

71 79

SUPERINDUSTRIA Y COMERCIO

Radicación : 01067401 00000005

Folios: 2

Fecha (AMB): 2004-02-26 16:26:58

Trámite : 002 PATENTES D 1 REGISTRO/ 530 PETITION

Dependencia: 2020 DIVISION DE NUEVAS CREACIONES

Señor

SUPERINTENDENTE DE INDUSTRIA Y COMERCIO

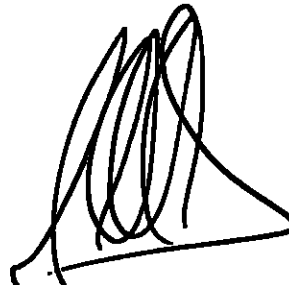
DIVISION DE NUEVAS CREACIONES

E. _____ S. _____ D. _____

Re: **P1.-CENTRO INTERNACIONAL DE FISICA. CIE: INSTITUTO COLOMBIANO PARA EL DESARROLLO DE LA CIENCIA Y LA TECNOLOGÍA "FRANCISCO JOSE DE CALDAS". COLCIENCIAS e INSTITUTO NACIONAL DE VIAS, "INVIAS".-Solicitud de Patente de Invención para "APARATO PARA MONITOREO DINAMICO DE ESTRUCTURAS , EL CUAL JUNTO CON UN NODO CENTRAL FORMA UN CONJUNTO PARA EL MONITOREO DINAMICO DE ESTRUCTURAS".-Clase G.01N.-Expediente número 01-067.481.-**

1. Me refiero a mi memorial de 3 de Julio de 2002.
2. De conformidad con el precepto del Artículo 44 de la Decisión 486 y estando dentro del plazo de seis meses contados desde la fecha de la publicación de la solicitud en la Gaceta de la Propiedad Industrial número 531 de 29 de Agosto de 2003, solicito a ese Despacho proceder a realizar el examen de patentabilidad de la presente invención.
3. Anexo me permito acompañar recibo número 04-1.298, expedido por la Superintendencia de Industria y Comercio, que acredita el pago de la tasa que dicho examen causa.

Señor Superintendente,



JOSE ANTONIO LLOREDA

T.P. 10.784

Código 231

72 75

SUPERINDUSTRIA Y COMERCIO
Radicacion : 01067481 00000005 Folios: 2
Fecha (HH): 2004-02-26 16:26:58
Tramite : 002 PATENTES D 1 REGISTRO/ 538 PETICION
NIT : 800176089 Dependencia: 2020 DIVISION DE NUEVAS CREACIONES

RECIBO OFICIAL DE CAJA : 04 - 1,298
FECHA : ENERO 8 DE 2004

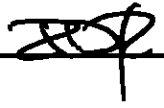
***** CONSIGNACION *****

DEPOSITANTE	TIPO PAGO	BANCO	CUENTA	No. PAGO	FECHA PAGO	Vr. PAGO
LLOREDA Y CIA S. A	CONSIGNACION	BANCO POPULAR	050-00110-6	13458908	08/01/2004	3,302,000.00

***** CONCEPTO *****

CANT. RENTISTICO	CONCEPTO	TOTAL CONCEPTO
1 50005-01-01 SOLICITUDES	05 EXAMEN DE PATENTABILIDAD DE INVEN	353,000.00
	TOTAL :	\$ 353,000.00

SON: TRESCIENTOS CINCUENTA Y TRES MIL PESOS

RESPONSABLE : 

RECIBO DE CAJA APLICADO AL EXPEDIENTE No. _____

DIVISION DE NUEVAS CREACIONES

RADICACIÓN EXPEDIENTE No. 01-67481

EL EXTRACTO DE LA PRESENTE SOLICITUD DE PATENTE DE INVENCION FUE PUBLICADO

EN LA GACETA DE PROPIEDAD INDUSTRIAL No 531, DE FECHA 29 DE AGOSTO DE 2003,

EL TERMINO HABIL SEÑALADO POR LA LEY EXPIRA EL 26 DE NOVIEMBRE DE 2003.

NOTA: Dentro del plazo de los seis (6) meses siguientes a partir de la fecha de publicación en la gaceta de Propiedad Industrial, deberá solicitar y cancelar el examen de patentabilidad so pena de que la solicitud caiga en abandono, de acuerdo con lo establecido en el Artículo 44 de la Decisión 486/2000.

SE PRESENTARON OPOSICIONES POR PARTE DE TERCEROS.

SI

NO **X**

SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO**DIVISIÓN DE NUEVAS CREACIONES**

2020
Bogotá D.C.

Doctor:
José Antonio Lloreda
Apoderado

REFERENCIA:

Radicación	01-67.481
Trámite	002
Evento	001
Actuación	430
Oficio No	6385
Folios	033

Como resultado del examen de fondo, realizado conforme a lo establecido por el artículo 45 de la Decisión 486 de la Comisión de la Comunidad Andina, se le comunica:

1. Documentos estudiados:

Para el presente estudio se tuvo en cuenta la descripción de los folios 4 a 34, los dibujos 1 a 5 de los folios 39 a 43 y las reivindicaciones 1 a 12 de los folios 35 a 38, apartes que corresponden a la radicación inicial, y que se aceptaron.

El artículo 9 de la Decisión 486 de la Comisión del Acuerdo de Cartagena establece que, "La primera solicitud de patente de invención... conferirá al solicitante o su causahabiente el derecho de prioridad para solicitar... misma materia. El alcance y los efectos del derecho de prioridad serán los previstos por el Convenio de París... a) doce meses para las patentes de invención y modelos de utilidad...".

La solicitud en estudio fue radicada el 17 de agosto de 2001, en ese momento ni posteriormente no se reclamó prioridad alguna, por lo tanto, acorde a lo dispuesto por los artículos 9 a 11 de la Decisión 486, no hay prioridad válida reivindicada.

2. Objeto de la Invención

Según la descripción, el objeto de la solicitud consiste en suministrar un aparato para monitoreo dinámico de estructuras, que proporciona información en tiempo real del estado de una o más estructuras para que, quienes hacen el mantenimiento puedan tomar las decisiones pertinentes.

De otra parte, el pliego reivindica: un aparato para el monitoreo dinámico de estructuras, relacionado en las reivindicaciones 1 a 8 y un conjunto de aparato(s) como el descrito en cualquiera de las reivindicaciones 1 a 8, relacionado en las reivindicaciones 9 a 12.

Según la IPC la clasificación del objeto reclamado es G05D 19/02.

3. Claridad de la solicitud:

El artículo 30 de la citada Decisión indica que: "las reivindicaciones definirán la materia que se desea proteger mediante la patente. Deben ser claras y concisas y estar enteramente sustentadas por la descripción".

Las reivindicaciones 1, 3, 4 y 9 incluyen explicaciones ajenas a la definición que se persigue, porque no son características de estructura o de función entre los componentes del equipo sino que explican el uso que se le va a dar a dicho equipo, en los siguientes apartes: "en donde dicho aparato... remota", "en donde el microcontrolador... monitoreo", "en donde la batería... solar", "en donde dicho nodo... ¿reivindicaciones 1 a 10?".

Las reivindicaciones 7 y 8 no aclaran o delimitan una característica de los medios que componen el aparato o una función entre aquellos sino se refieren a efectos del uso como lo señalan las afirmaciones: "en tiempo real y de manera permanente" y, "el envío de la información... se presentan".

La reivindicación 9 es inaceptable porque hace una doble referenciación, la primera a las reivindicaciones precedentes 1 a 8, lo cual NO se permite porque NO es posible determinar qué se trata de definir si un "conjunto" o un "aparato"; y al final se referencia de la 1 a la 10, esta última aún NO enunciada en el pliego.

Las observaciones de este punto se deberán resolver en conjunción con las observaciones del punto 5 de adelante.

Por las razones precedentes, se concluye que las reivindicaciones calificadas no cumplen las disposiciones del artículo 30.

4. Evaluación de la unidad de invención:

El artículo 25 de la Decisión 486 establece que, "La solicitud de patente sólo podrá comprender una invención o un grupo de invenciones relacionadas entre sí, de manera que conformen un único concepto inventivo".

El pliego calificado incluye dos grupos de reivindicaciones no enlazadas por un concepto común e inventivo, así:

El primer grupo lo integran las reivindicaciones 1 a 8 que se dirigen a un aparato para monitoreo dinámico de estructuras.

El segundo grupo son las reivindicaciones 9 a 12 dirigidas a un conjunto de aparato(s) y un nodo central enlazados en red en estrella.

5. No cumplimiento de los requisitos de patentabilidad:

El artículo 14 de la Decisión 486 establece que: "Los países miembros otorgarán patentes para las invenciones, sean de **producto** o de **procedimiento** (...) Industrial", (resaltado fuera de texto).

Para dar cumplimiento a tal requisito, y teniendo en cuenta que ni la Decisión ni el reglamentario ni el Manual Andino establecen, taxativamente, cómo se debe definir cada uno de esos conceptos, la oficina, acude a la *Guía sobre el examen de las solicitudes de patentes*, publicada por la OMPI en 1982, la cual es para ayudar a los examinadores de la oficinas nacionales en sus estudios.

En el párrafo 57 (de dicha guía) se especifica que existen dos tipos de reivindicaciones: de **producto** y de **procedimiento** (método). Adicionalmente, el citado párrafo indica que las reivindicaciones de **producto** deben definir, el objeto que se desea proteger, mediante las características estructurales ó de función.

De allí, es evidente que un **producto** debe ser definido o bien por las características de estructura o bien por las características de funcionamiento pero **N** mediante una mezcla

de ellas ni menos por los efectos del uso.

Las reivindicaciones del pliego calificado incluyen mezclas de características no permitidas, como se evidencia de su redacción, ejemplo:

"3. el aparato... un convertidor... para convertir... un microcontrolador... en donde... "

"5. el aparato... un modem... para el envío... y una antena...".

"11. el conjunto... para el envío...".

De lo anterior es evidente que la parte no subrayada son características estructurales, y la subrayada, características de uso o consecuencias de mismo.

Por las razones expuestas la oficina considera, que el pliego no cumple las disposiciones del artículo 14.

6. Determinación del estado de la técnica:

La fecha para determinar el estado de la técnica es 17 de agosto de 2001.

Consultadas las fuentes de información con que cuenta este despacho se encontraron los siguientes documentos anteriores a la fecha de radicación 17 de agosto de 2001, relacionados con la materia de la solicitud:

No	Documento	Título	Fecha de publicación
1	US 4 184 205	Data acquisition system	13 01 1980
2	DE 297 12 823U	Meßeinrichtung zur bauwerksüberwachung	18 09 1997
3	WO98/10 393	Vibration monitor and transmission system	12 03 1998
4	EP 1 022 702	Super high frequency multipoint fixed-access wireless communications system	26 07 2000

7. Evaluación de los requisitos de patentabilidad:

En cumplimiento del artículo 14 de la Decisión 486, el cual, dispone que: "Los países miembros otorgarán patentes para las invenciones, sean de producto o de procedimiento, en todos los campos de la tecnología, siempre que sean nuevas, tengan nivel inventivo y sean susceptibles de aplicación industrial"; se procedió a evaluar los requisitos de fondo con el objeto de establecer la patentabilidad de las reivindicaciones de la solicitud presentadas para tal efecto.

Evaluación del nivel inventivo

Conforme al artículo 18 de la decisión 486 que establece "Se considerará que una invención tiene nivel inventivo, si para una persona del oficio normalmente versada en la materia técnica correspondiente, esa invención no hubiese resultado obvia ni se hubiese derivado de manera evidente del estado de la técnica".

La persona del oficio, normalmente versada en la materia técnica correspondiente, que se puede encargar de solucionar el problema planteado en la presente solicitud, puede ser un ingeniero electromecánico con experiencia en sistemas electromecánicos de medición de vibraciones, que conozca la composición y los principios básicos de funcionamiento de dichos sistemas o, por lo menos, que cuente con las condiciones necesarias para informarse acerca de esos principios al consultar la literatura técnica respectiva.

La anterioridad 3 (WO 98/10.393) divulga una disposición (aparato) para monitorear estructuras (máquinas) que comprende:

- a) un sensor de aceleración o acelerómetros, (ver página 7 líneas 28 a 30, figuras 1, 3 posiciones 4, 408);
- b) un sistema de adquisición de datos (ver página 8 líneas 9 a 15, figura 3 posición 418);
- c) una fuente de alimentación o "sistema de suministro de energía", que puede ser una celda solar (ver página 10 líneas 14 a 20, figura 3 posición 438);
- d) un sistema de comunicaciones (ver página 9 líneas 10 a 14, figuras 1, 3);
- e) una carcasa o gabinete de protección que encierra y protege los componentes antes citados y tiene medios para fijarla a la estructura, (ver página 7 líneas 16 a 20, figura 2 posición 402). Dicho aparato (carcasa) es portátil, que puede fijarse a una estructura a ser monitoreada y transmitir datos a una estación central remota (ver figura 1 posición 6).

De lo precedente, es evidente que la publicación revela todas las características esenciales de lo reivindicado, la única diferencia consiste en que dicha publicación no menciona, explícitamente, que el sistema de adquisición de datos 418 sea para calcular las frecuencias y el desplazamiento.

Sin embargo, se trata de una técnica muy conocida en el arte como se puede ilustrar con el antecedente 1 (ver el extracto, de línea 25 columna 1 a línea 8 columna 2, columna 4 líneas 8 a 11) que se emplea para el mismo propósito.

Aún más, un técnico en la materia sabe que el monitoreo de las vibraciones de una estructura se realiza con base en la amplitud (desplazamiento) y la frecuencia de dichas vibraciones.

De lo anterior se concluye, que un técnico en la materia pudo haber derivado, de forma evidente lo reivindicado en 1 del estado del arte, en consecuencia, esa reivindicación NO tiene nivel inventivo.

Respecto a las reivindicaciones dependientes estas, de un lado, quedan sin soporte al no depender de una reivindicación patentable; de otro lado, se refieren a componentes ampliamente conocidos en el estado de la técnica, como se expone a continuación.

La anterioridad 2, modelo de utilidad alemán DE 297 12 823U, enseña un equipo fijable a una construcción (estructura) que incluye 3 sensores, uno para cada uno de los ejes x, y, z y que son acelerómetros (ver reivindicación 2, la figura). Lo anterior destruye el nivel inventivo de la reivindicación 2.

La anterioridad 3 (WO 98/10.393), que como se indicó arriba incluye un sistema de adquisición de datos, que se muestra en la figura 3, incluye un amplificador 412, un filtro 414 para la señal entregada por el sensor (acelerómetro), un convertidor A/D 416, un microprocesador 418 con una memoria 422. Esto destruye el nivel inventivo de la reivindicación 3.

La publicación 3 también divulga una fuente de energía que puede ser una batería 438, un monitor del estado de la batería o una celda solar (ver figura 3, página 10 líneas 14 a 25). De aquí que la reivindicación 4 tampoco tiene nivel inventivo.

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La anterioridad 3 enseña que el sistema de comunicación incluye medios de transmisión (ver reivindicación 15); además, tanto la misma anterioridad 3 como los antecedentes 2 y 4 divulgan las antenas transceptoras. Por esta razón la reivindicación 5 no tiene nivel inventivo.

Lo reivindicado en 6 es solo la elección de un tipo de modem para los datos a procesar, lo que forma parte del trabajo diario de un técnico, por ello esta reivindicación no tiene nivel inventivo.

Los documentos 1 a 3 realizan el monitoreo de una estructura (máquina o construcción) de forma continua y en tiempo real, (ver página 12 líneas 25 a 29 anterioridad 3); adicionalmente, el equipo transmite las señales en ciertos momentos (ver extracto de los documentos 3 y 4), lo cual, destruye el nivel inventivo de las reivindicaciones 7 y 8, además, son un uso como se señaló arriba en 3.

La reivindicación 9 se diferencia de lo revelado por el antecedente 3 en que no se revela, explícitamente, el equipo de "almacenamiento, análisis y alarma", porque dicha anterioridad divulga un conjunto de aparatos y un nodo central dispuestos en una red en estrella (ver figura 1) cuya estación central incluye un equipo receptor de comunicaciones 602, un computador 612 y una base de datos (ver figura 4, de línea 26 página 10 a línea 4 página 11).

En nuestra opinión, un técnico en el arte habría considerado muy necesario incluir un "sistema" de alarma que informe a un supervisor el mal funcionamiento de uno o más aparatos del conjunto. Aún más, la última referencia (EP 1 022 702) lo divulga en el mismo sentido, (ver de línea 9 columna 6 a línea 17 columna 7, figura 4 de ese documento). Lo anterior provoca que la reivindicación 9 no presente nivel inventivo.

Según lo revela el antecedente 3 (ver figura 7), la antena 802 es para el envío y la recepción de datos, que corresponde al dispositivo telemétrico que para poder funcionar debe incluir una batería o estar conectado a una fuente. Por esto la reivindicación 10 no tiene nivel inventivo.

Para un técnico en la materia es evidente, que para un sistema teleinformático pueda enviar o recibir datos además de una antena se debe contar con un transceptor o un modem; asimismo, un "conjunto" no funcionaría si no incluye una batería o está conectado a una fuente de alimentación; por estas razones, lo reivindicado en 11 y 12 es evidente del estado del arte, por lo que no tienen nivel inventivo.

A la luz de todo lo antes expuesto queda claro que el pliego calificado no presenta nivel inventivo respecto del estado de la técnica, puesto que un técnico en la materia lo habría podido derivar de allí sin ningún esfuerzo intelectual adicional.

En conclusión los requisitos de patentabilidad de la presente solicitud se encuentran afectados así:

N .	Documento	Reivindicación(es) Afectada(s)	Requisito que afecta
1	US 4 184 205; ver el extracto; de línea 25 columna 1 a línea 8 columna 2, columna 4 líneas 8 a 11 .	1	Nivel inventivo
2	DE 297 12 823U, ver todo el documento.	2	Nivel inventivo

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3	WO 98/ 10 393, ver de pagina 6 línea 31 a línea 30 página 7; página 8 líneas 9 a 15; página 9 líneas 10 a 14; página 10 líneas 14 a 25; página 12 líneas 25 a 29; de línea 26 página 10 a línea 4 página 11; figuras 1 a 4, 7; reivindicación 15.	1 a 12	Nivel inventivo
4	EP 1 022 702; ver el extracto; de línea 9 columna 6 a línea 17 columna 7; las figuras.	1 a 12	Nivel inventivo

En cumplimiento del artículo 45 de la decisión 486 de la Comisión de la Comunidad Andina, se le indica que debe dar respuesta dentro del término de sesenta días contados a partir de la fecha de notificación de la presente comunicación. En el caso de no dar respuesta al presente requerimiento, o si a pesar de la respuesta subsisten impedimentos para la concesión, se denegará la patente.

Notifíquese el presente oficio conforme a lo dispuesto en el numeral 5.2, literal e), del capítulo quinto del título primero de la Circular Única No 10 de 2001.


ALIX CÉSPEDES DE VERGEL
Jefe de la División de Nuevas Creaciones

El anterior requerimiento fue notificado por fijación en lista, de fecha 11 AGO. 2005

Concepto Técnico	Examinador Técnico IE	Examinador jurídico
Número: 1124	Código: 202004	Código:

[54] DATA ACQUISITION SYSTEM

[75] Inventor: Robert S. Marrow, Columbus, Ohio.

[73] Assignee: IRD Mechanicals, Inc., Columbus, Ohio

[21] Appl. No.: 854,939

[22] Filed: Nov. 23, 1977

[51] Int. Cl.² G06F 15/34

[52] U.S. Cl. 364/508; 73/577;

73/659; 340/683; 364/350

[58] **Field of Search** 364/308, 554, 550, 551;
340/683, 679, 72/570, 577, 578, 600, 602, 650

340/683, 679, 73/570, 577, 579, 600, 602, 658,
659, 673, 235/302.2, 304

859, 87.3; 233/302.2, 304

[36] References Cited

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You Anticipate and Prevent Failures," Instruments & Control Systems, Feb. 1975, pp. 59-62.

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Javid et al., *Analysis, Transmission, and Filtering of Signals*, McGraw-Hill Book Co., 1963, p. 180.

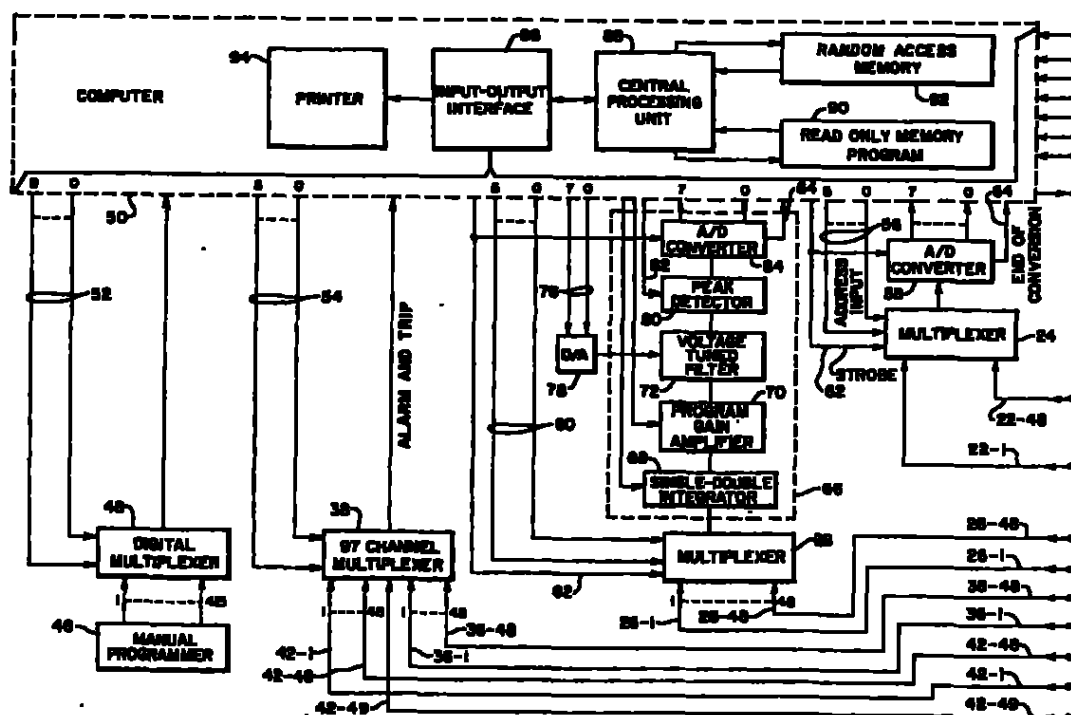
Primary Examiner—Ertol A. Krasn

Attorney, Agent, or Firm—Thomas H. Murray

[57] **ABSTRACT**

A data acquisition system utilizing a microcomputer and incorporating a plurality of monitors each adapted to produce an electrical signal indicative of a physical condition of apparatus to be monitored. The electrical signals are fed via multiplexing equipment and analog-to-digital converters into the microcomputer which is equipped with print-out means. The system is such that the level of any one or all of the signals from the respective monitors can be printed out as well as a change in the condition of any signal. Means are incorporated into the computer for calculating and printing the trend (i.e., the slope of a plot of signal amplitude versus time) of a succession of stored signals from any monitor which would indicate a probable malfunction of a device being monitored and the probable time to failure. In the case where the signals from the monitors comprise vibration signals, the system performs an automatic frequency spectrum analysis whenever a probable or actual malfunction is detected.

20 Claims, 6 Drawing Figures



DATA ACQUISITION SYSTEM

While not limited thereto, the present invention is particularly adapted for use in monitoring vibrations produced by rotating or other types of machinery in a complete industrial installation, such as a refinery. By monitoring vibrations in this manner, malfunctions and probable future failures of any machines within the industrial installation can be readily ascertained; and corrective action can be taken immediately and before a breakdown or possible dangerous condition occurs.

There are at present essentially two types of data acquisition systems—the dedicated minicomputer system and the simple data logger. Computer systems generally include disc memory for data storage, CRT terminals for display of data and line printers for hard copy of data. As a result, they require a relatively large capital investment. While simple data loggers are relatively inexpensive, they offer simple functions only such as logging data and comparing the data to setpoints.

SUMMARY OF THE INVENTION

In accordance with the present invention, a data acquisition system is provided which does not require a large capital investment but which, nevertheless, is capable of printing out complete system information including a malfunction of any one of a number of different devices being monitored, the time to failure of any piece of equipment being monitored, and an analysis of the input information. In the case where the invention is used in a vibration monitoring system, it performs the functions of automatic channel data logging, frequency spectrum analysis, and vibration level trend prediction. Each of these functions additionally may be manually selected for each individual monitor or channel via front panel controls. A built-in system fault detection circuit is used which will respond to either an internal or circuit fault or to an external system alarm relay closure. Data readout is obtained via a self-contained dot-matrix printer assembly.

All functions of the data acquisition system of the invention are under the control of an internal microcomputer which continuously samples data from a plurality of monitors. At each monitor, vibration input signals are obtained directly from velocity pickups, self-amplified accelerometers, noncontact signal sensors or from accelerometer preamps. In addition, direct current signals proportional to vibration level or amplitude and trip alarm signals are obtained from the monitors, these latter signals being derived by comparison of the actual vibration signal with reference signals proportional to preselected alarm and trip levels.

The system automatically indicates, via the computer print-out, those channels which go into a trip condition within a preselected time span. That is, the time to failure is calculated and displayed via the print-out. Each channel's "look ahead" time may be selected with a user-programmable jumper board within the computer. Additionally, trend prediction for any individual channel or monitor may be manually requested at any time via front panel trend and channel selection switches.

The system also incorporates frequency spectrum analysis circuitry which provides frequency spectrum sampling of input vibration signals over a wide range of frequencies in 1/20 octave steps. Only those frequencies whose amplitudes are greater than 10% of full scale are

listed on the paper tape computer print-out, along with the overall vibration level. Vibration analysis is performed automatically upon receipt of a trip or alarm signal, for a calculated trend alarm for any channel, or at preset intervals. The paper tape print-out indicates which channel has gone into a fault condition and what that condition was (i.e., trip, alarm or trend alarm) as well as a change in any channel's condition.

The above and other objects and features of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings which form a part of this specification, and in which:

FIGS. 1A and 1B (hereinafter referred to together as "FIG. 1") comprise a schematic block diagram of the data acquisition system of the invention;

FIGS. 2 and 3 graphically illustrate the manner in which successive sampled vibration level signals are stored in the computer of the acquisition system and the manner in which a trend (i.e., time to failure) is determined; and

FIGS. 4 and 5 graphically illustrate the operation of the voltage tuned filter utilized in the spectrum analyzer of the invention.

With reference now to the drawings, and particularly to FIG. 1, the data acquisition system shown includes forty-eight channels or monitors for monitoring a physical condition of a device to be monitored. Only monitor Nos. 1 and 48 are shown in the drawing and are identified by the reference numerals 10 and 12. It will be further assumed for purposes of explanation that the data acquisition system is to be used in a vibration monitoring system. Thus, each monitor, such as monitor 10, is connected to a vibration pickup 14 in contact with a bearing of a rotating member 16, for example, and adapted to produce either a displacement, velocity or acceleration vibration signal. Pickup 14 is connected through an amplifier 18 to a rectifier 20 which will produce an essentially steady-state direct current output signal on lead 22-1 which is applied to one input of a first multiplexer 24. Similarly, each of the other monitors will apply an input to the multiplexer 24, only the lead for the last monitor 48 being shown in the drawing and identified by the reference numeral 22-48.

The oscillatory vibration signal from the pickup 14 is also applied directly via lead 26-1 to a second multiplexer 28. The same is true of the remaining monitors, the oscillatory signal for the last monitor 12 being applied via lead 26-48 to multiplexer 28. Each of the monitors also incorporates first and second comparators and relays 30 and 32. In comparator 30, for example, the direct current signal from rectifier 20, representing the amplitude of the vibration signal, is compared with a direct current signal from D.C. reference voltage source 34. If the direct current signal from rectifier 20 equals or exceeds the magnitude of the signal from source 34, then a relay is actuated to produce a steady-state direct current signal on lead 36-1 connected to the input of a third multiplexer 38. The amplitude of the direct current signal from rectifier 20 at which the relay is closed to energize lead 36-1 is chosen arbitrarily and represents that amplitude of the vibration signal which signifies an alarm condition (i.e., an imminent malfunction). Similarly, the output of rectifier 20 is compared with a direct current signal from D.C. reference voltage source 40 in the comparator and relay 32, the arrangement being such that when the amplitude of the vibra-

tion signal reaches a point where the device being monitored should be shut down, the relay is actuated to energize lead 42-1. This trip signal on lead 42-1 is also applied to the third multiplexer 38. Even though the equipment in question may be shut down automatically upon receipt of a trip signal, ordinarily sufficient momentum of the rotating parts, for example, will keep the parts rotating for a sufficient period of time to permit a meaningful spectrum analysis and data log to be taken. Alarm and trip signals are also applied to the multiplexer 38 from each of the other forty-seven monitors, the alarm signal from monitor 12 being on lead 36-48 and the trip signal from monitor 12 being on lead 42-48.

Included in each monitor, such as monitor 10, is an external fault detector 44 adapted to detect faults such as a change in impedance due to breakage in the cable leading to the pickup 14 or an inaccurate gap for a non-contact vibration pickup such as that shown in U.S. Pat. No. 3,707,671. Whenever an external fault occurs, a signal is applied to the trip lead 42-49, common to all monitors, and applied to the multiplexer 38. As will be seen, in the particular embodiment of the invention shown herein, the occurrence of an external fault at any monitor causes a printer to print-out "SYSTEM ALARM" without identifying the channel from which the fault signal was derived. This must be derived by manual examination of each monitor.

A manual programmer 46, comprising an internal jumper board, allows manual selection of individual channel parameters such as trip level setpoint for trend prediction and full-scale range for each channel, along with appropriate units of measure such as mils, inches per second or G's. A selection of sixteen combinations of (i.e., four binary bits) full-scale range in engineering units is provided for each channel. These sixteen choices, specified by the user of the data acquisition system, are coded into the custom-programmed module or programmer 46 which forms part of the internal computer memory. The jumper board allows individual channel selection to any one of sixteen choices. In addition, functions common to all forty-eight channels may be selected on the jumper board 46, such as repetition rate of automatic data log print-out and "time until trip" setpoint of a trend alarm. Each of the inputs from the programmer 46 passes through a digital multiplexer 48 to a computer 50 along with the inputs from multiplexers 38 and 24.

The multiplexer 48 is controlled from the computer 50 by means of a nine-bit address input 52. Similarly, multiplexer 38 is controlled so as to select a particular input channel monitor via a seven-bit address input 54. Multiplexer 24 is controlled by a six-bit address input 56; however the output of the multiplexer 24 must pass through an analog-to-digital converter 58 before being fed into the digital computer 50 since the signals on leads 22-1 through 22-48 are direct current signals whose magnitudes are proportional to the magnitudes of the vibration signals being monitored. The multiplexer 28, to which the oscillatory vibration signals on leads 26-1 through 26-48 are applied, is also controlled by a six-bit address input 60. A strobe input is applied to each of the multiplexers 24 and 28 via leads 62; while an end of conversion signal from each of the analog-to-digital converters 58 and 64 is fed back into the computer via leads 64.

The oscillatory vibration signals at the output of the multiplexer 28 are applied to the novel spectrum analyzing apparatus of the invention, enclosed by broken lines

in FIG. 1 and identified generally by the reference numeral 66. It comprises a single-double integrator 68 controlled by a signal from the computer 50. It is desired to perform a spectrum analysis on a vibration displacement signal. Hence, if the signal detected by any monitor is not a displacement signal but rather a velocity signal, a single integration is performed to convert it to a displacement signal. On the other hand, if the signal produced by a monitor is an acceleration signal, a double integration is performed to convert the acceleration signal to a displacement signal.

From the sixteen combinations selected by the manual programmer 46, it is known whether or not integration is required and the gain required for amplifier 70. For example, if channel No. 21 is programmed in mils (i.e., displacement), a single integration is required to convert a velocity signal in inches per second to mils. Additionally, the gain of amplifier 70 is adjusted to give a full-scale output for the particular vibration pickup used. For example, if a velocity pickup for channel No. 10 has an output of 764 millivolts RMS per inch per second peak, then the amplifier gain must be ten to achieve a 7.64 volt full scale output required for a peak detector 80 adapted to detect a peak voltage of 10 volts, as dictated by an analog-to-digital converter 84.

The output of the integrator 68 is coupled through the programmable gain amplifier 70 to the input of a voltage tuned filter 72 which has a passband which sweeps through the expected range of frequency components of an incoming vibration signal. The operation of the voltage tuned filter is schematically illustrated in FIGS. 4 and 5. The passband of the filter, indicated by the reference numeral 74 in FIG. 4 is caused to sweep through a frequency range of 600 cycles per minute to 600,000 cycles per minute. This sweep takes a total of twenty-four seconds. However, in order to obtain a good frequency sample, it is necessary to have the passband dwell at each frequency being sampled for at least 2 cycles of the selected frequency. The dwell times are shown in FIG. 5 and it will be noted that the dwell time for each frequency is 2 divided by the selected frequency. Thus, at the lowest frequency of 600 cycles per minute (10 cps), the dwell time is about 1/5 of a second. The dwell time for each successive step decreases until, at a frequency of 6000 cycles per minute, for example, it is 1/30th of a second. The time to sweep through the band of frequencies from 600 to 6000 cycles per minute, as shown in FIG. 4, is about eighteen seconds; however the time required to sweep through the band between 6000 and 60,000 cycles per minute is only four seconds; and the time to sweep through 60,000 cycles per minute to 600,000 cycles per minute is only about two seconds.

The manner in which the passband sweeps through the spectrum is controlled via address inputs or bits on lead 76 from the computer 50 applied to the voltage tuned filter 72 through a digital-to-analog converter 78. Signals passing through the voltage tuned filter are applied to the peak detector 80, the arrangement being such that only those frequencies whose amplitudes are greater than 10% of the full-scale value as determined by the internal computer program will be listed in the computer print-out. The peak detector 80 is reset by signal on lead 82 from the computer prior to each frequency sample derived from the voltage tuned filter 72. From the peak detector 80, the signal passes through the analog-to-digital converter 84 to the computer 50. The computer 50 includes the usual input-output interface 86 connected to a central processing unit 88, the

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⑭ Meßeinrichtung zur Bauwerksüberwachung

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Die Erfindung betrifft eine Einrichtung mit Sensoren und Meßwertaufnahmen zur Bauwerksüberwachung. Derartige Meßeinrichtungen dienen der Analyse des Zustandes von Bauwerken, wie z. B. Brücken.

Die herkömmlichen Überwachungsmethoden von Bauwerken sind einerseits sehr aufwendig (Ultraschall, Werkstoffentnahme), geben aber andererseits nur unzureichend den Bauwerkszustand wieder. Individuelle Belastungen, Umweltbedingungen und unterschiedliche Sicherheitsanforderungen bewirken, daß die Nutzungsdauer und Instandsetzungsarbeiten nicht optimal geplant werden können. Bei der Vielzahl der vorhandenen Bauten und Instandsetzungskosten in Milliardenhöhe bringt eine genaue Kenntnis des Bauwerkszustandes einen hohen Nutzen, indem maximale Nutzungszeiträume und effektive Instandsetzung ermöglicht werden.

Zur Verbesserung der Überwachung, speziell bei Brücken, wurden verschiedene Meßsysteme entwickelt, die das Schwingungsverhalten, die Längenänderung oder den Korrosionszustand erfassen. Aus dem Vergleich mit den ursprünglichen Werten bzw. Veränderungen können Rückschlüsse auf den Bauwerkszustand gezogen werden.

Die bisherigen Meßeinrichtungen zum Schwingungsverhalten bestehen aus einzelnen Sensoren, die am Bauwerk befestigt werden. Über mehrere längere Kabel stehen diese mit der Energiequelle und einem Datenspeicher in Verbindung. Das erfordert einen größeren technischen Aufwand, da die Schwingungen in mehreren Ebenen und Bauwerksabschnitten erfaßt werden müssen. Die Übertragung über mehrere Leitungen kann die Meßwerte verfälschen. Die verwendeten Sensoren besitzen eine starre Kernlinie, so daß eine weitere negative Beeinflussung gegeben ist.

Zur Senkung des technischen Aufwandes ist es bei Meßköpfen für Wärmeleitungs-Vakuummeter bekannt, über ein zweiadriges Kabel sowohl den Speisestrom, als auch den Meßstrom zu übertragen (DE-OS 3130817). Nachteilig ist, daß jeweils eine separate Spannungsquelle erforderlich wird. Die DE-OS 3518388 enthält deshalb den Vorschlag, ein zusätzliches drittes Kabel für die Meßsignale zu verwenden.

Bei den bekannten Meßeinrichtungen sind somit Meßwertgeber und Meßwertanzeiger bzw. Speicher örtlich getrennt angeordnet. Das bedingt einen hohen technischen Aufwand und den Einfluß von Störfaktoren.

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Aufgabe der Erfindung ist es deshalb, die Meßwertaufassung von Schwingungen an Bauwerken zu verbessern und den technischen Aufwand zu senken.

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Erfindungsgemäß sind in der Meßeinrichtung mehrere Sensoren für jeweils eine Ebene über regelbare Verstärker und ADW mit einem Controller und Speicher verbunden. Dies sind in einem abgeschirmten Gehäuse zur unmittelbaren Befestigung am Bauwerk angeordnet. Der Controller ist direkt oder über einen zwischengeschalteten Master mit der seriellen Schnittstelle eines PC verbindbar.

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Mit der Anordnung in einem Gehäuse entfallen die Verbindungskabel, wodurch der Aufwand und die Störanfälligkeit gesenkt wird. Die unmittelbare Umwandlung in digitale Signale und deren Verarbeitung mindert zusätzlich mögliche Störeinflüsse bei analogen Informationen. Die steuerbaren Verstärker erweitern den Arbeits- bzw. Einsatzbereich. So kann der Multisensor in allen Ebenen bei unterschiedlichen Schwingungsintensitäten angeordnet werden. Veränderungen durch Temperatur- und Alterungseinflüsse sind ebenfalls korrigierbar.

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Weitere günstige Ausgestaltungen der Meßeinrichtung sind in den Unteransprüchen aufgeführt.

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Nachfolgend wird die Erfindung an einem Beispiel näher erläutert.

Figur 1 zeigt das Blockschaltbild einer Meßeinrichtung

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Diese ist in einem nicht dargestellten Gehäuse angeordnet, welches unmittelbar an einem Brückenbauwerk zu befestigen ist. Es ist jeweils ein Sensor für eine Raumachse, sowie ein Temperatur- und Schocksensor vorhanden. Die Sensoren mit regelbaren Verstärkern

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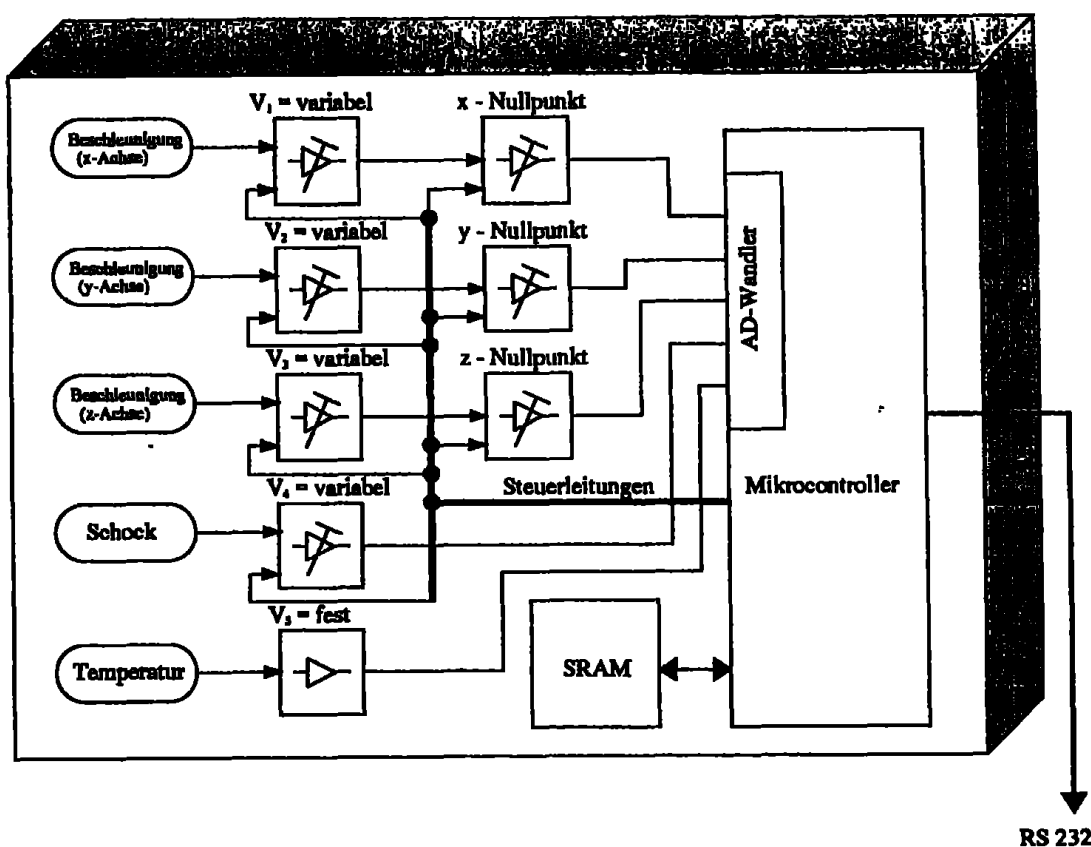
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und elektronischen Potentiometern zur Nullpunktkorrektur sind auf einem Board angeordnet. Die Ausgänge sind über einen AD- Wandler mit einem Mikrocontroller, und dieser mit einem Speicher verbunden. Diese Bauelemente sind auf einem weiteren Board befestigt. Der Mikrocontroller ist über eine Steuerleitung mit den Potentiometern verbunden.

Abtastfrequenz, Anzahl der Messungen, Anzahl und Nummern der zu messenden Kanäle, sowie Einstellungen der Potentiometer sind im Mikrocontroller festgelegt.

Schutzansprüche

1. Meßeinrichtung zur Bauwerksüberwachung, bestehend aus an diesen angebrachten Sensoren, die mit einem Speicher und Controller oder PC verbunden sind, dadurch gekennzeichnet, das
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 - mehrere Sensoren für jeweils eine Ebene über regelbare Verstärker und ADW mit einem Controller und Speicher verbunden
 - und in einem abgeschirmten Gehäuse zur unmittelbaren Befestigung am Bauwerk angeordnet sind,
 - 10• wobei der Controller direkt oder über einen zwischengeschalteten Master mit der seriellen Schnittstelle eines PC verbindbar ist.
2. Einrichtung nach Anspruch 1, dadurch gekennzeichnet, daß drei Beschleunigungssensoren für die drei Raumachsen, ein Temperatur- und ein Schocksensor auf einem Sensorboard angeordnet sind.
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3. Einrichtung nach Anspruch 1 und 2, dadurch gekennzeichnet, daß ein AD Wandler, Speicher und Controller auf einem Elektronikboard angeordnet sind.
204. Einrichtung nach Anspruch 1 bis 3, dadurch gekennzeichnet, daß die Sensoren zur steuerbaren Verstärkung und Nullpunktkorrektur mit dem AD-Wandler über elektronische Potentiometer verbunden sind.
5. Einrichtung nach Anspruch 1 bis 4, dadurch gekennzeichnet, daß diese über ein
25Modem und Netz oder Funk mit einem PC verbunden ist.
6. Einrichtung nach Anspruch 1 bis 5, dadurch gekennzeichnet, daß das Sensorboard schwingungsfest und das Elektronikboard elastisch in dem Gehäuse angeordnet ist.

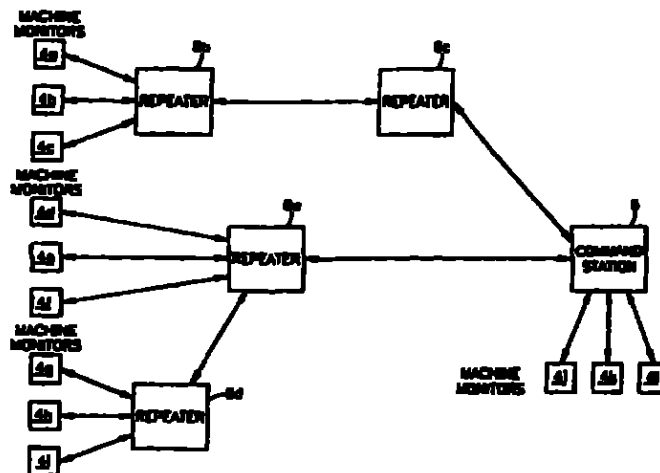




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(21) International Application Number: PCT/US97/14584 (22) International Filing Date: 19 August 1997 (19.08.97) (30) Priority Data: 08/697,372 23 August 1996 (23.08.96) US (71) Applicant: CSI TECHNOLOGY, INC. [US/US]; Suite 1704, 300 Delaware Avenue, Wilmington, DE 19801 (US). (72) Inventors: CANADA, Ronald, G.; 10614 Lakeshore Way, Knoxville, TN 37922 (US). PEARCE, James, W.; 254 Babb Road, Knoxville, TN 37771 (US). ROBINSON, James, C.; 1308 Chert Pit Road, Knoxville, TN 37923 (US). (74) Agents: NEELY, Andrew, S. et al.; Luodoka, Neely & Graham, P.C., P.O. Box 1871, Knoxville, TN 37901 (US).	(81) Designated States: CN, JP, KR, MX, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.	

(54) Title: VIBRATION MONITOR AND TRANSMISSION SYSTEM



(57) Abstract

An apparatus is disclosed consisting of one or more machine monitors (4a-1) which attach to one or more machines to sense a physical characteristic of the machine, such as vibration or temperature, and produce wireless transmissions corresponding to the sensed characteristic, and a command station (6) which receives the transmissions from the machine monitors (4a-1) and processes the information to give an indication of the condition of the machine. The machine monitor incorporates a wireless transmitter (446) to transmit the sensor data, and the command station (6) incorporates a wireless receiver (618) to receive the sensor data. In the preferred embodiment of the invention, the machine monitors (4a-1) are not continuously on, but turn on only at preprogrammed times according to turn-on commands generated by a timer circuit (424) within each monitor. Each machine monitor includes a microcomputer (418) to analyze the sensor data and a memory (422) to store the analyzed sensor data. Repeaters (8a-d) to facilitate communication between the command station and machine monitors are necessary.

scheduling commands. The monitor transmitter responds to the turn-on signals to power on and, under control of the monitor computer, produces wireless transmission signals. The monitor receiver is also responsive to the turn-on signals to power on and, under control of the monitor computer, receive wireless signals from the command station. The monitor receiver transfers the data received from the command station to the monitor computer for execution.

Brief Description of the Drawings

The preferred embodiments of the invention will now be described in further detail. Other features, aspects, and advantages of the present invention will become better understood with regard to the following description, appended claims, and accompanying drawings where:

FIG. 1 shows a block diagram of a preferred embodiment of the invention;

FIG. 2 is a drawing of the machine monitor element of a preferred embodiment of the invention;

FIG. 3 shows a block diagram of the machine monitor element of a preferred embodiment of the invention;

FIG. 4 shows a block diagram of the command station element of a preferred embodiment of the invention;

FIG. 5 shows a block diagram of the transmit and receive sections of the machine monitor and the command station of an alternative embodiment of the invention;

FIG. 6 shows a block diagram of the machine monitor element of an alternative embodiment of the invention; and

FIG. 7 shows a block diagram of the repeater element of a preferred embodiment of the invention.

Detailed Description of Preferred Embodiments

Shown in Fig. 1 is a block diagram of the preferred embodiment of the invention. The system shown in Fig. 1 is used when it is desirable to remotely monitor certain machine characteristics, but it is undesirable to install wiring between a remote monitoring station and a sensor on the machine. The system consists of: (1) one or more machine monitors 4 which are placed in various locations on, or in, one or more machines and which transmit

signals representative of characteristics of the machine, such as vibration or temperature, (2) a command station 6 which receives the signals transmitted from the machine monitors 4 and formats the data as desired by an operator, and (3) one or more repeaters 8 which aid in communication between the machine monitors 4 and the command station 6 when site conditions make such aid necessary.

The basic components of the system may be configured in various ways, some of which are illustrated in Fig. 1, to meet the requirements of the particular location where the system is used. If a particular machine is located such that machine monitors 4 placed on the machine are beyond the receiving range of the command station 6, or are out of the line of sight to the command station 6, a properly located repeater 8 is used to receive the signals from the machine monitors 4 and retransmit the signals to the command station 6. In some situations, more than one repeater 8 is necessary to provide for communication between the machine monitors 4 and the command station 6. In other situations, direct communication between the command station 6 and the machine monitors 4 is possible without the use of a repeater 8.

As shown in Fig. 2, the machine monitor 4 of Fig. 1 is contained in a compact housing 402, such as a two-inch diameter by three-inch long cylinder with self-contained attachment means 404, such as a magnetic mount, so that the monitor may be easily attached to the machine even in cramped locations. An antenna 406 is integrated with the housing of the preferred embodiment, such as shown in Fig. 2.

In Fig. 3, a functional block diagram of the machine monitor 4 of Fig. 1 is shown. Each machine monitor 4 contains at least one sensor 408 which is integrated with the machine monitor housing in such a manner that the desired machine characteristic is accurately measured when the machine monitor housing is fastened to the machine. The machine monitor 4 has connectors 410 so that one or more remote sensors 408 may be interfaced with the data processing and transmission circuitry of the machine monitor 4. In this manner, the characteristics of interest may be measured at several locations on the machine while transmitting the measured data from only one machine monitor 4. The integrated and remote sensors 408 are devices such as small, low-power, low-cost accelerometers, and instantaneous turn-on solid-state temperature sensors. The accelerometers, such as the type number 353B18, have an accuracy of $\pm 5\%$ from 1 to 10000 Hz and ± 3 dB up to 30 kHz, and a turn-on settling time of less than five second.

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The temperature sensors, such as the type number LM60, have an accuracy of $\pm 2^{\circ}\text{C}$ over a 0 to 80°C temperature range.

The sensor signals are amplified by an amplifier 412, such as a digitally-controlled variable gain amplifier incorporating a chip of type number LM6684. The sensor signals are filtered to eliminate aliasing by means of an anti-aliasing filter 414, such as a simple resistor-capacitor (RC) low-pass filter or a two-pole Sallen-Key active filter, and are then converted into digital format by an analog-to-digital converter 416, such as a 16-bit Sigma-Delta converter of type number CS5330.

The digital sensor signals are fed to a monitor computer 418, such as the Toshiba TMP93CM41 microcomputer. Examples of circuits incorporating this microcomputer are detailed in the Toshiba 16-Bit Microcontroller TLCS-900/L MCU Series (2) Data Book (March 1995). The monitor computer 418 includes a data processor 420 which performs 16-bit operations with 32-bit extended registers. The monitor computer 418 also incorporates a memory 422 consisting of at least 32 kilobytes of static RAM, a timer 424, a serial interface 426, and a battery status monitor circuit 428.

In the preferred embodiment of the invention, the sensors 408 are not continuously on, but are turned on at intervals which have been programmed into the monitor computer 418. The duration of the measurement interval, during which the sensors 408 are on, is three seconds, just long enough for the sensors 408 to settle and take a measurement. The frequency of the measurement interval, selectable by the operator, is typically on the order of one per every twelve hours, thus minimizing battery drain and extending battery life.

To conserve power, most of the time the monitor computer 418 stays in a standby mode requiring less than $100\ \mu\text{A}$ of current, and enters an operational state only at scheduled times. At these scheduled times, a message from the timer 424, the monitor computer's only active component while in standby mode, causes the data processor 420 to enter an operational mode and begin processing data from the sensors. The data processing tasks include such functions as (1) production of time wave form vibration data corresponding to the sensor signals, (2) calculation of fast Fourier transforms (FFT's) on the time-domain sensor data to produce frequency-domain data, (3) comparison of the analyzed sensor data to preprogrammed threshold criteria, and (4) production of an alarm message if the threshold criteria is exceeded. Depending on its preprogrammed instructions, the data

processor 420 either sends the processed data over the serial interface 426 to be immediately transmitted, or stores the data in memory 422 for transmission at a later scheduled time.

To further conserve power, the monitor 4 transmits the data only during preprogrammed intervals, the timing of the intervals provided by the timer 424. These transmit intervals either coincide with the measurement intervals of the sensors 408 such that real-time sensor data is transmitted, or the transmit intervals are scheduled such that data previously stored in the machine monitor memory 422 is transmitted. Transmission scheduling is controlled by the operator according to instructions programmed into the monitor computer 418.

In the preferred embodiment of the invention, the data is transmitted from the machine monitor 4 to the command station 6 in a spread spectrum format. In this scheme, a radio-frequency (RF) signal is modulated using a digital coding sequence which spreads the signal energy over a fairly broad bandwidth, thereby making the signal resistant to interference from other nearby RF emitters.

As shown in Fig. 3, the preferred embodiment incorporates a radio frequency (RF) transceiver 430 which performs data transmission as well as data reception. The transceiver 430 of this preferred embodiment further consists of a modulator/demodulator circuit 432, such as the Stanford Telecommunications STEL-2000A spread spectrum processor, which, in the transmit mode, modulates an intermediate frequency (IF) signal with the baseband digital sensor data. The IF signal is fed to an up-converter/down-converter circuit 434, such as the TriQuint FC0506BB, which converts the IF signal into an RF signal to be transmitted from the antenna 406.

The transceiver 430 of the preferred embodiment also provides for receiving and decoding messages from the command station 6 which are transmitted to the machine monitor 4 in the form of RF signals. Such messages include: (1) timing messages which synchronize the machine monitor timer 424 to the command station computer's clock, (2) scheduling messages which tell the machine monitor 4 when to measure, analyze, and transmit the sensor data and when to receive other messages from the command station 6, (3) confirmation messages which tell the machine monitor 4 that the command station 6 has accurately received the sensor data transmissions, (4) special request messages which command the machine monitor 4 to perform special data analysis functions, and (5) reprogramming messages which provide new programming for the monitor computer 418.

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The RF signals from the command station 6 are received by the antenna 406, down-converted to IF by the up-converter/down-converter circuit 434, demodulated by the modulator/demodulator circuit 432 to form baseband data signals, and fed over the serial interface 426 to the data processor 420.

5 The receive circuits of the machine monitor transceiver 430 are not continuously on, but, to conserve power, are turned on only when necessary to receive messages from the command station 6. The "on time" of the receive circuits is scheduled by the operator according to instructions programmed into the monitor computer 418. At the scheduled times, a message from the timer 424 causes the monitor computer 418 to send power-on
10 messages to the receive circuits of the monitor transceiver 430. The receive circuits stay energized until an error-free message is received from the command station 6, at which time the monitor computer 418 sends a shut-down message to the receive circuits of the monitor transceiver 430.

 With continued reference to Fig. 3, a power supply 438, such as a replaceable "D-
15 cell" flashlight battery provides the voltage necessary for the functioning of the active elements of the machine monitor 4. Under normal operational conditions, such a battery will provide power for the machine monitor 4 for at least one year. The power supply 438 may alternatively consist of a rechargeable battery, such as a nickel-cadmium cell, and a charging voltage source, such as a solar cell or a wire coil moving across a magnetic field
20 produced by the machine on which the machine monitor 4 is attached. The battery voltage is monitored by a battery status monitor circuit 428 which provides a battery status message to the monitor computer 418. The monitor computer 418 is programmed to transmit this battery status message to the command station 6 as part of a regularly scheduled sensor data message, and to transmit a battery status alert message when the battery voltage falls below
25 a programmed threshold level.

 A block diagram of the preferred embodiment of the command station 6 of Fig. 1 is shown in Fig. 4. The RF signal transmitted from the machine monitor 4 is received by an antenna 602 at the command station 6. A transceiver 604, which includes an up-
30 converter/down-converter circuit 606 and a modulator/demodulator circuit 608, such as those previously discussed in the description of the machine monitor 4, downconverts and demodulates the RF signal to recover the digital sensor data. The sensor data is fed over a serial interface 610 to a command station computer 612, such as a personal computer

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incorporating a Pentium processor or equivalent, where the information is monitored in real-time for machine fault conditions and is entered into a data base for off-line trend analysis. The transmit circuits of the command station transceiver 604, provide for the transmission of timing, scheduling, and programming messages to the machine monitor 4.

5 In an alternative embodiment of the invention, the machine monitor 4 communicates with the command station 6 by means of light waves. As shown in Fig. 5, the machine monitor transmitter 446 of this embodiment receives digital sensor data from the machine monitor serial interface 426 and modulates an electrical signal which drives a light emitting device 448, such as a light emitting diode (LED). The light emitting device 448 converts
10 the electrical signal from the transmitter 446 into light waves which are modulated with the digital sensor information. At the command station 6 of this embodiment, a light detecting device 616, such as a photodiode, receives the light waves from the light emitting device 448 of the machine monitor 4 and converts the light waves into an electrical signal. With continued reference to Fig. 5, the command station receiver 618 amplifies and demodulates
15 the electrical signal at the output of the light detecting device 616 to form a digital electrical signal which is compatible with the data format of the command station serial interface 610. The sensor data is then passed over the serial interface 610 to the command station computer 612 for processing as described above. A similar series of operations are performed to transmit messages from the command station 6 to the machine monitor 4 as shown in Fig. 5.

20 The preferred embodiment of the invention provides for error detection in the data that the command station 6 receives from the machine monitor 4. With the preferred error detection scheme, the machine monitor 4 transmits a 16-bit cyclic redundancy check (CRC16) message immediately after transmitting the sensor data message. Upon receipt of the sensor data message and the CRC16 message, the command station 6 computes its own
25 CRC16 message based on the received data and compares it to the received CRC16 message. If the received and computed CRC16 messages match, then no errors exist in the received sensor data, and the command station 6 transmits an acknowledgment message to the machine monitor 4 to confirm that the sensor data has been accurately received.

To preclude the possibility of a transmission from one machine monitor 4 interfering
30 with a transmission from another machine monitor 4, data transmission times for each machine monitor 4 are scheduled such that only one machine monitor 4 is transmitting at any given time (time division multiplexing). By accurate synchronization of the machine

qb 99

monitor timer 424 with the command station clock, the command station 6 "listens" for the transmission of only one machine monitor 4 at the precise time when the command station 6 has commanded the machine monitor 4 to transmit.

To enable the command station 6 to verify which machine monitor 4 is transmitting a data message, each machine monitor 4 transmits a unique identification code prior to the sensor data message. The identification code combined with the sensor data message comprise a data packet. The identification code is stored within the machine monitor 4 by means such as a set of DIP switches or a non-volatile RAM, the state of which determines the value of the identification code to be stored in the monitor computer memory. The identification code transmitted by the machine monitor 4 is received by the command station 6, and the command station computer 612 compares the code to values stored in a table within the command station computer 612.

In an alternative embodiment of the invention, the possibility of interference is reduced further by programming each machine monitor 4 to transmit with its own distinct spread spectrum pseudo-noise (PN) code (code division multiplexing). The command station 6 then listens for a particular code assigned to a particular machine monitor 4 at the designated transmission time.

Another alternative embodiment of the invention utilizes frequency multiplexing to preclude interference between transmissions from multiple machine monitors 4. In this embodiment, each machine monitor transceiver 430 is assigned a unique frequency band over which to transmit the sensor data to the command station 6. The command station transceiver 604, as commanded by the command station computer 612, listens for a particular machine monitor 4 on the assigned frequency band at the designated transmission time.

While the preferred embodiment of the invention transmits a signal from the machine monitor 4 to the command station 6 only at scheduled times, it is contemplated that the machine monitor 4 could also incorporate means of continuously sensing an extreme fault condition of the machine being monitored, such as the use of tuned reed switches for detecting an extreme vibration condition. When such an extreme fault condition occurs, the monitor computer 418 "wakes up" from the standby mode, processes the signal from its one or more sensors 408, and transmits a data packet consisting of the machine monitor's identification code and the sensor data to the command station 6. To avoid interference with

97 100

14. The system of Claim 1 further comprising said transmitter means and receiver means transmitting and receiving a digital signal, respectively, with an error checking protocol.

15. The system of Claim 1 wherein said transmitter means further comprise radio frequency transmitter means and said receiver means further comprise radio frequency receiver means.

16. The system of Claim 8 wherein said transmitter means further comprise radio frequency transmitter means and said receiver means further comprise radio frequency receiver means.

17. The system of Claim 1 wherein said transmitter means further comprise spread spectrum transmitter means and said receiver means further comprise spread spectrum receiver means, each using a spread spectrum communication protocol to avoid interference from other radio frequency emitters.

18. The system of Claim 8 wherein said transmitter means further comprise spread spectrum transmitter means and said receiver means further comprise spread spectrum receiver means, each using a spread spectrum communication protocol to avoid interference from other radio frequency emitters.

19. The system of Claim 1 wherein said transmitter means further comprise light wave transmitter means and said receiver means further comprise light wave receiver means.

20. The system of Claim 8 wherein said transmitter means further comprise light wave transmitter means and said receiver means further comprise light wave receiver means.

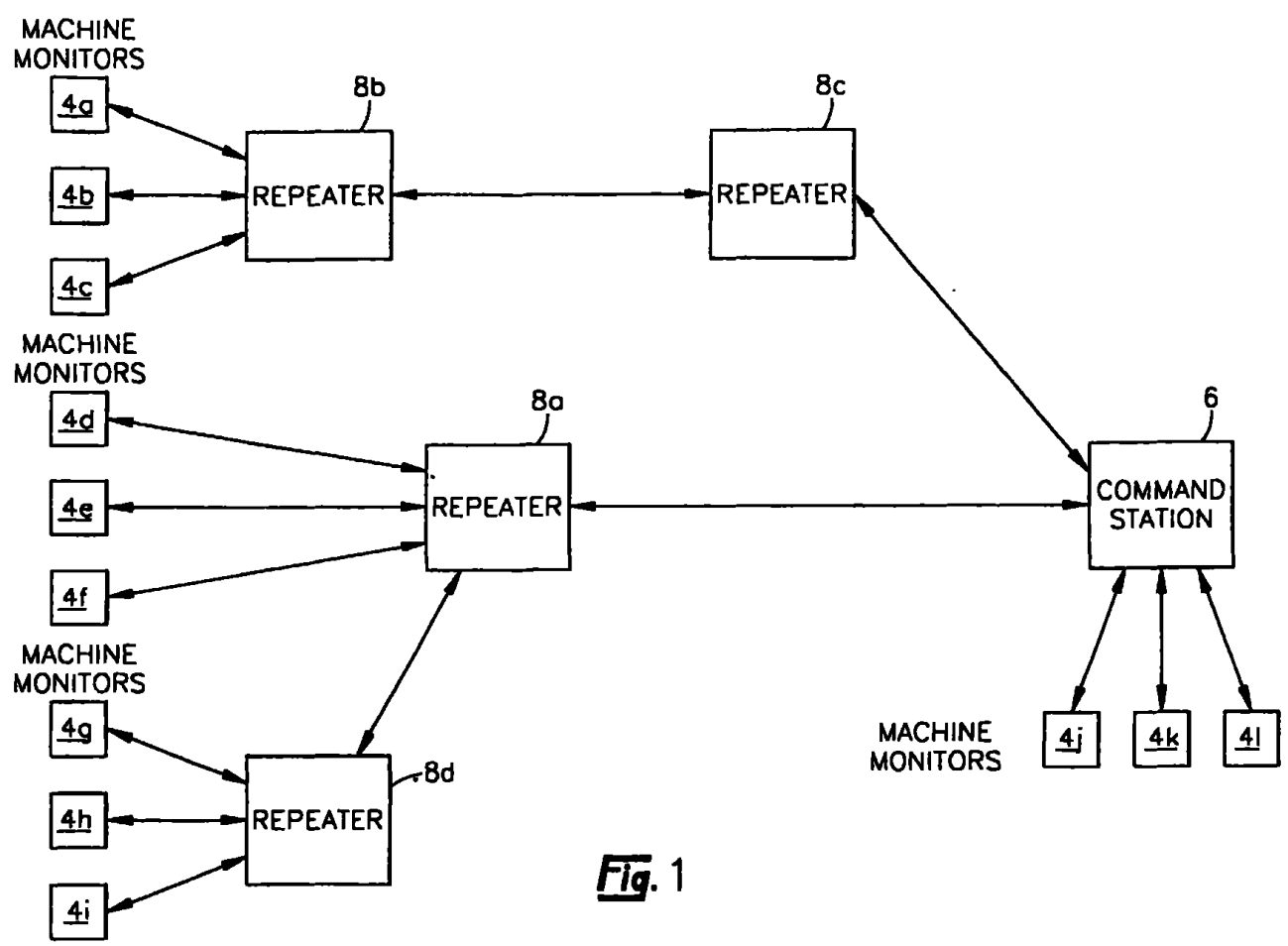


Fig. 1

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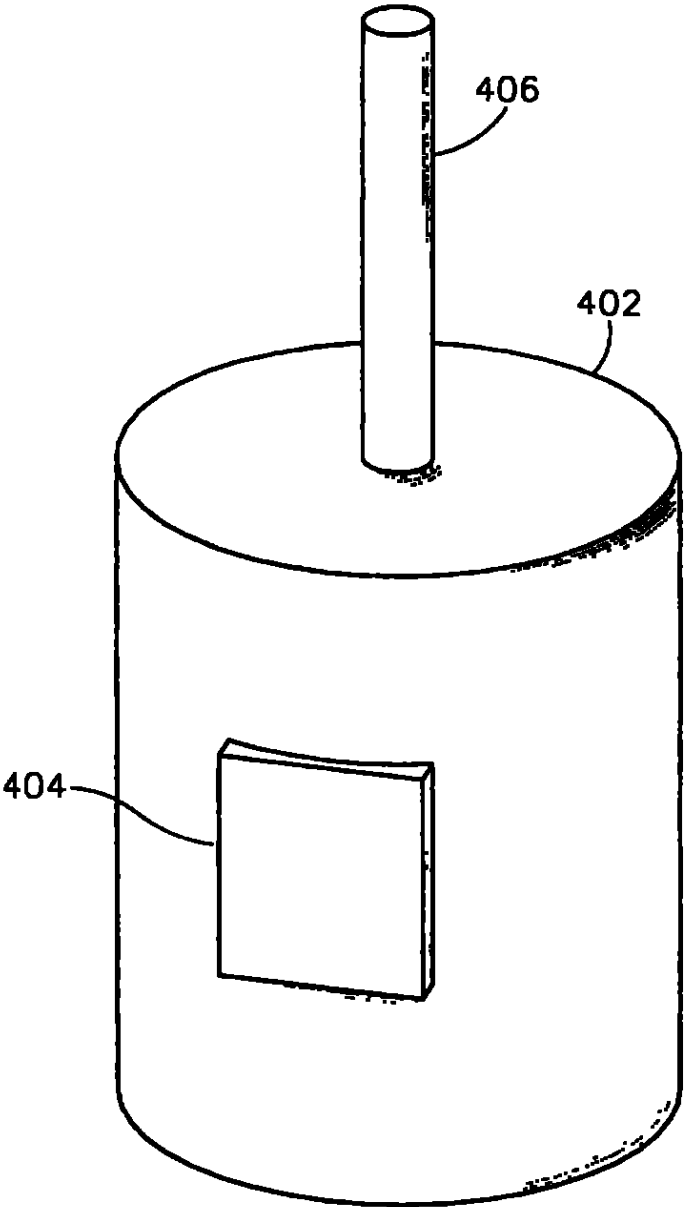


Fig. 2

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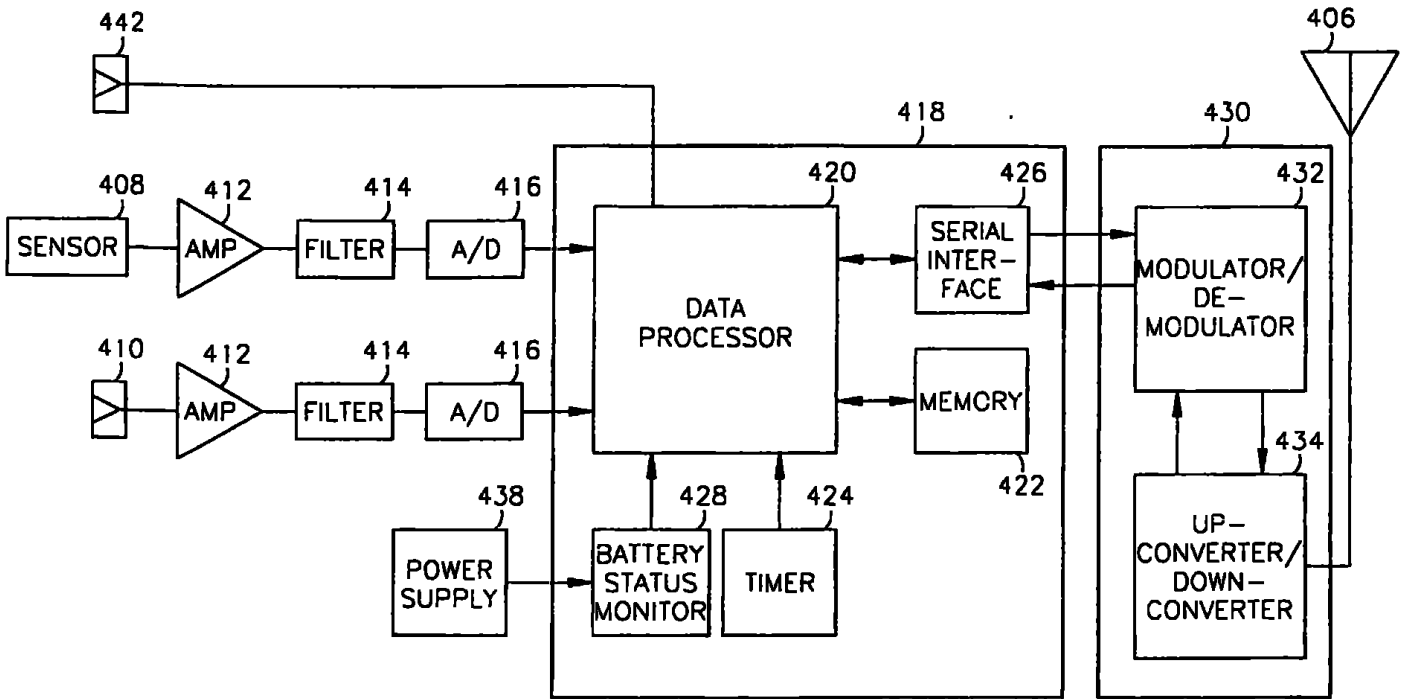
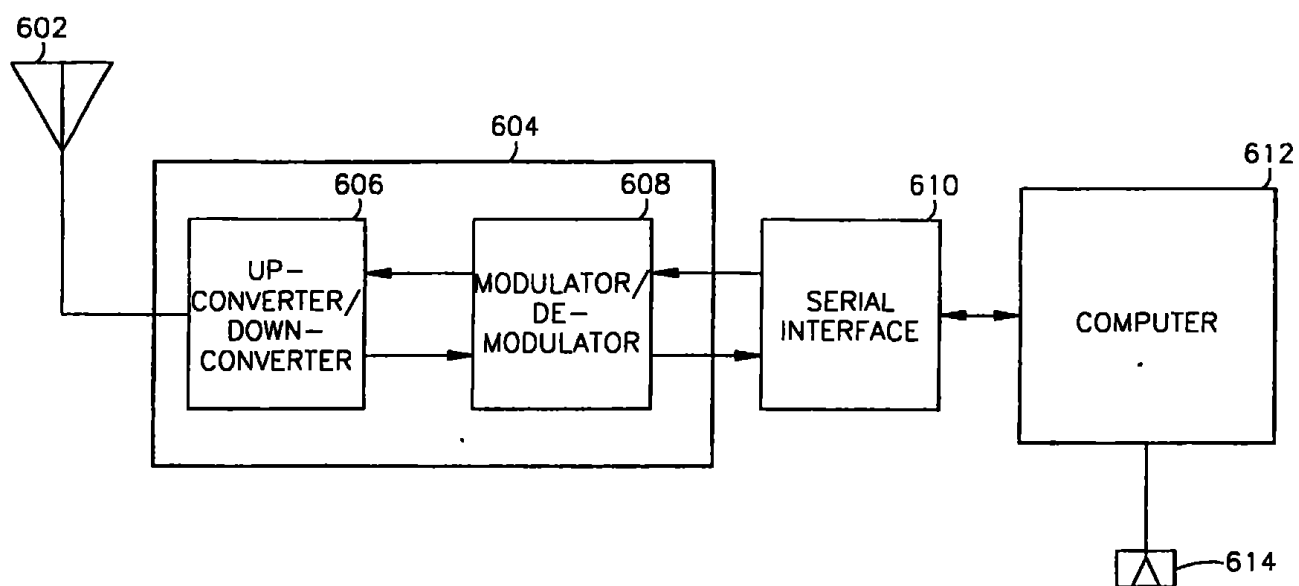


Fig. 3

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Fig. 4

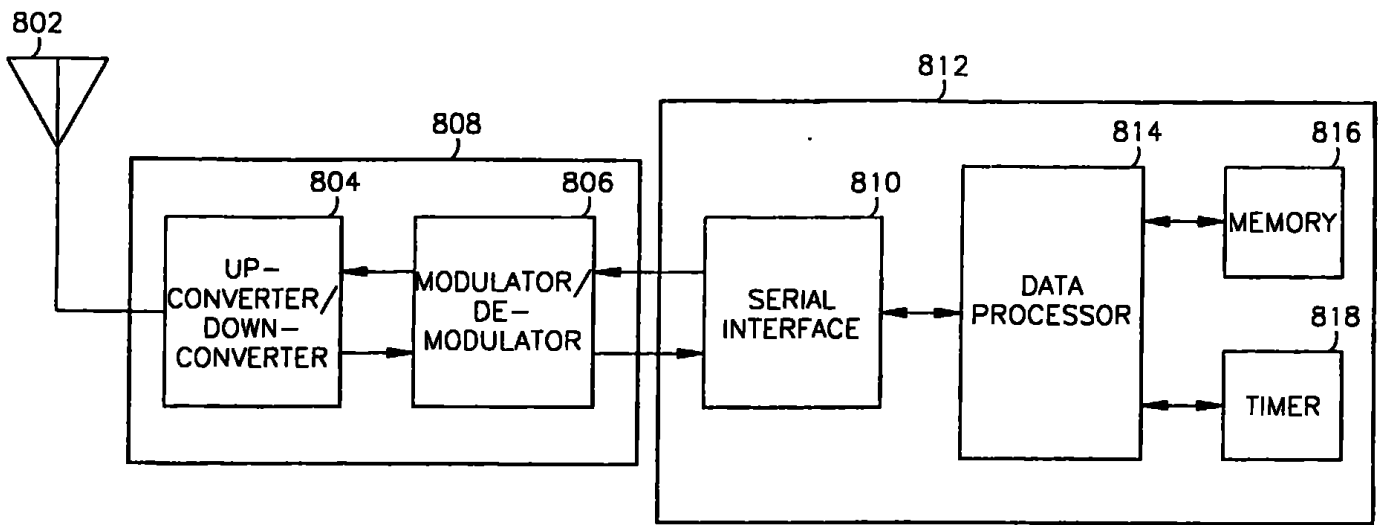


Fig. 7

(19)



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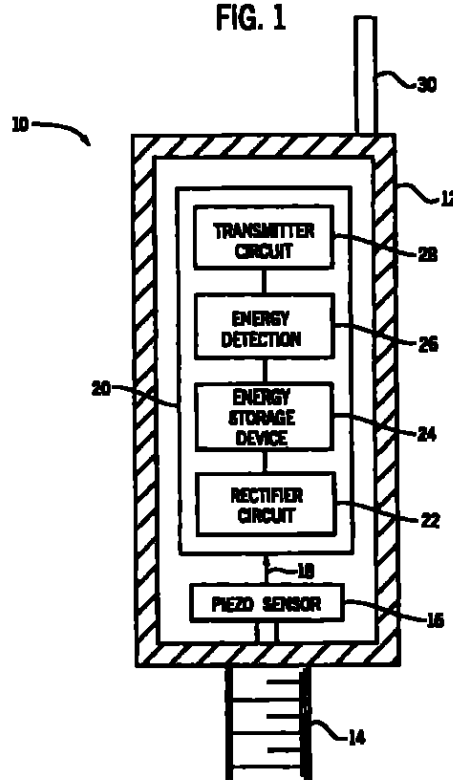
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(54) Self-powered wireless transducer

(57) A self-powered wireless transducer (10) is disclosed for monitoring external physical conditions, such as excessive vibrations in a bearing. The transducer includes an energy conversion source (16), such as a piezoelectric sensor to sense the external physical condition and create a power and characteristic signal that is used to power an RF transmitting circuit (28). A transmitter (30) is provided to transmit signals indicative of the external physical condition, or changes in that physical condition, such as increased vibrations in a bearing to detect bearing faults before a breakdown. In this manner, the monitored machinery can be shutdown in an orderly manner and preventative maintenance can be completed. The self-powered wireless transducer (10) includes a voltage storage device (24) to receive electrical voltage from the piezoelectric sensor (16) and a voltage detector (26) to detect the level of voltage on the voltage storage device (24). Once the voltage detector (26) detects a level of voltage at a predetermined level, an oscillating transmitting circuit (28) is activated for a brief hysteresis period of the voltage detector (26). The information transmitted not only includes any fault detection, it also includes an address of the origin of the transmission.

FIG. 1



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Component	Value
L1, L2	10 μ H
C1-C4	0.1 μ F
C5	4.7 μ F
C6, C7, C8	100pF
C9	2.2pF
C10	100pF
R1, R2	10k Ω
R3	10 Ω
L3	3.3nH
SAW 34	RFM RP1285
Q1	NEC NE85633
Voltage Detector 32	Panasonic MN13812C

[0020] In operation, the circuit 20 rectifies the A.C. inputs 18 from the transducer in the rectifier circuit 20 and charges a low leakage capacitor in the energy storage device 24 until the capacitor voltage reaches a predetermined threshold, approximately 2.1 volts, as determined by the voltage comparator 32. When the detector 32 senses that the predetermined voltage value has been reached, the output 33 of the detector gets pulled low which activates the RF transmitter circuit 28. The transmitter circuit 28 quickly discharges the capacitor C5 such that the output from the transmitter is a short RF burst. The duration of the burst is a function of the capacitance of capacitor C5 and the discharge rate of the transmitter circuit 28. By varying the values of capacitor C5 in different wireless transducer units, the RF burst duration can be used to identify that particular unit. Alternatively, the discharge rate of the transmitter circuit 28 can be modified to change the burst duration.

[0021] The hysteresis in the voltage detector 32 is set to approximately 100 mV such that if the predetermined voltage value were set to 2.1 volts, when the output 33 goes low causing the transmitter circuit 28 to begin to oscillate and thus drain capacitor C5, the transmitter circuit 28 continues to transmit until the voltage across capacitor C5 reaches 2.0 volts, at which time the output 33 of the detector 32 goes high, and the capacitor C5 begins to charge up to 2.1 volts and the cycle repeats. While the output 33 of the detector 32 is low, the transmitter circuit 28 transmits at the frequency of the resonator 34, which in the preferred embodiment, is 918.5 MHz.

[0022] Referring to Fig. 3, an exemplary RF signal 38 is shown to define the pulse width 40 and the pulse repetition period 42 for an RF signal from any particular transmitter. As indicated by the pulse width of the RF

signals TX1 and TX2, each of the transmitters is provided a unique address based on the width of the pulse, which does not change. However, the pulse repetition period changes as the external physical condition changes. For example, in the case of sensing vibratory motion, as the vibrations increase, the pulse repetition period increases. The transmitted signal can then be processed after reception at a remote location.

[0023] Referring to Fig. 4, the wireless transducer of the present invention is incorporated into a fault detection system 48 comprising a number of self-powered wireless transducers 50, 52, each mounted in an external structure 54, 56, respectively. The external structure can be different locations on the same structure, or can be completely different structures such as two different bearings in the same machine, or two different bearings in different machines. The number of different transmitters that can be used is limited only by the precision of the components selected and the amount of processing desired to be done after reception. Each of the self-powered wireless transducers 50, 52 therefore transmit at a distinct frequency 58, 60.

[0024] The fault detection system 48 also includes a receiver 62 and a processor 64 to receive each of the distinct frequency transmissions 58, 60, from each of the transmitters 50, 52 and differentiate which self-powered wireless transducer 50, 52 produced each of the distinct frequency transmissions 58, 60 and determine whether any of the transmissions contain a fault detection. In the preferred embodiment, the distinct frequency transmission is the same RF frequency, but it is transmitted at different pulse intervals. If no faults are detected, the processor 64 displays or illuminates a clear or OK indication 66. However, if the processor 64 locates a fault, the processor 64 activates an alarm 68 and provides an indication 70 of which of the self-powered wireless transducers 50, 52 is transmitting the fault detection signal. The processor 64 and receiver 62 receive power via bus 72 and optionally provide an output to a network on bus 74 for centralized display and reporting.

[0025] The present invention also includes a method of detecting vibration faults which includes the steps of mounting a housing on a structure to be monitored so as to receive vibratory motion from the structure on at least a portion of the housing and converting vibratory power within the housing as a result of receiving the vibratory motion into electrical energy. The method next includes storing the converted energy at least until the stored energy reaches a predetermined level, and then activating an RF transmitter when the stored energy reaches the predetermined level. The method next includes transmitting an RF signal indicative of any vibratory faults in the structure which the housing is mounted in.

[0026] The step of transmitting the RF signal is further defined as transmitting an RF signal indicative of an RF transmitter's identity such that a receiver and a proc-

essor can identify the RF transmitter that transmitted that particular RF signal. The process next includes receiving the RF signal at a remote location and processing the RF signal to determine a change in received vibratory motion in the structure being monitored. Optionally, the method can include displaying an indication of the RF transmitter's identity and activating an alarm to indicate any fault condition found. The process includes comparing past RF signals received to a present RF signal, and if a present RF signal increases in frequency beyond a predetermined limit, then an alarm is activated to indicate that vibratory motion has increased beyond tolerance within the structure and preventative maintenance is required. In the preferred embodiment, the frequencies compared are the pulse repetition period. However, the particular RF frequency may equivalently be modified.

[0027] The present invention has been described in terms of the preferred embodiment, and it is recognized that equivalents, alternatives, and modifications, aside from those expressly stated, are possible and within the scope of the appending claims.

Claims

1. A wireless transducer (10) comprising:

a housing (12) adaptable to monitor an external physical condition of an external structure (54, 56);

an energy conversion source (16) mounted within the housing (12) to sense the external physical condition and create a power and characteristic signal in response to the external physical condition, the power and characteristic signal having a characteristic of the external condition;

a transmitter (30) mounted in the housing (12) and connected to the energy conversion source (16) to receive the power and characteristic signal and transmit a monitoring signal, the transmitter (30) receiving power only from the energy conversion source as a source of power.

2. The wireless transducer (10) of claim 1 wherein the housing (12) is adapted to sense vibratory movement and the energy conversion source (16) is a piezoelectric sensor which provides the power and characteristic signal.

3. The wireless transducer (10) of claim 1 wherein the power and characteristic signal is an A.C. voltage signal and wherein the wireless transducer (10) further comprises a rectifier circuit (22) to rectify the A.C. power and characteristic signal.

4. The wireless transducer (10) of claim 3 further comprising

an energy storage device (24) and a energy level detector (26), the energy storage device (24) is connected to the energy conversion source (16) and the energy level detector (26) is connected to the energy storage device (24), and wherein the energy storage device (24) is capable of storing the rectified A.C. power and characteristic signal at least until the energy level detector (26) detects a predetermined energy level.

5. The wireless transducer (10) of claim 4 wherein the energy storage device (24) is a capacitor (C5), the capacitance of which is selected to set a pulse width (40) of the monitoring signal (38) such that a number of wireless transducers (50, 52) can each produce a unique monitoring signal (TX1, TX2), and the energy level detector (26) comprises a voltage comparator (32) having a hysteresis in which the monitoring signal (38) is transmitted.

6. The wireless transducer (10) of claim 5 further comprising a transmitter circuit (28) containing the transmitter (30) and connected to the energy storage device (24) and the energy level detector (26), the transmitter circuit (28) being activated when the energy level detector (26) detects the predetermined energy level which thus activates the transmitter (30) in response thereto.

7. The wireless transducer (10) of claim 6 wherein the transmitter circuit (28) comprises a transistor (Q1) and a resonator (34) connected to a base of the transistor (Q1) to activate the transmitter (30) at a desired frequency.

8. The wireless transducer (10) of claim 1 wherein the transmitter (30) is a radio frequency RF transmitter.

9. The wireless transducer (10) of claim 6 wherein the transmitter circuit (28) drains the energy storage device (24) when activated until energy in the energy storage device (24) falls below the predetermined energy level.

10. A fault detection system (48) comprising:

a plurality of self-powered wireless transducers (50, 52), each comprising:

a housing (12) adaptable to monitor an external physical condition of an external structure;

an energy conversion source (16) mounted within the housing (12) to sense the external physical condition and create a power and characteristic signal in response to the external physical condition, the power and characteristic signal having a characteristic of the external condition;

a transmitter (30) mounted in the housing (12)

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PS

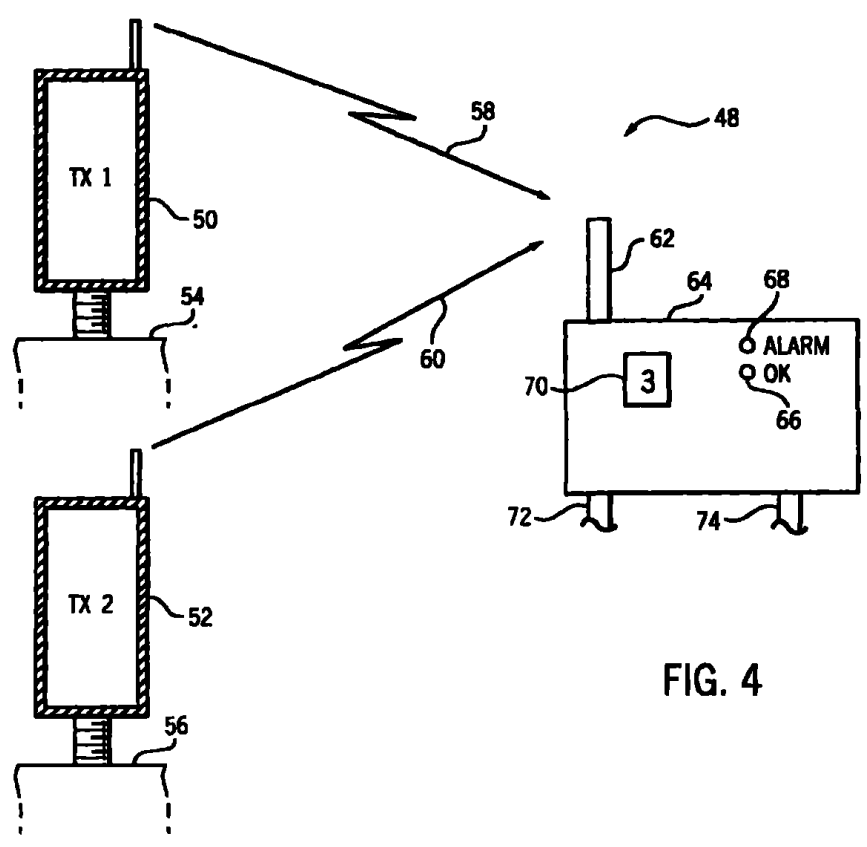


FIG. 4

102

SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO

RADICACIÓN: 1-87481

EDICTO No. 18527

**LA SECRETARÍA GENERAL AD-HOC
HACE SABER:**

Que esta Superintendencia profirió Resolución No. 31666 de 28-NOV-2005. Que el contenido de la parte resolutive es como sigue: El Superintendente de Industria y Comercio.

RESUELVE

ARTICULO PRIMERO: Negar el privilegio de patente de invención para la solicitud correspondiente a "APARATO PARA MONITOREO DINAMICO DE ESTRUCTURAS, EL CUAL JUNTO CON UN NODO CENTRAL FORMA UN CONJUNTO PARA EL MONITOREO DINAMICO DE ESTRUCTURAS".

Sede Centro: Carrera 13 No. 27-88 Pisos 2, 5, 7 y 10
Sede Páramo: 70. 490 Ma. 100 000 Páramo, Boyacá 350000

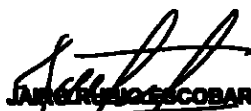
ARTICULO SEGUNDO: Notificar personalmente el contenido de la presente resolución al doctor José Antonio Lloreda, o a quien haga sus veces, en su calidad de apoderado del Centro Internacional de Física, CIF; Instituto Colombiano Para el Desarrollo de la Ciencia y la Tecnología "Francisco José de Caldas" -COLCIENCIAS-, e Instituto Nacional de Vías -INVIAS-, entregándole copia de la misma, advirtiéndole que contra ella procede el recurso de reposición interpuesto ante el Superintendente de Industria y Comercio, al momento de la notificación o dentro de los 5 días hábiles siguientes a ella.

NOTIFÍQUESE Y CUMPLASE

Dada en Bogotá, D.C., a los

28 NOV. 2005

EL SUPERINTENDENTE DE INDUSTRIA Y COMERCIO,


JAIME RODRIGUEZ ESCOBAR

Para notificar a los interesados, se fija el presente EDICTO en lugar visible al público en la SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO, por el término de (10) diez días hábiles contados a partir de las 8:30 a.m. de hoy.

Secretaría General Ad-Hoc 20-DIC-2005

Este edicto se desfija hoy 02-ENE-2006 a las cinco (5:00 p.m.)

Secretaría General Ad-Hoc

EDICTO No. 18527