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WIND TUNNEL REAL-TIME DATA ACQUISITION SYSTEM

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ABSTRACT

The Transonic Dynamics Wind Tunnel facility at the NASA Langley Research Center is uniquely designed for aeroelastic research and testing which requires acquisition of large amounts of dynamic data over a wide frequency range The computer-controlled tunnel Data Acquisition System (DAS) is specifically tailored to acquire such dynamic data and to provide real-time, interactive data reduction, analysis, and display Furthermore, the DAS provides the capability for on-line monitoring and control of a wide variety of analog instrumentation The range in types of testing and the uniqueness in instrumentation for each individual test requires that the DAS be flexible, versatile and easy to use

The paper describes the hardware configuration of the DAS which consists of an analog front end that can process up to 260 channels of data, a multi-channel analog-to-digital subsystem that can process up to 50,000 samples of data per second, and a digital computer with standard and nonstandard devices, including graphics capability Also described are the software configuration of the DAS and complex hardware/software interfaces providing, for example, automatic amplifier gain and offset adjustment for each data channel Finally, this paper provides a summary of specific DAS applications including the real-time processing of dynamic deflection data, unsteady pressure measurements, and flutter and buffet data

INTRODUCTION

As the complexity of wind tunnel testing and model instrumentation increases, the need for computer-controlled digital data acquisition becomes more important This need was recognized by researchers using the Transonic Dynamics Wind Tunnel (TDT) located at NASA's Langley Research Center in Hampton, Virginia (Figure 1) Unlike most other wind tunnels, the TDT was uniquely designed for testing and basic research in the field of aeroelasticity, including flutter, requiring large amounts of dynamic model response data The work done in the TDT, therefore, requires that data be sampled at high rates over a wide frequency range

Prior to 1974, analog data were acquired and recorded during a test but could not be reduced or digitized until completion of a test Much of the data reduction was done by hand

In 1974, after several years of design and development, the Data Acquisition System (DAS) was installed The system was designed to be flexible and versatile and to provide a relatively convenient user interface into what is otherwise an extremely complicated system Since then, the DAS has grown in terms of the total hardware configuration and the development of application software Researchers continue to improve their expertise and ingenuity in using the DAS effectively

The DAS provides computer-controlled data acquisition and display along with near real-time data reduction and interactive analysis Sufficient data can be displayed to the test engineer while the test is in progress to allow adjustment of the course of a test The DAS also monitors and displays test and tunnel parameters and provides automatic setting of most instrumentation, therefore, the test engineer is free from many routine concerns and can concentrate on the progress of the test and the significance of the data

Presented in this paper is a functional overview of the hardware and software configuration of the DAS with attention to the internal and external interfaces involved Also summarized are specific applications that have evolved, with emphasis on the operational aspects of the system

TRANSONIC DYNAMICS WIND TUNNEL

Aeroelasticity is the study of the elastic response of aerospace vehicles under forces exerted by the motion of air over surfaces An example of such a response is a phenomenon called flutter in which structural behavior and aerodynamic forces combine to produce a self-perpetuating oscillation which may increase in amplitude until the structure is destroyed In the TDT, models are tested to establish safe flight boundaries for avoiding flutter Basic research in flutter prediction and suppression is also conducted Other areas of interest to TDT researchers include buffet, helicopter rotor-blade behavior, active controls, and unsteady aerodynamics, including oscillating pressures across surfaces (Figure 2)

The type of data acquired for such studies can be categorized as static or dynamic. Most wind tunnels are designed for static data, i e , data obtained under steady, unchanging model and tunnel conditions. The TDT was uniquely designed not only for the study of static forces but also for the study of unsteady forces and dynamic model response which requires that data be sampled over wide frequency ranges and at high sampling rates

Models tested in the TDT range from abstracted wing-shaped sheets of aluminum to aeroelastically scaled, instrumented replicas of entire vehicles that cost hundreds of thousands of dollars Types of model transducers include accelerometers, strain gages, and pressure sensors. Models are mounted in the tunnel test section either on a side-wall, a sting projecting into the test section, a turntable or pedestal, or a complex cable system(1) allowing several degrees of freedom of motion (Figure 2)

The wind tunnel is a continuous flow facility providing test section speeds up to Mach 1 2 Either air or Freon-12 may be used as a test medium Freon-12 is a heavy gas having a speed of sound approximately half that of air Because of these properties, Freon-12 is ideally suited for use as a medium for aeroelastic model testing Both Mach number and dynamic pressure (i e , altitude) can be controlled continuously while a test is in progress The tunnel is relatively large with the test area cross section measuring approximately 4 9 meters by 4 9 meters (16 ft x 16 ft)

Test personnel observe the model through windows in a control room looking into the test section In the control room (Figure 3) is a tunnel operator's console for monitoring and controlling wind tunnel Mach number and dynamic pressure The tunnel operator also controls some tunnel equipment and communicates with personnel responsible for the electrical and the Freon systems at other locations in the facility A computer operator's console is used for interaction with the computer-controlled digital Data Acquisition System (DAS) Other equipment in the control room includes strip charts, specialized analog devices, and other instrumentation as appropriate to each individual test

The facility also includes a calibration laboratory and an aeroelastic model laboratory (Figure 4) The calibration laboratory is used for general model pretesting and calibration and for software checking. Pretesting also can be accomplished in the aeroelastic model laboratory which provides a duplicate of the test section cable mount system This allows a model to be mounted as it would be for the actual tunnel test entry Data can be acquired through the DAS for a model located in either laboratory as well as in the tunnel test section The building (Figure 1) which houses the laboratories also provides office space and shop facilities along with a data room containing most of the DAS hardware

DATA ACQUISITION SYSTEM HARDWARE

Analog Front End

The Analog Front End (AFE) consists of those hardware components of the DAS by which analog data are acquired, conditioned, monitored, and recorded Analog data either from a model in the test section, calibration laboratory, or model laboratory, from prerecorded analog tape, or from a signal generator, enter the DAS through the AFE. The AFE contains fifty DC and ten AC amplifiers (Figure 5) Forty of the DC amplifiers can each be switched among six channels, therefore, a maximum of 260 channels of data can be input to the system On each amplifier are switches for specifying input source, gain, and offset Each switch can be operated manually in local mode or under computer control in remote mode Local (only) switches for manually setting low-pass filters are also located on each amplifier

Other AFE instrumentation facilitates monitoring and conditioning of data In six selectable groups of ten, the unfiltered outputs of all sixty amplifiers can be monitored and adjusted using a bank of ten oscilloscopes In addition to the amplification and filtering of data, the AFE also provides for transducer excitation voltage and signal conditioning of the transducers The excitation voltage and signal conditioning equipment can be read but not set while under computer control

Analog recording of data is also provided by the AFE Two analog tape recording units (Figure 6), one for low bandwidth data not exceeding 200 Hz, and the other for intermediate bandwidth data not exceeding 20 KHz are available The low bandwidth tape recorder is used for frequency-multiplexing of up to 60 data channels onto 12 analog tape tracks Demodulators (Figure 7) are available for playback of the multiplexed tape The intermediate bandwidth tape recorder is used for recording 12 tracks of data, one track of time code information, and one track of time-share information The time-share track is necessary since data from 60 AFE amplifiers may be time-shared on the 12 data recording tracks Time code generation and time code reading units are incorporated into the AFE along with a tape searching unit The analog tapes and their associated instrumentation may be operated either in a local or a remote mode for recording and for playback

Digital Computer

The other major component of the DAS is the digital computer with associated peripherals (Figure 8) It is in the central processing unit (CPU) that the majority of the control, interaction, and data reduction functions of the DAS are implemented Originally, 32K 32-bit words of multi-port, interleaved core memory were provided To accommodate increasingly complex software and larger amounts of data, the core memory has been expanded to 96K over the past four years The original DAS also used one disk for rapid-access auxiliary storage

Another significant expansion of the system, indicative of increased system use, was the addition of a second disk in a slave mode to the single original disk, providing a total of twelve million bytes of direct access storage Three nine-track digital magnetic tape units provide sequential auxiliary storage Other standard system peripherals include a card reader, a card punch, and a high speed line printer. For hard copy plotting, both a portable pen plotter and a portable electrostatic printer/plotter are integrated into the system Batch-processing communication and real-time program initialization are accomplished via a teletype printer The digital computer also has three Multiple Input-Output Processors (MIOP) that provide input/output (I/O) processing independent of the CPU In addition to the I/O lines, the digital computer provides multi-level interrupt lines connected to devices Interrupts are used to signal such events as the initiation or completion of a function, the occurrence of an abnormal condition, or the initiation of status change by the operator Peripherals that provide communication links for real-time processing are described under the external interface section of this paper

Internal Interfaces

Due to the integration of several functional subsystems in the DAS, a complex network of interfaces exists These interfaces can be viewed as internal or external in terms of the total system Internal interfaces (Figures 7 and 9) are considered to be connections between hardware components External interfaces (Figure 10) are those that allow real-time interaction between researchers and the DAS

The major internal interface between the analog front end and the digital computer is the Analog-to-Digital Subsystem (ADS) which executes in parallel with the CPU The ADS samples data from selected analog channels and converts them to digital form An automatic dynamic gain unit produces an optimal gain range In addition to normal sampling, all channels can be specified for sample-and-hold, thereby eliminating tracking time skew The individual channels may be sampled at different frequencies with a maximum total sampling rate for all channels of 50,000 samples per second

The second internal interface is the Digital Multiplexer (DM) which connects the DAS with external devices that provide digital inputs to the system The DM takes data from several digital links and transfers them over a single link to the digital computer memory The inputs are stored in coded bit formats Input to the DM includes switch settings from all analog front end instrumentation, counts from shaft encoders, operator thumbwheel inputs, and device status data Spare digital links are available for inputs unique to each particular test

Analogous to the DM is the third internal interface in the system, the Control Signal Distributor (CSD) The CSD demultiplexes commands, such as for instrumentation starting, stopping, and setting, to the external devices In a local mode, the bit-coded command words are input at the CSD control panel When the CSD is in remote mode, the CSD commands are generated by the digital computer

It is through the DM and CSD that the important control functions of the DAS are implemented For example, the automatic adjustment of gains and offsets to optimize amplifier output is especially important due to the large number of channels potentially used for input With the amplifiers in remote mode, the digital computer can read the current gain and offset settings through the DM. If the settings are not optimal, the amplifier gains and offsets can be recalculated and then reset automatically by commands to the CSD

External Interfaces

Because of the real-time nature of the DAS, the most commonly used external interface is a Graphic Display Unit (GDU) located in the control room (Figure 10) It provides several methods of communication between researchers and the digital computer The GDU provides visual information on a cathode-ray tube display with refreshed vector graphics capability along with alphanumerics A lightgun can be used for selection of lighted points on the displayed image Nonlighted points can also be selected if a raster scan is initiated prior to use of the lightgun The GDU keyboard can be used as the system controlling device during real-time processing Action switches, generally used to indicate decisions pertaining to processing options, and function buttons, generally used for task selection, are also supplied All GDU commands are formatted in a reserved data display buffer in the digital computer memory The primary controller of the GDU is connected directly to a memory port and therefore the GDU can operate without the need for CPU intervention

Each of three typewriter communication terminals can also be used as the system controlling device These typewriters are located in the calibration and model laboratories and in the data room The controlling device is specified to the system by the setting of a selector switch

Lighted numeric output displays and digital constant input thumbwheels comprise the other major external interfaces of the DAS A bank of ten lighted displays are located overhead in the control room Three displays are used to display tunnel Mach number, dynamic pressure, and temperature The remaining overhead displays can be programmed to display other parameters of importance to researchers during testing A similar bank of six displays provides tunnel parameters for the tunnel operator Six other lighted displays—three in the control room, one in the data room, one in the calibration laboratory, and one in the model laboratory—can be programmed for the display of numerous different values depending on the setting of a three-digit thumbwheel adjacent to each display Finally, twenty-six five-digit thumbwheels are provided for entering constants into the system Ten are located in the control room, eight are available in the calibration laboratory, and eight are located in the model laboratory

DATA ACQUISITION SYSTEM SOFTWARE

A tri-level software system (Figure 11) consisting of a basic operating system, a secondary real-time operating system, and user application programs makes the DAS a viable system The software was designed to integrate the complex structure of hardware components while at the same time making this complexity relatively transparent to the user Software development was oriented toward modularity with the goal of making the system flexible, easy to maintain, and cumulative in terms of programming effort

Basic Operating System

The basic operating system is a commercially produced real-time and batch monitor (RBM) RBM interacts with the digital computer via prioritized interrupts Its main function is to handle real-time processing Background programs can also be executed for software compiling, loading, and debugging and for post-test, off-line data reduction Most of the system and application software is stored in object module form on the disks and the operating system provides an editor for rapid retrieval and storage of program overlays during processing

Secondary Real-Time Operating System

Uniquely designed for the TDT and developed under contract at a cost exceeding $1 million, the secondary real-time operating system is called the Operating Measurements Program (OMP) and is actually an application program that executes under RBM However, due to the size, complexity and encompassing nature of OMP, it is functionally considered as an extension of the basic operating system for real-time processing It is through OMP that interfaces between the user, the hardware, the basic operating system, and the application software are effected OMP consists of a nucleus and a set of user-callable subroutines (UCSUB)

The nucleus of OMP maintains extensive common and system data bases As mentioned earlier, each of forty analog front end amplifiers can be switched among six data channels For each of six switch positions, the nucleus maintains two separate files of system data base information One file for each switch position holds the test section data base and the other file holds either the calibration or the model laboratory data base A total of twelve files is maintained The files can be swapped between main memory and the disks to describe totally the amplifier configuration of the DAS for a given test, including engineering unit coefficients, gains and offsets, identifiers, and sampling rates Other system data base information includes numerous flags and pointers pertaining to all aspects of the DAS The common data base, which can be accessed easily by the user, includes arrays of such information as tunnel parameters, channel lists, program constants, and thumbwheel settings.

The nucleus also provides three basic modes of operation setup, test, and user service During setup mode, parameters defining the user application programs (described in next section), the hardware configuration of the test environment, and software system constants are input to the DAS via operator type-in or via the reading of a card file (Figure 12) or a disk file The parameters are validated, checked for compatibility with actual hardware settings, and then stored in the data base Default values are supplied by OMP for most parameters, thereby greatly reducing the complexity of the setup procedure for the user OMP can be returned to setup mode for subsequent altering of these parameters It is during test mode that user application programs are executed under OMP In parallel with test mode, OMP automatically provides user service utilities such as error checking and automatic calculation and monitoring of tunnel condition parameters

The UCSUB's can be called both by the OMP nucleus and by user application programs. Special utility routines and library routines provided with the digital computer software can also be accessed by the nucleus or by the user programs and, hence, can be considered extensions of the set of UCSUB's The UCSUB's were written to perform such functions as handling operator interaction and plotting on the GDU display screen, reading or setting devices through OMP, recording on and playing back analog and digital tapes, sampling and converting data, and reducing data by defined calculations

User Application Programs

Designed to execute under control of OMP, the user application programs are commonly called First Level User Programs (FLUP) Typically, a new FLUP is written for every new wind tunnel test However, FLUP's are modular in design, and some parts of previously written FLUP's often can be used or modified for a new FLUP With this cumulative effort as a base, new FLUP's are increasingly sophisticated

Over the past four years, a typical structure for a FLUP has evolved (Figure 13) which takes advantage of RBM overlay structures to optimize memory use A FLUP might have a control routine that interrogates the GDU function buttons to determine the task to be executed One key task, a version of which is common to every FLUP, is a tab-a-point (TAB) routine TAB usually increments and records the test point number, sets the time code generator, prints the current tunnel parameters, and prints (and perhaps displays on the GDU) the status of all configured channels An extended TAB might also calculate, record and display a quick-look average voltage for each channel and/or the model angle-of-attack based on shaft encoder counts obtained through the DM Another task often used causes a gain and offset optimization routine to be executed Other tasks of a utility nature might erase the GDU screen, record on digital tape a specified number of samples, or terminate the FLUP

In addition to such standard tasks, a FLUP generally will include one or more data reduction and analysis tasks Usually, such a task provides for operator interaction via the GDU keyboard, lightgun, and action switches Data for a specified number of channels might be sampled with optional digital tape recording if additional post-test processing is anticipated In real-time, the data might be converted to engineering units and subjected to an analysis technique as, for example, a Fourier transform in a power spectral density calculation The calculated results might be listed on the line printer and plotted on the GDU Through operator interaction the plots might be edited and/or stored on digital tape for post-test batch hardcopying. The multitude of options available for input, output, and interaction through OMP, combined with known or experimental mathematical techniques, gives the writers and users of a FLUP an enormous amount of application software flexibility

A FLUP may also include routines that are connected through clock interrupts to be executed in short periodic bursts These routines are known as "cyclics " OMP provides two handlers for two second cyclics and one handler for a half second cyclic, hence, up to three cyclic subroutines may be active within a FLUP during test mode The cyclic subroutines are activated or deactivated by operator commands and are often used for applications which require constant monitoring of certain conditions or instrumentation

DATA ACQUISITION SYSTEM APPLICATIONS

Since the DAS was first installed, many programs designed for specific applications have been developed and used successfully New applications and new software are constantly being created Examples of some of the subroutines and FLUP's currently available are summarized below

Pre-Test

In preparation for tunnel testing, the DAS can be used for model and instrumentation calibration and check-out Physical loads are applied to the model and the resulting transducer readings are checked to verify proper installation The transducers and their associated signal conditioning equipment are calibrated to establish the relationship of the physical forces and the signals received by the DAS Excitation voltages may be read and bridge shunt equivalents of physical forces may be electrically applied to the transducer circuitry. Readings are taken for various loads and a curve fitting procedure is applied

A large, multi-purpose FLUP, Transducer Calibration (XDCR), was developed to support these pre-test activities. The main purpose of XDCR is to provide the coefficients necessary for removing transducer nonlinearities and offsets and for converting amplifier outputs back to the transducer input values The coefficients are output on cards by the card punch for subsequent input during setup mode for actual testing. Optional displays, listings and plots of XDCR data are provided

Real-Time

An important aeroelastic phenomenon studied in the TDT is flutter (as previously discussed). Because flutter can cause catastrophic structural failure of expensive test models, it is preferable when possible to predict flutter boundaries rather than to actually experience flutter points when testing in the TDT One method of attempting to predict flutter while testing involves the measurement of frequency and damping from dynamic response data below the actual critical points This technique is not effective unless the damping can be continuously monitored as a flutter boundary is approached. Continuous monitoring of damping in near real-time is possible through application programs implemented on the DAS

Subroutines to obtain damping values by Randomdec analysis and/or Moving-Block analysis[2] of dynamic data have been developed for the DAS. These subroutines are typically associated with GDU function buttons to be executed as tasks under a FLUP Data are acquired and then analyzed using Fast Fourier Transform techniques and averaging over blocks of data Operator interaction is an important feature in this type of analysis. Through operator interaction, parameters may be varied and frequencies may be selected using the GDU lightgun on displayed plots (Figure 14)

In addition to Randomdec/Moving-Block analysis, other time-series analysis techniques have been implemented on the DAS Generalized routines to calculate Fast Fourier Transforms are available Several versions of a Power Spectral Density (PSD) subroutine have been widely used for examining the frequency content of data signals (Figure 15)

In other wind tunnel tests, steady and unsteady pressure measurements are of interest Pressure transducers on a model are located along several lines (chords) from the leading to the trailing edge of an airfoil Pressure distributions over the surface of an oscillating airfoil are studied. A large-scale generalized FLUP has been developed for a series of wind tunnel tests of this nature. The FLUP includes, among other functions, tasks that cause static (steady) pressure data to be taken through ports of up to 36 pressure scanning valves. Each scanning valve consists of a rotary solenoid-operated stepping switch which directs 47 separate pressure readings, in addition to a reference reading, to a single transducer Therefore, a maximum of 1692 pressures and 36 reference values can be sampled through the DAS The data are then reduced and the pressure distributions over the airfoil are plotted on the GDU under control of the FLUP Other tasks in the FLUP accomplish the processing of dynamic (unsteady) data from pressure transducers The peak amplitude (modulus) of the oscillating pressure and its relationship to the movement of a wing or control surface (phase) are calculated. These values are plotted as a function of transducer location and displayed on the GDU for real-time analysis by the test engineer

Many analysis and utility routines have been written for incorporation into FLUP's as needed A generalized scanning value subroutine is available Separate routines have also been written to acquire, reduce, and display, in near real-time, static and dynamic deflection data and also strain gage balance data Balance data are used to calculate forces and moments resulting from loads on a model

Post-Test

A stand-alone version of OMP, a subset of the real-time system, was created to allow detailed post-test data reduction and analysis The real-time characteristics of OMP were eliminated from the stand-alone version with the advantage of a significant increase in available core memory Operator interaction via the GDU was retained. Therefore, larger amounts of data (input from prerecorded analog or digital tape) can be scrutinized in a non-time-critical mode

For some analyses, real-time programs such as the PSD routines were modified for stand-alone use. In real-time, PSD calculations were restricted to one channel at a time, however, multiple PSD's can be calculated in parallel by the stand-alone program. This saves a significant amount of time in data acquisition and the researcher may vary parameters and analyze data at length

Another example of post-test processing is illustrated by a program called MOVY Data prerecorded on digital tape during real-time processing for an unsteady pressure measurement test are input to MOVY At specified time intervals, the pressures at individual transducers located along a chord of the wing model are plotted, with the points connected by lines, on the GDU screen Data for several chords are displayed at the same time The resulting effect is a representation of shock waves moving over the wing as it oscillates The speed of the "movie" can be increased or decreased by varying the length of the time interval Partly due to the success of MOVY, plans are currently underway to enhance the graphics capability of the DAS.

CONCLUDING REMARKS

A computer-controlled digital data acquisition system has been successfully implemented and used extensively for aeroelastic research in a transonic dynamics wind tunnel. This unique system was specifically tailored to handle many channels of dynamic test data over a wide frequency range The DAS provides test engineers with reliably valid data in a real-time environment. It also facilitates pretest calibrating and model preparation, and post-test data analysis Plans are underway for improving the DAS with expanded graphics capabilities due to the numerous benefits of real-time interaction. This system of interdependent hardware and integrated, modular software fulfills its original design criteria of being usable, modifiable, and versatile.

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(2) Hammond, Charles E , Doggett, Robert V , Jr , "Determination of Subcritical Damping by Moving-Block/Randomdec Applications," Paper No 3, Proceedings of the NASA Conference on Flutter Testing Techniques, Edwards, CA, NASA SP-415, Oct 1975

NOMENCLATURE

ADS	Analog-to-Digital Subsystem
AFE	Analog Front End
CPU	Central Processing Unit
CSD	Control Signal Distributor
DAS	Data Acquisition System
DM	Digital Multiplexer
FLUP	First Level User Program
GDU	Graphic Display Unit
I/O	Input/Output
MIOP	Multiple Input/Output Processor
OMP	Operating Measurements Program
PSD	Power Spectral Density
RBM	Real-time Batch Monitor
TAB	Tabulate-a-Point
TDT	Transonic Dynamics Tunnel
UCSUB	User Callable Subroutine
XDCR	Transducer Calibration

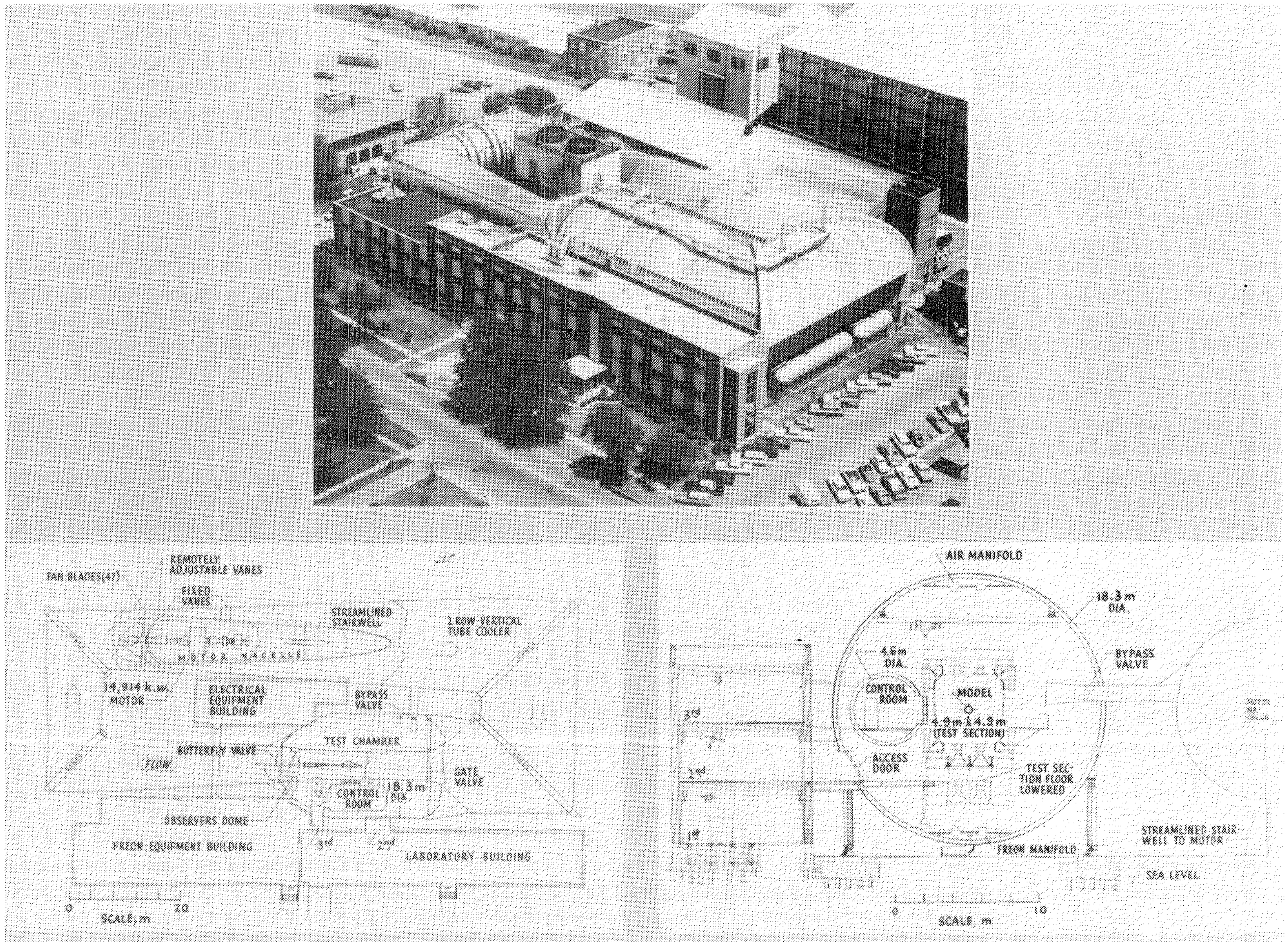

FIGURE 1 - NASA LANGLEY RESEARCH CENTER TRANSONIC DYNAMICS WIND TUNNEL.

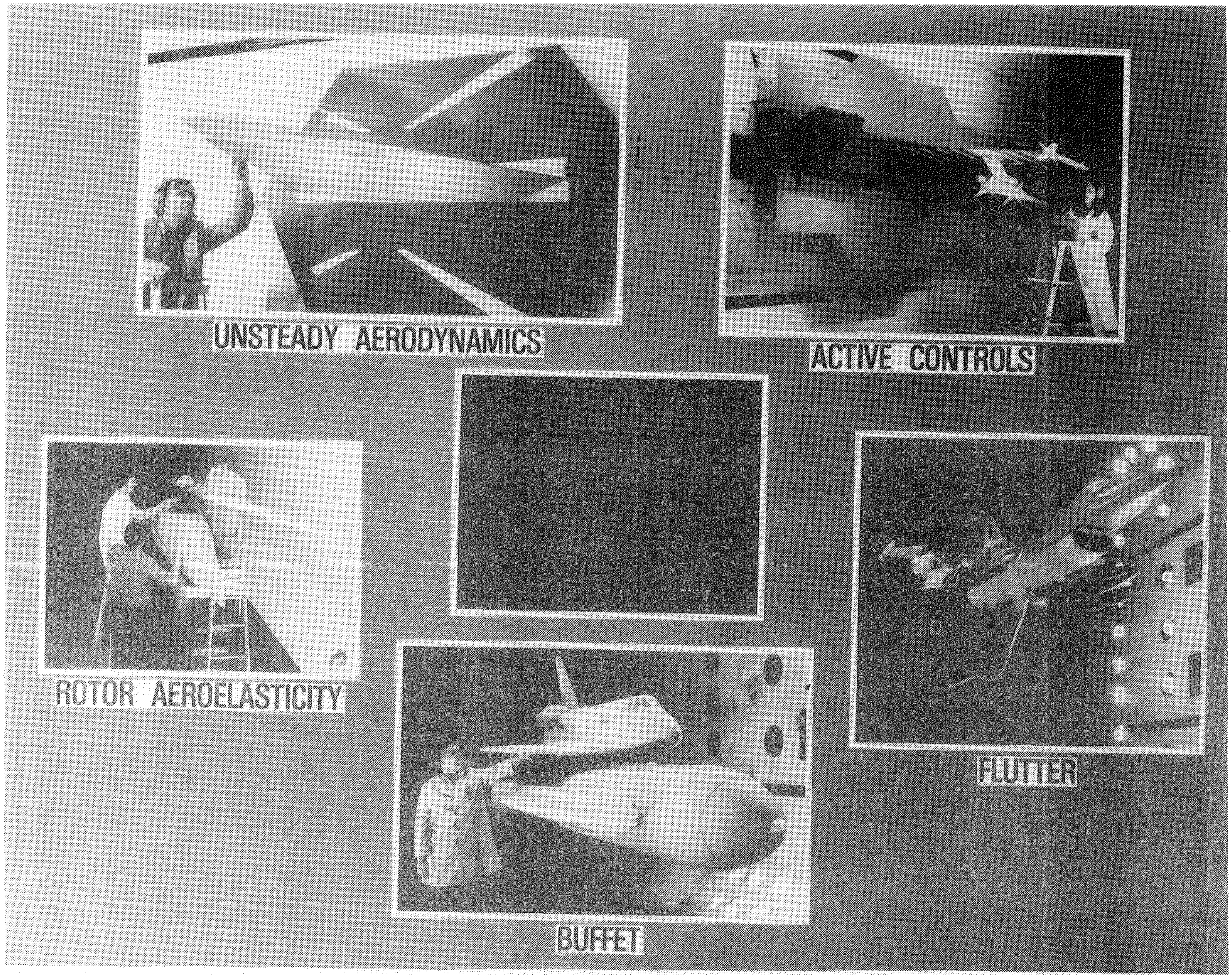

FIGURE 2 - TYPE OF RESEARCH AND TESTING WITH REPRESENTATIVE MODELS AND MOUNTING TECHNIQUES.

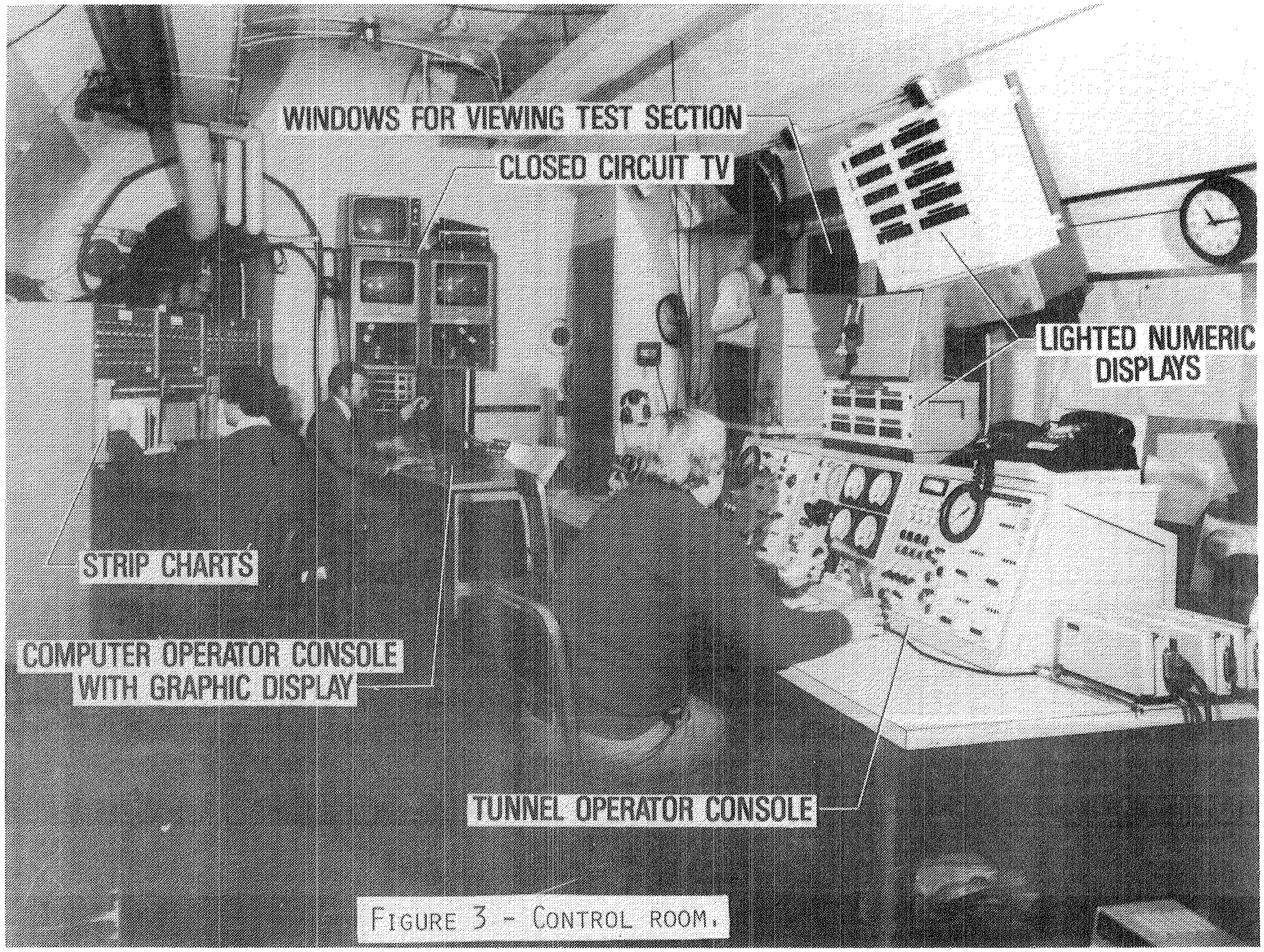

FIGURE 3 - CONTROL ROOM.

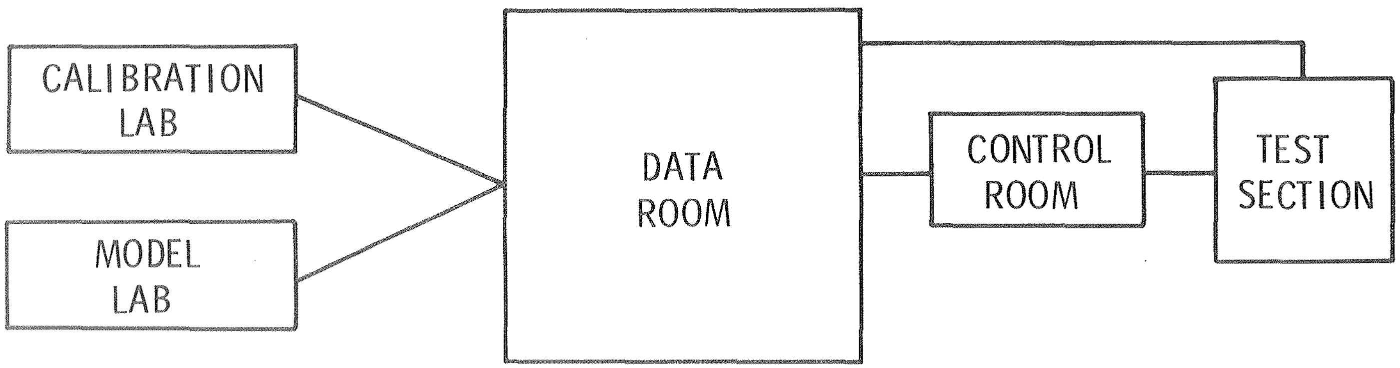

Figure 4 - Functional work areas for tunnel facility.

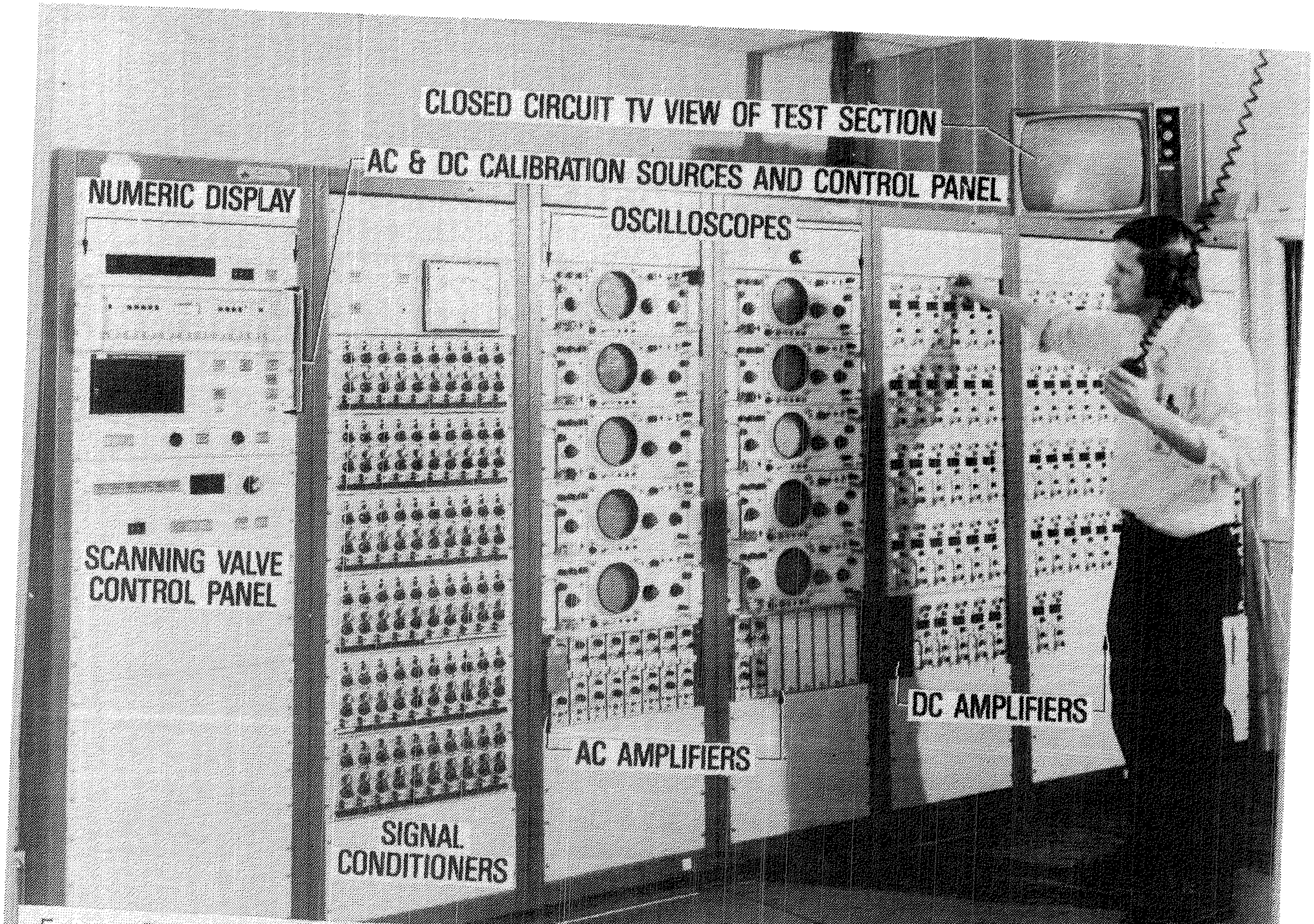

FIGURE 5 - ANALOG FRONT END DATA ACQUISITION, MONITORING, AND CONDITIONING EQUIPMENT.

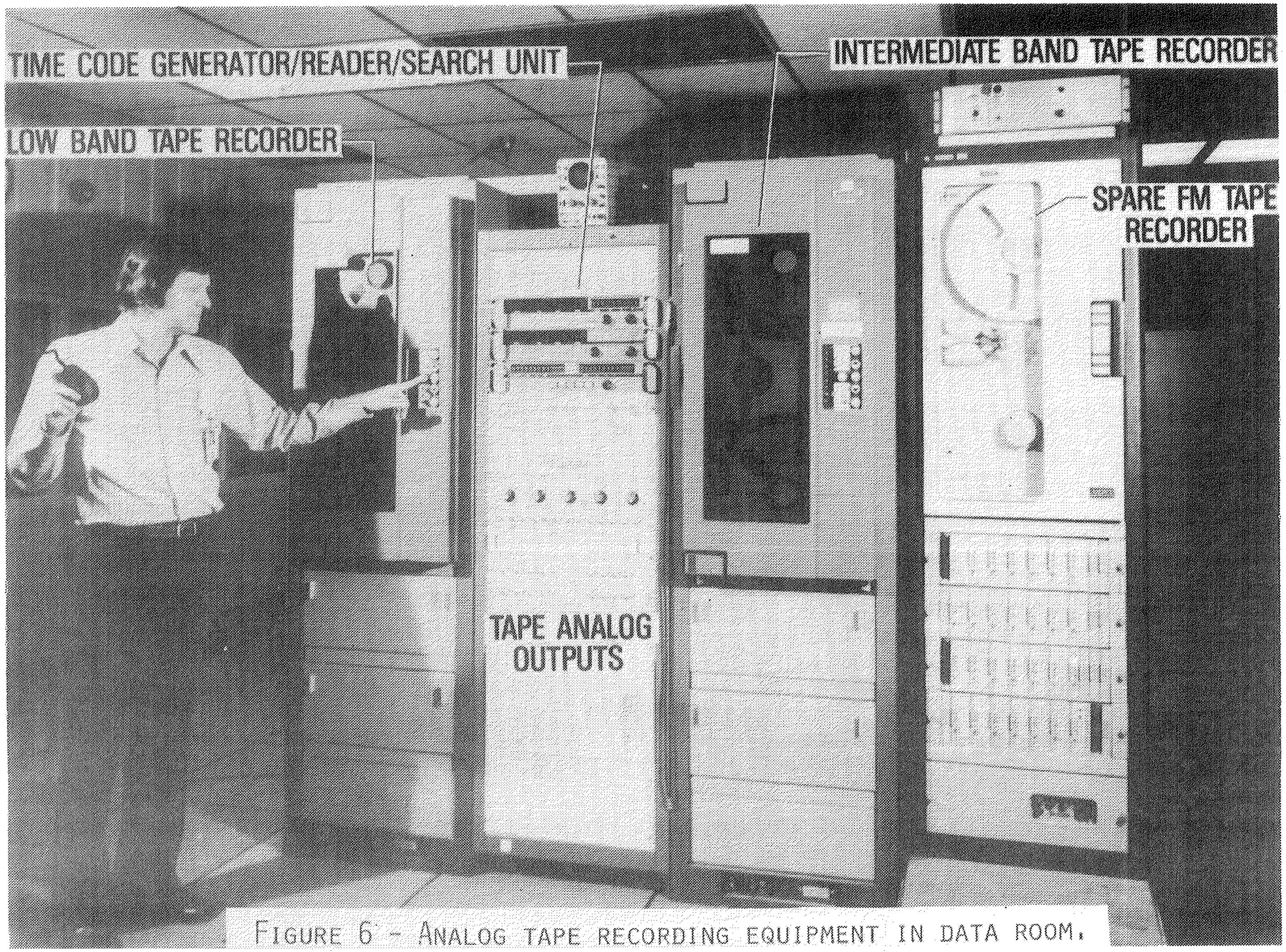

FIGURE 6 - ANALOG TAPE RECORDING EQUIPMENT IN DATA ROOM.

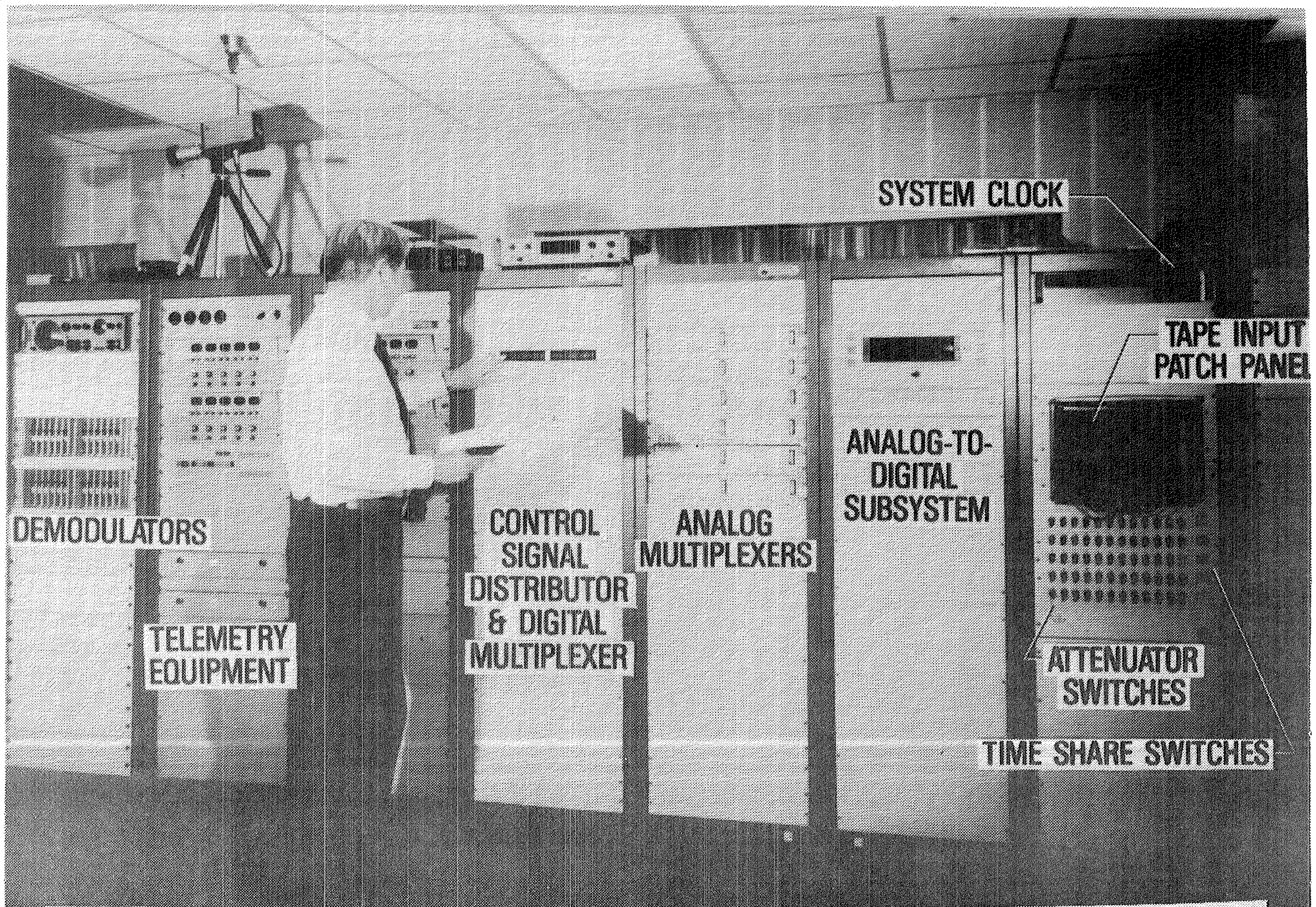

FIGURE 7 - ANALOG TAPE MULTIPLEXING AND TIME-SHARING EQUIPMENT, AND HARDWARE INTERNAL INTERFACES.

FIGURE 8 - DIGITAL COMPUTER AND PERIPHERALS IN DATA ROOM.

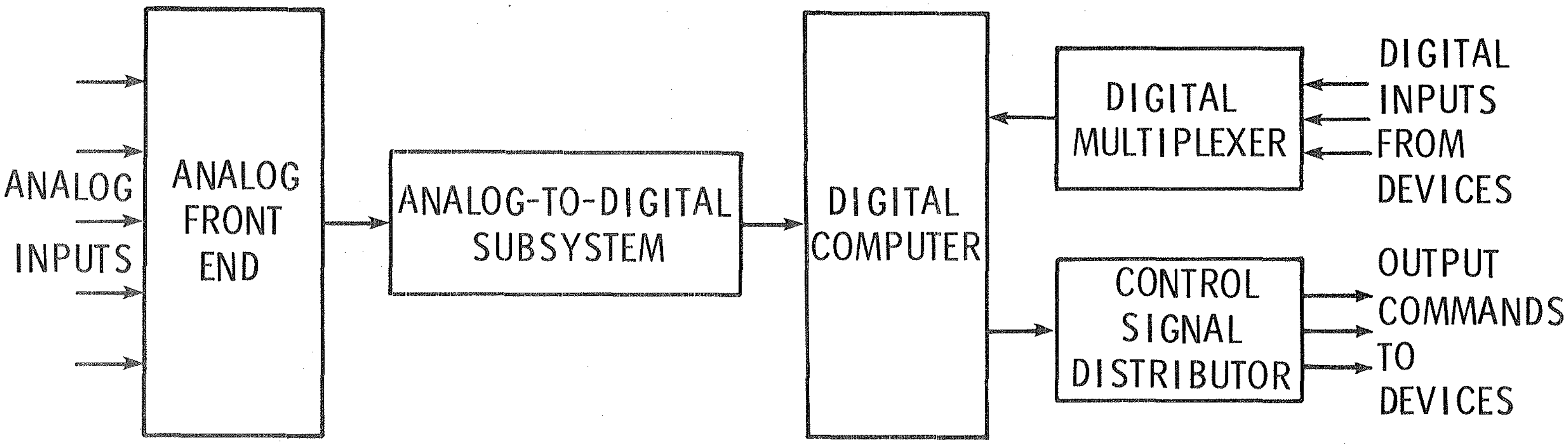

Figure 9 - Simplified block diagram of internal interfaces.

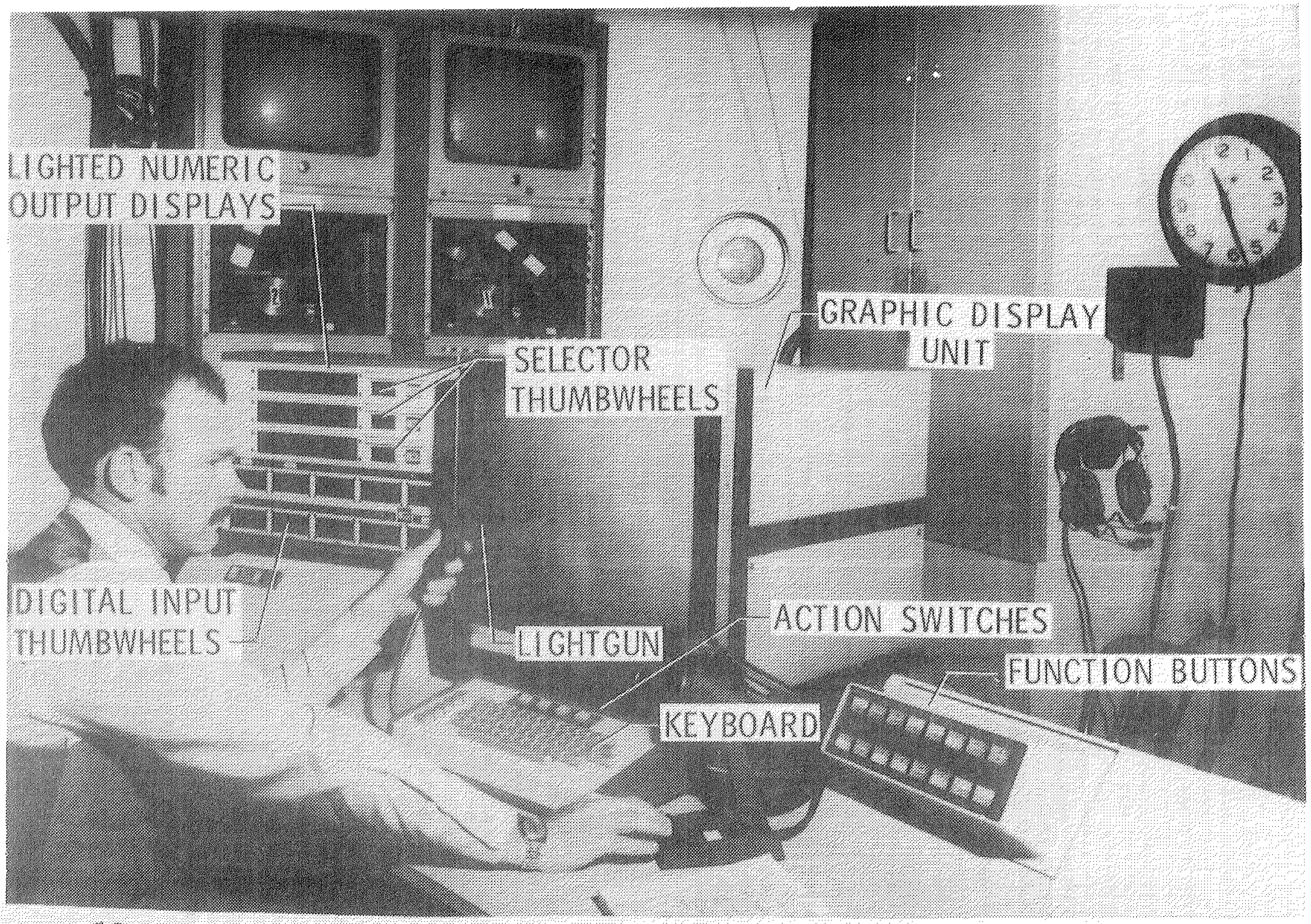

FIGURE 10 - EXTERNAL INTERFACES AT COMPUTER OPERATOR'S CONSOLE IN CONTROL ROOM.

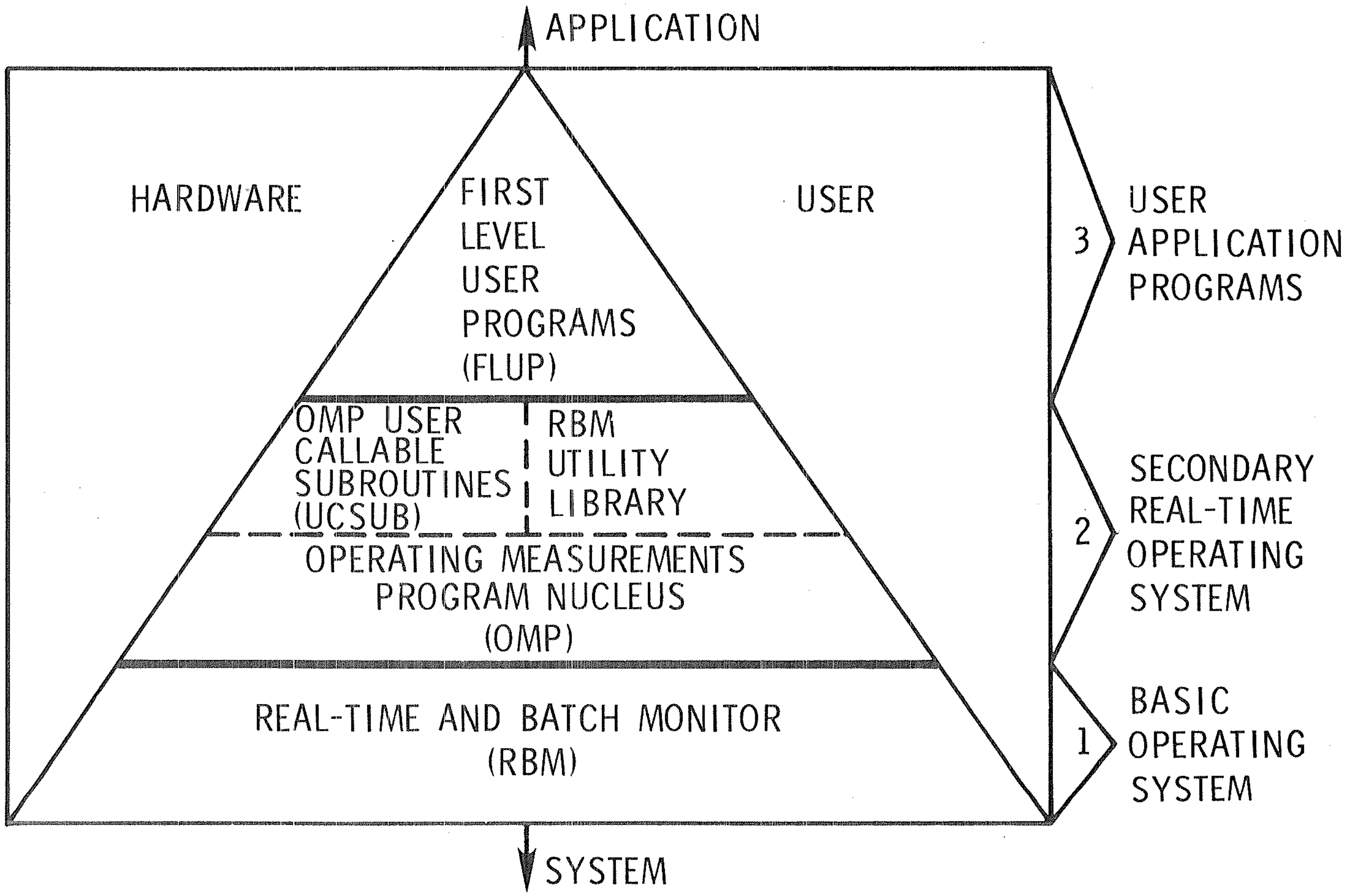

FIGURE 11 - SOFTWARE STRUCTURE.

(1) DEFINE PROGRAMS

(2) LICENSE ANALOG CHANNELS. SPECIFY SELECTED SAMPLE RATE, GAIN, EXCITATION VOLTAGE, IDENTIFIER.

(3) TRANSDUCER COEFFICIENTS FOR CHANNEL 3

(4) PRESET A PROGRAM VARIABLE

(5) SPECIFY A CHANNEL LIST

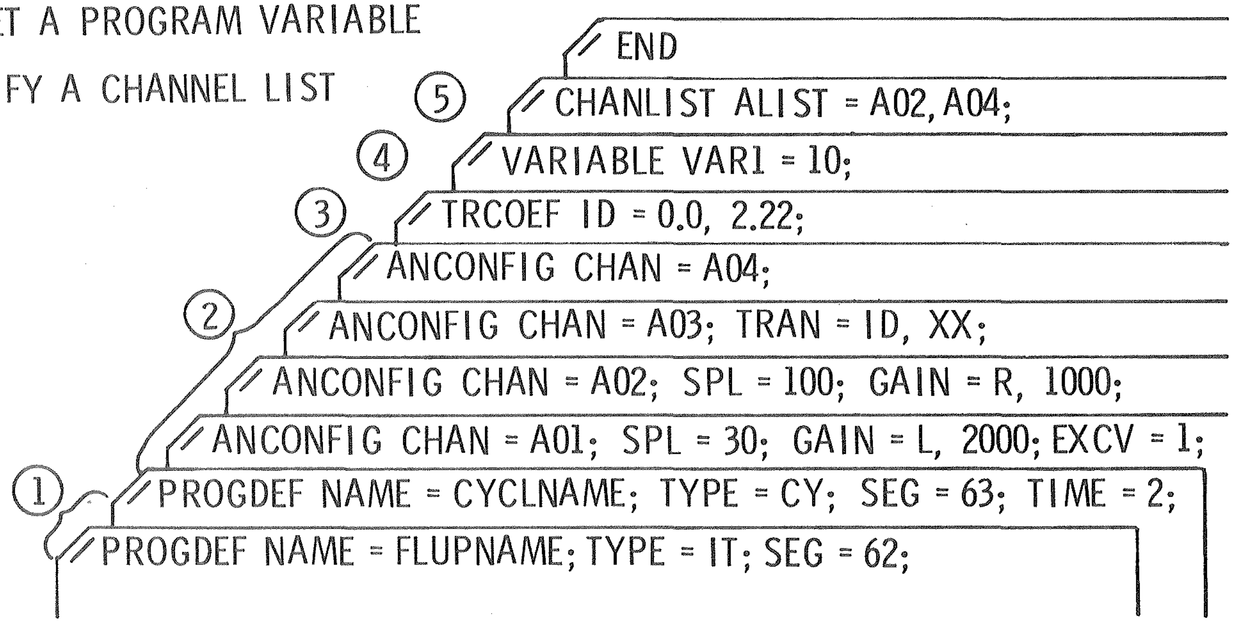

FIGURE 12 - REPRESENTATIVE FILE FOR SETUP MODE INPUT TO OMP.

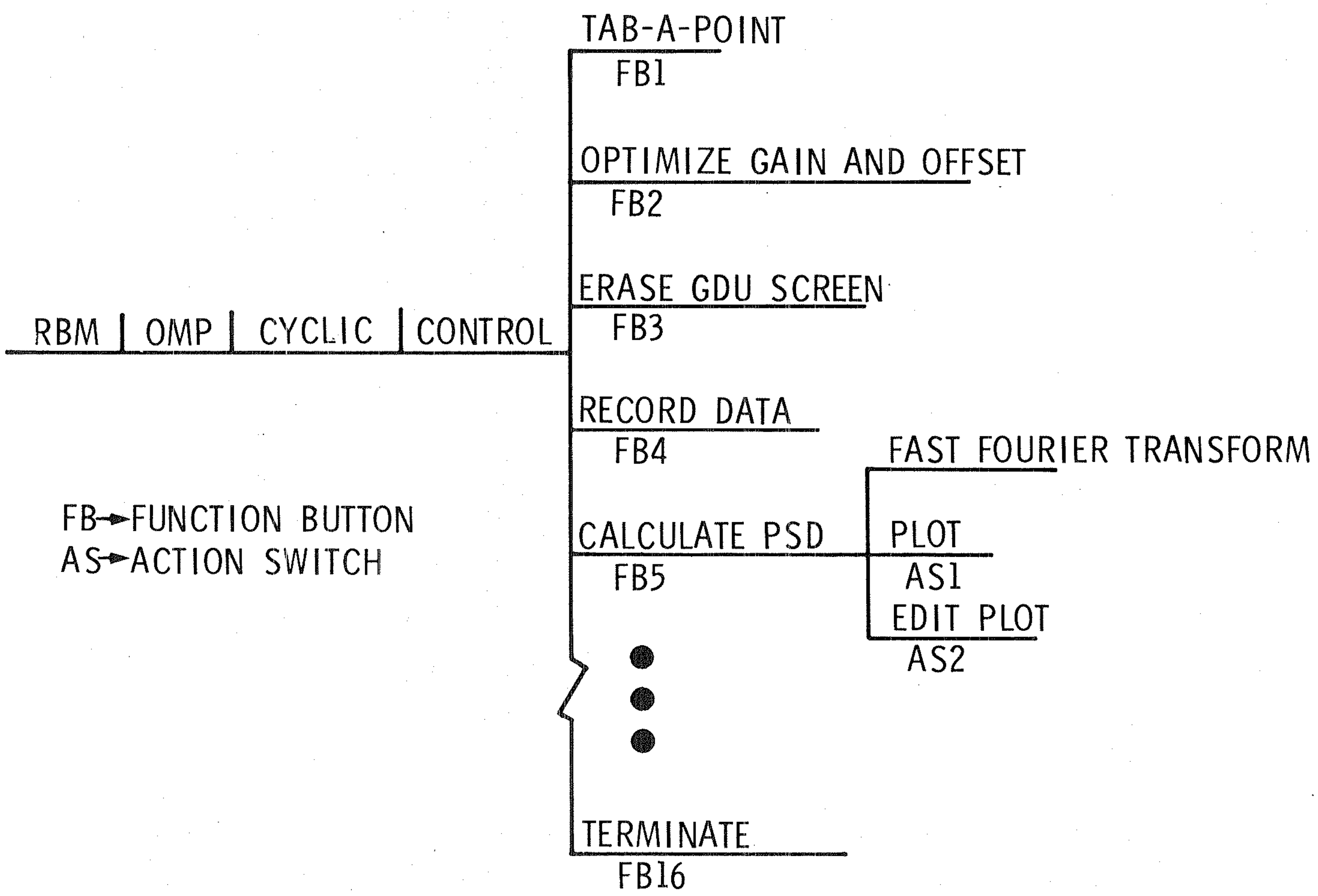

FIGURE 13 - TYPICAL FLUP WITHIN TOTAL SOFTWARE STRUCTURE.

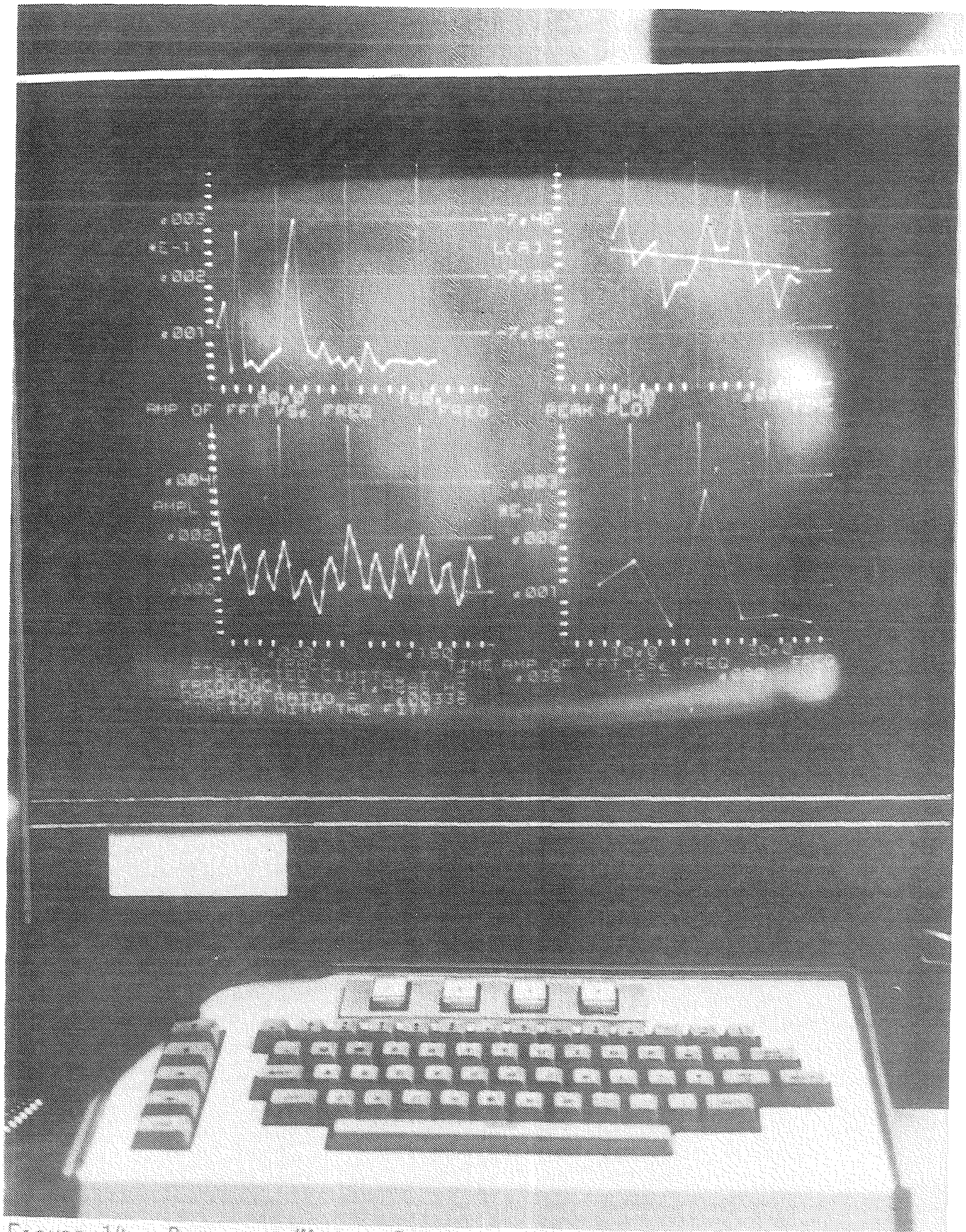

FIGURE 14 - RANDOMDEC/MOVING-BLOCK ANALYSIS USING INTERACTIVE GRAPHICS

- CALIBRATION
- TIME-SERIES ANALYSIS
  - FAST FOURIER TRANSFORM
  - POWER SPECTRAL DENSITY
  - RANDOMDEC ANALYSIS
  - MOVING BLOCK ANALYSIS
- UNSTEADY PRESSURE MEASUREMENT
- DYNAMIC WING DEFLECTION MEASUREMENT
- BALANCE DATA FORCE AND MOMENT CALCULATION

FIGURE 15 - MAJOR APPLICATIONS IMPLEMENTED BY CURRENTLY AVAILABLE FLUP's.

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16. Abstract

The Transonic Dynamics Wind Tunnel facility at the NASA Langley Research Center is uniquely designed for aeroelastic research and testing which requires acquisition of large amounts of dynamic data over a wide frequency range. The computer-controlled tunnel Data Acquisition System (DAS) is specifically tailored to acquire such dynamic data and to provide real-time, interactive data reduction, analysis, and display. Furthermore, the DAS provides the capability for on-line monitoring and control of a wide variety of analog instrumentation. The range in types of testing and the uniqueness in instrumentation for each individual test requires that the DAS be flexible, versatile and easy to use.

The paper describes the hardware configuration of the DAS which consists of an analog front end that can process up to 260 channels of data, a multi-channel analog-to-digital subsystem that can process up to 50,000 samples of data per second, and a digital computer with standard and nonstandard devices, including graphics capability. Also described are the software configuration of the DAS and complex hardware/software interfaces providing, for example, automatic amplifier gain and offset adjustment for each data channel. Finally, this paper provides a summary of specific DAS applications including the real-time processing of dynamic deflection data, unsteady pressure measurements, and flutter and buffet data.

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