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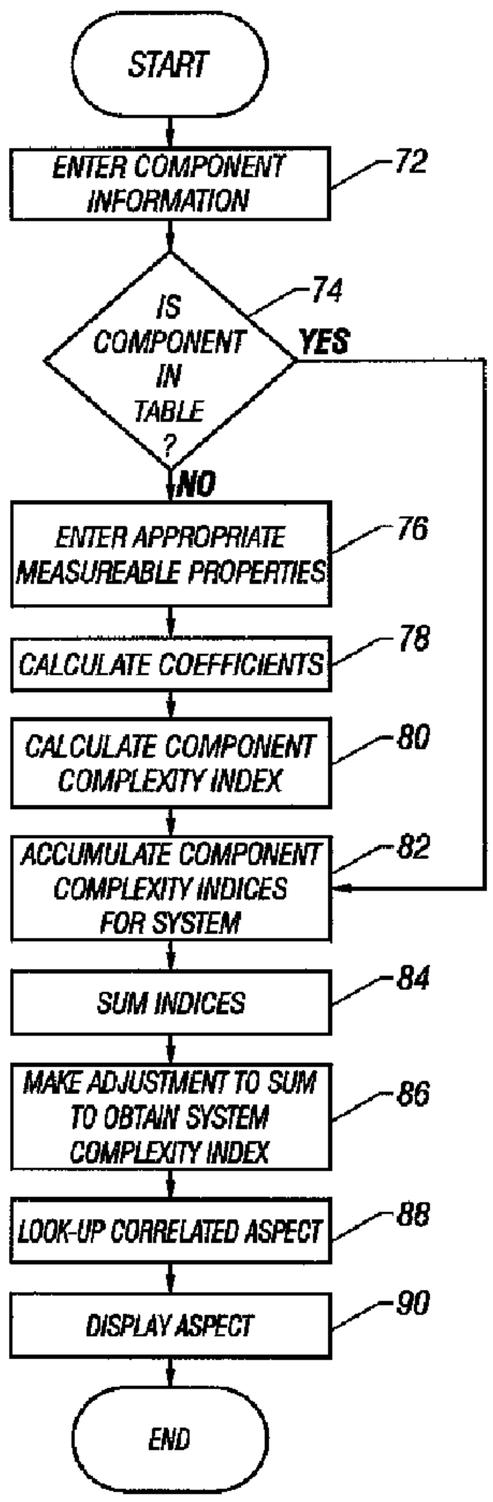
(54) Titre : METHODOLOGIE AXEE SUR L'INDEX DE COMPLEXITE POUR L'ANALYSE DE LA DUREE DE VIE UTILE
(54) Title: COMPLEXITY INDEX METHODOLOGY FOR THE ANALYSIS OF RUN LIFE PERFORMANCE



(57) Abrégé/Abstract:
A system and method for predicting a specific aspect, such as run life, of a component or system. The system utilizes a variety of complexity index values that are assigned to each component of the system. Each complexity index value is determined according

CA 2331482 C 2009/10/20

(11)(21) 2 331 482

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(57) Abrégé(suite)/Abstract(continued):
to select physical parameters of the component. The summing of the complexity index values provides a system complexity index value that can be used to accurately estimate, for example, the run life of the system. The use of individual complexity index values permits the addition, subtraction or changing of components in a given system without losing predictability of the desired aspect, e.g. run life.

ABSTRACT OF THE DISCLOSURE

A system and method for predicting a specific aspect, such as run life, of a component or system. The system utilizes a variety of complexity index values that are assigned to each component of the system. Each complexity index value is determined according to select physical parameters of the component. The summing of the complexity index values provides a system complexity index value that can be used to accurately estimate, for example, the run life of the system. The use of individual complexity index values permits the addition, subtraction or changing of components in a given system without losing predictability of the desired aspect, e.g. run life.

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COMPLEXITY INDEX METHODOLOGY FOR THE ANALYSIS OF RUN LIFE PERFORMANCE

FIELD OF THE INVENTION

This present invention relates generally to a methodology for the derivation and use of dimensional values for qualities that are not normally dimensionally defined, and particularly to a methodology that may be utilized in estimating, for example, the run life of components or systems of components.

BACKGROUND OF THE INVENTION

In many environments, systems and applications, it is difficult to predict with any accuracy the ultimate occurrence of specific events. For example, the estimation of run life for virtually any machine, system, component or application is difficult. The accumulation of data, e.g. run time till failure, for a specific device or component permits the determination of an average run life. However, if the complexity of the device or component is changed, or additional components are added to form a system, the run life of the component and/or system once again becomes largely unpredictable. Any predictability tends to be derived from consistent data obtained on the actual use and

failure of a statistically significant number of same or similar components or systems.

It would be advantageous to have a methodology that could be utilized on a computer, for example, to more accurately predict non-dimensional parameters or events, such as run life.

SUMMARY OF THE INVENTION

According to one aspect the invention provides a method for accurately estimating service life of a system having a plurality of components, comprising: establishing a complexity index value for each component of a system of components by comparing one or more component parameters of each component when in good operational condition to reference parameters of a corresponding reference component; adding the complexity index values of the plurality of components to obtain a system complexity index value; determining a run life based on the system complexity index value prior to operation of the system; and outputting a run life value to a display.

According to another aspect the invention provides a system for determining an output value related to a service parameter of a device, comprising: an interface to permit the entering of information related to physical parameters of the device when the device is in a desired operational condition; a comparison module able to compare physical parameters of the device to corresponding physical parameters of a reference device to obtain a comprehensive complexity index; a correlation module configured to correlate the comprehensive complexity index with an output value related to the active service of the device prior to

operation of the device; and a display by which a user can view the output value.

According to another aspect the invention provides a method for utilizing physical dimensional parameters as a predictor of an aspect of the operation of a device, comprising: selecting one or more dimensional parameters for a device; comparing the one or more dimensional parameters to one or more corresponding reference parameters; deriving a complexity index based on the comparison; utilizing the complexity index to predict a desired operational aspect of the device, prior to operation of the device; and outputting a desired operation aspect value to a display.

According to yet another aspect the invention provides a method for predicting the run life of a downhole pumping system utilized in pumping a production fluid from a well, comprising: assigning a complexity number to each component of a well-related pumping system, the complexity number reflecting the relative complexity of a given component to a reference component based on corresponding physical properties; adding together the complexity number of each component to obtain a comprehensive complexity index; predicting the run life of the well-related pumping system based on the comprehensive complexity index, prior to operation of the well-related pumping system; and outputting a run life value to a display.

According to another aspect the invention provides a system for determining an output value related to a service parameter of a device having a plurality of components, comprising: an interface to permit the entering of information related to the physical description of each

of the plurality of components when each of the plurality of components is in an unused condition; a comparison module able to compare physical parameters of each component of the plurality of components to corresponding physical parameters of corresponding reference components to obtain a unique complexity index for each component; a correlation module to process the complexity index of each component and to determine a run life of the device; and a display on which the run life is displayed to an operator.

According to another aspect the invention provides a system for determining an output value related to a service parameter of a device, comprising: means for permitting the entering of information related to the physical description of the device; means for comparing physical parameters of the device to corresponding physical parameters of a reference device to obtain a comprehensive complexity index; means for correlating the comprehensive complexity index with an output value related to the active service of the device prior to operation of the device; and means for viewing the output value.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements, and

Figure 1 is a flow chart illustrating the general methodology used to predict a desired operational aspect of a component or system of components;

Figure 2 is a table that illustrates the derivation of complexity index values for exemplary components of an exemplary system;

78543-14

Figure 3 provides specific examples of the calculation of various system complexity index values;

Figure 4 provides a table of predetermined complexity index values for a variety of components that can be utilized in an exemplary submersible pumping system;

Figure 5 is a schematic illustration of an exemplary computer system that can be utilized in carrying out the predictive methodology;

Figure 6 is a schematic view similar to that of Figure 5 but having additional features; and

Figure 7 is a flow chart for carrying out the predictive methodology in, for example, a computer.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present system and method utilize what can be referred to as the "complexity" of a component or components as a general predictor of some aspect of an individual component or system of components. In the discussion below, the present system and methodology are explained in detail in conjunction with the specific example of predicting run life for an electric submersible pumping system used to pump subterranean fluids, such as oil. However, this exemplary use should not be construed as limiting, because the present

system and method have potential application in a wide variety of components, systems, and applications.

A generic methodology is outlined via a series of steps arranged as a flow chart in Figure 1. Initially, a subject of investigation is identified, as illustrated in block 20. Then, each of the components of the subject are identified, as represented in block 22. As discussed below, an exemplary subject is an electric submersible pumping system, and exemplary components are a pump, an intake, a protector and a motor, that form a given submersible pumping system.

For each component, a set of measurable properties are defined, as represented in block 24. The measurable properties typically have a range of values depending on alternate selections of a given component. For example, submersible pumps may be available in a range of diameters and lengths. Each measurable property of a component has a specific value, that can be referred to as a candidate value, as represented in block 26. Each candidate value, of course, falls somewhere within the range of values for that particular measurable property.

The minimum value within the range of values for a given measurable property is referred to as the reference

value, as illustrated in block 28. By way of example, the reference value for a property, such as a pump diameter, is the smallest pump diameter for a series of submersible pumps.

A coefficient for each property is then defined, as represented in block 30. The coefficient for each property is the candidate value divided by the reference value. This coefficient is sometimes referred to as the complexity coefficient used in driving a complexity index for a given component. The least or lowest complexity coefficient for each property is the minimum candidate value or reference value divided by the reference value, as represented in block 32. In other words, the coefficient assigned to the simplest or least complex form of a given property is equal to one.

Summing the coefficients for each property of the subject component defines that particular component in a measurable manner, as referenced in block 34. This summation of coefficients can be referred to as a complexity index for a given component. The complexity index measures the complexity of a given component relative to the simplest form of the component, defined as the component having the minimal values for each property measured.

By adding the summation of coefficients for each component, the overall subject is defined, as represented in block 36. In many systems and applications, this summation can be described as the summation of the complexity indices for each component. This provides a subject or system complexity index that can accurately be utilized as a predictor with respect to the subject or system. For example, the run life of a submersible pumping system can be readily predicted by the subject or system complexity index.

Initially, the component complexity indices and system or subject complexity index are applied against known data on the component and/or subject to verify the accuracy and usefulness of the measured properties in indicating a desired operational aspect of the subject. Once the properties and values are verified against known data of the subject, the methodology can be used to evaluate performance, e.g. run life, throughout a generated range of values for other sizes and grades of each component as well as for other combinations of components in the overall subject, e.g. system.

Referring generally to Figure 2, an exemplary implementation of the present methodology is illustrated in a table of relationships and values that apply to components of

a system. In this example, the system is an electric submersible pumping system of the type utilized in pumping, for example, oil from a well. A typical electric submersible pumping system includes a pump (block 38), an intake (block 40) through which wellbore fluids are drawn into pump 38, a motor protector (block 42) and an electric motor (block 44). In this example, there are a variety of measurable properties 46. The specific properties for each component may vary, but they are measurable, physical properties that relate to the run life of the component.

For example, diameter, length and certain mechanical aspects of the pump are utilized in determining the component complexity index for a given submersible, centrifugal pump. With respect to diameter, the contributing coefficient for that property is determined by taking the square of the candidate value, i.e. the outside diameter of the actual pump used in the system, divided by the square of the reference value, e.g. reference outside diameter. The reference OD is obtained from the pump having the smallest outside diameter and available for the same type of pumping application. The coefficient for length is determined by dividing the length of the candidate pump by the length of the reference pump. The reference pump is the shortest available pump. The mechanical coefficient is determined by dividing the maximum

length of the candidate pump by the maximum number of pump stages and dividing the resultant quotient by a corresponding quotient for the reference pump. By adding the three coefficients, diameter, length and mechanical, the complexity index for the candidate pump is determined. It should be noted that in a typical situation there are a variety of individual components to choose from in constructing the overall electric submersible pumping system. Additionally, the components typically come in a range of diameters for placement in a variety of wellbores.

The pump intake complexity index also is calculated from coefficients based on diameter length and mechanical. For intakes, however, the mechanical coefficient is derived from dividing the length of the candidate intake by the length of the reference intake with static intakes being given a coefficient of zero.

As further illustrated in the table of Figure 2, a motor protector complexity index is determined by adding the coefficients related to the properties of diameter, length, mechanical and also shaft. The shaft coefficient is determined by dividing the shaft outside diameter of the candidate protector by the shaft outside diameter of the reference protector. In calculating the mechanical

coefficient for protectors, the candidate length is divided by the reference length.

In calculating the complexity index for motor 44, the coefficients of the properties related to diameter, length, mechanical and electrical are summed. In this instance, the mechanical coefficient is derived through division of the maximum length of the candidate motor by the maximum number of rotors in the candidate motor and further dividing the resultant quotient by the corresponding quotient of the reference motor. The electrical coefficient is calculated by dividing the work per foot or horsepower of the candidate motor by the horsepower of the reference motor.

Three different exemplary electric submersible pumping systems are illustrated in the table of Figure 3. In this table, the three pumping systems are labeled A, B and C. In the first column, individual components of the three systems are listed. In the second column the complexity index for each component is listed and has been derived by summing the coefficients as discussed with reference to Figure 2. In column 3, information about the component type has been listed. Each of the components listed in this particular example is available from Reda Pump Co. of Bartlesville, Oklahoma.

Systems A and B each use a pump, intake, protector and motor, but the pumps, intakes and motors have different measurable properties. Accordingly, the overall complexity index of each system is different, with system A having an overall index of 18.73 and system B having an overall index of 23.71.

Example systems A and B utilize the simplest system necessary for pumping a production fluid from a well in that only a single pump, single intake, single protector and single motor are utilized. In example C, the system has greater complexity due to an additional pump that results in a five component system having two pumps. When the complexity of the system goes beyond the base or simplest system available, the complexity index for the additional component or components is summed with the other component complexity indices. Further, the resultant sum is multiplied by a factor derived from the number of components in the actual system divided by the number of components in the simplest or least complex system. Thus, the addition of individual component complexity indices results in 28.69, but the actual system complexity index is determined by multiplying that sum by 5/4 to obtain a system complexity index of 35.86.

When a company, for instance, has a variety of available components with known measurable property values, the component complexity indices can be pre-calculated, as illustrated in the table of Figure 4. Thus, a company can determine the complexity index for each of its system components to facilitate computation of the overall system complexity index when individual components are selected and combined. However, if certain components are obtained elsewhere, the complexity index for that particular component can readily be calculated by summing the coefficients obtained from measurable properties as described with respect to Figure 2.

The methodology described above typically is carried out on a computer. As illustrated in Figures 5 and 6, an exemplary computer system 50 may comprise a personal computer having a computer 52 operatively coupled to, for example, a monitor 54 having a display screen 56, a keyboard 58 and a mouse 60. The display screen 56, keyboard 58 and mouse 60 may be used as an interface to permit the entering of information related to the candidate device or system. Of course, other interfaces or systems, available now or in the future, can be used to enter data. The exemplary display

screen 56 further serves as a display by which a user can view the output values or other information.

The methodology typically is embodied in software and includes three basic modules, a comparison module 62, an adder module 64 and a correlation module 66. The comparison module 62 is configured to compare parameters or properties of a candidate device to the corresponding properties of a reference device to obtain the appropriate coefficients used in deriving the component complexity index. Preferably, the comparison module 62 includes a lookup table 68 which can be used for pre-established component complexity indices, as illustrated in Figure 4, for specific components that may be selected by a user of system 50. Thus, comparison module 62 permits an individual to automatically obtain the component complexity index for pre-catalogued components or to have the component complexity index calculated from individual property coefficients by entering the appropriate dimensional values for each candidate component property that contributes to the component complexity index.

Adder module 64 is utilized in summing the coefficients, if any, to obtain the individual component complexity indices, and it is utilized in adding the component complexity indices to derive the overall subject or

system complexity index. Additionally, the adder module 64 is utilized in adjusting the sum of the component complexity indices, where necessary. For example, if the system includes a greater number of components than the base system, as discussed with reference to example C of Figure 3, then adder module 64 makes an appropriate adjustment to obtain the system complexity index. Similarly, the adder module can be programmed to make appropriate adjustment to the sum of the component complexity indices for other factors, such as factors related to environment. For example, adjustments may be made according to the specific type of production fluid produced, the depth at which the electric submersible pumping system operates, and the heat and/or pressure affecting the system.

The correlation module 66 is configured to correlate the complexity index with an output value related to the aspect being predicted. In the specific example of an electric submersible pumping system, the aspect typically is run life of the system. In one exemplary embodiment, correlation module 66 cooperates with a lookup table 70 that includes the values for expected service life that correlate to a given system complexity index value. Those values typically are determined and verified by actual data on the

run life of specific components and systems that have been used in the field.

A flow chart for implementing the methodology on system 50 is illustrated in Figure 7. This flow chart is merely exemplary and should not be construed as limiting. The sequences and steps may be adjusted to accommodate the prediction of a given aspect in a variety of applications and according to a variety of strategies. In the illustrated approach, a user is initially prompted via a display, such as display screen 56, to enter information on one or more components, as referenced in block 72. Typically, a given aspect, e.g. run life, is desired for a system, and information is entered on a plurality of components. For each component, a check is made whether the component complexity index has been pre-established in, for example, lookup table 68, as referenced in decision block 74. If the component complexity index has not been pre-established, the user is prompted to enter the parameters or properties for the specific component, as referenced in block 76. The coefficient for each property is then calculated (see block 78) as described above, for example, with reference to Figure 2. The component complexity index is then calculated by summing the coefficients as referenced in block 80. Ultimately, the component complexity indices for the entire

system, e.g. electric submersible pumping system, are accumulated, as illustrated by block 82. If, on the other hand, one or more of the components is available in a lookup table at step 74, that component complexity index is immediately made available for accumulation, as referenced in block 82.

When the component complexity indices are accumulated, those indices are summed, as referenced in block 84. If necessary, corrections or adjustments are made to the sum, as referenced in block 86. Such corrections or adjustments may be necessary when a greater number of components are utilized in the system than necessary in the simplest system or to accommodate other factors, such as environment. The corrected sum provides a subject or system complexity index that can be correlated with a desired aspect, such as run life. In an exemplary system, the correlated aspect may be maintained in a lookup table, such as lookup table 70, referenced in block 88. The desired aspect, e.g. run life, may then be displayed for the user on a display, such as display screen 56, as referenced in block 90.

It will be understood that the foregoing description is of preferred exemplary embodiments of this invention, and that the invention is not limited to the specific forms

shown. For example, the general methodology can be applied to a variety of applications, including individual devices or components, systems of components, and other types of systems, such as financial systems, workforce or employee systems, technical systems, etc. that require a method for predicting a certain aspect. Additionally, the methodology may be carried out on other systems or in conjunction with additional applications. Also, the reference components need not be the least complex provided potential coefficients of less than one are acceptable. These and other modifications may be made in the design and arrangement of the elements without departing from the scope of the invention as expressed in the appended claims.

78543-14

CLAIMS:

1. A method for accurately estimating service life of a system having a plurality of components, comprising:

establishing a complexity index value for each component of a system of components by comparing one or more component parameters of each component when in good operational condition to reference parameters of a corresponding reference component;

adding the complexity index values of the plurality of components to obtain a system complexity index value;

determining a run life based on the system complexity index value prior to operation of the system; and

outputting a run life value to a display.

2. The method as recited in claim 1, further comprising adjusting the system complexity index value when the number of components in the system exceeds the number of reference components in a reference system.

3. The method as recited in claim 1, wherein adjusting comprises multiplying the system complexity index value by fraction the numerator of which is the number of components and the denominator of which is the number of reference components.

4. The method as recited in claim 1, wherein establishing includes selecting one or more component parameters that are readily measurable and each indicative of a greater component complexity.

5. The method as recited in claim 1, further comprising adjusting the system complexity index value to compensate for application parameters.

6. The method as recited in claim 1, wherein establishing includes selecting a corresponding reference component having a lower complexity than the component compared thereto.

7. The method as recited in claim 3, further comprising adjusting the system complexity index value to compensate for application parameters.

78543-14

8. A system for determining an output value related to a service parameter of a device, comprising:

an interface to permit the entering of information related to physical parameters of the device when the device is in a desired operational condition;

a comparison module able to compare physical parameters of the device to corresponding physical parameters of a reference device to obtain a comprehensive complexity index;

a correlation module configured to correlate the comprehensive complexity index with an output value related to the active service of the device prior to operation of the device; and

a display by which a user can view the output value.

9. The system as recited in claim 8, wherein the comparison module is a computer readable medium having stored thereon computer readable code for causing a computer to implement specific steps.

10. The system as recited in claim 9, wherein the correlation module is a computer readable medium having stored thereon computer readable code for causing a computer to implement specific steps.

11. The system as recited in claim 10, wherein the interface comprises a keyboard.

12. The system as recited in claim 10, wherein the display comprises a computer display screen.

78543-14

13. The system as recited in claim 8, wherein the device comprises a plurality of components.

14. The system as recited in claim 13, wherein the comparison module compares parameters of each component to corresponding parameters of reference components to obtain a unique complexity index for each component.

15. The system as recited in claim 14, further comprising an additive module able to add the unique complexity indices to obtain the comprehensive complexity index.

16. A method for utilizing physical dimensional parameters as a predictor of an aspect of the operation of a device, comprising:

78543-14

selecting one or more dimensional parameters for a device;

comparing the one or more dimensional parameters to one or more corresponding reference parameters;

deriving a complexity index based on the comparison;

utilizing the complexity index to predict a desired operational aspect of the device, prior to operation of the device; and

outputting a desired operation aspect value to a display.

17. The method as recited in claim 16, further comprising obtaining the one or more corresponding reference parameters from a reference device.

18. The method as recited in claim 17, wherein the reference device has a lesser degree of complexity than the device.

19. The method as recited in claim 17, wherein selecting includes selecting one or more dimensional

parameters from each of a plurality of components of the device.

20. The method as recited in claim 19, wherein utilizing includes predicting a run life of the device.

21. The method as recited in claim 20, wherein predicting includes predicting the run life of an electric submersible pumping system.

22. The method as recited in claim 20, wherein deriving includes dividing a dimensional parameter by a corresponding reference parameter to obtain a indicator of relative complexity with respect to the dimensional parameter.

23. A method for predicting the run life of a downhole pumping system utilized in pumping a production fluid from a well, comprising:

assigning a complexity number to each component of a well-related pumping system, the complexity number reflecting the relative complexity of a given component to a reference component based on corresponding physical properties;

78543-14

adding together the complexity number of each component to obtain a comprehensive complexity index;

predicting the run life of the well-related pumping system based on the comprehensive complexity index, prior to operation of the well-related pumping system; and

outputting a run life value to a display.

24. The method as recited in claim 23, further comprising adjusting the comprehensive complexity index by a complexity factor derived from a comparison of the well-related pumping system to a reference system.

25. The method as recited in claim 23, further comprising adjusting the comprehensive complexity index by an environmental factor.

26. The method as recited in claim 24, further comprising adjusting the comprehensive complexity index by an environmental factor.

27. The method as recited in claim 23, wherein assigning includes assigning a complexity number to a submersible pump, a pump intake, a submersible electric motor and a motor protector.

28. A system for determining an output value related to a service parameter of a device having a plurality of components, comprising:

an interface to permit the entering of information related to the physical description of each of the plurality of components when each of the plurality of components is in an unused condition;

78543-14

a comparison module able to compare physical parameters of each component of the plurality of components to corresponding physical parameters of corresponding reference components to obtain a unique complexity index for each component;

a correlation module to process the complexity index of each component and to determine a run life of the device; and

a display on which the run life is displayed to an operator.

29. The system as recited in claim 28, further comprising an additive module able to add the unique complexity indices to obtain a comprehensive complexity index.

30. The system as recited in claim 28, further comprising a correlation module configured to correlate the unique complexity index with an output value related to the active service of the device.

31. The system as recited in claim 30, further comprising a display by which a user can view the output value.

32. The system as recited in claim 12, wherein the comparison module is a computer readable medium having stored thereon computer readable code for causing a computer to implement specific steps.

33. The system as recited in claim 12, wherein the correlation module is a computer readable medium having stored thereon computer readable code for causing a computer to implement specific steps.

78543-14

34. The system as recited in claim 31, wherein the display comprises a computer display screen.

35. The system as recited in claim 28, wherein the interface comprises a keyboard

78543-14

36. A system for determining an output value related to a service parameter of a device, comprising:

means for permitting the entering of information related to the physical description of the device;

means for comparing physical parameters of the device to corresponding physical parameters of a reference device to obtain a comprehensive complexity index;

means for correlating the comprehensive complexity index with an output value related to the active service of the device prior to operation of the device; and

means for viewing the output value.

37. The system as recited in claim 36, wherein the means for permitting comprises a keyboard.

38. The system as recited in claim 36, wherein the means for comparing comprises a comparison software module.

39. The system as recited in claim 36, wherein the means for correlating comprises a correlation software module.

40. The system as recited in claim 36, wherein the means for viewing comprises a computer display.

SMART & BIGGAR

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PATENT AGENTS

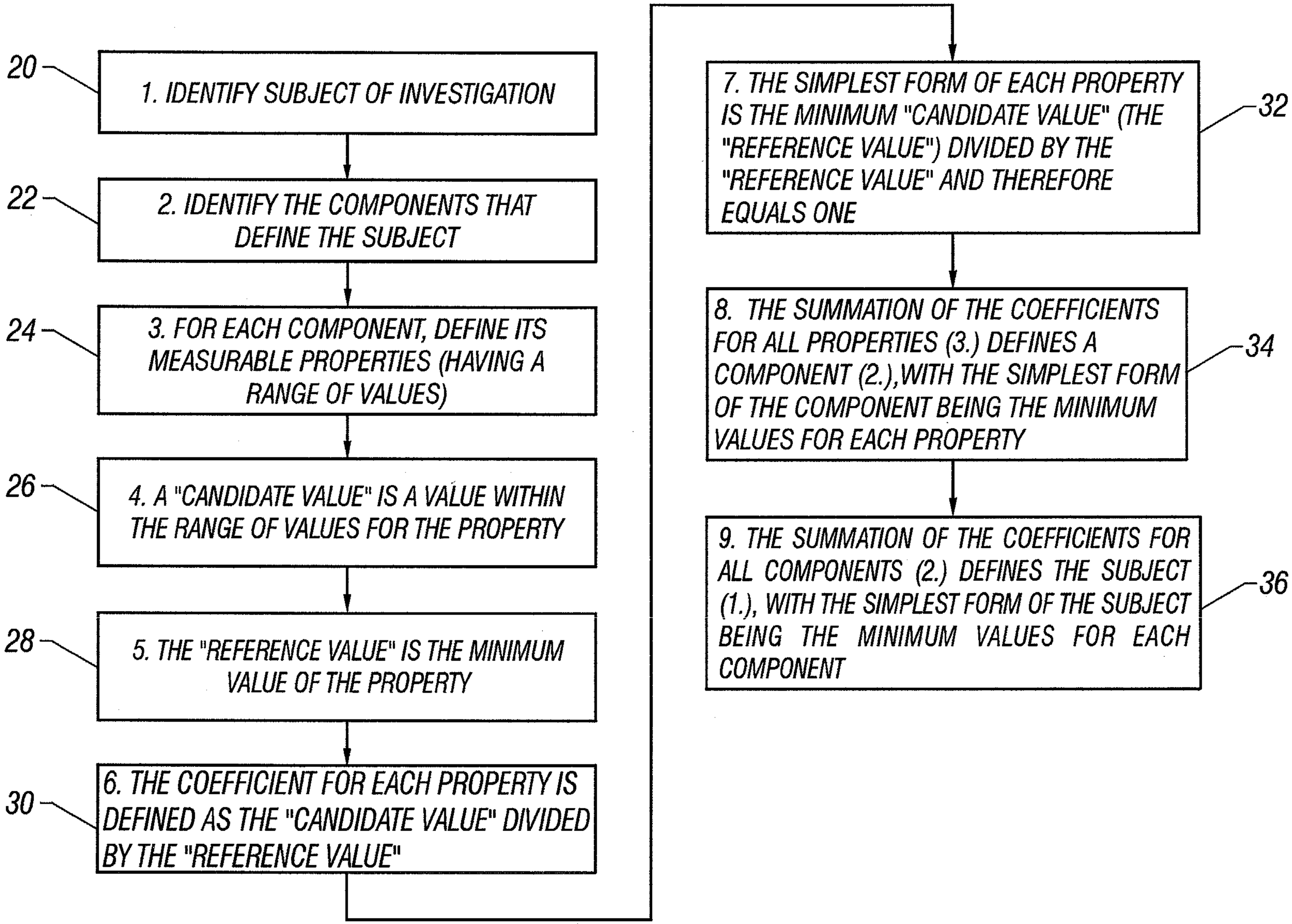


FIG. 1

TABLE OF RELATIONSHIPS AND VALUES

		46 DIAMETER (1)	SHAFT (2)	LENGTH (3)	MECHANICAL (4)	ELECTRICAL (5)
38	PUMP	SERIES O.D.^{2}-C / SERIES O.D.^{2}-R	N.A.	LENGTH C / LENGTH R	MECH C^A / MECH R^A	N.A.
40	INTAKE	SERIES O.D.^{2}-C / SERIES O.D.^{2}-R	N.A.	LENGTH C / LENGTH R	MECH C^B / MECH R^B	N.A.
42	PROTECTOR	SERIES O.D.^{2}-C / SERIES O.D.^{2}-R	SHAFT O.D.-C / SHAFT O.D.-R	LENGTH C / LENGTH R	MECH C^C / MECH R^C	N.A.
44	MOTOR	SERIES O.D.^{2}-C / SERIES O.D.^{2}-R	N.A.	LENGTH C / LENGTH R	MECH C^D / MECH R^D	ELECTRICAL C / ELECTRICAL R

C= CANDIDATE COMPONENT R= REFERENCE COMPONENT

(1) RELATING TO PRESSURE ACTING ON THE ROTORS/IMPELLERS
- *INTAKES: THIS VALUE WILL BE 0 (ZERO) FOR STATIC INTAKES BECAUSE THERE ARE NO MOVING PARTS.*
- *PROTECTORS: ARE SUBJECT TO GREATER LOADS WITH AN INCREASE IN O.D.*

(2) PROTECTOR: RELATED TO THE SEALING ABILITIES OF THE SHAFT SEALS. SEALING IS A FUNCTION OF THE PERIMETER, THEREFORE OF THE O.D. OF THE SHAFT.

(3) RELATES TO THE LENGTH OF THE COMPONENT. EACH COMPONENTS "REFERENCE" LENGTH IS THE LENGTH OF THE SIMPLEST (SHORTEST) PIECE FOR THAT COMPONENT. THE "CANDIDATE" PIECE IS THE PIECE FOR WHICH THE INDEX NUMBER IS BEING CALCULATED.

(4) MECHANICAL RELATES TO THE DISTANCE BETWEEN BEARINGS.
(A) = FOR PUMPS; (CANDIDATE MAX LENGTH/MAX STAGES) / (REFERENCE MAX LENGTH/REF. MAX STAGES)
(B) = FOR INTAKES; C. LENGTH / R. LENGTH WITH STATIC INTAKES=0.
(C) = FOR PROTECTORS; C. LENGTH / R. LENGTH.
(D) = FOR MOTORS; (C. MAX LENGTH/ C. MAX ROTORS) / (R. MAX LENGTH / R. MAX ROTORS)

(5) ELECTRICAL IS RELATED TO THE AMOUNT OF WORK PER FOOT (Hp) INVOLVING TEMPERATURE RISE.

FIG. 2

	COMPONENTS	CI	Equipment Design
	PUMP	8.20	22´/stg = 136 stg =153 stg, 80 Hsg. pump
	INTAKE	2.43	Type 70 Intake
A	PROTECTOR	3.82	LSB 400/456 protector
	MOTOR	4.28	.26 hp/stg = 39.8 = 50 hp 456 SX motor
		18.73	*(4/4) = 18.73
	PUMP	10.87	22´/stg = 227 stg = 229 stg, 120 Hsg. pump
	INTAKE	4.43	Intake
B	PROTECTOR	3.82	LSB 400/456 protector
	MOTOR	4.59	.26 hp/stg = 59.5 = 62.5 hp 456 SX motor
		23.71	*(4/4) = 23.71
	PUMP		22´/stg = 318 stg = 325 stg, 170 Hsg
	PUMP	8.20	= stg, 80 Hsg pump
	INTAKE	8.87	= stg, 90 Hsg pump
C	PROTECTOR	2.43	Type 70 Intake
	MOTOR	3.82	LSB 400/456 protector
		5.37	.26 hp/stg = 84.5 = 88 hp 456 SX motor
		28.69	*(5/4) = 35.86

FIG. 3

4/6

PART	SERIES	CI
INTAKE	338	1
INTAKE	400	1.4
INTAKE	540	2.3
INTAKE	562	2.77
INTAKE	675	3.99
MOTOR	375	1
MOTOR	456	1.48
MOTOR	540	2.1
MOTOR	562	2.25
MOTOR	738	3.87
PROTECTOR	325	1
PROTECTOR	375	1.33
PROTECTOR	400	1.51
PROTECTOR	540	2.49
PROTECTOR	562	3
PROTECTOR	738	5.16
PROTECTOR	950	8.54
PUMP	338	1
PUMP	400	1.4
PUMP	538	2.53
PUMP	540	2.3
PUMP	562	2.77
PUMP	675	3.99
PUMP	862	6.52
PUMP	950	7.9
PUMP	1000	8.75
PUMP	1125	11.08

FIG. 4

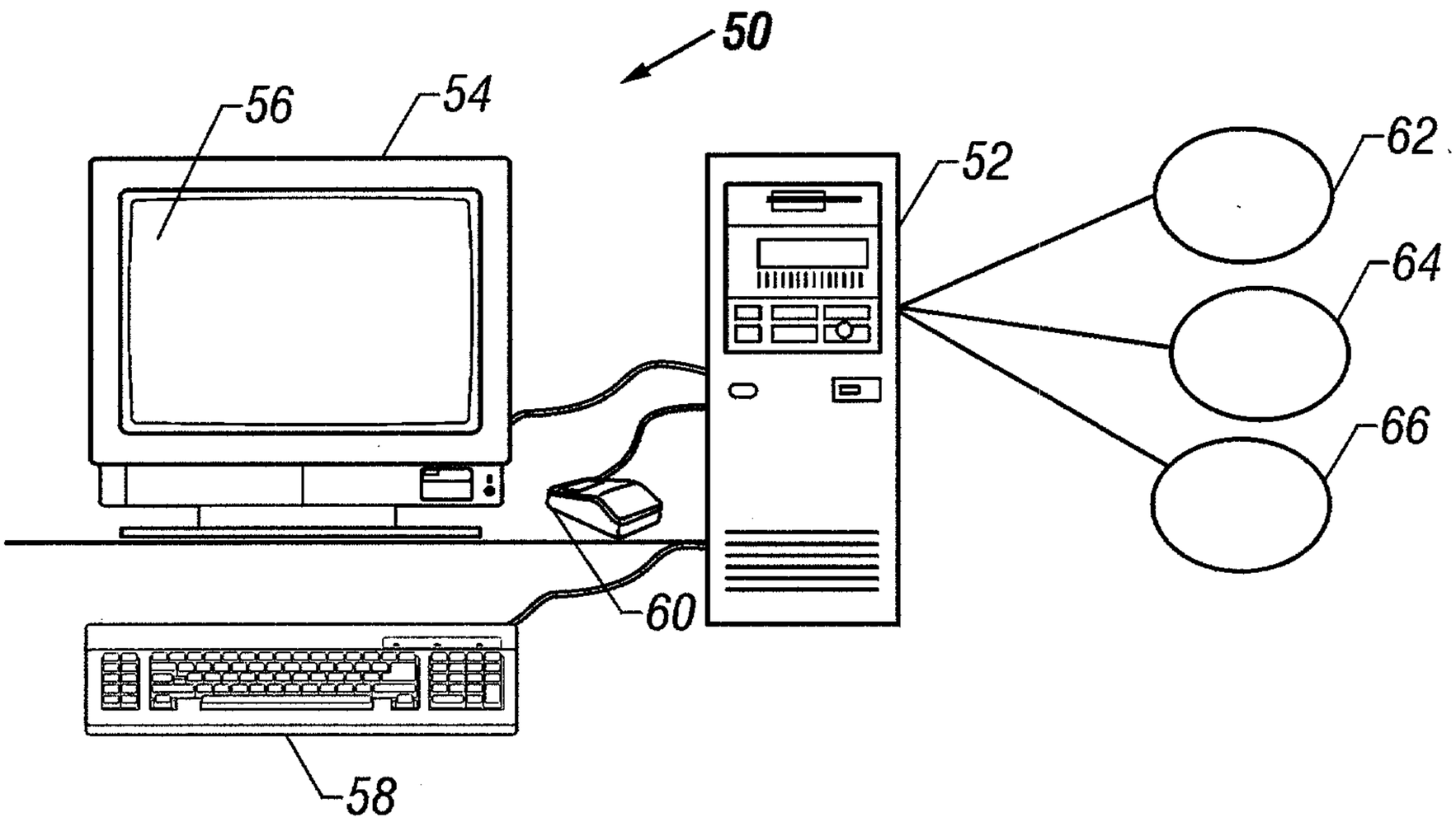


FIG. 5

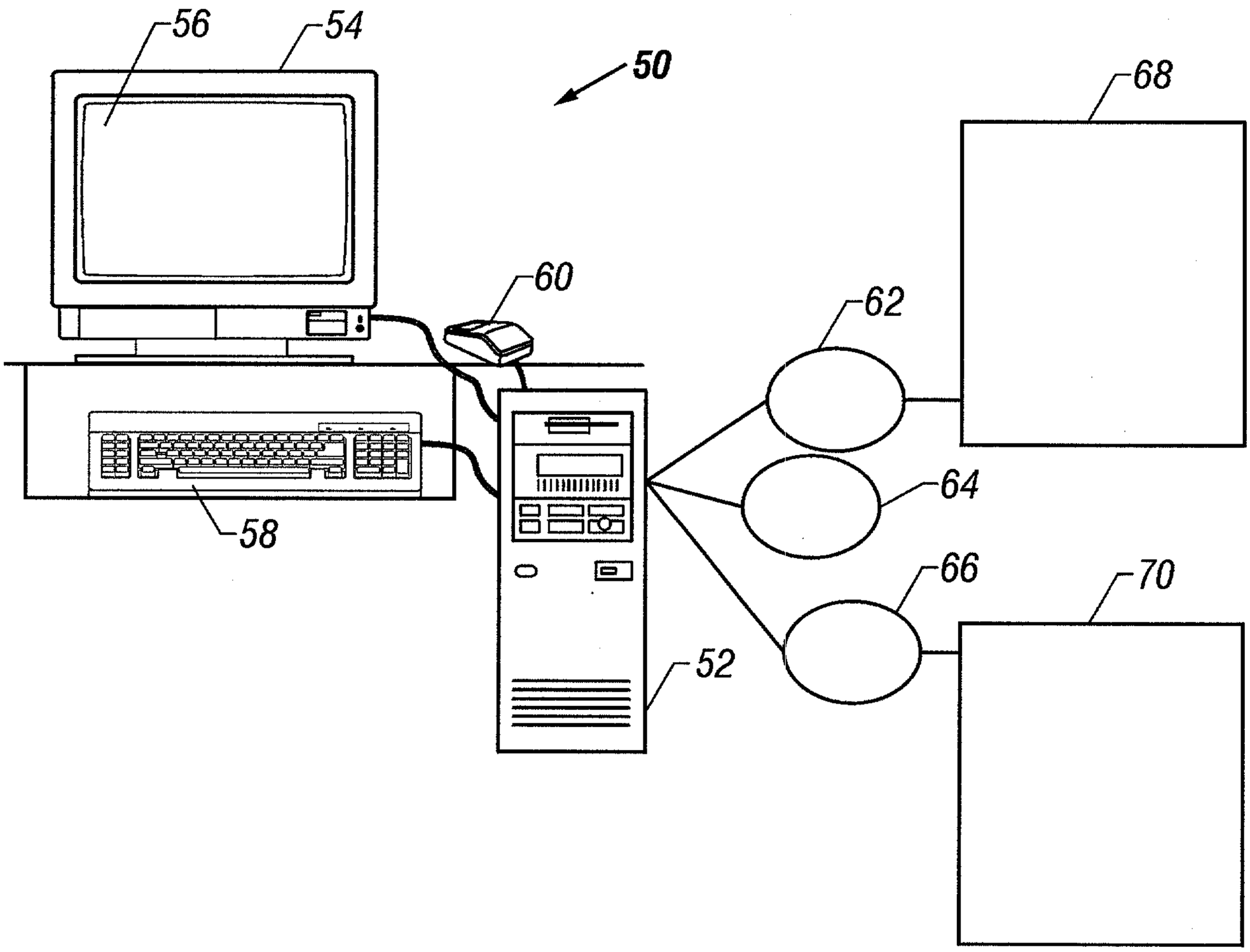


FIG. 6

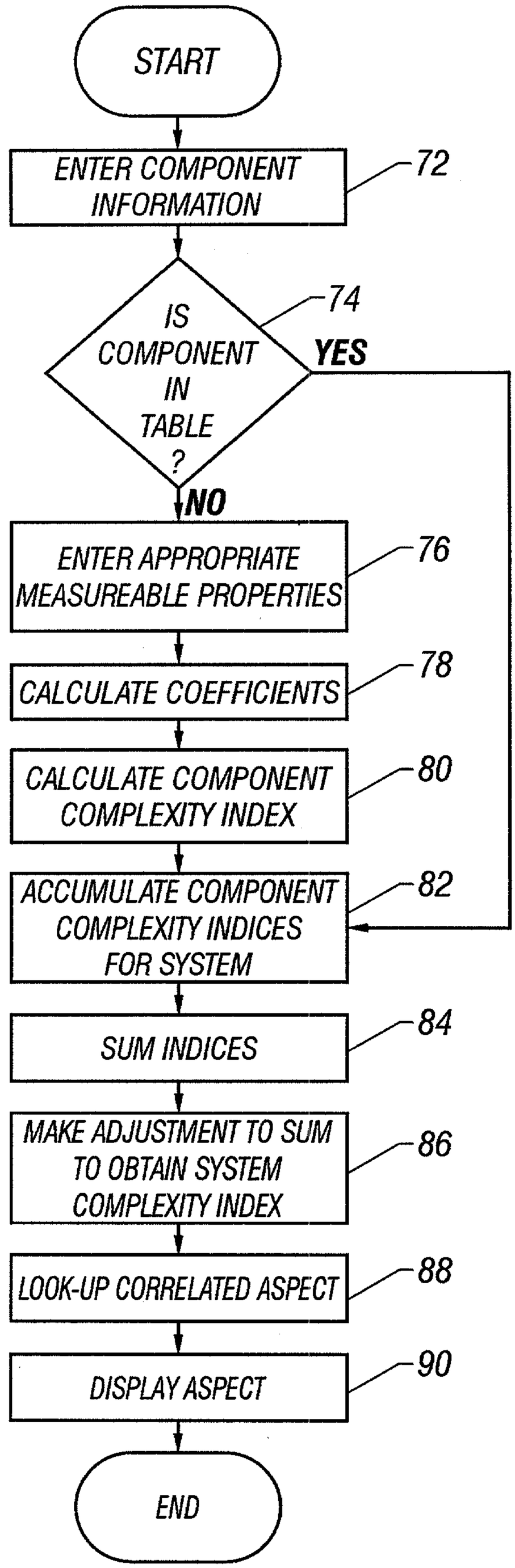
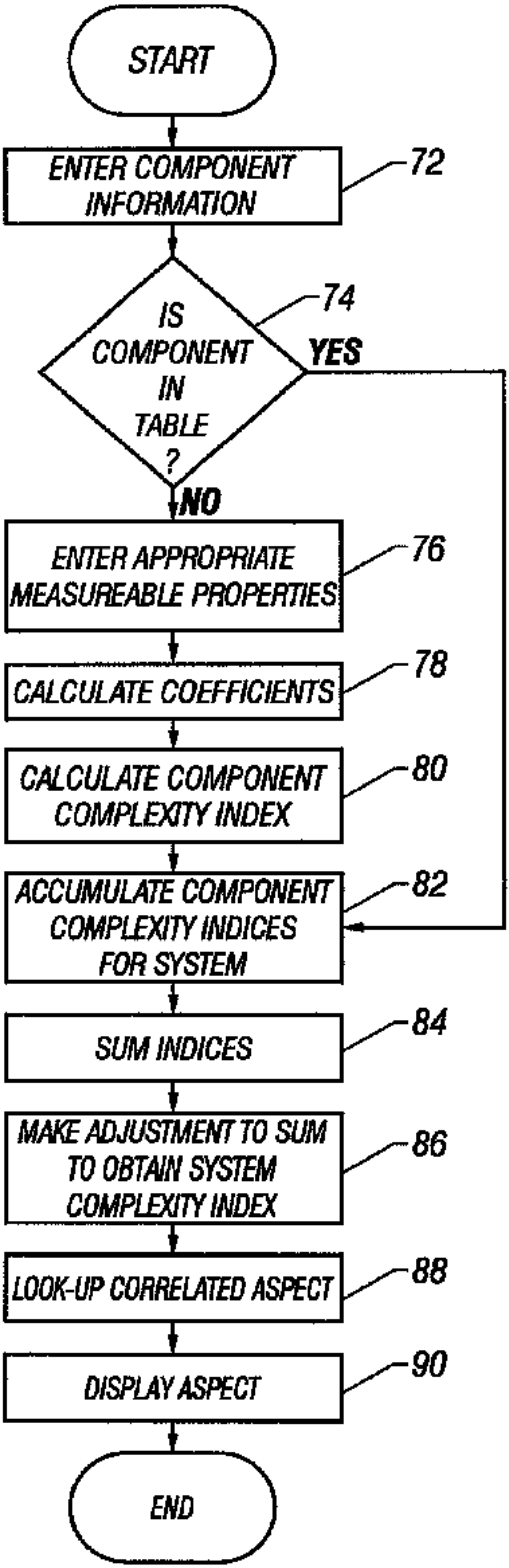

START
ENTER COMPONENT INFORMATION
72
IS COMPONENT IN TABLE ?
74
YES
NO
ENTER APPROPRIATE MEASUREABLE PROPERTIES
76
CALCULATE COEFFICIENTS
78
CALCULATE COMPONENT COMPLEXITY INDEX
80
ACCUMULATE COMPONENT COMPLEXITY INDICES FOR SYSTEM
82
SUM INDICES
84
MAKE ADJUSTMENT TO SUM TO OBTAIN SYSTEM COMPLEXITY INDEX
86
LOOK-UP CORRELATED ASPECT
88
DISPLAY ASPECT
90
END

FIG. 7


START
ENTER COMPONENT INFORMATION
72
IS COMPONENT IN TABLE ?
74
YES
NO
ENTER APPROPRIATE MEASUREABLE PROPERTIES
76
CALCULATE COEFFICIENTS
78
CALCULATE COMPONENT COMPLEXITY INDEX
80
ACCUMULATE COMPONENT COMPLEXITY INDICES FOR SYSTEM
82
SUM INDICES
84
MAKE ADJUSTMENT TO SUM TO OBTAIN SYSTEM COMPLEXITY INDEX
86
LOOK-UP CORRELATED ASPECT
88
DISPLAY ASPECT
90
END