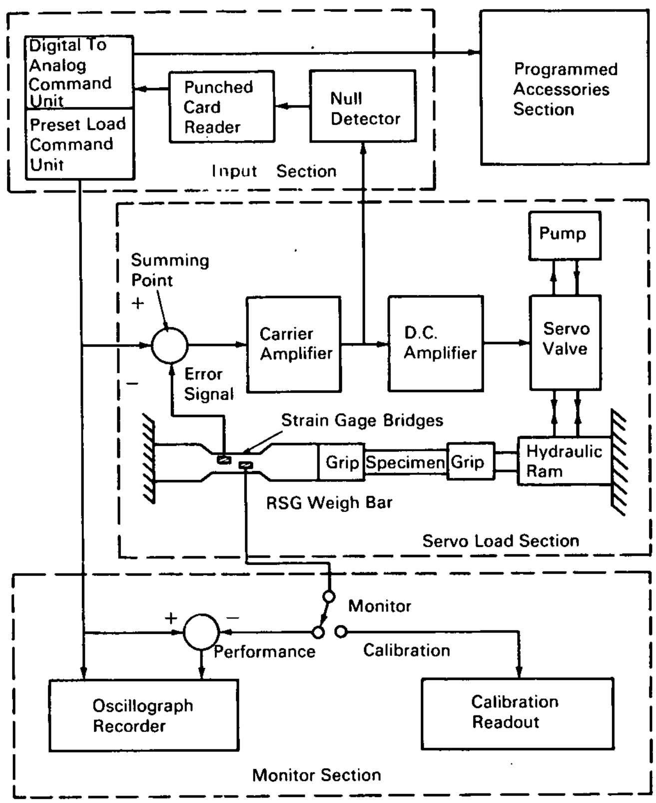
NASA TECH BRIEF

Material Fatigue Data Obtained by Card-Programmed Hydraulic Loading System



The problem:

Airframe designers rely on fatigue testing to obtain an estimate of material strength since theories are not generally available to accurately predict this property under service loading. Previous fatigue testing methods have generally been limited to simple cyclic loading.

The solution:

A system in which programmed fatigue tests are performed using load distributions obtained from actual loading histories encountered in flight. The system can apply up to 55 discrete, individually adjustable load levels to a test specimen in any desired sequence, as programmed on punched electronic accounting machine (EAM) cards.

How it's done:

The system consists of four major portions; an input section, a servo load section, a monitor section, and a programmed accessories section. The card reader transmits a coded signal to the digital-to-analog command unit where logic circuitry selects a particular, manually preset load command. This command signal is introduced at the summing point in the servo load section. The output of the summing point, or error signal, is amplified to control the servo valve which, in turn, controls the oil flow to the hydraulic

(continued overleaf)

ram. The ram produces a force on the test specimen which is mechanically coupled to the resistance strain-gaged (RSG) weigh bar (force transducer). The output of the first bridge formed by the strain gages, which represents the force, is fed back to the summing point. As the load approaches a value proportional to the reference input, the error approaches zero. The null detector in the input section monitors the amplified error and generates an output to advance the card reader as the value of the error approaches zero.

The digital-to-analog command unit consists of switching logic and potentiometers necessary to produce 55 discrete but adjustable load level commands. The card reader presents the code signal to the logic circuits which perform two functions: they make a parity check of the code signals to detect reading errors, and they select the load level potentiometer. The error signal is the difference between the weigh bar bridge output and the combined output of the mean load and load-level potentiometers. Only one load-level potentiometer may be selected at any one time, but the mean-load potentiometer is in the circuit at all times. Operation about a preset mean load level, which is adjustable to any value between the full-scale tension and compression loads, is made possible by the use of the mean-load potentiometer. Calibrated dials on the potentiometer shafts simplify the setup procedure.

The first amplifier in the servo loader section is a 3 kHz carrier amplifier with a gain of 2000. This unit amplifies and demodulates the error signal from the summing point to produce a dc voltage. The second amplifier is a dc amplifier with a gain adjustable to 50 and an output matched to the servo value. A feedback network is included in this amplifier to obtain system stability. Both amplifiers and associated power supplies are commercial transistorized plug-in modules. Balancing controls and circuits for monitoring voltage levels are provided.

The null detector circuit monitors the carrier amplifier output. This circuit consists of two comparators and a high-level AND gate. One comparator will turn off when there is a tension load error (the load is at a greater tension level than the value set on the selected potentiometer), and it will turn on as the load approaches the command value. The other comparator will turn off when there is a compression load error (the load is on the compressive side of the value set on the selected potentiometer), and it will turn on as the load approaches the command value. The points at which the comparators turn on are adjustable for load errors from zero to approximately 300 pounds in tension on the first comparator and from zero to approximately 300 pounds in compression on the second comparator. Therefore, at least one comparator is off any time a load error exists outside the preset band. As the error comes within the preset band, both comparators are on. The two comparator outputs drive the AND gate which delivers an output signal to advance the card reader only when both comparators are on. A delay is built into the two comparator outputs to prevent improper triggering of the AND gate by noise. System precision will be determined by the width of the preset band.

The digital-to-analog unit, in addition to selecting load commands, provides contact closures corresponding to particular card codes which are used to operate a temperature programmer, a recorder programmer, and a load-hold timer. The temperature programmer consists of a timer and an associated circuit to turn on and off an automatic temperature controller which controls power to heaters mounted on both sides of the specimen. The recorder programmer turns on an oscillograph recorder and, after a warm-up period of one minute, starts a timer which determines record length. The load-hold timer stops the machine from cycling so that the existing load is held for the period set on the timer.

In the monitor section, the load command signal and the signal from a second (monitor) strain-gage bridge on the weigh bar are displayed on an oscillograph recorder and a calibration readout unit. This section includes readout instrumentation needed to calibrate and monitor performance. Performance is monitored on two channels of the oscillograph recorder. The input to one channel is a signal proportional to load command. The second input is a signal proportional to load error, or the difference between the commanded load and the actual load. This error signal is obtained by combining the command signal with the output of the second strain-gage "monitor" bridge on the weigh bar. The requirements on recording accuracy are much less since load error is being measured rather than load value. A precision ac nulling bridge along with the monitor bridge on the weigh bar is used as a calibration readout for a convenient means of setting the load pots. This bridge is periodically calibrated on the basis of precision applied loads with an accuracy of 0.05 percent of full scale.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia 23365
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Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: William T. Davis
(LAR-10042)

Category 03