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(71) Applicant: **SOL.GE. S.p.A.**
38068 Rovereto (TN) (IT)

(72) Inventors:
- **Perelli, Luca**
40024, CASTEL SAN PIETRO TERME (BOLOGNA) (IT)
- **Santini, Alessandro**
40134, BOLOGNA (IT)

(74) Representative: **Fanzini, Valeriano**
Bugnion S.p.A.
Via Goito, 18
40126 Bologna (IT)

Remarks:
Claims 16 to 25 are deemed to be abandoned due to non-payment of the claims fees (Rule 45(3) EPC).

(54) Apparatus for determining the effective operating life of a machine

(57) An apparatus for determining the effective operating life, or working life, of a machine for moving loads, in particular in the form of a crane, comprises means (Cnm) for counting the number of cycles (Nnm) that have occurred for corresponding oscillation intervals (Pnm) of the signal detected. The apparatus also comprises means that use this count for calculating a data item defining the effective operating life in relation to the operating life limit defined for the machine and means (25, 25’, 26) for displaying the effective working life.

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Description

[0001] This invention relates to an apparatus for determining the effective operating life of a machine.

[0002] In particular, the machine is in the form of a machine for moving loads, preferably a crane, used for lifting loads, and especially a hydraulic crane.

[0003] At present, there is no way of directly determining the effective operating life of a crane or the like. This type of information is estimated by using methods for calculating the stress cycles of a structure by storing stress data over defined periods of time and subsequently analysing the data. In the case of machines, such as cranes, that do not work continuously or on a regular basis and are subjected to stochastically and rapidly variable loads, the period of time over which stress analysis data must be collected is necessarily very long and substantially equal to the operating life of the crane. Thus, the resources required in terms of storage or hardware capacity are huge. The equipment needed is rarely provided in lifting machines constructed in series and is not available for crane trucks, either at present or in the foreseeable future, also because the costs involved are very high.

[0004] At present, estimates of the effective operating life of crane trucks can be made, though tentatively, only by detecting the number of occurrences of sporadic extreme events - for example, each time the maximum operating pressure of the hydraulic crane drive system is exceeded. In other cases, the oil flow rate of the crane's hydraulic system is measured.

[0005] Whatever the case, crane trucks may currently be fitted with means for detecting a signal corresponding to the maximum pressure in the hydraulic system and which can be assumed to indicate the stress state of the machine, and means for processing said signal and designed to display on suitable display means the number of times this event is detected.

[0006] However, in this way, it is obviously not possible either to determine the actual operating life of the crane or to make sufficiently accurate estimates of future use, for example to calculate maintenance intervals designed to extend its operating life.

[0007] It is provided an apparatus for determining the effective operating life, or working life, of a machine for moving loads, in particular in the form of a crane having a load lifting boom comprising at least one actuator, in particular in the form of a hydraulic actuator. The apparatus comprises means for detecting a signal corresponding to a quantity representing the stress state of the machine, means for processing the signal and display means, and is characterized in that it further comprises: means for counting the number of cycles that have occurred in corresponding oscillation intervals of the signal detected; means that use these counts to calculate a data item defining the effective operating life in relation to the operating life limit defined for the machine; and means for displaying the effective operating life.

[0008] In this way, it is possible to easily determine the effective operating life without having to use large memory or hardware resources.

[0009] These and other characteristics of the invention are clearly described in the appended claims and the advantages of the invention are apparent from the detailed description which follows, with reference to the accompanying drawings which illustrate a preferred non-limiting embodiment of it provided purely by way of example, and in which:

- Figure 1 schematically illustrates a load moving machine, in particular a crane truck, mounting the apparatus according to this invention for determining the effective working life of the machine;
- Figure 2 is a block diagram representing a preferred embodiment of the apparatus for determining the effective working life of the machine;
- Figure 3 shows a hypothetical pattern of the signal detected over time;
- Figure 4 is a graph obtained from the time pattern of Figure 3, expressed in terms of oscillation intervals of the signal;
- Figure 5 is a table showing the basic oscillation counters;
- Figure 6 illustrates a display page showing the value of effective operating life and the graph illustrating the time pattern of the effective operating life;
- Figure 7 is a flow diagram of the program for determining the stress cycles;
- Figure 8 shows a detail of the discretized curve corresponding to the signal detected.

[0010] Figure 1 illustrates a load moving machine in the form of a hydraulic crane 10 for lifting loads, mounted on a motor vehicle 13, in particular a truck, and having a respective boom 12 for lifting the load, comprising a plurality of elements 14b, 14c, 14d, 14e, 14f telescopically connected to each other starting from a main element 14b from which the other crane elements extend and which is connected to the crane mounting structure 15 by a primary crane element 14a.

[0011] In particular, the telescopic boom is lifted and lowered by a hydraulic drive cylinder 17 mounted, in this embodiment, between the fixed crane element 14a and the main element 14b of the telescopic crane boom from which the other telescoping elements extend.

[0012] The crane truck driver's cab is labelled 13' in Figure 1.

[0013] The lifting boom may be completed, as illustrated, by a respective extension, or fly jib, 18, having a plurality of elements 19a, 19b, 19c, 19d telescopically connected to each other starting from a main element 19a from which the other telescoping elements extend and which is connected to the end element 14f of the boom.

[0014] The fly jib 18 in turn comprises a main hydraulic drive cylinder 17', used in particular for rotationally driving the main element 19a of the jib 18.

[0015] The above machine is advantageously fitted with an apparatus for determining the effective operating life, or working life, of the load moving or lifting machine. The apparatus advantageously comprises means 20, in the form of electronic processing means comprising a CPU, a memory unit with a respective program for determining the machine's operating life, and interface means, respectively having means 22 for detecting the signal and a radio-control unit 24 which is designed to remotely control the movements of the crane and which comprises a respective keypad 24' and a display 25' mounted on board the crane truck 13.

[0016] The apparatus for determining the operating life, or working life, further comprises means for interfacing with electronic processing means 26 located remotely from the machine and being, in particular, in the form of a PC mounted at a maintenance centre for monitoring machine 10 operation and which is connected to the means 20 through cables, Hertz waves or other means.

[0017] As illustrated, the radio transmitter 24 has a display unit 25, while the remote processing means 26 comprise a respective screen or display unit 27. Advantageously, as may be inferred from Figure 3, the sensor means 22 detect, in a predetermined time - or detection - interval Δt, the time pattern of a physical quantity P representing the stress state of the machine, to obtain a graph like the one shown by way of example in Figure 3, or in block 51 in Figure 7.

[0018] This time pattern of the quantity P obtained by the detection means 22 is then transmitted to the processing means 20 where it is suitably converted, broken down and stored.

[0019] For this purpose, the means for determining the operating life, or working life, comprise a program through which the processing means 20, mounted on board the vehicle 13, operate on the signal detected.

[0020] In practice, said means, or program, for determining the operating or working life operate on a plurality of signals P detected in succession, each of which corresponds to a respective detection stage performed in a predetermined, or partial, interval of time Δt.

[0021] In practice, the effective operating life is advantageously determined at each signal detection stage (Δt) incrementally with respect to previous detections.

[0022] In particular, as will become clearer as this description continues, the program implements a suitable algorithm which might, for example, be embodied by what is known as the Rainflow algorithm or by the Tank algorithm, both known in the trade, or by algorithms based on these, which convert or break down the signal detected into a plurality of basic oscillation intervals, or oscillation events, as shown for example in Figure 4, which also shows the number of occurrences or the number of cycles, in each oscillation interval or oscillation event.

[0023] In practice, the time variable signal P is converted into a plurality of oscillation intervals Pnm, or oscillation events, consisting of the oscillation between one value, level or threshold Pn and another value, level or threshold Pm.

[0024] For example, as illustrated in Figure 4, the interval P65 consists of the oscillation between a maximum pressure value, level or threshold P6 and a pressure value P5 just below the maximum pressure value P6, while the interval P64 consists of the oscillation between a maximum pressure value or level P6 and a pressure value P4 slightly lower than the previous level P5, and so on, as illustrated concisely in Figure 4 or as illustrated in specific blocks within the general block 55 in Figure 7.

[0025] In practice, in the example illustrated here, six pressure levels or thresholds P1 to P6 are predetermined, each one obtained by incrementing the previous, lower one by a predetermined value and the conversion program residing in the local processing means 20 counts the number of times, or cycles, Nnm, a certain basic oscillation, or oscillation band, generically denoted by the reference characters Pnm, included between the threshold Pn and the threshold Pm, is present in the detected signal P.

[0026] Thus, the basic oscillation interval P65 corresponds to a certain number of occurrences, or cycles, labelled N65, and the basic oscillation interval P64 corresponds to a certain number of occurrences, or cycles, labelled N64, and so on.

[0027] Generically, the number of occurrences, or cycles, corresponding to a respective basic oscillation interval Pnm, or event, is labelled Nnm in Figure 4.

[0028] Figure 7 illustrates a flow diagram schematically representing the operation of the program that determines the number of cycles corresponding to a particular basic oscillation interval, or band, Pnm of the signal detected.

[0029] The program comprises two sub-programs called, as shown in the diagram, "filter program" and "cycle recognition program", which can in turn be defined by or comprise other sub-programs or program routines.

[0030] The first sub-program, the 'filter program', receives a substantially continuous signal 'P' as a function of the time 't' (as shown in the block labelled 51 or as shown in Figure 3) of a quantity that can indicate the stress applied to the machine structure. Preferably, as illustrated, it is a pressure signal from a hydraulic cylinder of the lifting machine.

[0031] This signal is suitably processed by the "filter program", as shown by block 52 in Figure 7, to identify defined values indicating the quantity "P", in particular the respective maximums and minimums, labelled K1 and K2, corresponding to respective values or thresholds Pn and Pm.

[0032] In this way, the continuous quantity P is suitably discretized.

[0033] The discretization of the continuous quantity P performed by the filter program is based on the predetermined thresholds, or values, such as, for example, the thresholds, or values, P1, P2, P3, P4, P5, P6, described above with reference to Figure 4. In practice, starting from the predetermined thresholds, or values, P1, P2, P3, P4, P5, P6, the continuous signal P detected as a function of time (illustrated in block 51, or in Figure 3), and in a predetermined interval of time Δt, is converted into a discrete signal or into values corresponding to this signal and which is determined from a limited number of predetermined values or thresholds Pn, for example, the above mentioned thresholds P1, P2, P3, P4, P5, P6, as shown in block 53, Figure 7. As may be inferred from block 53, the converted signal is substantially defined by a broken line made up of a series of straight lines, each corresponding to a respective band, or interval, Pnm defined by corresponding values Pn and Pm.

[0034] In practice, the "filter program" analyses the input quantity P as a function of time and determines the relative maximum points K1 and the relative minimum points K2 corresponding to bands or intervals Pnm of the values, or thresholds, Pn and Pm.

[0035] For example, considering the band, or interval, between the values P4 and P3, shown more clearly in Figure 8, the "filter program" analyses the input quantity P as a function of time and determines the relative maximum point K1, corresponding to the predetermined value P4, and the relative minimum point K2, corresponding to the predetermined value P3 in the respective band.

[0036] More specifically, in order to determine the points K1 and K2 in a suitable and advantageous manner, the 'filter program' also considers the type of fluctuations of the quantity 'P', as shown by the dashed line 'F' in Figure 8, within the same band.

[0037] As shown in block 53, for each event identified, the "filter program" simultaneously determines and stores the relative maximum K1, corresponding to the threshold, or value, Pn, and the relative minimum K2, corresponding to the threshold, or value, Pm.

[0038] Thus, with reference to the example shown in Figure 8, for event number 3, the "filter program" simultaneously determines and stores the relative maximum K1, corresponding to the threshold, or value, P4, and the relative minimum K2, corresponding to the threshold, or value, P3. The determination of the points K1 and K2 may also depend on any fluctuations detected by the program within the respective band, or interval, Pnm.

[0039] In practice, the events detected by the "filter program" correspond to the identification of relative maximums and minimums corresponding to bands, or intervals, defined by respective predetermined thresholds, or values, of the quantity P.

[0040] A curve, or corresponding data, is thus determined having the events on the x-axis, each event corresponding to respective relative maximum and minimum corresponding to respective intervals or bands defined by predetermined thresholds or values Pn, Pm.

[0041] The number of events detected by the 'filter program' depends on the thresholds set and not on the time pattern of the quantity P.

[0042] This makes it possible to store only the significant events, independently of the time domain, and saving considerably in terms of hardware memory.

[0043] The second sub-program, called "cycle recognition program", represented by way of example in block 54, operates on the results of block 53, determined by the "filter program", and identifies and stores the cycles, or number of occurrences, Nnm of the oscillation between the corresponding thresholds Pn and Pm (as shown in block 55, Figure 7, and as shown as a whole in Figure 4), on the basis of the tank or rainflow method, and according to the discretization level set, that is to say, according to the set number Pn of thresholds, for example the thresholds P1, P2, P3, P4, P5, P6.

[0044] Immediately after identifying and storing in the corresponding counters Cnm respective cycles Nnm (as shown in block 55) corresponding to the continuous signal P, as a function of time, detected in the predetermined time interval Δt, the two sub-programs 52 and 54 eliminate from the memory the significant relative maximum and minimum values K1, K2 of the events of block 53, which are no longer necessary since they have already been used for counting the cycle Nnm already stored in the counters Cnm (shown in Figure 5).

[0045] After determining and storing the cycles Nnm in the respective counters, corresponding to the continuous signal P, as a function of time, detected in the respective predetermined, partial time interval Δt, (as shown in block 55 or in Figure 4) the procedure is repeated; the "filter program" resumes analysis of the continuous quantity P as a function of time, for the next predetermined time interval Δt, storing new data, as shown in block 53, on which the "cycle recognition program" then operates in such a way as to determine and store the new cycles Nnm in the respective counters, as shown in block 55 or in Figure 4.

[0046] Since both the programs 52 and 54 operate substantially simultaneously on a corresponding partial detection of the quantity P, the hardware memory resources necessary are certainly limited.

[0047] Advantageously, the program can count the crane cycles for the entire operating life of the crane without storing the entire quantity 'P' for the full duration of the operating cycle of the crane, thus using a limited amount of hardware memory.

[0048] In practice, the "filter program" constitutes means for discretizing, or parameterizing, the continuous signal detected, that is to say, means for determining significant values K1, K2 (relative maximums and minimum) of the detected signal P, starting from predetermined thresholds or values Pn, Pm, while the "cycle recognition program" constitutes means for determining the number of cycles Nnm between corresponding thresholds Pn and

[0049] Pm, calculated from the significant values of the quantity P determined by the "filter program".

[0050] Thus, the signal processing means 20 mounted on board the crane truck 13 comprise a corresponding program that is advantageously designed to count the number of cycles Nnm that have occurred in respective oscillation intervals Pnm of the quantity representing the stress state of the machine.

[0051] In other terms, the program residing in the memory and implemented by the on-board processing unit 20 constitutes means which, for each oscillation interval, count the number Nnm of cycles that have occurred during the respective life period of the load lifting machine.

[0052] In practice, general counters are provided, as shown in Figure 5.

[0053] More in detail, the counter 65 is used to store the total number of occurrences or cycles N65 corresponding to the basic oscillation interval or event P65 for the entire life of the crane up to the time of detection. Similarly, the counter 64 is used to store the total number of occurrences or cycles N64 corresponding to the basic oscillation interval or event P64 for the entire life of the crane up to the time of detection, and so on for all the other counters.

[0054] In practice, the following relation generically applies :

$$Cnm = \Sigma\ Nnm.$$

[0055] Starting from these counts Cnm, in corresponding counters, the processing means 20, or a program residing in and implemented by said means, calculates the effective operating life in relation to the operating life limit defined for the machine, and sends this effective operating life data item to the display means 25 of the radio control 24 and/or of the display units 25' and 27.

[0056] In other terms, the program residing in the local processing means 20 constitutes means for calculating the data item defining the effective operating life, labelled CL in Figure 6, in relation to the operating life limit defined for the machine. Advantageously, the effective operating life data item is expressed as a percentage of the operating life limit defined for the machine. However, other ways of representing the effective operating life relative to the life limit are also imaginable.

[0057] In practice, the detected signal P corresponds to strain applied to the crane boom and is the signal indicating the pressure of a specific hydraulic cylinder forming part of the lifting machine. More specifically, the signal is the pressure signal from the main hydraulic cylinder 17 of the telescopic crane boom, that is, the hydraulic cylinder for lifting and lowering the boom or the pressure signal from the main hydraulic cylinder 17' of the fly jib 18 extending from the crane boom.

[0058] As shown in Figure 3, the means 22 for detecting the time pattern of the detected signal P detect the signal in predetermined, successive intervals Δt and the respective time pattern is temporarily stored in a memory of the local processing means 20.

[0059] In the embodiment described here, there are 15 base oscillation intervals, or bands, Pnm. The number of basic oscillation intervals Pmn might, however, vary according to requirements so as to obtain a desired and optimum compromise between the accuracy of the estimate and memory use.

[0060] The means for counting the total number of cycles Cnm that occur in each oscillation interval Pnm also comprise means, in the form of a program or routine residing in, and implemented by, the local processing means 20, and which are designed to sum the number of cycles Nnm that occur in respective basic oscillation intervals Pnm of the signal detected in the corresponding time interval Δt to the number of cycles Cnm already counted for all the previous detections.

[0061] Once the cycles Pnm have been counted, the new counts Cnm are stored and the time pattern P of the signal detected in the respective time interval Δt is deleted from the memory of the local processing means 20, and, as mentioned above, the significant values are calculated from this signal.

[0062] At this point, the system stores the next time pattern of the quantity P for a respective time interval Δt in order to proceed to another counting step, as described above.

[0063] The effective life, or effective life data item, is determined from the counts Cnm of the number of cycles that have occurred in the oscillation intervals Pnm, according to the design class of the machine.

[0064] In particular, the means for determining, or calculating, the effective life, or effective life data item, comprise a program that implements an algorithm based on Miner's rule or fatigue damage rule.

[0065] Thus, for each machine, or for the design class to which the machine belongs, it is possible to determine the effective operating life in a manner easy to understand by an expert in the trade using Miner's rule and the counts Cnm, that is to say, the number of occurrences of the predetermined basic oscillations Pnm which the machine has actually been subjected to.

[0066] As illustrated, the display units 25, 25' and 27 show the effective life CL, which in this embodiment is in the form of a numeric data item expressed as a percentage of the hypothetical life for that machine design class, thus providing a piece of information that is quick and easy for the machine user to understand.

[0067] The invention also contemplates the provision of means for determining the time pattern of the effective life, in the form of a program residing in, and implemented by, auxiliary processing means 26, preferably remote or separate from the machine 12 and from the crane truck 13, and/or residing in, and implemented by, the processing means 20 on board the machine.

[0068] The effective life time pattern is preferably represented as a graph like the one labelled SWP shown by way of example in Figure 6, that is displayed on the display unit 27 of the remote PC 26 and/or on the display unit 25' on board the crane truck.

[0069] Obviously, the program that determines the effective life time pattern includes instructions for displaying the effective life time pattern SWP on the basis of the counts Cnm which are periodically updated by the local processing unit 20.

[0070] On the graph shown in Figure 6, the effective life time pattern SWP is advantageously compared with a reference pattern R based on the design class and highlighting the deviations from a hypothetical, or theoretical, operating life so as to allow the user to see clearly and easily whether the machine has been subjected to more or less stress than the stress it was designed for.

[0071] It is therefore easy for inspection personnel to plan routine and extraordinary maintenance schedules or decide whether the machine should be decommissioned.

[0072] For this purpose, the graph of Figure 6 includes a straight line RL corresponding to the maximum working life of the machine. Thus, the point where the curve SWP intersects the line RL indicates the maximum operating life of the machine, corresponding to 100% of CL (crane life).

[0073] Advantageously, the processing means 26 that define the time pattern SWP are placed in communication with the processing means 20 to receive from the latter the data relating to the counts Cnm.

[0074] Also shown on the display means is the machine's design class "cl" which the theoretical pattern R defining the maximum life, usually 10 years, corresponds to.

[0075] The count data, or counter values, Cnm are stored each time by the corresponding processing means and the effective life time pattern SWP is determined incrementally relative to the previously determined patterns on the basis of the updated count data.

[0076] In practice, the program in the local processing means 20 or in the remote processing means 26 located, for example, at the machine's monitoring and maintenance centre, includes instructions for storing the counts Cnm so as to incrementally update the graph SWP, which, as illustrated, is defined by a broken line composed of a series of straight lines.

[0077] As illustrated, the effective life time pattern SWP may include sections that rise more steeply than the reference line R, corresponding to heavier duty, sections that rise less steeply than the reference line R, corresponding to lighter duty, and horizontal sections indicating periods of machine inactivity.

[0078] As shown, the effective life time pattern SWP is represented on a graph having, on the x-axis, the years of service life and, on the y-axis, the theoretical life, also in years.

[0079] The apparatus according to the invention thus implements a procedure for determining the effective operating life, or working life, of a machine by recursively acquiring or detecting a continuous signal of a quantity representing the stress state of the machine, determining significant values of the quantity P from this continuous signal on the basis of predetermined thresholds Pn and determining, from these significant values of the quantity P, the number of occurrence cycles Nnm of corresponding oscillations Pnm between respective thresholds Pn and Pm, and then storing each number of cycles Nnm in a respective counter Cnm.

[0080] The procedure then uses the data stored in the counters to calculate the effective operating life, or working life, of the machine.

[0081] The invention described above is susceptible of industrial application. It may also be modified and adapted in several ways without thereby departing from the scope of the inventive concept. Moreover, all the details of the invention may be substituted by technically equivalent elements.

Claims

1. An apparatus for determining the operating life, or working life, of a machine for moving loads, in particular in the form of a crane (10) having a load lifting boom (12) comprising at least one actuator, in particular in the form of a hydraulic actuator (17, 17'), the apparatus comprising means (22) for detecting a signal corresponding to a quantity representing the stress state of the machine, means (20) for processing the signal and display means, and is **characterized in that** it further comprises: means (Cnm) for counting the number of cycles (Nnm) that have occurred for corresponding oscillation intervals (Pnm) of the signal detected; means that use the counts for calculating a data item defining the effective operating life in relation to the operating life limit defined for the machine; and means (25, 25', 26) for displaying the effective operating life (CL).

2. The apparatus according to claim 1, **characterized in that** the signal detected is the signal indicating the pressure of at least one hydraulic actuator forming part of the machine.

3. The apparatus according to either of the foregoing claims, **characterized in that** it comprises means (22) for detecting the time pattern of the detected signal (P) for predetermined time intervals (Δt).

4. The apparatus according to any of the foregoing claims, **characterized in that** it comprises means for determining the number of cycles (Nnm) that have occurred in corresponding oscillation intervals (Pnm) of the signal detected in corresponding time intervals (Δt).

5. The apparatus according to claim 4, **characterized in that** it comprises means for summing the number of cycles (Nnm) that have occurred in respective oscillation intervals (Pnm) of the signal detected in the corresponding time interval (Δt) to obtain a total count (Cnm).

6. The apparatus according to claim 5, **characterized**

in that it stores the total count (Cnm) of cycles that have occurred in respective basic oscillation intervals (Pnm) of the detected signal.

7. The apparatus according to claim 5 or 6, **characterized in that** each total count (Cnm) is stored in a respective counter.

8. The apparatus according to any of the foregoing claims from 5 to 7, **characterized in that** the effective life (CL) is determined on the basis of the total counts (Cnm) of the number of cycles that occur in respective oscillation intervals (Pnm) of the signal detected, according to the design class of the machine.

9. The apparatus according to any of the foregoing claims, **characterized in that** it comprises means for displaying the effective life (CL) on a display unit (25, 25') of the lifting machine.

10. The apparatus according to any of the foregoing claims, **characterized in that** the effective life (CL) is displayed on the display unit (27) of an apparatus (26) remote from the lifting machine.

11. The apparatus according to any of the foregoing claims, **characterized in that** it comprises means for determining a time pattern (SWP) of the effective life.

12. The apparatus according to claim 11, **characterized in that** the effective life time pattern (SWP) is determined by processing means (20), in particular at the machine.

13. The apparatus according to claim 11 or 12, **characterized in that** the effective life time pattern (SWP) is displayed in particular on a display unit (25, 25') at the machine.

14. The apparatus according to any of the foregoing claims, **characterized in that** it comprises means for determining the effective operating life, or working life, of a machine on the basis of predetermined values, or thresholds (Pn).

15. The apparatus according to any of the foregoing claims, **characterized in that** the time pattern (P) of the signal detected in the time interval (Δt) and/or the significant values of this is/are deleted from the memory.

16. The apparatus according to any of the foregoing claims from 11 to 15, **characterized in that** the effective life time pattern (SWP) is compared with a reference pattern (R, RL) of the operating life.

17. The apparatus according to any of the foregoing claims, **characterized in that** the detected signal corresponds to strain applied to the crane boom.

18. The apparatus according to any of the foregoing claims from 2 to 17, **characterized in that** the detected signal is the pressure signal from a hydraulic cylinder (17) of the main element (14a) of the telescoping crane boom and/or from a hydraulic cylinder (17') of boom extension means (18).

19. The apparatus according to any of the foregoing claims from 11 to 18, **characterized in that** it comprises means for determining an effective life time pattern (SWP) on the basis of the total counts (Cnm) of the number of cycles that occur in respective oscillation intervals (Pnm).

20. The apparatus according to any of the foregoing claims from 11 to 19, **characterized in that** the effective life time pattern (SWP) is in the form of a graph.

21. The apparatus according to any of the foregoing claims from 11 to 20, **characterized in that** the effective life time pattern (SWP) is generated by processing means (26) remote from the machine.

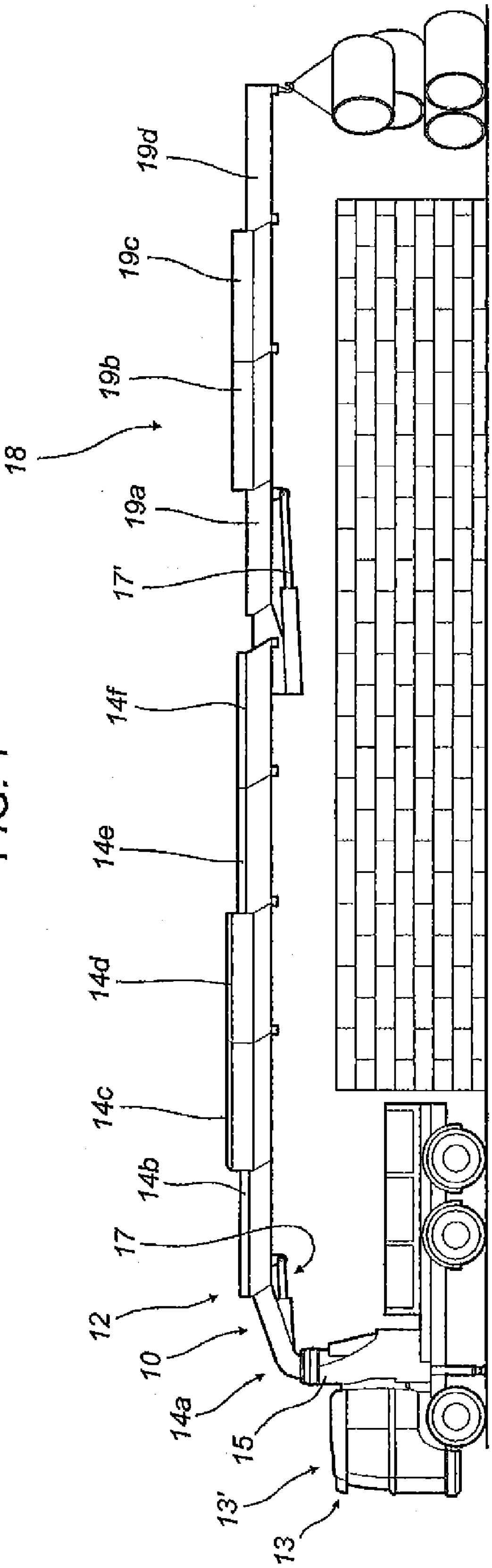
22. The apparatus according to any of the foregoing claims from 11 to 21, **characterized in that** the effective life time pattern (SWP) is displayed on a display unit (27) remote from the machine.

23. The apparatus according to any of the foregoing claims from 11 to 22, **characterized in that** the effective life time pattern (SWP) is determined incrementally relative to the previously determined patterns on the basis of updated counts.

24. The apparatus according to any of the foregoing claims, **characterized in that** the design class (cl) of the machine is displayed.

25. A load moving machine, in particular in the form of a hydraulic crane for lifting loads and having a respective boom for lifting the load, comprising a plurality of elements telescopically connected to each other starting from a main element connected to the mounting structure, the machine being **characterized in that** it comprises an apparatus according to any of the foregoing claims, for determining its operating life, or working life.

FIG. 1



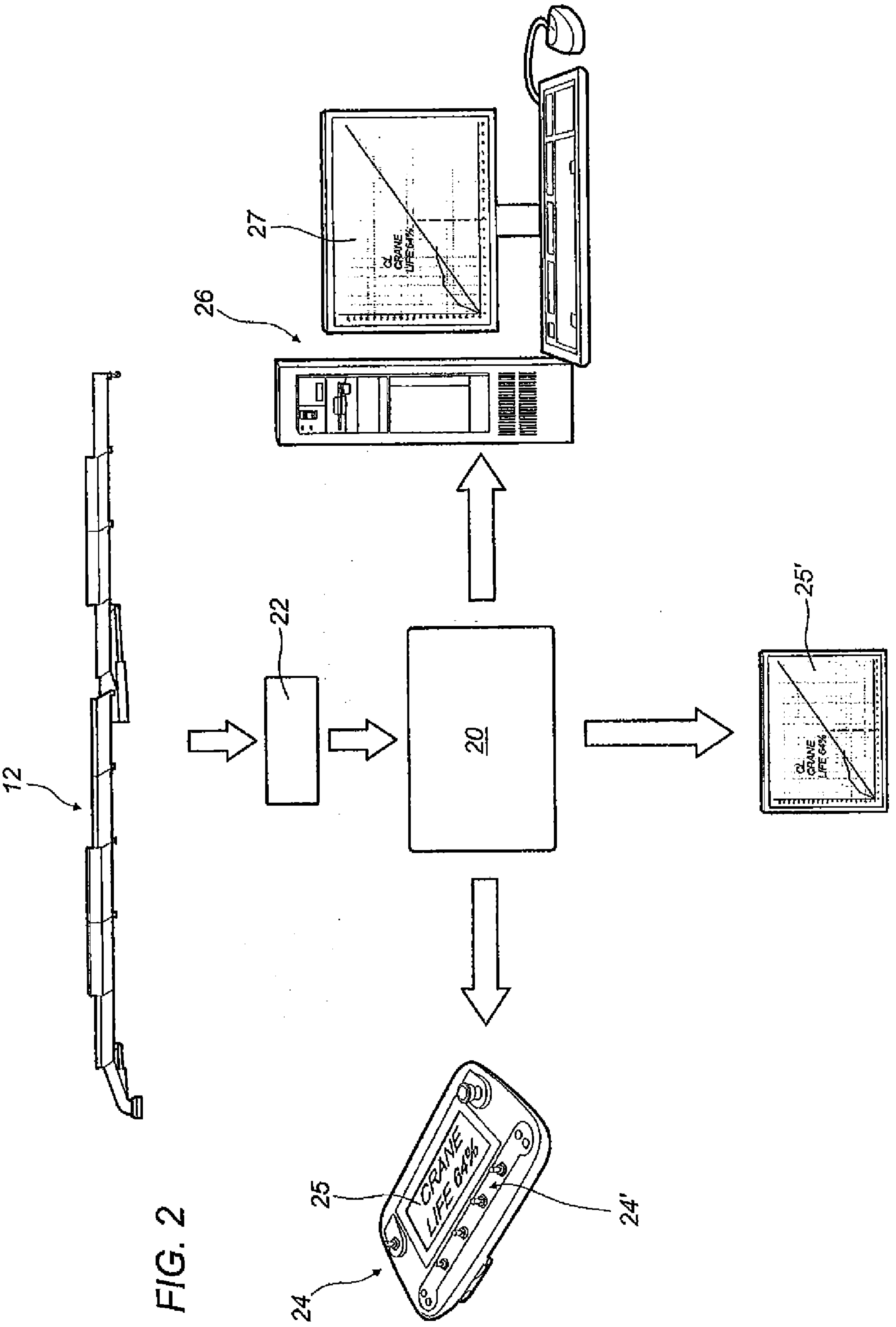


FIG. 2

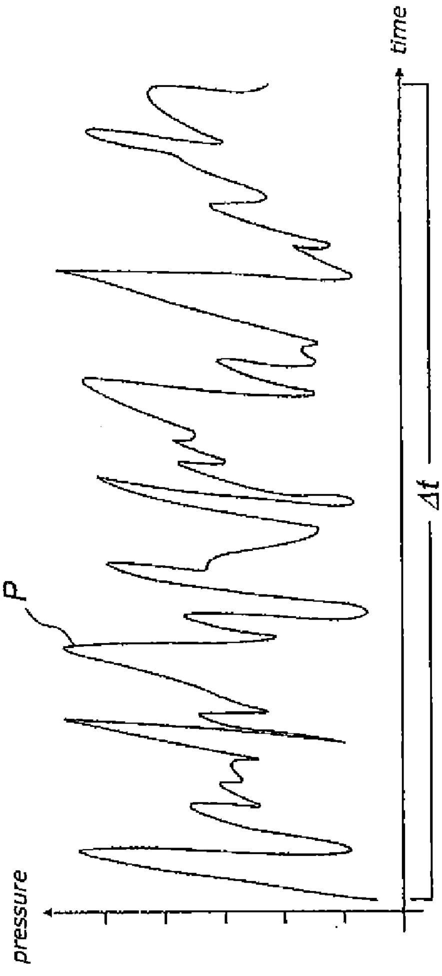

pressure
time
P
Δt

FIG. 3

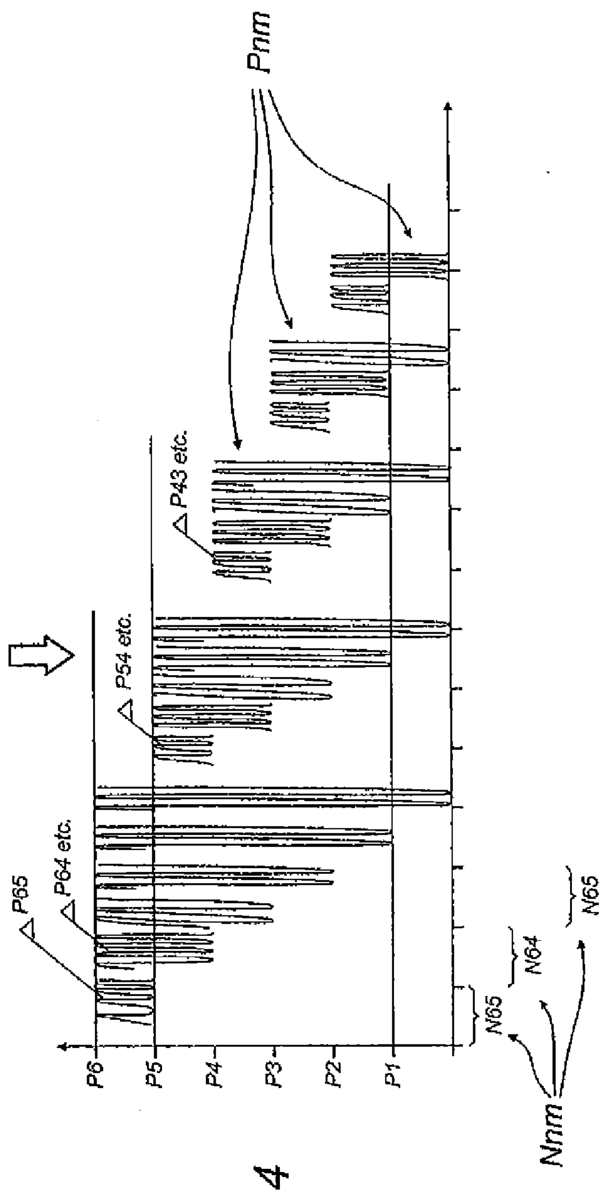

P6
P5
P4
P3
P2
P1
P65
P64 etc.
P54 etc.
P43 etc.
Pnm
Nnm
N65
N64
N65

FIG. 4

FIG. 5

COUNTERS	Value
Counter 21	431
Counter 31	328
Counter 32	726
Counter 41	280
Counter 42	288
Counter 43	580
Counter 51	136
Counter 52	163
Counter 53	176
Counter 54	234
Counter 61	154
Counter 62	61
Counter 63	48
Counter 64	30
Counter 65	33

Cnm

FIG. 6

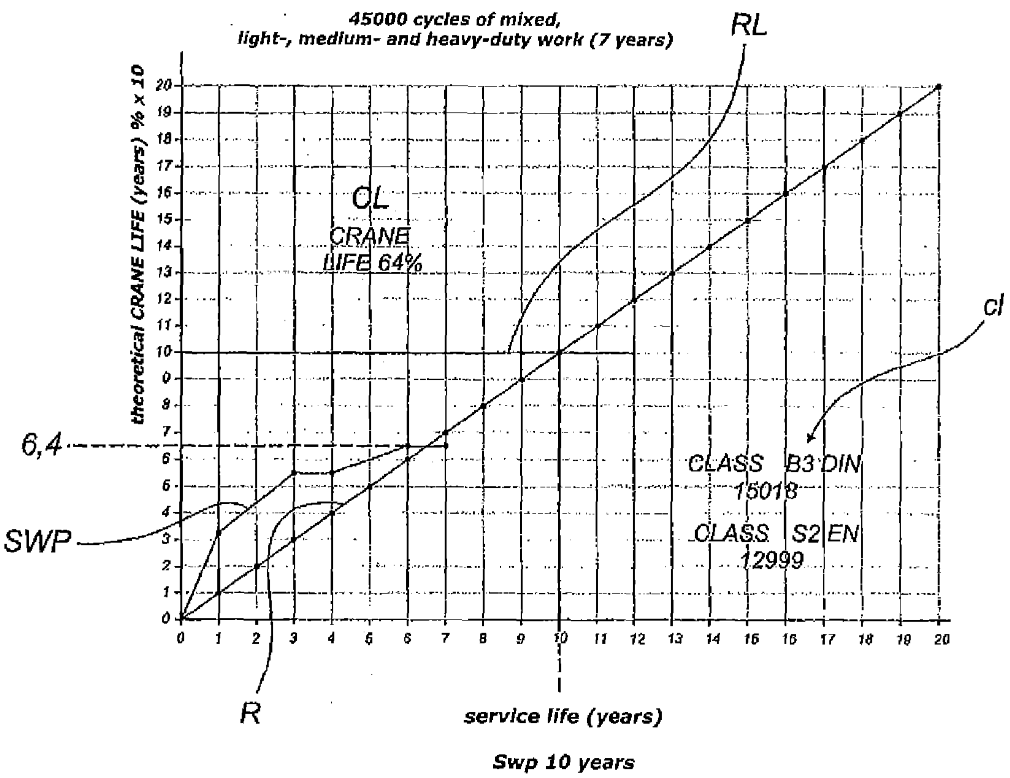


FIG. 7

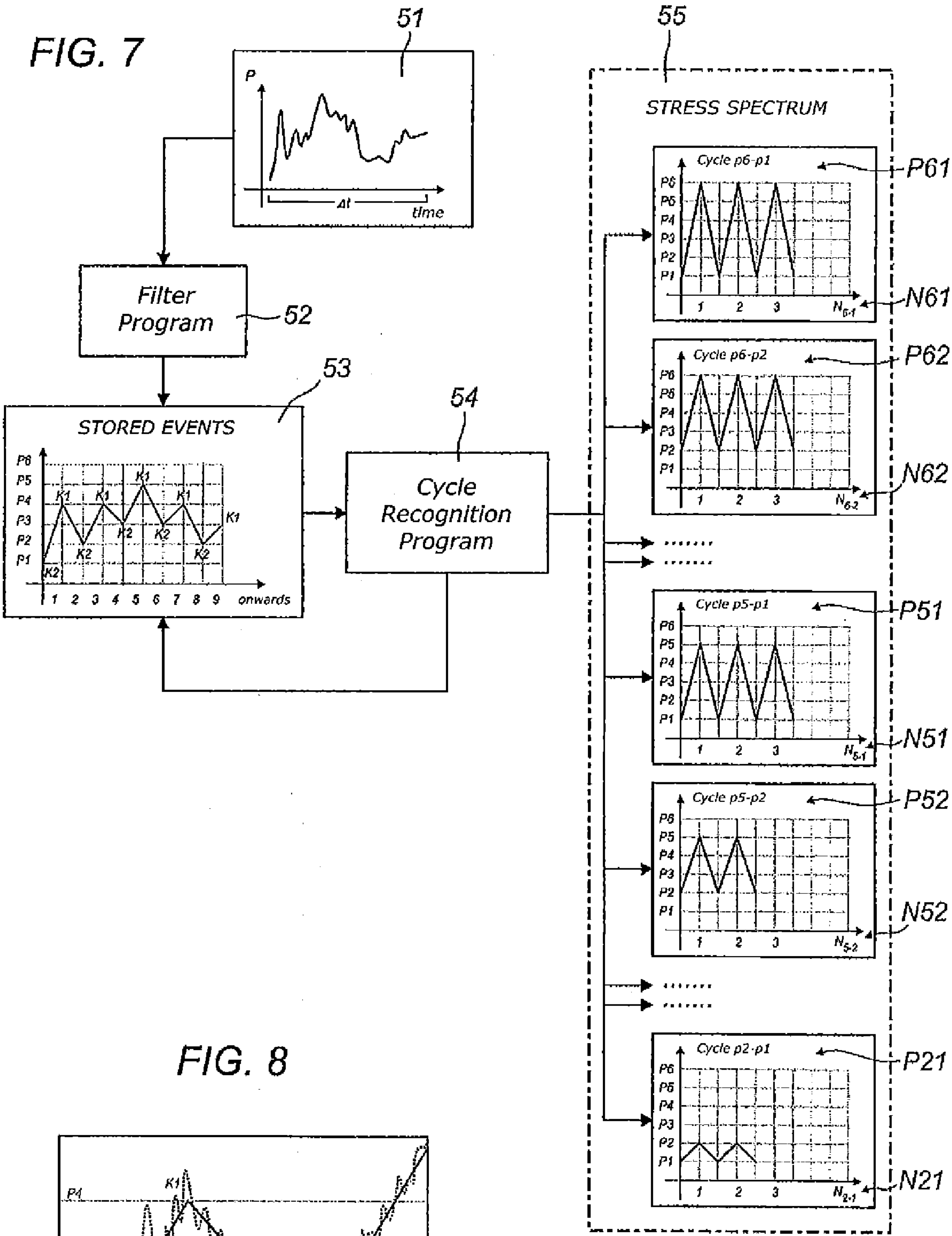
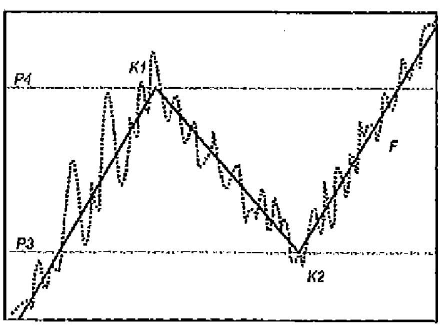

51
P
Δt
time
Filter Program
52
53
STORED EVENTS
P6
P5
P4
P3
P2
P1
K1
K2
onwards
54
Cycle Recognition Program
55
STRESS SPECTRUM
Cycle p6-p1
P61
N61
Cycle p6-p2
P62
N62
Cycle p5-p1
P51
N51
Cycle p5-p2
P52
N52
Cycle p2-p1
P21
N21

FIG. 8


P4
K1
P3
K2
F