TO: KSI/Scientific & Technical Information Division  
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No.: 3,733,424

Government or Corporate Employee: U.S. Government

Supplementary Corporate Source (if applicable): 

NASA Patent Case No.: LAR-10756-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

Yes [ ] No [X]

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words "... with respect to an invention of . . . ."

Elizabeth A. Carter
Enclosure
Copy of Patent cited above
An electronic strain level counter for obtaining structural strain data on in-flight aircraft. The device counts the number of times the strain at a point on a structural member of the aircraft exceeds each of several preset levels. A dead band is provided at each level to prohibit the counting of small strain variations around a given preset level.

2 Claims, 3 Drawing Figures
FIG. 2

FIG. 3

OUTPUT VOLTAGE

DEAD BAND

INPUT VOLTAGE

V_2 V_1
ELECTRONIC STRAIN-LEVEL COUNTER

ORIGIN OF THE INVENTION

The invention described herein was made by employees of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

The invention relates generally to strain measurements and more specifically concerns a device for counting the number of times that the strain in a structural member exceeds each of several preselected levels.

Structural fatigue assessment of in-service aircraft is based primarily on visual and x-ray inspection procedures. An electronic device which counts the number of times the strain at a point in a structural member exceeds each of several preset levels is needed to augment these established procedures. The complexity of the structural-fatigue assessment of aircraft does not allow structural-lifetime prediction to be based entirely on data generated by strain-level counters. However, use of the strain counters in a fleet of aircraft can yield a statistical-data body on the number and severity of the in-service structural strains. Based on this information, a graduated scale of aircraft-use severity can be generated and used to aid in scheduling inspection and maintenance. In addition, correlation of the data with observed fatigue failures might aid in general fatigue assessment of aircraft of the same type.

In the past, devices such as extensiometers and mechanical scratch gages have been used to accomplish the strain level counter function. The disadvantage of the extensiometer approach is that a long gage length is required to obtain high sensitivity. The primary disadvantage of the mechanical scratch gage is that the data output is an analog scratch waveform on a small metallic disk which results in difficult data reduction.

It is therefore the primary object of this invention to provide a simple, accurate and reliable electronic device which counts the number of times the strain at a point in a structural member exceeds each of several preselected levels. Another object of the invention is to provide an adjustable dead band around each of the preselected levels to prohibit the counting of small strain variations due to flexural oscillations around the preselected levels.

SUMMARY OF THE INVENTION

The strain level counter that constitutes this invention counts the number of times the strain at a point in a structural member exceeds each of several preset levels. By using hysteresis, a dead band is provided at each level so that after the strain exceeds a given level and a count is registered, the strain must decrease below the dead band and then increase again before another count is registered. The adjustable dead band prohibits the counting of small strain variations due to flexural oscillations around a given level.

In the present invention, each of several separate counters counts the number of times the strain exceeds a different preselected level. The system uses a metallic resistance strain gage as the sensor, micro-electronic and discrete solid state circuits for signal processing, and electromechanical counters for data storage. The bridge output is a low-level differential analog voltage proportional to the applied strain. This low-level signal is amplified and used as an input to several level detectors with hysteresis. As the input to each level detector increases through a preset upper threshold voltage, the state of the output changes from high to low. The state of the output cannot change again until the input decreases below a preset lower threshold voltage. When the input increases through the upper threshold voltage, a pulse is generated to drive an electromechanical counter.

In order to circumvent the drift problems of d.c. coupled amplifiers, a.c. bridge excitation obtained from an astable multivibrator is employed. The output from the bridge is a pulse train with an amplitude proportional to the strain input. This signal is amplified by an a.c. coupled amplifier. The output of the amplifier is coupled to the level detectors, which are enabled during each data pulse by a signal from a strobe-pulse generator. The astable multivibrator also provides the input to the strobe-pulse generator. When the amplitude of the data pulse exceeds a preset level, a signal generated by the level detector causes a count to be registered in an electromechanical counter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an embodiment of the invention; FIG. 2 is a schematic drawing of the level detectors shown in FIG. 1; and FIG. 3 is a graph for the purpose of describing the transfer function of the level detectors.

DETAILED DESCRIPTION OF THE INVENTION

Turning now to the embodiment of the invention selected for illustration in the drawings, the number 11 designates a strain gage bridge which is attached to the structural member whose strain is to be measured. Strain gage bridge 11 is of the well known resistance type strain gage which produces an output signal whose amplitude is proportional to the strain. Strain gage bridge 11 is excited by an astable multivibrator 12 with a frequency of approximately 90 hertz and a pulse duration of approximately 0.5 millisecond. The pulse duration of the multivibrator is long enough to allow all system transients to decay before the level detectors are enabled. Hence, the output of strain gage bridge 11 is a series of pulses whose amplitudes are proportional to the strain. If there is no strain on the bridge 11, the bridge is balanced and hence there is no output. If a strain is applied to the bridge 11, then the bridge becomes unbalanced and a series of pulses are produced at the output whose amplitudes are proportional to the strain being applied to the bridge. The output of bridge 11 is amplified by an a.c. coupled amplifier 13 which is an operational amplifier with a closed loop gain that is determined by the feedback resistor and the output impedance of the bridge. The output of amplifier 13 is capacitively coupled through a capacitor 14 to level detectors 15, 15a, and 15b so that d.c. drift does not affect the system performance so long as it is not severe enough to cause saturation. Only three level detectors are shown in FIG. 1; however, as many of these level detectors as desired can be used. In addition to exciting bridge 11, astable multivibrator 12 is also applied to a strobe pulse generator 16. Strobe pulse generator 16 is a one-shot multivibrator that is triggered on by the asta-
The output of the flip-flop becomes high again only when the signal pulse amplitude decreases to a value below $V_s$ and a positive transition of the strobe pulse occurs. The hysteresis voltage $V_1 - V_2$ is given by

$$V_1 - V_2 = \frac{R_{23}(V_{\text{max}} - V_{\text{min}})}{(R_{23} + R_{26})}$$

Calibration of the system is accomplished by use of a shunt resistance across one leg of the bridge to simulate a desired strain level. The upper threshold for each channel of the level detector is set by adjusting $V_r$ and the hysteresis is set by adjusting resistor $R_{23}$.

The advantages of the electronic strain level counter that constitutes this invention is the small gage length of the metallic strain gage sensors; in addition, the data reduction is mechanized within the electronic strain level counter and the data output is stored in easy-to-read electromechanical counters.

It is to be understood that the form of the invention hereafter shown and described is to be taken as a preferred embodiment. Various changes may be made in the shape, size and arrangement of parts. For example, equivalent elements may be substituted for strain gage bridge 11, astable multivibrator 12, strobe-pulse generator 16, amplifier 13, drive circuits 17 and counters 18 without departing from the spirit or scope of the invention as defined in the following claims.

What is claimed is:

1. An electronic strain level counter for obtaining strain data on a structural member comprising:

   a generator means receiving said constant amplitude electrical pulses for generating electrical pulses having amplitudes indicative of the strain on said structural member;

   a plurality of level detector means with said strobe pulses for generating strobe pulses;

   a means connected to the output of said comparator for comparing said electrical pulses having amplitudes indicative of the strain on said structural member to said preset level and for providing an electrical signal each time the amplitude of one of said electrical pulses indicative of strain exceeds said preset amplitude and for providing a dead band so that after the strain exceeds the preset amplitude and an electrical signal is produced
the strain must decrease below the dead band and then increase again before another electrical signal is produced; and means associated with each of said level detector means for counting said electrical signals whereby the count on each of said counting means is the number of times the strain exceeds the preset amplitude in the corresponding level detector means.

2. An electronic strain level counter according to claim 1 wherein said means for producing an electrical signal each time the amplitudes of one of the electrical pulses indicative of strain exceeds said preset amplitude and for providing a dead band is a D-type flip-flop with means for adding the output of the flip-flop to said preset amplitude.