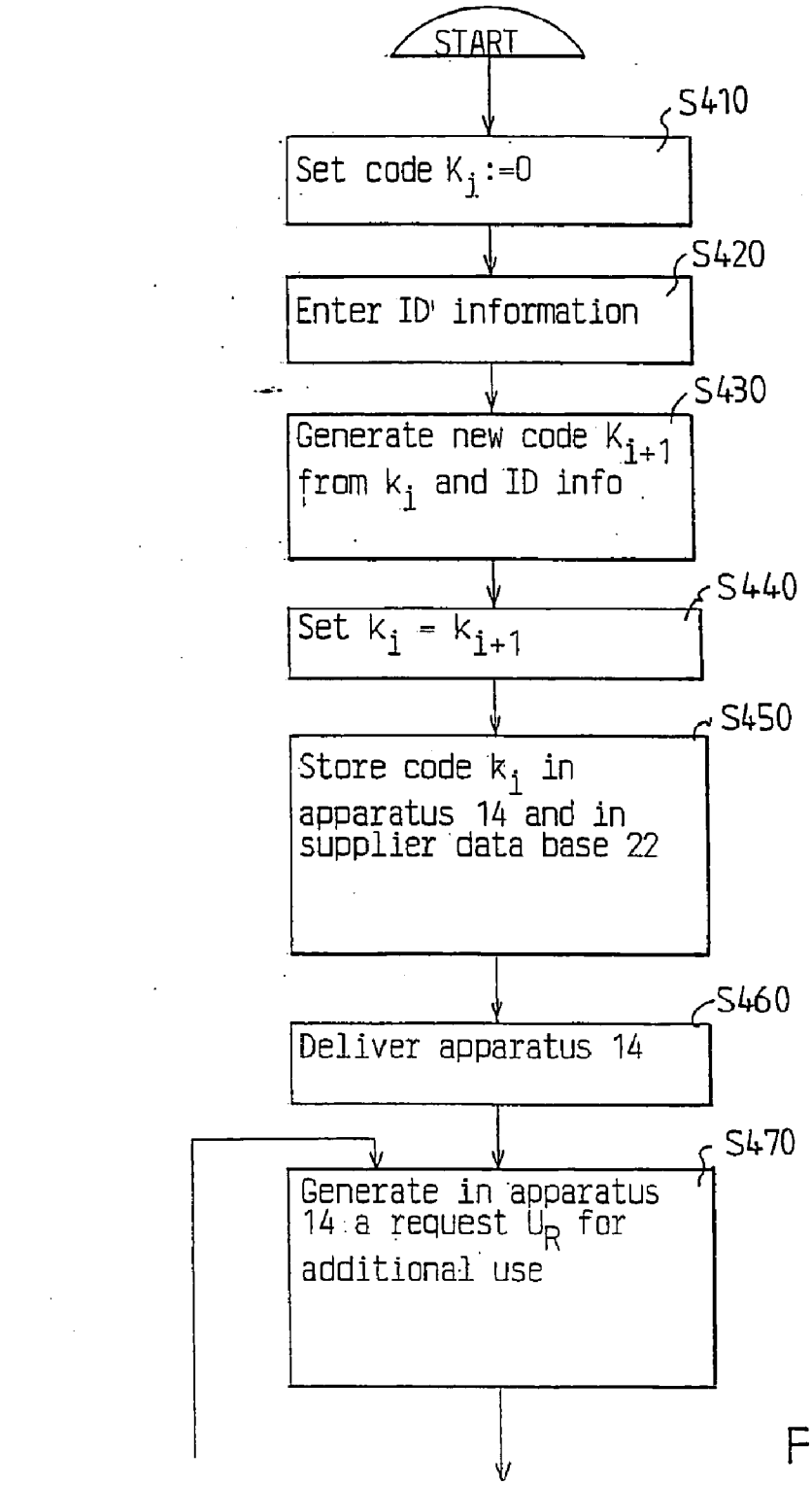
START
S410
Set code K_j:=0
S420
Enter ID' information
S430
Generate new code K_{i+1} from k_i and ID info
S440
Set $k_i = k_{i+1}$
S450
Store code k_i in apparatus 14 and in supplier data base 22
S460
Deliver apparatus 14
S470
Generate in apparatus 14 a request U_R for additional use
From FIG. 14B
To FIG. 14B

FIG.14A

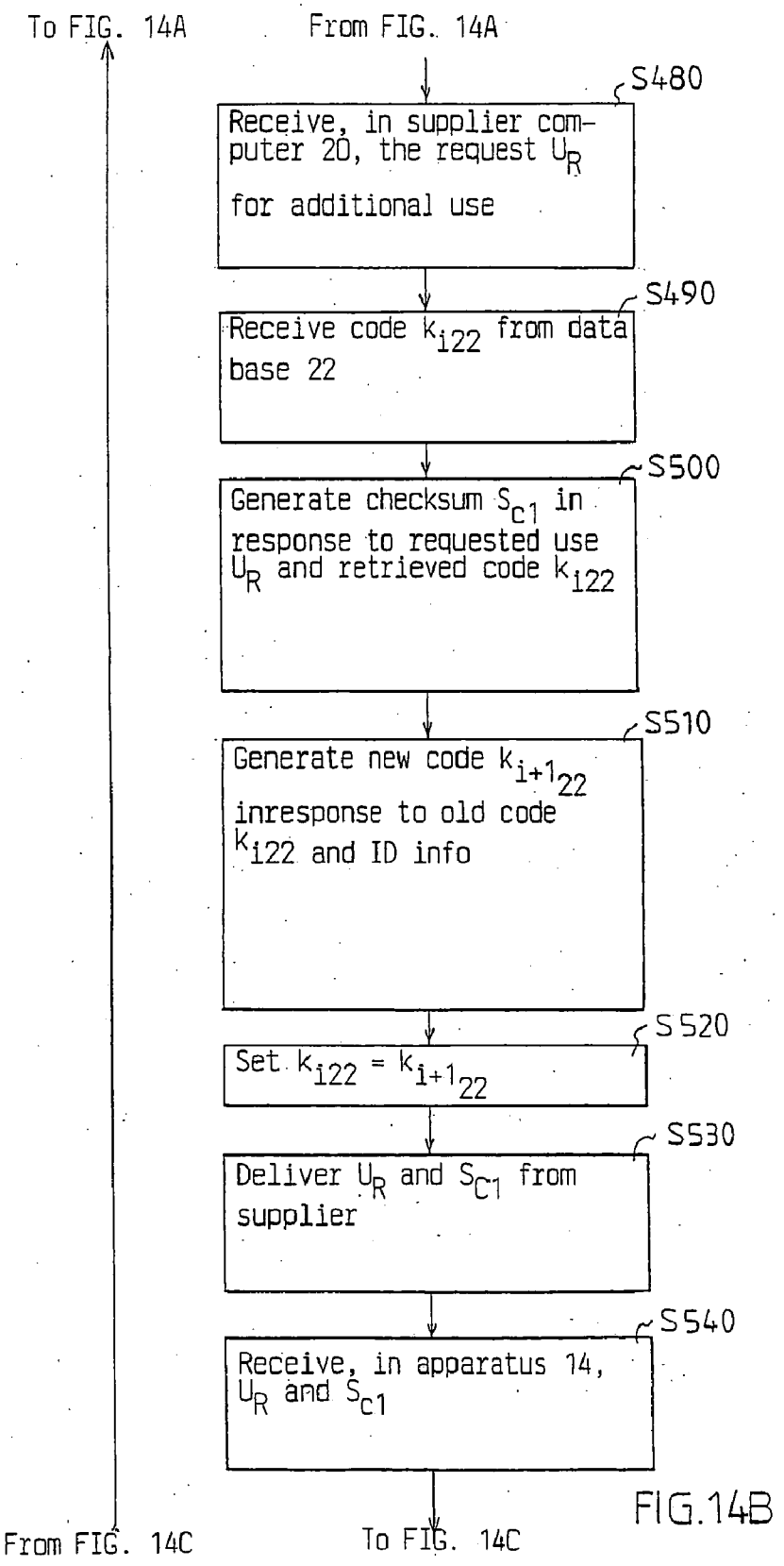
To FIG. 14A
From FIG. 14A
S480
Receive, in supplier computer 20, the request U_R for additional use
S490
Receive code k_{i22} from data base 22
S500
Generate checksum S_{C1} in response to requested use U_R and retrieved code k_{i22}
S510
Generate new code $k_{i+1_{22}}$ inresponse to old code k_{i22} and ID info
S520
Set $k_{i22} = k_{i+1_{22}}$
S530
Deliver U_R and S_{C1} from supplier
S540
Receive, in apparatus 14, U_R and S_{C1}
From FIG. 14C
To FIG. 14C

FIG.14B

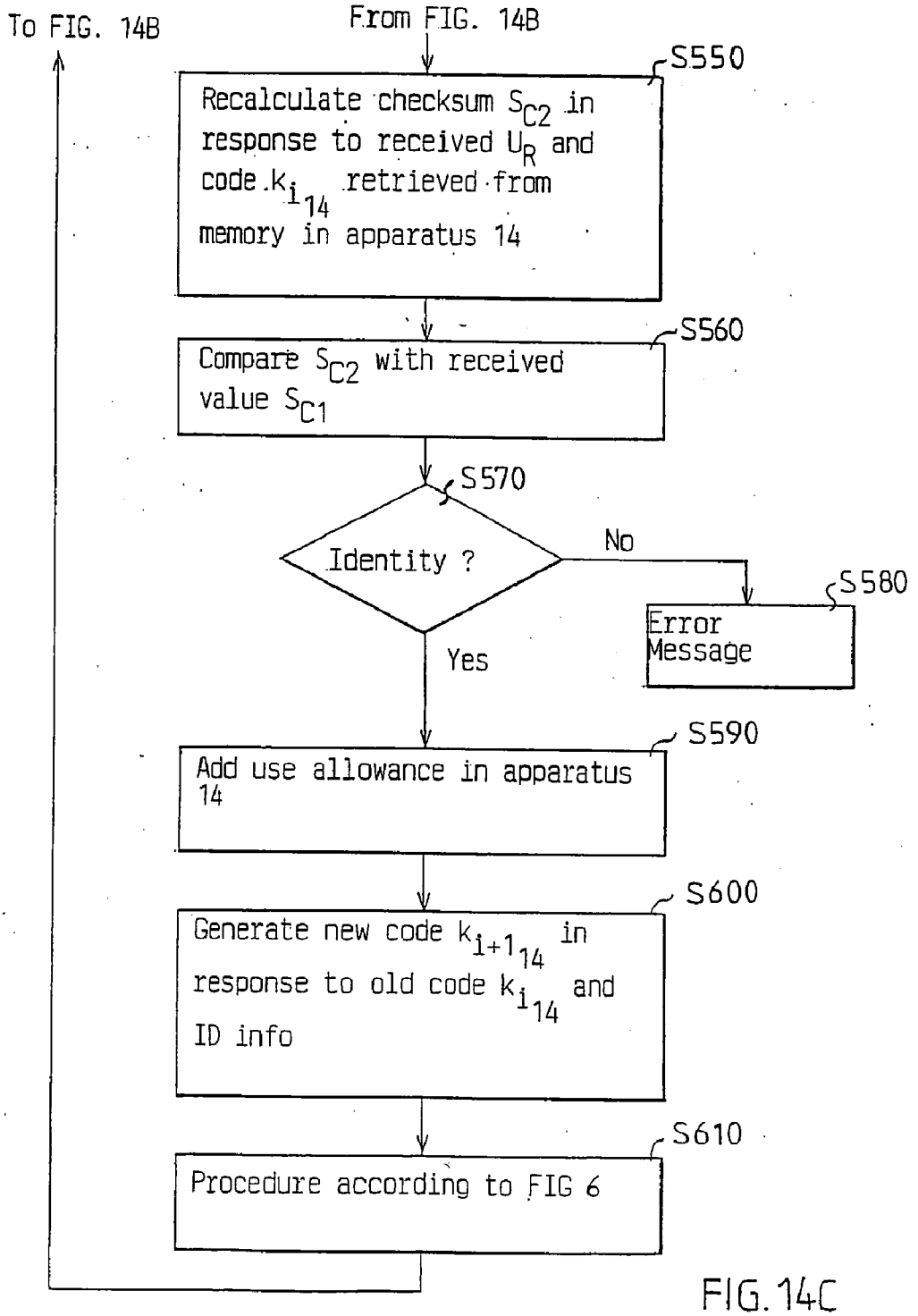
To FIG. 14B
From FIG. 14B
S550
Recalculate checksum S_{C2} in response to received U_R and code $k_{i_{14}}$ retrieved from memory in apparatus 14
S560
Compare S_{C2} with received value S_{C1}
S570
Identity ?
No
S580
Error Message
Yes
S590
Add use allowance in apparatus 14
S600
Generate new code $k_{i+1_{14}}$ in response to old code $k_{i_{14}}$ and ID info
S610
Procedure according to FIG 6

FIG. 14C

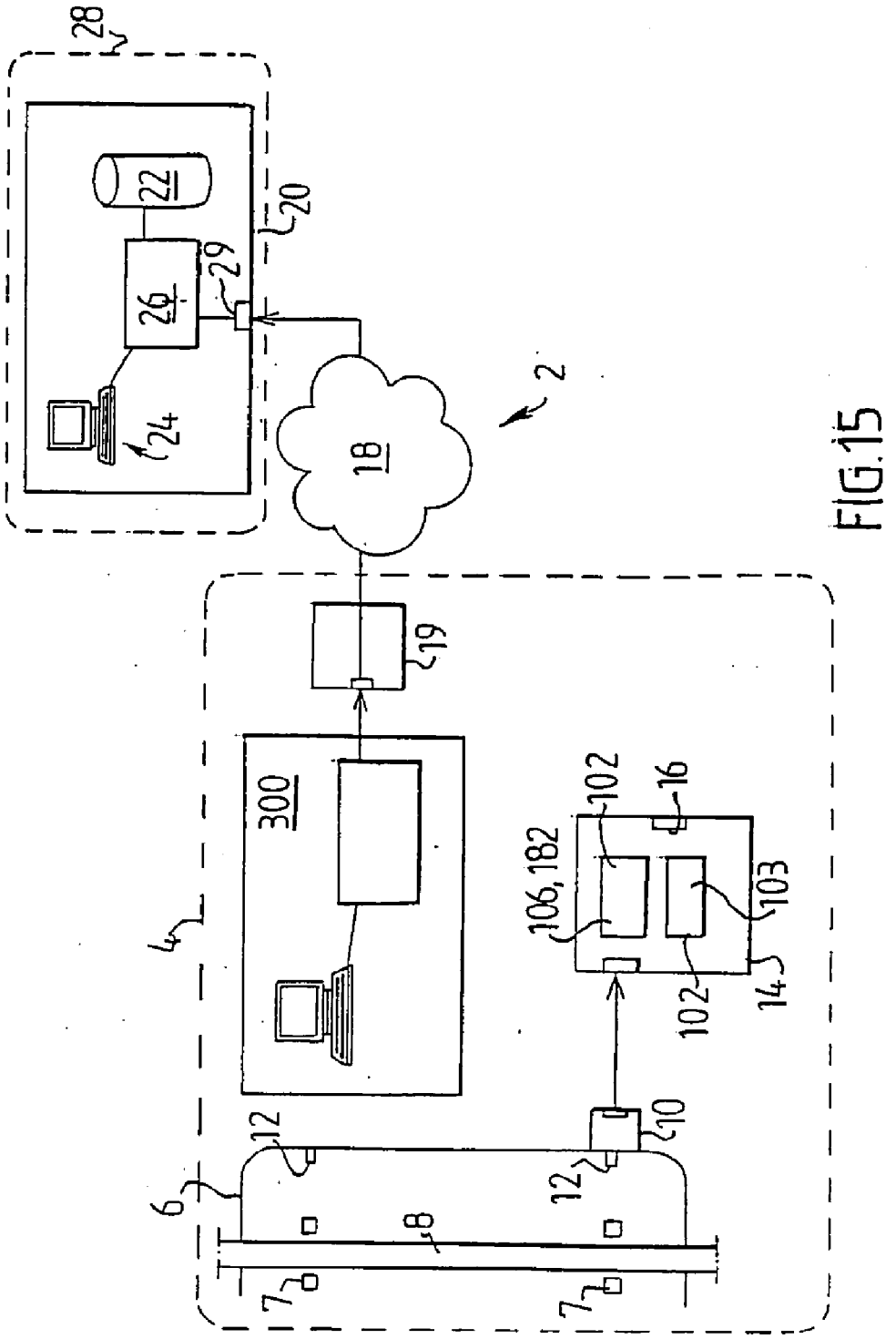
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FIG.15

ANALYSIS SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a division of co-pending application Ser. No. 11/934,24 filed on Nov. 2, 2007, which is a division of U.S. Pat. No. 7,324,919 (application Ser. No. 10/501,767) filed on Feb. 24, 2005, which is the 35 U.S.C. §371 national stage of International PCT/SE03/00079 filed on Jan. 20, 2003, which claims priority to U.S. provisional Application No. 60/384,118 filed on May 31, 2002, Swedish Application No. 0200147-7 filed on Jan. 18, 2002 and Swedish Application No. 0200215-2 filed on Jan. 25, 2002. The entire contents of each of the above-identified applications are hereby incorporated by reference.

TECHNICAL FIELD OF THE INVENTION

[0002] The present invention relates to an apparatus for analysing the condition of a machine, and to a system for analysing the condition of a machine. The invention also relates to method of operating such a system.

DESCRIPTION OF RELATED ART

[0003] Machines with moving parts are subject to wear with the passage of time, which often causes the condition of the machine to deteriorate. Examples of such machines with movable parts are motors, pumps, generators, compressors, lathes and CNC-machines. The movable parts may comprise a shaft and bearings.

[0004] In order to prevent machine failure, such machines should be subject to maintenance, depending on the condition of the machine. Therefore the operating condition of such a machine is preferably evaluated from time to time. The operating condition can be determined by measuring vibrations emanating from a bearing or by measuring temperature on the casing of the machine, which temperatures are dependent on the operating condition of the bearing. Such condition checks of machines with rotating or other moving parts are of great significance for safety and also for the length of the life of such machines. It is known to manually perform such measurements on machines. This ordinarily is done by an operator with the help of a measuring instrument performing measurements at measuring points on one or several machines.

[0005] A number of commercial instruments are available, which rely on the fact that defects in rolling-element bearings generate short pulses, usually called shock pulses. State of the art shock pulse measuring apparatuses may include proprietary technology for generating a value indicative of the condition of a bearing or a machine.

[0006] WO 98/01831 discloses a machine having a measuring point and a shaft with a certain shaft diameter, wherein the shaft can rotate when the machine is in use. WO 98/01831 also discloses an apparatus for analysing the condition of a machine having a rotating shaft. The disclosed apparatus has a sensor for producing a measured value indicating the vibration or temperature at the measuring point. The apparatus disclosed in WO 98/01831 has a microprocessor and an analysis routine stored in a memory. According to WO 98/01831 the following process can be performed by running the analysis routine on the microprocessor:

[0007] producing the measured value;

[0008] acquiring interpretation information from an information carrier which is mounted by the measuring point;

[0009] producing an actual condition value, indicating the actual condition of the machine at the measuring point, dependent on the measured value and the interpretation information;

[0010] acquiring a second condition value, indicating the condition of the machine at measuring point at an earlier point of time, from the information carrier;

[0011] producing a relation value dependent on the actual condition value and the second condition value, which relation value indicates a change in the condition.

SUMMARY

[0012] An aspect of the invention relates to the problem of providing a flexible high performance apparatus for analysing the condition of machines.

[0013] This problem is addressed by an apparatus for analysing the condition of a machine having a rotating shaft, comprising:

[0014] at least one input for receiving measurement data from a sensor for surveying a measuring point of the machine; said measurement data being dependent on rotation of said shaft;

[0015] data processing means for processing condition data dependent on said measurement data; said data processing means comprising means for performing a plurality of condition monitoring functions, wherein

[0016] said data processing means includes a Field Programmable Gate Array circuit coupled to said at least one input.

[0017] The Field Programmable Gate Array circuit advantageously provides a combination of flexibility and very high performance to the analysis apparatus in that a large amount of data can be processed relatively fast by means of the Field Programmable Gate Array circuit. This solution advantageously enables simultaneous execution of two, three or more of the condition monitoring functions. Moreover, the functions executed by the FPGA may be software controlled and the FPGA allows for truly parallel processing, which also contributes to increased performance to the analysis apparatus.

[0018] The solution may also involve an apparatus for analysing the condition of a machine having a rotating shaft, comprising:

[0019] at least one input for receiving measurement data from a sensor for surveying a measuring point of the machine; said measurement data being dependent on rotation of said shaft;

[0020] data processing means for processing condition data dependent on said measurement data; said data processing means including a Field Programmable Gate Array circuit coupled to said at least one input for performing a plurality of condition monitoring functions.

[0021] According to an embodiment said data processing means comprises at least two data processing devices cooperating so as to control operation of said condition analysis apparatus; a first one of said data processing devices being said Field Programmable Gate Array circuit.

[0022] According to an embodiment a second one of said data processing devices operates to control the operation of the Field Programmable Gate Array circuit.

[0023] According to an embodiment the apparatus further comprises a plurality of memory segments for storing program code; and

[0024] program code means, stored on at least one of said memory segments, which when run on said Field Programmable Gate Array circuit causes the condition analysis apparatus to execute a condition monitoring function.

[0025] According to this embodiment the apparatus further comprises program code means, stored on at least one of said memory segments, which when run on said second data processing device causes the second data processing device to control the operation of the Field Programmable Gate Array.

[0026] An aspect of the invention relates to the problem of providing equipment for analysing the condition of a machine satisfying the conflicting requirements of reducing the price for a piece of condition monitoring equipment while maintaining profitability for the supplier of the analysis system.

[0027] This problem is addressed by an apparatus for analysing the condition of a machine, comprising an apparatus for analysing the condition of a machine, comprising:

[0028] at least one input for receiving measurement data from a sensor for surveying a measuring point of the machine;

[0029] data processing means for processing condition data dependent on said measurement data; said data processing means comprising means for performing a plurality of condition monitoring functions; and

[0030] a logger for registering use of at least one of said condition monitoring functions.

[0031] This advantageously enables charging a cost for use of the apparatus.

[0032] An embodiment of the apparatus comprising:

[0033] a communication port; wherein

[0034] said apparatus is adapted to be capable of delivering data indicative of said registered use on said communication port.

[0035] This advantageously enables delivery of use info to a supplier, for charging a cost. i.e. reporting the amount of use to the supplier.

[0036] An embodiment of the apparatus further comprises:

[0037] means for comparing said registered use with a first reference value,

[0038] means for disabling said data processing means or at least one of said condition monitoring functions in response to the outcome of said comparison.

[0039] This solution encourages a user to buy additional usage so as to maintain operability of desired functions of the analysis apparatus. Such additional usage may be in the form of a number of measurements using a desired function, or a period of time the duration of which is defined by the registered use and the first reference value.

[0040] An embodiment of the apparatus further comprises: key reception means adapted to allow further use of said data processing means in response to reception of a first key.

[0041] This advantageously enables a supplier to amend the relation between a registered use value and the reference value. Thereby it is possible to increase "the stored amount of use" available before the data processing means is disabled.

[0042] An embodiment of the apparatus further comprises:

[0043] key reception means adapted to allow further use of a selected one of said condition monitoring functions in response to reception of a key associated with said selected function.

[0044] This advantageously enables a supplier to amend the relation between the reference value and a registered use value for a selected function. Thereby it is possible to increase "the stored amount of use" available before the selected function is disabled.

[0045] An embodiment of the apparatus further comprises:

[0046] means for reading a current value of said registered use;

[0047] means for comparing said current value with a second reference value;

[0048] means for registering use at a first rate when said current value is above the second reference value; and

[0049] means for registering use at a second rate when said current value is below the second reference value.

[0050] This advantageously enables a supplier to sell usage at different costs. When, according to one embodiment, a user has paid for a certain amount A_p of usage, the second reference value is a level indicating that the whole amount A_p of usage has been spent. This means that any further use will be usage which has not yet been paid for. By the feature of registering such further use at a second rate it is possible to charge a higher cost per unit of usage for such further use.

[0051] An embodiment of the apparatus wherein:

[0052] at least some of said plurality of condition monitoring functions is at least partly embodied by computer program code.

[0053] An aspect of the invention relates to the problem of achieving a cost-effective improvement of the length of life of machines with a moving part.

[0054] An aspect of the invention relates to the problem of achieving an analysis apparatus for evaluating the condition of a machine,

[0055] This problem is addressed by

[0056] An apparatus for monitoring the condition of a machine, comprising:

[0057] at least one input for receiving measurement data from a sensor for surveying a measuring point of the machine;

[0058] data processing means for processing condition data dependent on said measurement data; said data processing means comprising means for performing at least two condition monitoring functions;

[0059] at least one of said plurality of condition monitoring functions having a locked state and an unlocked state; said locked state prohibiting complete execution of said condition monitoring function; and said unlocked state allowing execution;

[0060] means for changing the state of a selected condition monitoring function between the locked state and the unlocked state.

[0061] This advantageously provides the analysis apparatus with an improved versatility. A manufacturer can manufacture the apparatus in a single fashion, and a supplier can sell the apparatus in several versions. More precisely, an apparatus having two individually lockable/unlockable functions can be provided in the following versions:

[0062] with only the first function unlocked;

[0063] with only the second function unlocked;

[0064] with the first function and the second function unlocked.

[0065] Hence, a supplier can offer the apparatus in three versions, and this allows for selling it at different price levels dependent on the functionality included. Each client is therefore provided with a choice as to which functions to choose.

[0066] An embodiment of the apparatus further comprises:

[0067] key reception means adapted to allow use of a selected one of said condition monitoring functions in response to reception of a key associated with said selected function;

[0068] a logger for registering use of at least one of said condition monitoring functions.

[0069] means for comparing said registered use with a first reference value,

[0070] means for disabling said data processing means or at least one of said condition monitoring functions in response to the outcome of said comparison.

[0071] Hence, A manufacturer can manufacture the apparatus in a single fashion, and a supplier can sell the apparatus in more than four versions:

[0072] with only the first function unlocked;

[0073] with only the second function unlocked;

[0074] with the first function and the second function unlocked.

[0075] with both functions locked but each function individually or collectively unlockable for a limited amount of use.

BRIEF DESCRIPTION OF THE DRAWINGS

[0076] For simple understanding of the present invention, it will be described by means of examples and with reference to the accompanying drawings, of which:

[0077] FIG. **1** shows a schematic block diagram of an embodiment of a condition analyzing system according to an embodiment of the invention.

[0078] FIG. **2** is a schematic block diagram of an embodiment of a part of the condition analyzing system **2** shown in FIG. **1**.

[0079] FIG. **3** is a simplified illustration of an embodiment of a memory and its contents.

[0080] FIG. **4** is a simplified illustration of a second embodiment of the memory and its contents.

[0081] FIGS. **5**A and **5**B show a flow chart illustrating an embodiment of a procedure according to the invention.

[0082] FIG. **5**C is a simplified illustration of a principle of an embodiment of an account value or amount of usage parameter.

[0083] FIG. **5**D is an illustration of a principle of an embodiment wherein the cost per use changes after a certain level of use has been attained.

[0084] FIG. **6** is a flow chart illustrating an embodiment of a procedure according to the invention.

[0085] FIG. **7** is a physical embodiment of an apparatus.

[0086] FIG. **8** is a side view of the apparatus shown in FIG. **7**.

[0087] FIG. **9** illustrates the apparatus, shown in FIG. **7**, being gripped by a hand **140** of a user.

[0088] FIG. **10** is a top view of an embodiment of the apparatus, illustrating the physical dimensions thereof.

[0089] FIG. **11** is a side view of the apparatus shown in FIG. **10**.

[0090] FIG. **12** is a block diagram of an embodiment of the apparatus shown in FIG. **1** and/or FIGS. **7** and **8**.

[0091] FIG. **13**A illustrates a part of memory **60** comprising a function F_k and an associated status field **142**.

[0092] FIG. **13**B illustrates a part of memory **60** according to an embodiment, comprising a function F_k and an associated status field $\mathbf{142}_k$.

[0093] FIG. **14** is a flow chart illustrating an embodiment of a procedure for delivering an apparatus, and for adding use or functionality to the apparatus by means of a key from the supplier.

[0094] FIG. **15** shows a schematic block diagram of another embodiment of a condition analyzing system **2**.

DETAILED DESCRIPTION OF EMBODIMENTS

[0095] In the following description similar features in different embodiments may be indicated by the same reference numerals.

[0096] FIG. **1** shows a schematic block diagram of an embodiment of a condition analyzing system **2** according to an embodiment of the invention. Reference numeral **4** relates to a client location with a machine **6** having a movable part **8**. The movable part may comprise bearings **7** and a shaft **8** which, when the machine is in operation, rotates. The operating condition of the shaft **8** or of a bearing **7** can be determined in response to vibrations emanating from the shaft and/or bearing when the shaft rotates. Additionally the operating condition of a bearing **7** can be determined in response to temperature measured on the casing of the machine. The client location **4**, which may also be referred to as client part or user part, may for example be the premises of a paper mill plant, or some other manufacturing plant having machines with movable parts.

[0097] An embodiment of the condition analyzing system **2** is operative when a sensor **10** is firmly attached on or at a measuring point **12** on the body of the machine **6**. Although FIG. **1** only illustrates two measuring points **12**, it to be understood that a location **4** may comprise any number of measuring points **12**. The condition analysis system **2** shown in FIG. **1**, comprises an analysis apparatus **14** for analysing the condition of a machine on the basis of measurement values delivered by the sensor **10**.

[0098] The analysis apparatus **14** has a communication port **16** for bi-directional data exchange. The communication port **16** is connectable to a communications network **18**, e.g. via a data interface **19**. The communications network **18** may be the world wide internet, also known as the Internet. The communications network **18** may also comprise a public switched telephone network.

[0099] A server computer **20** is connected to the communications network **18**. The server **20** may comprise a database **22**, user input/output interfaces **24** and data processing hardware **26**, and a communications port **29**. The server computer **20** is located on a location **28**, which is geographically separate from the client location **4**. The server location **28** may be in a first city, such as the Swedish capital Stockholm, and the client location may be in another city, such as Stuttgart, Germany or Detroit in Mich., USA. Alternatively, the server location **28** may be in a first part of a town and the client location may be in another part of the same town. The server location **28** may also be referred to as supplier part **28**, or supplier part location **28**. A supplier company who may sell and deliver analysis apparatuses **14** occupies the supplier part location **28**. The supplier company may also distribute use allowance to analysis apparatuses **14** having use restricted condition monitoring functions, as discussed in further detail elsewhere in this document.

[0100] According to one embodiment of the system **2** the apparatus **14** is a portable apparatus which may be connected to the communications network **18** from time to time.

[0101] According to another embodiment of the system **2** the apparatus **14** is connected to the communications network **18** substantially continuously. Hence, the system **2** according to this embodiment may substantially always be "on line" available for communication with the supplier computer **20**.

[0102] FIG. **2** is a schematic block diagram of an embodiment of a part of the condition analyzing system **2** shown in FIG. **1**. The condition analyzing system, as illustrated in FIG. **2**, comprises a sensor unit **10** for producing a measured value. The measured value may be dependent on movement or, more precisely, dependent on vibrations. Alternatively the measured value may be dependent on temperature.

[0103] An embodiment of the condition analyzing system **2** is operative when a device **30** is firmly mounted on or at a measuring point on a machine **6**. The device **30** mounted at the measuring point may be referred to as a stud **30**. A stud **30** can comprise a connection coupling **32** to which the sensor unit **10** is removably attachable. The connection coupling **32** can, for example comprise double start threads for enabling the sensor unit to be mechanically engaged with the stud by means of a ¼ turn rotation.

[0104] A measuring point **12** can comprise a threaded recess in the casing of the machine. A stud **30** may have a protruding part with threads corresponding to those of the recess for enabling the stud to be firmly attached to the measuring point by introduction into the recess like a bolt.

[0105] Alternatively, a measuring point can comprise a threaded recess in the casing of the machine, and the sensor unit **10** may comprise corresponding threads so that it can be directly introduced into the recess. Alternatively, the measuring point is marked on the casing of the machine only with a painted mark.

[0106] The machine **6** exemplified in FIG. **2** may have a rotating shaft with a certain shaft diameter d1. The shaft in the machine **24** may rotate at a certain speed of rotation V1 when the machine **6** is in use.

[0107] The sensor unit **10** may be coupled to the apparatus **14** for analysing the condition of a machine. The analysis apparatus **14** comprises a sensor interface **40** for receiving a measured signal or measurement data, produced by the sensor **10**. The sensor interface **40** is coupled to a data processing means **50** capable of controlling the operation of the analysis apparatus **14** in accordance with program code. The data processing means **50** is also coupled to a memory **60** for storing said program code.

[0108] According to an embodiment of the invention the sensor interface **40** comprises an input **42** for receiving an analog signal, the input **42** being connected to an analogue-to-digital (A/D) converter **44**, the digital output of which is coupled to the to the data processing means **50**.

[0109] The program memory **60** is preferably a non-volatile memory. The memory **60** may be a read/write memory, i.e. enabling both reading data from the memory and writing new data onto the memory **60**. According to an embodiment the program memory **60** is embodied by a FLASH memory. The program memory **60** may comprise a first memory segment **70** for storing a first set of program code **80** which is executable so as to control the analysis apparatus **14** to perform basic operations (FIG. **2** and FIG. **3**). The program memory may also comprise a second memory segment **90** for storing a second set of program code **100**.

[0110] According to some embodiments of the invention the second set of program code is initially disabled so as to prohibit execution of said second set of program code. The disabled data **100** may be enabled in response to reception of a key.

[0111] According to an embodiment of the invention the apparatus **14** comprises an interface means for receiving the key.

[0112] The data processing means **50** is also coupled to a read/write memory **52** for data storage. Moreover, the data processing means **50** may be coupled to an analysis apparatus communications interface **54**. The analysis apparatus communications interface **54** provides for bi-directional communication with a measuring point communication interface **56** which is attachable on, at or in the vicinity of the measuring point on the machine.

[0113] The measuring point **12** comprises a connection coupling **32**, a readable and writeable information carrier **58**, and a measuring point communication interface **56**.

[0114] The writeable information carrier **58**, and the measuring point communication interface **56** may be provided in a separate device **59** placed in the vicinity of the stud **30**, as illustrated in FIG. **2**. Alternatively the writeable information carrier **58**, and the measuring point communication interface **56** may be provided within the stud **30**. This is described in more detail in WO 98/01831, the content of which is hereby incorporated by reference.

[0115] The sensor unit **10** comprises a vibration transducer, the sensor unit being structured to physically engage the connection coupling of the measuring point so that vibrations of the machine at the measuring point are transferred to the vibration transducer.

[0116] The analysis apparatus **14** comprises an analog-to-digital converter **44** electrically connected to receive an output delivered by the sensor unit **10**, a microprocessor **50** electrically connected to receive an output of the analog-to-digital converter, and an analysis apparatus communication interface **54** connected to the microprocessor.

[0117] The system **2** is arranged to allow bidirectional communication between the measuring point communication interface **56** and the analysis apparatus communication interface **54**. The measuring point communication interface **56** and the analysis apparatus communication interface **54** are preferably constructed to allow wireless communication. According to an embodiment the measuring point communication interface and the analysis apparatus communication interface are constructed to communicate with one another by radio frequency (RF) signals. This embodiment includes an antenna in the measuring point communication interface **56** and another antenna the analysis apparatus communication interface **54**.

[0118] Embodiments of the measuring point **12** and the communications interfaces **54**/**56** are described in more detail in WO 98/01831, the content of which is hereby incorporated by reference.

[0119] FIG. **3** is a simplified illustration of an embodiment of the memory **60** and its contents. The simplified illustration is intended to convey understanding of the general idea of storing different program functions in memory **60**, and it is not necessarily a correct technical teaching of the way in which a program would be stored in a real memory circuit. The first memory segment **70** stores program code for controlling the analysis apparatus **14** to perform basic operations. Although the simplified illustration of FIG. **3** shows pseudo code, it is to be understood that the program code **80** may be

constituted by machine code, or any level program code that can be executed or interpreted by the data processing means **50** (FIG. **2**).

[0120] The second memory segment **90**, illustrated in FIG. **3**, stores a second set of program code **100**. The program code in segment **90**, when run on the data processing means **50**, will cause the analysis apparatus **14** to perform an added function. The added function may comprise an advanced mathematical processing of a measured signal received via the sensor interface **40**. The added function, however, will be enabled and available only if the corresponding key or keyword has been entered.

[0121] A Keyword Embodiment

[0122] According to an embodiment of the analysis apparatus **14** (FIG. **2**), the interface means comprises a user input interface **102**, whereby an operator may introduce the key in the form of a code word, also referred to as keyword. According to this embodiment the first set of program code **80** in the apparatus **14** comprises a program routine for requesting a code word, and for determining whether a received code word is accepted. According to an embodiment the user input interface **102** comprises a set of buttons **104**. An embodiment of the analysis apparatus **14** comprises a user output interface **106**. The user output interface may comprise a display unit **106**. The data processing means **50**, when it runs a basic program function provided in the basic program code **80**, provides for user interaction by means of the user input interface **102** and the display unit **106**. The set of buttons **104** may be limited to a few buttons, such as for example five buttons, as illustrated in FIG. **2**, or nine buttons as illustrated in FIGS. **7** and **9**. A central button **107** may be used for an ENTER or SELECT function, whereas other, more peripheral buttons may be used for moving a cursor on the display **106**. In this manner it is to be understood that symbols and text, such as the above mentioned code word, may be entered into the apparatus **14** via the user interface. The display unit **106** may, for example, display a number of symbols, such as the letters of alphabet, while the cursor is movable on the display in response to user input so as to allow the user to input a code word and/or other information. Hence, a key for enabling a disabled condition monitoring function, and/or for adding an amount of usage allowance to a use restricted condition monitoring function may be entered via the user interface **102**, **106** in an advantageously user friendly manner.

[0123] The enabled, executable version **110** of the second set of program code **100** may comprise an analysis routine for processing measured signals or measurement data received on the input **40** from the sensor **10**.

[0124] According to an embodiment of the invention the second set of program code **100** is disabled by means of encryption. Hence, according to this embodiment the second set of program code **100** is an encrypted set of data **100**. The encrypted data **100** is decryptable. Decryption may be achieved by means of a decryption program routine, provided that a correct decryption key, e.g. in the form of a data word, is received.

[0125] The decryption routine may be comprised in one of the basic functions **80**, illustrated in FIG. **3**.

[0126] In the course of decrypting an encrypted set of data **100**, the decrypted data **110** may be stored at a third memory location **112**. When decrypted, the second set of program code is an executable version **110** of the second set of program code **100**. Hence, the memory location **90** may store a disabled version of computer program code and, provided a correct key has been entered, the memory location **112** will provide access to an enabled version of that computer program code.

[0127] Although, in the above, enabling of program functions has been described in detail only for a single program function, it to be understood that a large number of analysis functions may be provided in a disabled state in the analysis apparatus **14**.

[0128] The number of disabled program functions stored by the apparatus **14** may be in the range from one to twenty-five, or even more. This advantageously leads to a wide selection of functions, and the apparatus **14** may be sold at a competitive and relatively low price in a version where only one or a few of the program functions are enabled. According to a preferred embodiment an enabled program function remains enabled for a limited amount of use such that when the limited amount of use has been consumed, the program function will automatically become disabled again. An additional amount of use of the program function can be added by means of a dedicated usage enabling procedure. Execution of the dedicated usage enabling procedure may require clearance by the distributor. This embodiment of the invention advantageously makes it possible to provide, on the market at a competitively low price, a condition analysis system comprising a wide variety of program functions so that users may obtain a very versatile instrument at low initial cost. The user may instead pay a certain amount of money for obtaining an additional amount of use of a selected program function.

[0129] According to an embodiment of the invention the apparatus **14** stores at least five different disabled program functions, when the apparatus is ready to be delivered to a customer. According to another embodiment the apparatus **14** stores at least fifteen different disabled program functions upon delivery to a customer. According to some embodiments at least two of the initially disabled program functions are, when enabled, for generating indications of the condition of a machine in response to measured vibrations. According to preferred embodiments at least half of the initially disabled program functions are, when enabled, for generating indications of the condition of a machine in response to measured vibrations.

[0130] Each one of the disabled functions can be individually enabled in dependence of a key. According to some embodiments of the invention each function is individually enabled dependent on a unique key word. According to an embodiment a group of program functions can be enabled in dependence of one single keyword.

[0131] A Mechanical Key Embodiment

[0132] According to another embodiment the interface means in the apparatus **14** comprises a receptor for receiving a mechanical key (not shown). According to this embodiment an operator may introduce the key in the form of a mechanical key for the purpose of enabling an additional analysis apparatus function. The receptor for receiving a key may comprise contact means operating to enable the disabled data **100** on reception of the corresponding correct key. According to one version of this embodiment the correct mechanical key may be rotated to cause a contact device to close an electric contact coupled to the memory **60**, thereby enabling the reading of a range of memory addresses. Following such a procedure, the data processing means **50** is capable of reading and executing the second set of program code **100** which is stored on said second memory segment **90**, i.e. on said range of memory addresses.

[0133] A Procedure and a System Providing Tailored Functionality for Evaluating the Condition of a Machine

[0134] Analysis of a machine's vibration signature is valuable for reducing unscheduled down time, reducing downtime for repair, minimizing periodic disassembly of a machine for inspection and greatly reducing the probability of catastrophic and unexpected machine failure.

[0135] According to one embodiment of the invention, a manufacturer of condition monitoring systems may provide customers with a very versatile, yet non-expensive analysis apparatus **14**. The analysis apparatus **14** according to this embodiment allows for "tailored" outfit of Machine Condition Monitoring functions (MCM functions), in accordance with the individual preference of each customer. Potential customers of condition monitoring apparatus range from maintenance personnel—spending all their professional time analysing the condition of machines with the use of advanced analysis functions—to workshop personnel with a need to make an occasional control of a few machines.

[0136] The workshop personnel usually require only a few basic monitoring functions for detection of whether the condition of a machine is normal or abnormal. On detecting an abnormal condition, the workshop personnel may call for professional maintenance personnel to establish the exact nature of the problem, and for performing the necessary maintenance work. The professional maintenance personnel frequently needs and uses a broad range of evaluation functions making it possible to establish the nature of, and/or cause for, an abnormal machine condition. Hence, different users of an analysis apparatus **14** may pose very different demands on the function of the apparatus.

[0137] In order to satisfy this broad range of demands, an embodiment of the present condition analysis system advantageously includes an apparatus **14** having a plurality of disabled Machine Condition Monitoring functions, each one of which may be enabled and activated on demand. Such an apparatus **14** for monitoring the condition of a machine can comprise:

[0138] at least one input **42** for receiving measurement data from a sensor **10** for surveying a measuring point **12** of the machine; and

[0139] data processing means **50** for processing condition data dependent on said measurement data; said data processing means comprising means for performing at least two condition monitoring functions F1, F2. At least one of said plurality of condition monitoring functions F1, F2 has a locked state and an unlocked state; said locked state prohibiting complete execution of said condition monitoring function; and said unlocked state allowing execution of said condition monitoring function. The apparatus **14** also comprises means **141** (FIG. **4**) for changing the state of a selected condition monitoring function F1, F2 between the locked state and the unlocked state.

[0140] This solution advantageously provides the analysis apparatus with an improved versatility. A manufacturer can manufacture the apparatus in a single fashion, and a supplier can sell the apparatus in several versions. More precisely, an apparatus having two individually lockable/unlockable functions can be provided in the following versions:

[0141] with only the first function F1 unlocked;

[0142] with only the second function F2 unlocked;

[0143] with the first function F1 and the second function F2 unlocked.

[0144] Hence, a supplier can offer the apparatus in three versions, and this allows for selling it at different price levels dependent on the functionality included. Each client is therefore provided with a choice as to which functions to choose.

[0145] The data processing means may comprise a large number of locked or disabled functions F1, F2, F3 . . . Fn, where n is a positive integer. Each one of the functions F1, F2, F3 . . . Fn may be individually enabled/unlocked or disabled/locked.

[0146] FIG. **4** is a simplified illustration of a second embodiment of the memory **60** and its contents. As described above, the first memory segment **70** stores program code for controlling the analysis apparatus **14** to perform basic operations.

[0147] The second memory segment **90**, illustrated in FIG. **4**, stores a second set of program code **100**. The program code in segment **90**, when run on the data processing means **50**, will cause the analysis apparatus **14** to perform a first Machine Condition Monitoring function (MCM function) F1.

[0148] The memory **60** may also include a third memory segment **120**, as illustrated in FIG. **4**, storing a third set of program code **130**. The program code in segment **120**, when run on the data processing means **50**, will cause the analysis apparatus **14** to perform a second Machine Condition Monitoring function F2.

[0149] The memory **60** may comprise a large number of functions F1, F2, F3 . . . Fn, where n is a positive integer. Each one of the functions F1, F2, F3 . . . Fn may be individually enabled/unlocked or disabled/locked as described elsewhere in this document.

[0150] Once a function F1, F2, F3 . . . Fn has been enabled it may be individually activated on demand, e.g. by an operator, so that the program function causes the analysis apparatus to perform the tasks prescribed by the computer program function. The functions F1 and F2 have been described in FIG. **4** as being stored on separate memory locations, for the purpose of simplifying the understanding of this embodiment of the invention. It is, however, to be understood that the functions F1, F2, F3 . . . Fn may be stored in other manners.

[0151] Additionally, one function Fi, where i is a integer in the range 1 . . . n, may use some, or all, of the program code for another function Fj, where j is an integer in the range 1 . . . n. This means that one function Fi may use another function Fj as a sort of subroutine.

[0152] Examples of Machine Condition Monitoring functions

[0153] The condition monitoring functions F1, F2 . . . Fn includes functions such as: vibration analysis, temperature analysis, shock pulse measuring, spectrum analysis of shock pulse measurement data, Fast Fourier Transformation of vibration measurement data, graphical presentation of condition data on a user interface, storage of condition data in a writeable information carrier on said machine, storage of condition data in a writeable information carrier in said apparatus, tachometering, imbalance detection, and misalignment detection.

[0154] According to an embodiment the apparatus **14** includes the following functions:

[0155] F1=vibration analysis;

[0156] F2=temperature analysis,

[0157] F3=shock pulse measuring,

[0158] F4=spectrum analysis of shock pulse measurement data,

[0159] F5=Fast Fourier Transformation of vibration measurement data,

[0160] F6=graphical presentation of condition data on a user interface,

[0161] F7=storage of condition data in a writeable information carrier on said machine,

[0162] F8=storage of condition data in a writeable information carrier **52** in said apparatus,

[0163] F9=tachometering,

[0164] F10=imbalance detection, and

[0165] F11=misalignment detection.

[0166] F12=Retrieval of condition data from a writeable information carrier **58** on said machine.

[0167] F13=Performing vibration analysis function F1 and performing function F12 "Retrieval of condition data from a writeable information carrier **58** on said machine" so as to enable a comparison or trending based on current vibration measurement data and historical vibration measurement data.

[0168] F14=Performing temperature analysis F2; and performing function "Retrieval of condition data from a writeable information carrier **58** on said machine" so as to enable a comparison or trending based on current temperature measurement data and historical temperature measurement data.

[0169] F15=Retrieval of identification data from a writeable information carrier **58** on said machine.

[0170] Embodiments of the function F7 "storage of condition data in a writeable information carrier on said machine", and F13 vibration analysis and retrieval of condition data is described in more detail in WO 98/01831, the content of which is hereby incorporated by reference.

[0171] The vibration analysis function F1 and shock pulse measuring F3 for the evaluation of the condition of a machine may comprise the step of obtaining a condition value by performing a measurement at the measuring point, such that the condition value is dependent on the actual condition of the machine. According to embodiments, the routines F1 and F3 may comprise the step of the microprocessor **50** requesting measured values from the sensor unit **10** (FIG. **2**). According to one embodiment of the invention the sensor unit comprises a transducer having a piezo-electric element. When the measuring point **12** vibrates, the sensor unit **10**, or at least a part of it, also vibrates and the transducer then produces an electrical signal of which the frequency and amplitude depend on the mechanical vibration frequency and the vibration amplitude of the measuring point **12**, respectively. The electrical signal is delivered to the analog-to-digital converter **44**, which with a certain sampling frequency fs converts the analog signal to consecutive digital words in a known way. The microcomputer **50** stores a series of digital words, which correspond to a time sequence of the electrical signal in the memory **60**, and then performs an analysis of the signal sequence, whereby the frequency and amplitude of the signal may be determined. Consequently, a measured value for the vibration amplitude Av and the vibration frequency fv may be determined.

[0172] According to an embodiment of the above mentioned function F7 "storage of condition data in a writeable information carrier on said machine", one or both of the values vibration amplitude Av and/or vibration frequency fv are delivered to the communications interface **54** (FIG. **2**). The microcomputer **50**, delivers data to the communications interface **54** for the purpose of transmitting such data to the readable and writeable information carrier **58**. This may be achieved by means of the communications interfaces **54** and **56**, as described above in connection with FIG. **2**.

[0173] The above mentioned function F12 "Retrieval of condition data from a writeable information carrier **58** on said machine" comprises: acquiring a value indicating the condition of the machine at an earlier point of time from an information carrier **58** which is placed on, at or in the vicinity of the measuring point **12**.

[0174] The above mentioned function F13 includes a combination of the above described functions F1 and F12. Hence function F13 includes "Performing vibration analysis" and performing "Retrieval of condition data from a writeable information carrier **58** on said machine" so as to enable a comparison or trending based on current vibration measurement data and historical vibration measurement data. An embodiment of function F13 comprises the steps of:

[0175] producing an actual condition value, said value being dependent on the actual condition at the measuring point, and

[0176] acquiring a stored value, indicating the condition of the machine at an earlier point of time from an information carrier **58** which is placed on the machine **6**. The function F13 may also include presentation of the actual condition value and the stored value on the display **106** for indication of changes. Also, a plurality of stored condition values may be acquired, wherein each condition value is associated with a time and/or date so that trends may be presented on the display.

[0177] When the apparatus **14** executes the function F15 "Retrieval of identification data from a writeable information carrier **58** on said machine" it obtains information indicative of the current machine and the current measuring point. Such identification data may be used for storage and retrieval of data in a data base in the memory **52**. Such a data base may include stored condition values wherein each condition value is associated with a time and/or date. The retrieved identification data may be used for fetching the relevant previously stored data relating to the current measuring point.

[0178] An embodiment of the function F15 "Retrieval of identification data from a writeable information carrier **58** on said machine" may include the data processor **50** retrieving interpretation information relating to the measuring point. The interpretation information may include technical type values such as a diameter value d1 and a rotational speed value V1 relating to a rotating shaft in the machine.

[0179] An embodiment of the function F12 "Retrieval of condition data from a writeable information carrier **58** on said machine" also includes retrieving interpretation information relating to the measuring point. With knowledge of the interpretation information d1 and V1, respectively, a measured vibration can be converted to an actual condition value Ka. A predetermined interpretation algorithm is stored in the memory **60**, and starting from an amplitude value Av and interpretation information, such as d1 and V1, the microcomputer produces a corresponding condition value Ka dependent thereon. Such an interpretation algorithm is based on an embodiment of a method for producing a condition value described in the Swedish Laid-Open Document 339 576.

[0180] According to one embodiment, the interpretation algorithm is based on the machine classification standard ISO 2954.

[0181] According to preferred embodiments the apparatus **14** does not have any function for establishing whether steam leaks or not from a steam trap.

[0182] According to an embodiment of the invention the apparatus **14** includes a function for statically aligning a first shaft with a second shaft. According to an embodiment a function F16 for aligning a first shaft with a second shaft can be performed by connecting a first dual-axis position sensing detector providing a first signal and a second dual-axis position sensing detector providing a second signal to port **16** of the analysis apparatus (FIG. **2**, FIG. **12**). When executing the function F16 for aligning shafts, the user interface **106** of apparatus **14** operates to provide readout means having defined alignment conditions and being responsive to the first signal and the second signal for visually displaying shaft alignment, whereby with adjustment of the first shaft with respect to the second shaft, alignment of the first shaft with the second shaft will be indicated on the readout means according to the defined alignment conditions. In order to perform the alignment function an alignment detection device comprising the first dual-axis position sensing detector for generating the first signal and the second dual-axis position sensing detector for generating the second signal is connected to port **16**. The alignment detection device also comprises first mount means for mounting the first dual-axis position sensing detector to the first shaft; second mount means for mounting the second dual-axis position sensing detector to the second shaft; a first alignment radiation source mounted on the first mount means and oriented to provide a first alignment radiation beam to the second dual-axis position sensing detector to generate the second signal; and a second alignment radiation source mounted on the second mount means and oriented to provide a second alignment radiation beam to the first dual-axis position sensing detector to generate the first signal. According to an embodiment of the invention, the apparatus **14**, when executing the alignment function in co-operation with the alignment detection device, operates as disclosed in U.S. Pat. No. 4,518,855, the content of which is hereby incorporated by reference.

[0183] According to an embodiment of the invention the apparatus **14** also includes a function F17 for balancing a rotating shaft. Also a device to be balanced can be attached to an already balanced shaft of a machine, and thereafter the apparatus **14**, when executing the function F17 for balancing, will operate to provide information about the position and weight of the balancing weight(s) needed to counteract an imbalance of the rotating device. The apparatus **14**, when executing a version of the function F17 for balancing, will operate to provide information about weight to be removed from the device-to-be-balanced in order to counteract an imbalance and information about the position where that weight needs to be removed. Removal of weight can be achieved, e.g. by drilling.

[0184] A Usage Debiting/Crediting Procedure

[0185] FIG. **5** is a flow chart illustrating an embodiment of a procedure according to the invention. An operator planning to perform a round of measurements may first consider what type of measurements and analysis is to be done, i.e. what type of Machine Condition Monitoring function is required. The choice of Machine Condition Monitoring function depends on the type of machinery to be inspected, and on how advanced an evaluation the operator intends to achieve, as described above.

[0186] A user help function, provided among the basic functions **80** in the first memory segment **70**, can be activated by the operator to provide information about the purpose of any individual function F1-Fn. This can advantageously contribute to a stepwise increase of the competence of the operator, since the operator may start using relatively simple MCM functions and then, being informed by the user help function, the operator may choose to proceed to using more advanced functions.

[0187] Once the operator has decided that he will need to enable a presently disabled function from the group consisting of functions F1-Fn the operator may activate the Usage Debiting/Crediting Routine **132** (FIG. **4**). The Usage Debiting/Crediting Routine **132** can also be used for changing the value of a level parameter. The value of the level parameter decides the extent to which the analysis apparatus **14** may be used, as described in further detail below.

[0188] The Usage Debiting/Crediting Routine **132** (FIG. **4**) is one of the basic functions **80** in the first memory segment **70**, which is described in connection with FIG. **4** above.

[0189] By means of the user interface **102**,**106** (FIG. **2**) the operator can activate the Usage Debiting/Crediting Routine, as illustrated by step S**110** in FIG. **5**.

[0190] In step S**120** (FIG. **5**), the Usage Debiting/Crediting Routine **132** causes the apparatus **14** to display a list of the available functions, e.g. via the user interface **102**/**106** (FIG. **2**). This may include a listing of a plurality of different functions and an indication about status for each individual function. According to a preferred embodiment the status information indicates for each function whether it is disabled or enabled. For the enabled functions the status information may also include information about the remaining amount of use for the associated function. The remaining amount of use for the associated function is indicated by variables Use_F1 and Use_F2, respectively, for the functions illustrated in FIG. **4**. As illustrated in FIG. **4**, there may be a status field **142** associated with each function F1 , F2, F3 . . . Fn, the status field **142** comprising information about whether it is disabled or enabled and, when enabled, information about the remaining amount of use for the associated function. According to this embodiment the level parameter may be a counter value, herein referred to as "Use_F_k", where k is an integer indicating the association with the corresponding function F1, F2, F3 . . . Fn. Hence, function F1 is associated with level parameter "Use_F_1", and function F2 is associated with level parameter "Use_F_2" etc.

[0191] In step S**130** the operator selects to buy more usage of a function. In response thereto a request for an additional amount of usage is generated (S**140**).

[0192] According to an embodiment the request includes information identifying the function whose usage is to be increased, and payment information. The payment information identifies a person responsible for paying the cost of the requested usage or, alternatively the payment information can in itself effect payment. The payment information may include data such as a credit card number. According to another embodiment the payment information may include information indicating that payment has already been effected.

[0193] According to an embodiment, the above mentioned request includes information identifying the individual analysis apparatus, and the function whose usage is to be increased, and payment information.

[0194] The request is delivered to the premises **28** of a supplier (S**150**). According to an embodiment the request is delivered by means of the communications network **18** (FIG. **1**). Hence, request may be delivered from the apparatus **14** to the server computer **20**, e.g. via data communication.

[0195] At the supplier premises **28** the request is processed (S**160**), the processing including a verification step for establishing whether the request is to be granted or not. The verification may, for example, include an evaluation of the payment information to decide whether the payment information satisfies certain predetermined payment criteria. According to a preferred embodiment the request is processed automatically by the server computer **20**.

[0196] According to an embodiment this payment information evaluation includes a step of checking whether the payment information indicates that payment has already been effected, or whether it merely indicates a person responsible for paying the cost. If the payment information merely indicates a person responsible for paying the cost, the server computer **20** may proceed to check with a dedicated database for establishing whether clearance may be given for this person. The dedicated database may include information about the financial situation for the person responsible for paying the cost. According to one embodiment, the server computer limits this clearance check to a verification using data in the database **22** internal to the premises of the supplier **28**. According to another embodiment the payment evaluation includes a communication with a financial services database.

[0197] Step S**170** illustrates that if step S**160** results in the request being granted, the supplier will deliver a key to the client (S**180**). If, on the other hand, the request is not granted, the supplier computer **20** will generate a Request_denied-message. The Request_denied-message may be delivered to a supplier sales person (not shown) for the purpose of alerting the supplier about a failed attempt buy function usage. According to an embodiment, a Request_denied-message is also sent to client part **4** (See FIG. **1**) for causing the apparatus **14** to display information to the effect that the request was denied. The Request_denied-message may include information indicative of the reason for denial of the request, as well as a copy of the original request message, as described in step S**140** above.

[0198] In step S**190** the key is received in the apparatus. The reception of a key may be achieved via the user interface **102**,**104**,**106**, **182** (See FIGS. **2**, **7**, **9**, **12** and **15**). Alternatively the key may be received via port **16**.

[0199] After reception, there is a verification procedure S**200** for ascertaining the validity of the key. The result of the verification procedure S**200** is an acceptance or a discarding of the key. If the key is not accepted, the apparatus will provide a non-acceptance indication by means of the user interface **106** (Step S**210**).

[0200] If the key is accepted the apparatus **14** will, in response to the key, amend (step S**220**) a level parameter "Use_F_k"to change an amount of usage status and/or the enabled/disabled parameter **143** for the selected function.

[0201] According to an embodiment, the key is associated with the selected function so that, when correctly applied to the apparatus **14**, the key will increase the allowed amount of usage of that function. In other words, the key may cause a level parameter associated with the selected function to be amended. The level parameter associated with a selected function is a parameter whose purpose is to indicate how much the apparatus **14** may execute the selected function.

[0202] With reference to FIG. **4**, an embodiment of the invention involving a level parameter is described. According to this embodiment the level parameter may be a counter value, herein referred to as "Use_F_k", where k is an integer indicating the association with the corresponding function F1, F2, F3 . . . Fn. Hence, function F1 is associated with level parameter "Use_F_1", and function F2 is associated with level parameter "Use_F_2" etc. According to this embodiment, the key will include a first data portion for associating the key with the corresponding function F1, F2 or F3 etc; and a second data portion for indicating the amount of use purchased.

[0203] After execution of step S**220**, the user interface of the apparatus will present information (step S**230**) for the purpose of allowing the operator to select a next operation to be executed. This includes selecting between e.g. starting a measurement, returning to step S**110** for repeating the above procedure, or turning off the apparatus **14**.

Example 1

[0204] FIG. **5**C is a simplified illustration of a principle of an embodiment of an account value or amount of usage parameter for use in an apparatus wherein a user pays to get a number of credits, also referred to as "units of use". It is noted that in the Example 1 embodiment the computer program routine "Function_F1" becomes disabled when the parameter Use_F1 reaches a first reference value (zero in the example).

[0205] This example describes an embodiment relating to the above-mentioned procedure. When a client has purchased e.g. ten units of use for the computer program routine "Function_F1" (See FIG. **4**), the amount indication portion of the key may cause the parameter Use_F1 to increase by ten units. Hence, if the parameter Use_F1 had a numerical value zero (0) before reception of the key, then the parameter Use_F1 will have numerical value "10" (ten) after correct reception of that key. For each execution of the computer program routine "Function_F1" the numerical value of the parameter Use_F1 will be decreased by one (1). When the computer program routine "Function_F1" has been executed ten times so that the parameter Use_F1 again has the numerical value zero (0), the computer program routine "Function_F1" will become disabled.

[0206] In order to enable the computer program routine "Function_F1", the client can purchase a new amount of use by means of the procedure described above.

Example 2

[0207] This example describes an embodiment similar to the Example 1 embodiment above. According to example 2, the cost per use changes after a certain level of use has been attained. A user can enter a number Ap of credits or units of use for a selected function, such as function F1, by means of entering a key. When the function F1 is executed by the apparatus **14** the use of the condition monitoring function F1 will be registered by deducting e.g. one credit for each execution. However, the method may also include the steps of:

[0208] reading a current value of said registered use;

[0209] comparing said current value with a second reference value;

[0210] registering use at a first rate when said current value is above the second reference value; and

[0211] registering use at a second rate when said current value is below the second reference value.

[0212] This advantageously enables a supplier to sell usage at different costs. When, according to one embodiment, a user has paid for a certain amount A_p of usage, the second reference value is a level indicating that the amount A_p of usage already paid for has been spent. This means that any further use will be usage which has not yet been paid for. By the feature of registering such further use at a second rate it is possible to charge a higher cost per unit of usage for such further use. Accordingly, one execution of the function F1, when registered at the second rate, may result in a deduction of two credits.

[0213] FIG. **5**D is an illustration of Example 2. A user, when entering a number Ap of credits or units of use for a selected function, such as function F1, by means of entering a key for the first time, will get Ap credits that will be deducted at the first rate. Assuming that the user has bought ten credits (Ap=10), the parameter Use_F1 will assume the value 10. Hence, if the first rate is deduction of one credit per execution of function F1, the parameter Use_F1 will assume the value zero ("0") after ten executions of function F1. When the value zero ("0") is the second reference value, any further execution of the function F1 will be registered at the second rate, e.g two credits per execution. Hence, the user will advantageously still be able to use the function F1, although this use has not yet been paid.

[0214] If the first reference value is −4, as illustrated in FIG. **5**D, the apparatus will allow the function F1 to be executed twice before the parameter Use_F1 assumes the first reference value "minus four" (−4). When the parameter Use_F1 assumes the first reference value, the computer program routine "Function_F1" will become disabled.

[0215] However, next time that the user enters a key indicating a value of ten credits, the parameter Use_F1 will assume the value six, since it starts from a negative value:

$$-4+10=6$$

[0216] The above example values of first and second reference values are merely examples. Of course, the number of credits, and the reference values may have other values without departing from the inventive concept described herein. Additionally, the amount of use may be counted as duration of time, the first and second reference values also being indicative of time duration. For example a user may buy allowance to use a selected function for a first total period, e.g. sixty hours, the second reference value being indicative of a time when the charge rate is to be changed, and the first reference value being indicative of a when disabling occurs.

[0217] An Embodiment of a Usage Registering Procedure

[0218] FIG. **6** is a flow chart illustrating an embodiment of a procedure according to the invention.

[0219] The procedure may start with step S**230**, i.e. the user interface of the apparatus presents information for the purpose of allowing the operator to select a next operation to be executed.

[0220] In step S**240** the operator selects to request the apparatus to perform a Condition analysis function. This means that the operator may select one of the functions whose use is to be registered. The operator may do this by means of the user interface **102**,**106**.

[0221] In a step S**250** (FIG. **6**) the computer program **80** (FIG. **4**) will in response to the operator input check whether the selected operation involves any of the of the functions whose use is to be registered. The functions whose use is to be registered includes the above discussed MCM functions F1-Fn. A function whose use is to be registered is referred to as a "restricted function" in the following text.

[0222] If the selection involves only unrestricted functions the apparatus **14** (FIG. **2**) will initiate and perform such operation (step S**260**) and then return to step S**230**.

[0223] If a restricted function is selected, the computer program **80** (FIG. **4**) will in response thereto check whether the selected function is enabled or disabled (Step S**270**).

[0224] If the selected function is disabled, the computer program **80** will present information to this effect (S**280**), and offer to proceed to any of steps S**230**, step S**110** or S**120**, described above. According to an embodiment, the program **80** will offer to proceed with step S**470** in the procedure described in FIG. **14**.

[0225] If the selected function is enabled, the computer program **80** will register the use of the selected restricted function (S**290**), and execute the selected restricted function (Step S**300**). Although FIG. **6** illustrates a certain order between activities, it to be understood that the invention is not restricted to performing the steps in that particular order. In particular, the registration of use (step S**290**) may be performed before or after or sometime during the execution of the restricted function.

[0226] According to a preferred embodiment the use is registered by changing the value of a counter parameter Use_F_k. The index k in "Use_F_k" indicates association to function F_k. When the parameter Use_F_k has a value 100, this may indicate that one hundred units of use remains. One unit of use may correspond to one complete execution of the function F_k. Hence, according to an embodiment, the counter parameter Use_F_k can correspond to the number of times the function F_k may be used before all the allowed use has been spent. With reference to FIG. **4** step S**290** may therefore include amending the parameter Use_Fk in status field **142** for the selected function to update the information indicating the remaining amount of use.

[0227] After successful execution and registration of use the computer program **80** may update a status register or status field **142** (step S**310**). Such update may include updating any and all variables/parameters needed for delivering status information correctly next time step S**120** is performed (See FIG. **5** and corresponding description). Hence, step S**310** may include detection of a usage parameter value Use_F_k indicating that a certain act is to be performed in response to the changed status. For example, if a parameter indicates that all usage for one or all restricted functions has been spent, the said certain act may include disabling the restricted function or functions. Such disabling may include erasing a decrypted version **110**, so that only encrypted versions remain.

[0228] FIG. **7** is a physical embodiment of an apparatus **14**. The apparatus has an apparatus body; and a display **106** provided on at least one surface of said apparatus body. Also provided on the body is a user input interface **102** comprising a key board **103**.

[0229] The apparatus body is portable; and it is shaped and adapted to enable a one-hand grip, as illustrated in FIG. **9**. FIG. **9** illustrates the apparatus **14** being gripped by a hand **140** of a user. Moreover the user input interface **102** is positioned and adapted so as to enable user interaction by means of the user hand **140**. In the embodiment shown in FIG. **9** the user input interface **102** is operable by means of a thumb **150** of the user.

[0230] FIG. **8** is a side view of the apparatus shown in FIG. **7**. The apparatus body is provided with fasteners **160** for a wrist strap **170**. The wrist strap **170** is illustrated in FIG. **9**.

[0231] The body also has a holder **180** for an elongated device. The elongated device may be a pen or a pointing device for user input via the display **106**. The display **106** may be a touch sensitive display allowing user input by means of the pointing device. The display **106** therefore includes a display area which is provided with touch sensors **182**, also referred to as a touch screen **182**, co-operating with a touch input interpreter. Hence, the display may comprise an LCD unit, for displaying images and text, having integrated touch sensor means for detecting user input via the display area.

[0232] The provision of touch sensors **182** for receiving user input via the area of the display **106** provides for an improved user interaction. For example, as described above, the function F13 may include presentation of an actual condition value and a plurality of stored condition values so that trends may be presented on the display **106**, wherein each condition value is associated with a time and/or date. When such a trend is displayed, for example in the form of a curve indicating the temporal progression of the condition of the machine, the user may touch the screen at an interesting part of the curve for the purpose of obtaining information associated with that part of the curve. In response to such user interaction the apparatus may therefore display e.g. the time and date information associated with that part of the curve.

[0233] FIG. **12** is a block diagram of an embodiment of the apparatus **14** shown in FIG. **1** and/or FIGS. **7** and **8**. The apparatus according to the FIG. **12** embodiment may comprise a memory **60** having a plurality of program functions F1, F2, F3 . . . Fn, where n is a positive integer. Each one of the functions F1, F2, F3 . . . Fn may be individually enabled/unlocked or disabled/locked.

[0234] The memory **60** includes program functions for causing the data processing means **50** to perform the methods described with reference to FIGS. **5** and **6**. Hence, the memory **60** includes a program function **140** (FIG. **4**) for registering use of any of the functions F1, F2, F3 . . . Fn. The program function **140** may be referred to as a logger, which operates to update the above mentioned use parameters Use_Fk.

[0235] Moreover, the memory **60** also includes a program function **141** for changing the state of an individual selected condition monitoring program function between an enabled state and a disabled state. The state control function **141** may operate to read the parameters Use_Fk, as described in connection with step S**310** in FIG. **6** above. The state control function **141** may operate to disable a function Fk in response to the outcome of a comparison between a parameter Use_Fk and a first reference value Rk. The first reference value Rk is a reference value indicative of a limit. The state control function is adapted to disable function Fk when the parameter Use_Fk reaches the first reference value Rk.

[0236] The apparatus **14** includes data processing means **50** in the form of a central processing unit (CPU) **50**A co-operating with a Field Programmable Gate Array circuit (FPGA) **50**B. According to an embodiment the central processing unit **50**A operates to execute the basic functions **80**, such as the program functions for causing execution of the methods described with reference to FIGS. **5** and **6**. The Field Programmable Gate Array circuit **50**B is programmable to execute the functions F1, F2, F3 . . . Fk . . . Fn. In effect, the CPU **50**A, in response to the basic program functions **80** and user input, operates to control the operation of the FPGA **50**B. The CPU **50**A may, for example, control which of the functions F1, F2, F3 . . . Fk . . . Fn are to be executed by the Field Programmable Gate Array circuit **50**B.

[0237] The Field Programmable Gate Array circuit **50**B advantageously provides a combination of flexibility and very high performance to the apparatus **14** in that the functions executed by the FPGA may be software controlled and the FPGA allows for truly parallel processing. Hence, a large amount of data can be processed relatively fast by means of the FPGA. This solution advantageously enables simultaneous execution of two, three or more of the condition monitoring functions F1, F2, F3 . . . Fk . . . Fn. The apparatus **14** is highly versatile and flexible in that it can be upgraded to perform new functions simply by adding or changing a program. Hence a new or different condition monitoring function can be added to the apparatus **14** by a simple upgrade of the programs in memory **60** (FIG. **2**, FIG. **3**, FIG. **4**, FIG. **12**). When the changed program runs on the FPGA the new function can be executed without necessarily changing any of the hardware in the apparatus **14**.

[0238] Moreover, the FPGA provides a large processing capability in relation to the amount of space it requires. The FPGA may be mounted on a circuit board, where it requires a small surface in relation to the large processing capability it provides. According to an estimate, the amount of surface saved on a circuit board by using an FPGA exceeds 25%. In other words, the volume of the apparatus **14** can be significantly reduced while the data processing capability is maintained or increased as a result of using an FPGA circuit in the apparatus **14**. Therefore the choice of FPGA contributes to enable the provision of a portable instrument satisfying the conflicting requirements of having a large processing capability and a compact instrument which makes it easier to carry for the user.

[0239] Additionally the FPGA has a low power consumption as compared to traditional logic circuits as well as when compared to traditional data processors.

[0240] The FPGA **50**B is coupled to receive digital Shock Pulse Measurement data from an A/D-converter **44**A, which is coupled to an input **42**A for an analogue Shock Pulse Measurement signal (SPM signal). The FPGA **50**B is also coupled to receive digital temperature data from an A/D-converter **44**B, which is coupled to an input **42**B for an analogue temperature measurement signal. The FPGA **50**B is also coupled to receive digital vibration data from an A/D-converter **44**C, which is coupled to an input **42**C for an analogue vibration measurement signal. Moreover the FPGA **50**B is coupled to receive digital data from an A/D-converter **44**E, which is coupled to an input **42**E for an analogue measurement signal indicative of a measured electric voltage or a measured electric current. The FPGA **50**B is also coupled to an input **42**D for receiving binary tachometering measurement signals.

[0241] The FPGA **50**B is also coupled to a communications interface **54** for bi-directional communication with a device **59** on a machine **6**, as described in connection with FIG. **2**.

[0242] Moreover the apparatus **14** includes a user interface **102**. The user interface **102** includes a display **106** having touch sensors **182** for associating information displayed at a certain position of the display area with user activation of the sensor at said certain position. In the block diagram of FIG. **12** the touch sensor **182** is illustrated as a block separated from the display **106**. In a physical embodiment, however, the

touch sensors **182** are integrated with the display area **106**, as illustrated in FIG. **7**, such that the touch sensors **182** detect user interaction with the display area **106**.

[0243] The CPU **50**A is coupled to a data port **16** as described in connection with FIG. **1**, for enabling communication with a supplier computer **20**.

[0244] The apparatus **14** also includes clock functionality **210** for providing time and date information. This is useful for generating a time stamp, e.g. when a condition value has been produced, and the value is to be stored for future retrieval. Additionally, the time and date information may be used for controlling the enabling and disabling of functions F1, F2, F3 . . . Fk . . . Fn. According to an embodiment, the apparatus **14** may receive, via port **16**, a key comprising a code for enabling a selected function from a first predetermined date, such as e.g Mar. 1, 2003, until a second date such as Apr. 15, 2003. Such a key may include a data portion indicative of the identity of the analysis apparatus, a data portion indicative of the function to be enabled, a data portion indicative of the first date and a code portion indicative of the second date.

[0245] Alternatively the key may cause a selected function to be enabled for a certain duration starting from a certain date.

[0246] According to an embodiment the apparatus comprises a logger operating to register the amount of use for one, some or all condition monitoring functions, as described above. This may be done by counting the number of executions of the restricted functions, as described above. According to an embodiment a Reporting function is provided, among the Basic Program Functions **80** (FIGS. **3** & **4**), for causing the apparatus **14** to deliver a report about the accumulated registered use. The reporting function is adapted to deliver such a report with a certain periodicity. For example, the Reporting function may be set to deliver a report no less than once every 30 days. The reporting function is set to deliver the report via the port **16** for transmission to the supplier computer **20** via the communications network **18** (FIG. **1**). Upon reception of the report, the supplier computer may be adapted to cause an output to the supplier indicative of the amount of use accumulated for that particular analysis apparatus. Alternatively the supplier computer may be arranged to automatically generate an invoice with a certain regularity, such as no less than once every 30 days, the invoice thereafter being delivered to a user associated to the analysis apparatus. For this purpose the usage report may include data indicative the identity of the user. This may be achieved by providing unique identities for each analysis apparatus, and keeping, at the supplier, a data base **22** associating each unique analysis apparatus identity with a corresponding client/user. The reporting function co-operates with the timer functionality **210** such that if no usage report has been transmitted at the expiration of the certain period, the timer co-operates with the State control function **141** to disable one, several or all the restricted functions F1, F2, F3 . . . Fk . . . Fn.

[0247] According to another embodiment the apparatus **14** expects to receive a receipt from the supplier part **20**, **28** after sending a usage report. The receipt should include information, preferably in a coded manner, indicating that the usage report has been received by the supplier part **20**, **28**. If no receipt has been received within a first time period the apparatus will provide a warning to the user by means of the user interface **106**. If no receipt has been received within a longer, second time period the apparatus will disable one, several or all the restricted functions F1, F2, F3 . . . Fk . . . Fn.

[0248] FIG. **15** shows a schematic block diagram of another embodiment of a condition analyzing system **2**. According to the FIG. **15** embodiment the client part **4** comprises an apparatus **14**, and a separate client computer **300**. The client computer **300** may be connectable to a communications network **18**, e.g. via a data interface **19**. The communications network **18** may be the world wide internet, also known as the Internet. The communications network **18** may also comprise a public switched telephone network. The supplier part may be able to exchange information with the computer **300** via the communications network **18**, e.g. in the manners discussed above in connection with FIG. **1**.

[0249] According to an embodiment the apparatus **14** is connectable to the computer **300** via port **16**, for exchanging information relating to usage. According to a preferred embodiment the apparatus **14** is capable of delivering the above mentioned usage report to the supplier via the computer **300**. According to an embodiment information exchange between the apparatus **14** and the computer **300** may be achieved by transfer of a writeable memory device connectable to the computer **300** as well as to the apparatus **14**. Information exchanged in this manner may include the above mentioned usage report, and/or the above mentioned receipt indicating to the apparatus **14** that the usage report has been received by the supplier part **20**, **28**. The coded information in the receipt may also be read by a user from the user interface of computer **300**, and input into the apparatus **14** by means of user interface **106**, **182**, **103**.

[0250] FIG. **13**A illustrates a part of memory **60** comprising a function F_k and an associated status field **142**. The status field **142** includes a segment **143** for data indicative of the state of the associated function: enabled or disabled. The status field **142** also includes a segment **144** having data indicative of the cost C_{fk} for executing the associated function Fk. For example, function F1 may have a cost value C_{fk}=1 charging unit per execution, and function F3 may have a cost value C_{fk}=3 charging units per execution. In another example, function F1 may have a cost value C_{fk}=1 charging unit per unit of time, whereas function F3 may have a cost value C_{fk}=3 charging units per unit of time. Hence, different functions may be charged at different cost rates, by providing a certain exchange rate between one charging unit and a certain monetary currency. For example one charging unit may correspond to x US cents, where x is a number such as 10, 15, 50, 100, 1000 or another number dependent on what price is suitable.

[0251] An alternative embodiment for registering use, i.e. an embodiment of step S**290** in FIG. **6**, is as follows: The use maybe registered by counting a duration of execution of a restricted function, in which case the registration of use may include a registration of a start time in a step S**290**A (as indicated in FIG. **6**) and the registration of a stop time in a step S**290**B. In such an embodiment the step S**290**A may be performed immediately before the execution of the restricted function, and the step S**290**B is executed immediately thereafter. According to this embodiment the parameter Use_F_k may be indicative of a total duration of time the function F_k has been activated. FIG. **13**B illustrates a part of memory **60** according to this embodiment, comprising a function F_k and an associated status field **142**$_k$. The parameter Use_F_k, indicative of an accumulated total duration of active time for the function F_k, is stored by the logger in a segment **220**$_k$ in status field **142**$_k$. A reference duration value is stored in segment **230**$_k$, and a cost factor may be stored in a segment **240**$_k$. The

reference duration value is set by reception of a key, and it indicates an amount of use that has been paid for. According to this embodiment the state control function may be arranged to disable Function F_k when the parameter Use_F_k in segment **220** is equal to the reference duration value in segment **230**$_k$. Different charges per time unit for different functions F_k, F_i may be obtained by a multiplying the duration of execution of a restricted function F_k with a cost factor C_k, and multiplying the duration of execution of another restricted function F_i with a different cost factor C_i. The cost factors for functions F_k and F_i, respectively, may be stored in a memory segments **240**$_k$ and **240**$_i$ respectively. In accordance with the same principle, different charges per execution for different functions F_k, F_i may be obtained by a multiplying the number of executions of a restricted function F_k with a cost factor C_k, and multiplying the number of executions of another restricted function F_i with a different cost factor C_i. In this manner the mutually different functions F_k, F_i can be charged at different costs per execution.

[0252] Another Embodiment of a Usage Debiting/Crediting Procedure

[0253] This embodiment differs from the Usage Debiting/Crediting Procedure described with relation to FIG. **5** in that there is provided a centralized debit/credit account parameter **250** rather than separate accounts for each function. There is a plurality of restricted functions having individually settable states: either disabled or enabled. The enabling/disabling procedure is a separate procedure being performed in response to a state key associated with the selected function. There is a separate credit/debit key for allowing a supplier to amend the value of the centralized debit/credit account parameter **250**.

[0254] According to this embodiment the request includes information identifying the individual analysis apparatus, and payment information. The key to be received may cause a level parameter associated with the use of all relevant functions in that individual analysis apparatus to be amended. Hence, such a level parameter may be associated with all MCM functions.

[0255] Whenever a client operator selects to use a restricted function, the amount of use is deducted from centralized debit/credit account **250**. Only those functions which are in the enabled state can be activated for execution, provided the centralized debit/credit account parameter **250** has a value above a first reference value. The first reference value is a limit value, such that if an operator attempts to execute a restricted function when the value of the centralized debit/credit account parameter **250** is equal to, or exceeds the first reference value, then the registering routine causes the apparatus **14** to disable all restricted functions.

[0256] One version of this embodiment further comprises the steps of:

[0257] reading a current value of the centralized debit/credit account parameter **250**;

[0258] comparing said current value with a second reference value;

[0259] deducting credit units from the centralized debit/credit account parameter **250** at a first rate when said current value is above the second reference value; and

[0260] deducting credit units from the centralized debit/credit account parameter **250** at a second rate when said current value is below the second reference value.

[0261] This advantageously enables a supplier to sell usage at different costs. When, according to one embodiment, a user has paid for a certain amount A_p of usage, the second reference value is a level indicating that the whole amount A_p of prepaid usage has been spent. This means that any further use will be usage which has not yet been paid for. By the feature of registering such further use at a second rate it is possible to charge a higher cost per unit of usage for such further use.

[0262] Moreover, the amount of use may be charged at different rates for different functions by means of individual cost factors (C_k and C_i, respectively) associated with each individual function, as described above and as illustrated in FIGS. **13**A and **13**B.

[0263] The centralized debit/credit account parameter **250** may be stored in a memory location **260** in the memory **60**, as illustrated in FIG. **4**.

[0264] FIG. **14** is a flow chart illustrating an embodiment of a procedure for delivering an apparatus **14**, and for adding use or functionality by means of a key from the supplier part **28**. The method also relates to an embodiment of a method for generating a request for such a key or code. Such a key/code may be used for amending the centralized debit/credit account parameter **250** and/or for enabling a disabled function. Step S**610** in FIG. **14** may include the procedure according to FIG. **6**, starting e.g. with step S**230**. It is to be understood that FIG. **14** focuses on certain mathematical or technical details that may also be used in the context of the procedure described in connection with FIGS. **5**A and **5**B above. The method may start at the supplier **28** (FIG. **1**, FIG. **15**) before delivery of the apparatus. In a step S**410** a code ki is set to a start value, which may be chosen to e.g. 0. Thereafter identity information is entered. This may be a number identifying an individual apparatus **14**, or information identifying an individual condition monitoring function or both. A new code K_{i+1} is generated in accordance with a first mathematical algorithm in dependence of the identity information and the previous code k_i (S**430**).

[0265] The variable K_i is updated to the value of the new code K_{i+1} (step S**440**). The updated value K_i is stored in the apparatus **14**, and in the supplier database **22** (step S**450**). The copy stored in supplier database **22** is herein referred to as K_{i22}, and the copy stored in the apparatus **14** is herein referred to as K_{i14}.

[0266] The apparatus is delivered to a client/user (step S**460**). Thereafter the user may operate the apparatus as described in connection with FIGS. **5**A, **5**B and/or FIG. **6**.

[0267] At some point in time the user may want to buy additional use allowance. The user may then cause the apparatus to generate a request U_R (Use Request) for additional Use allowance (step S**470**). Step S**470** may be attained as described in connection with steps S**130**, S**140** in FIG. **5**A. The request U_R is received in supplier computer **20** (step S**480**). In supplier computer **20** the code K_{i22} is retrieved from database **22**. The code K_{i22} and the content of the request U_R are used in a predetermined mathematical algorithm, and a checksum S_{c1} with a certain number of bits is produced. Hence checksum S_{c1} is generated in response to code K_{i22} and the content of the request U_R (step S**500**).

[0268] A new code K_{i+1_22} is generated in response to the old code K_{i22} and identity information (step S**510**). This may be done in a manner analogous to step S**430**.

[0269] In step S**520** the new code value K_{i+1_22} is stored in database **22** as updated code new code K_{i22}.

[0270] A key comprising the information in the request U_R and the checksum Sc1 is delivered from the supplier (step S**530**). This may be achieved as discussed elsewhere in this document, e.g. as discussed in connection with FIG. **5**A.

[0271] The key, comprising the information U_R and Sc1 is received in apparatus **14** (step S**540**). This may be achieved as discussed elsewhere in this document, e.g. as discussed in connection with FIG. **5**A (S**190**). A key verification procedure is performed, as discussed in connection with connection with FIG. **5**A (S**200**). The key verification procedure includes calculating a checksum. In apparatus **14** the code K_{i14} is retrieved from memory. The code K_{i14} and the content of the request U_R are used in the above in step S**500** mentioned predetermined mathematical algorithm, and a checksum S_{c2} with a certain number of bits is produced. Hence checksum S_{c2} is generated in response to code K_{i14} and the content of the request U_R (step S**550**).

[0272] In a subsequent step S**560**, the generated checksum S_{c2} is compared to the received checksum S_{c1} (step S**560** and step S**570**). If they are not identical an error message is displayed, as discussed in connection with S**210** above in connection with FIG. **5**B.

[0273] If they are identical then this means that the key is accepted, and the apparatus **14** proceeds to add the use allowance i apparatus **14** (step S**600**). Thereafter the user may use the apparatus, as discussed in FIG. **6** (step S**610**).

[0274] When additional usage allowance is desired the user may again request additional use, by following the above described procedure, starting with step S **470** as illustrated in FIGS. **14**A, **14**B, & **14**C and as described above.

[0275] FIG. **10** is a top view of an embodiment of the apparatus **14**, illustrating the physical dimensions thereof. FIG. **11** is a side view of the apparatus shown in FIG. **10**.

[0276] The display **106** has an extension xd in a first direction and an extension Yd in a orthogonal direction such that the display area is at least 4125 mm^2.

[0277] The apparatus body has a first portion **190** adapted for gripping by a user. The first portion has an extension x1 in a first direction, an extension y1 in a second direction. The body has an extension z1 in a third direction, as illustrated in FIG. **11**. The body also has a second body portion **200** having an extension x2 in a first direction, and an extension y2 in a second direction. The second portion comprises at least a part of the display **106**.

[0278] According to an embodiment:

[0279] x1 is less than 80 mm

[0280] y1 is less than 140 mm

[0281] z1 is less than 35 mm

[0282] x2 is less than 100 mm

[0283] y2 is less than 160 mm

[0284] xd is at least 60 mm

[0285] yd is at least 80 mm

[0286] This embodiment provides an apparatus **14** having a body volume of less than 952 000 mm^3, and the display **106** has a display area of at least 4800 mm^2. Therefore the apparatus **14** is easily portable in a handheld manner, whereas the user interface is advantageously user friendly by means of a large display in relation to the body volume of the apparatus.

[0287] According to another embodiment:

[0288] x1 is less than 65 mm

[0289] y1 is less than 145 mm

[0290] z1 is less than 35 mm

[0291] x2 is less than 80 mm

[0292] y2 is less than 145 mm

[0293] xd is at least 60 mm

[0294] yd is at least 80 mm

[0295] This embodiment provides an apparatus **14** having a body volume of less than 735 875 mm^3, and the display **106** has a display area of at least 4800 mm^2. This embodiment of the apparatus **14** is even easier to carry in in a handheld manner, while providing a large display in relation to the body volume of the apparatus.

[0296] According to yet another embodiment:

[0297] x1 is less than 60 mm

[0298] y1 is less than 120 mm

[0299] z1 is less than 30 mm

[0300] x2 is less than 80 mm

[0301] y2 is less than 140 mm

[0302] xd is at least 60 mm

[0303] yd is at least 80 mm

[0304] This embodiment provides an apparatus **14** having a body volume of less than 552 000 mm^3, and the display **106** has a display area of at least 4800 mm^2.

[0305] According to another embodiment the apparatus **14** has a body volume of less than 1006 250 mm^3, and said display has a display area of at least 4800 mm^2. According to another embodiment the apparatus **14** has a body volume of less than 800 000 mm^3.

What is claimed is:

1. An apparatus for analysing the condition of a machine having a rotating shaft, comprising:

at least one input for receiving measurement data from a sensor for surveying a measuring point of the machine; said measurement data being dependent on rotation of said shaft;

data processing means for processing condition data dependent on said measurement data; said data processing means comprising means for performing a plurality of condition monitoring functions (F1, F2, Fn), wherein

said data processing means includes a Field Programmable Gate Array circuit coupled to said at least one input.

2. The apparatus according to claim **1**, wherein:

said data processing means comprises at least two data processing devices co-operating so as to control operation of said condition analysis apparatus; a first one of said data processing devices being said Field Programmable Gate Array circuit.

3. The apparatus according to claim **1**, wherein:

a second one of said data processing devices (**50**A) operates to control the operation of the Field Programmable Gate Array circuit.

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