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COMPUTER CAPABILITY AND INTERFACING AVAILABLE IN THE 50 MEGAWATT ELECTROGASDYNAMICS FACILITY

BY

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FOREWORD

This memorandum was prepared by Charles L. DeMarsh of the Arc Technology Group, Thermomechanics Branch, Aeromechanics Division, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio. This work was conducted under Project Number 1988, "Aerothermodynamic Simulation Technology", Task Number 1988 02, "Arc Research and Implementation".

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ABSTRACT

The 2 test legs of the AFFDL 50 Megawatt Electrogasdynamics Facility, the RENT and the HTL, share a common data acquisition system that is structured around a hybrid computer. The computer allows on-line display of variables and calculations during a tunnel run, fast data reduction, and computer control of the facility and/or model. This memorandum discusses the present uses for data acquisition and also the analog input/output capabilities that are available to the users.

TABLE OF CONTENTS

NOMENCLATURE

AMBILOG is a trademark used by Adage, Inc., to designate its hybrid information-processing devices and systems having both analog (i.e., continuous) and digital (i.e., discrete) input and/or output signals.

AMBILOGICAL is a trademark used by Adage, Inc., to designate the hybrid logical and/or arithmetic operations performed by AMBILOG devices and/or systems, or these devices and systems themselves.

D/A	Digital-to-Analog Converter
CRT	Cathode Ray Tube
ACE	AMBILOGICAL Computing Element
SAH	Sample-and-Hold Amplifier

ILLUSTRATIONS

I. INTRODUCTION

The Hypersonic Test Leg (HTL) of the 50 Megawatt Electrogasdynamics Facility has the capability of testing large-scale models or full-scale components of hypersonic reentry vehicles for up to twenty minutes.

The Re-Entry Test Facility (RENT) generates a high density, high shear flow that is used for testing nose tip materials for reentry missiles.

Both wind tunnels generate large volumes of data that must be recorded, processed, and analyzed both on-line and off-line. Also, control of facility parameters and model injection systems require analog control inputs.

The data acquisition system is structured around an Ambilog 200 Hybrid computer, which is an integral part of the facility. The computer is used for data acquisition and processing, and also for interfacing with facility controls and other data recording devices.

II. DESCRIPTION OF COMPUTER

The computer used in the AFFDL 50 Megawatt Facility is an Ambilog 200 manufactured by Adage, Inc. It is a high-speed, solid-state, modular, hybrid (analog and digital) data system that was specifically designed for on-line data acquisition as an integral part of the facility. The installation as shown in Figure 1 includes an on-line printer (1000 lines per minute), a control console with a paper punch and reader, a CRT display including light pen, 8 "nixie" displays (5 tubes each, 4 displays on the control console and 4 at the tunnel operator's control console), and the computer main frame containing CPU, memory, and hybrid elements.

The Ambilog 200 system itself accepts both analog and digital inputs. Within the system, hybrid subsystems are used not only for analog-to-digital and digital-to-analog conversions, but also to perform many arithmetic and logical operations involved in signal processing.

Inputs include 256 multiplexer channels, 12 sample and hold amplifiers, a 30-bit digital input register, and a 30-bit sense line register. Outputs consist of 6 D/A channels and 60 program controllable line drivers.

The digital portion of the machine uses a 30-bit word length while the analog section uses 15-bits. Machine cycle time is 4 microseconds for a fetch and execute operation.

Two thumbwheel switch registers are located on the console which provide the instruction source for 2 of the 8 priority interrupts. Two manually controlled flip-flops are available at the console for interrupt execution. The other 6 interrupts are controlled by analog inputs generated either external or internal to the machine.

III. COMPUTER SOFTWARE

The Ambilog 200 uses a 30-bit digital word length with the upper 15-bits used for the instruction and the lower 15-bits used for the address or operand. Symbolic machine language is entered into the machine via the console typewriter, with a running display of the input text displayed on the CRT. The display scope allows for fast and efficient editing of source programs and eliminates the need for a punched card reader system since the display shows exactly what has been entered in memory and where. After editing, source programs are assembled using a 2 pass assembler, and are then output as a binary file on magnetic tape. A symbol list can also be appended after the binary file when desired.

A complete library of utility and mathematical subroutines are available for input/output and for computational requirements.

The computer can also be used as a digital machine using a Fortran compiler; however, this type of use has been rather limited due to the fact that the machine is intended primarily for data acquisition, and also due to the availability of much larger digital machines.

IV. ON-LINE DATA ACQUISITION

The program for on-line data acquisition can be loaded and set-up in a few minutes. After the program has been loaded and started, the computer is trapped in a wait loop waiting for a signal pulse from the tunnel operator's control console, at which time the computer proceeds with the data acquisition.

The data acquisition program consists essentially of a closed loop that starts by sampling all 256 channels sequentially at approximately a 50 Hz rate. This sampling loop is repeated 16 times for a total sampling time per each program loop of approximately .378 sec. The averaged data is then dumped onto magnetic tape. The remaining program loop consists of computing 17 separate calculations and dumping the results onto magnetic tape, updating the "nixie" tube displays, and general program maintenance. The total program loop time is approximately 1 sec. The variable or calculation appearing on any or all "nixie" displays can be changed at any time during the tunnel run merely by typing the desired variable or calculation into the memory via the console typewriter. When a test condition is reached during a run, the tunnel operator sends a signal pulse to the computer to record the beginning and the end of a particular test condition.

Immediately after the tunnel run is over the data is printed out via the high-speed printer by means of 1 or more of 5 available options.

1. The entire block of data for each test point is averaged and printed out.
2. The data for each test point is averaged over a desired time increment (example: average and print data every 2 sec during each test point).
3. The data is averaged over a desired time increment and is printed out for the entire length of the tunnel run (example: average and print data every 5 sec for the entire length of the tunnel run).
4. The data is averaged over a desired time increment and is printed out starting at some desired time in the tunnel run (example: average and print data every 3 sec, 10 minutes after the tunnel started).
5. The data is averaged over a desired time increment and is printed out only when a desired analog input or calculation exceeds a desired value (example: average and print data every 4 sec whenever the mass flow exceeds 2 lbs/sec).

Several other programs are available to process the data tape for further computational analysis, and to plot the data using the

X - Y plotters, strip charts, and high-speed printer as output devices.

The computer has also been used for on-line plotting and heat flux probe position control during a tunnel run in the Hypersonic Test Leg. When the desired test conditions are reached, the tunnel operator sends a signal pulse to the computer which then turns control of the probe over to the computer. The probe, under program control, enters the flow and starts to make a survey of the hypersonic gas flow. The probe moves from station to station across the gas, the number of stations having been predetermined and entered programmatically, stopping on each station long enough for the program to analyze the data and determine that stable conditions have been met. When the predetermined tolerances are reached, the data for that station is taken for a predetermined time and is then stored on magnetic tape. After the survey is complete the probe fully retracts from the flow and control is returned back to the tunnel operator who may again signal the computer for another survey later in the tunnel run. During the survey the computer is also plotting on-line the calculated heat flux, enthalpy, pressure, etc. versus probe position on the X - Y plotter located at the tunnel operator's control console. The probe survey and the X - Y plotting increase the program loop time by a very small amount since the basic data acquisition program continues to run in the background during the surveying and plotting.

Some work to-date has been to display a dot matrix on the CRT, the X and Y axis representing 2 parameters say model nose temperature and angle-of-attack respectively, and by using the light pen to describe a predetermined curve on the scope, the computer can on command output control voltages representing a desired flight simulation. This would allow several different flight simulations to be performed during a tunnel run merely by using the light pen to change the curve representing the flight path.

A long and complex subroutine is available in one version of the data acquisition program that allows high-speed data to be recorded in addition to the normal data acquisition. This version is used to record model data in the RENT Test Leg. The data acquisition program is loaded and started exactly like the previous version. The only difference being that each time through the program loop a signal is monitored from the model carriage inject system. A pulse indicates to the program that the tunnel operator has initialized the carriage injection. The program then enters the high-speed data subroutine. After the subroutine has determined which channels are to be sampled and prepares for high-speed data acquisition, the computer sends a ready pulse back to the injection system and then goes into standby, waiting for a data trigger signal. The injection system, after receiving the computer ready pulse, then injects the models sequentially into the flow. As each model enters the flow a trigger signal is sent to the computer requesting that high-speed data be taken. When the program determines that the requested number of models have passed through the flow, a normal exit from the subroutine is executed and the program returns to facility data acquisition.

There are 12 analog input channels available per model for high-speed data. The inputs are multiplexed external to the computer and then fed into sample and hold amplifiers to eliminate time shew between channels. Sampling frequency for this particular program version is 1 KHZ. Another version currently under development will sample 4 channels at a 5 KHZ rate. The maximum sampling rate obtainable could feasibly be 28.5 KHZ for 1 channel for short data bursts.

Immediately after the tunnel run the high-speed data is printed out either in 1 ms or 15 ms time increments, whichever is desired. The data is then transferred onto a master magnetic tape for permanent storage. Data may be read off the master tape at some later date either for print-out or to copy onto another tape for further data reduction.

V. OFF-LINE USES

Transducers can be calibrated one of three ways, by using the computer on-line during the calibration, by entering the data digitally via the console typewriter after the data has been recorded, or by recording the data on paper tape via a data logger and then reading the tape into the computer.

On-line the transducer output is fed directly into the computer where the voltage input is recorded by use of one of the push-button flip-flops located at the control console. The calibration standard, such as pressure, can then be entered via an analog input or digitally through the console typewriter for each calibration point. After the points have been recorded, the program computes a least squares fit. The scale and offset are then output through the high-speed printer together with the data for each calibration point, the percent accuracy, and percent deviation.

Off-line, the recorded data is entered digitally via the console typewriter or by reading paper tape with the same output being printed out as for an on-line calibration.

Numerous diagnostic programs are available for monitoring the status of the various analog and digital systems in the machine. Each component of the analog section can be displayed on the CRT showing noise levels, error bands, offsets, etc. Typically, the multiplexer inputs can be displayed in groups on the display scope to determine their integrity just prior to a tunnel run. A display menu, together with a light pen, allows the computer operator to step through the entire analog section looking for any possible malfunction.

VI. COMPUTER INTERFACING

The computer has multiple input/output channels, both analog and digital, plus a high-speed multi-level priority interrupt system which allows the computer and internal processing to be synchronized with external events.

Input analog channels for data acquisition consists of 256 multiplexer channels accepting inputs from -10 to +10 volts. The accuracy of these devices normally range from .01 to .1 percent. Sample and hold amplifiers are connected in front of 12 multiplexer channels to avoid time shew when these channels are used for high frequency sampling rates.

There are 4 D/A outputs available for use under program control which range from -10 to +10 volts. These may be programmed to output as a level, ramp, pulse, etc. The 2 ACE modules are presently wired to allow use as a 2 channel programmed output of 0 to +10 volts; however, these can only be output as a level or a pulse. The 12 sample and hold amplifiers can be reversed and used as D/A outputs with a range from -5 to +5 volts. Also available as programmed analog outputs are 60 line drivers which are compatible with TTL logic.

The machine has a 30 bit digital input register that can be used to accept external data words or trigger control bits. Another register contains 30 bits that are used as sense lines to communicate with I/O devices and the outside world. Both registers are TTL compatible.

A Priority Interrupt system is organized to select program interrupts, on a predetermined multi-level priority basis, from a number of external sources in response to external service requests. Five channels of Priority Interrupt are available with an external instruction source associated with each channel. These external instruction sources may take any of several forms, including diode boards, thumbwheel switches, signal lines from an external system, or flip-flop registers.

VII. CONCLUSIONS

The hybrid data acquisition system used in the AFFDL 50 Megawatt Electrogasdynamics Facility has proven to be a valuable tool providing on-line data displays and fast data processing. The computer has also provided useful analog control outputs which undoubtedly will be used more strenuously in the future.

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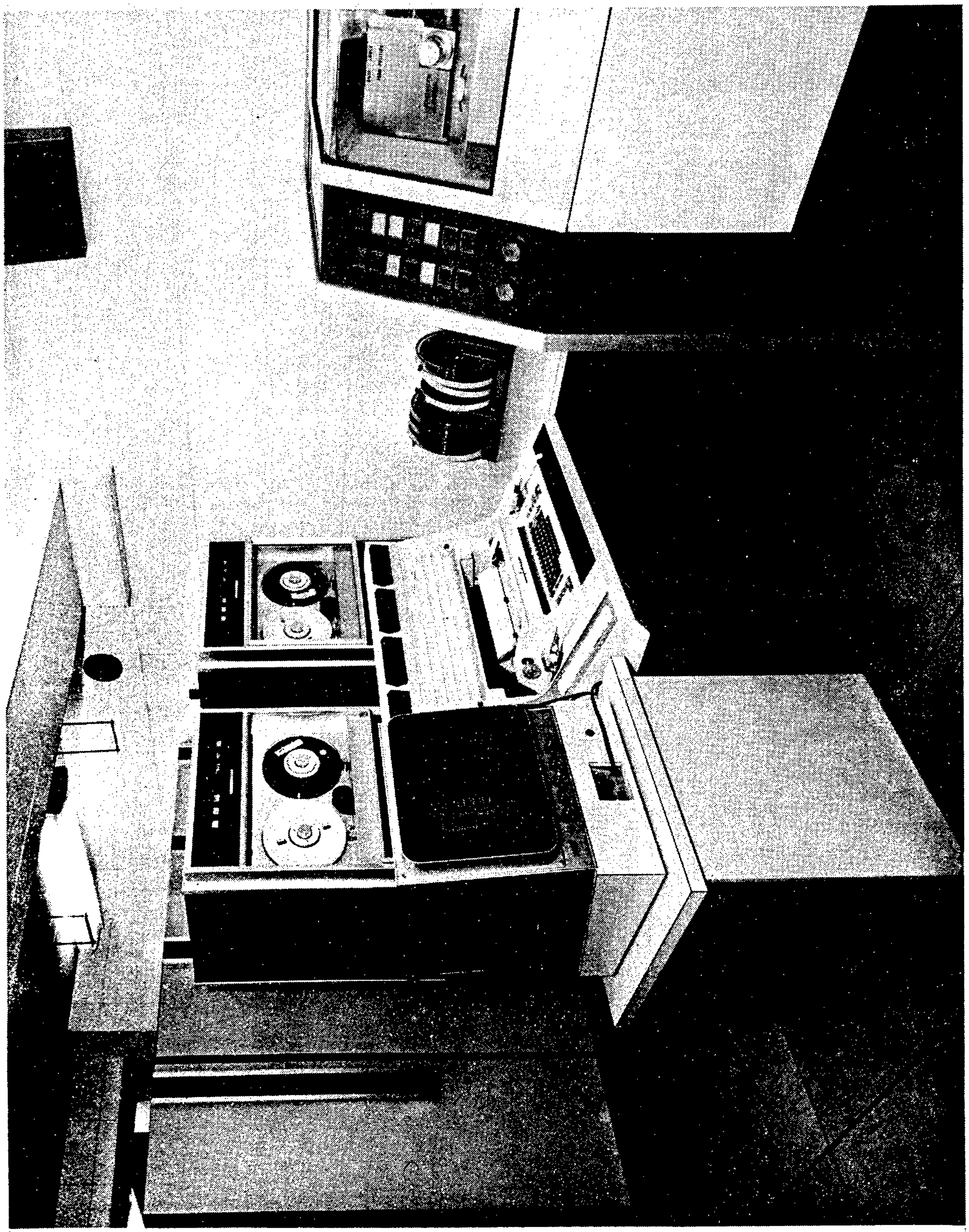

FIGURE 1. COMPUTER INSTALLATION