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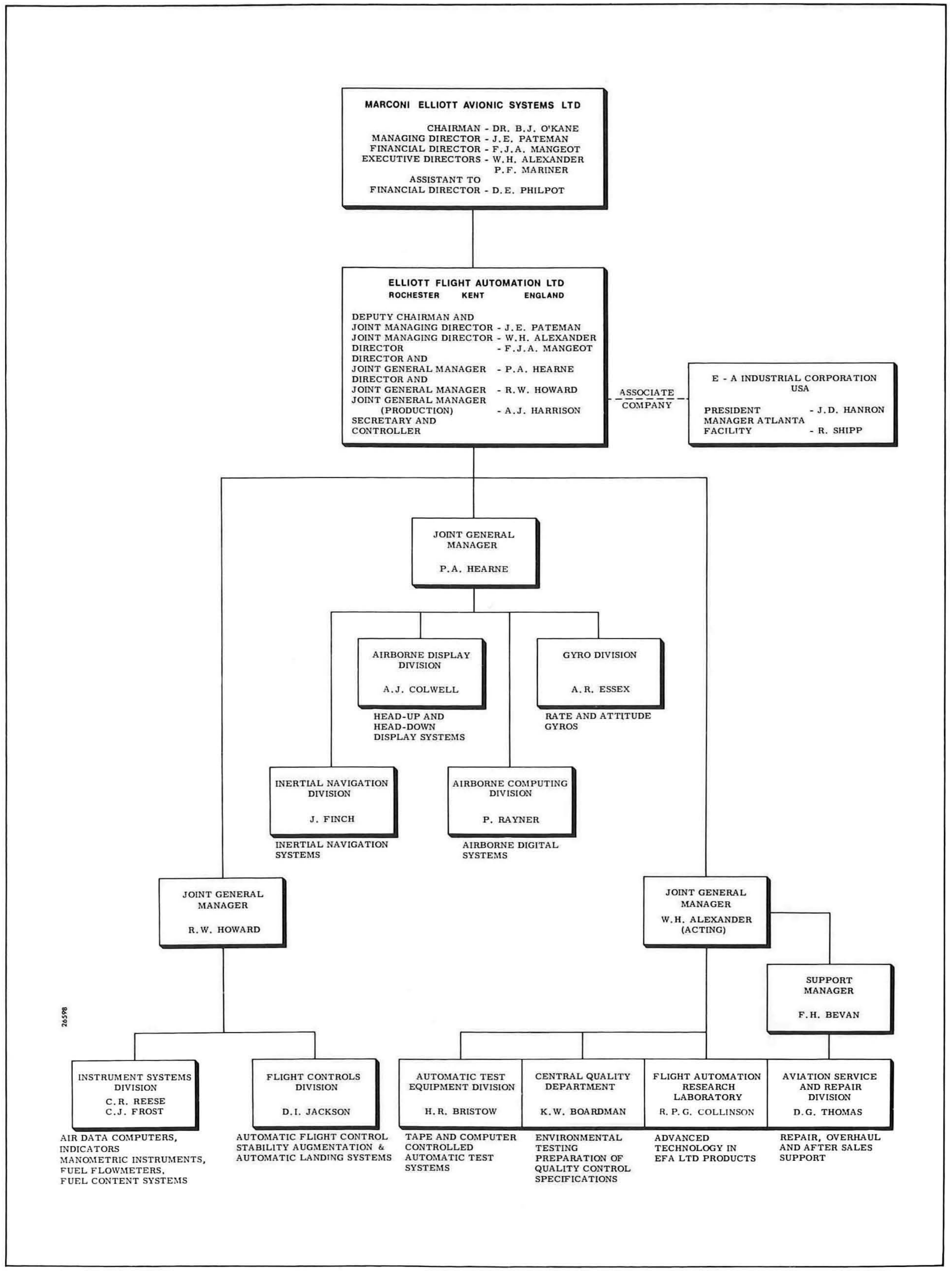
A GEC-Marconi Electronics Company

MARCONI
ELLIOTT
AVIONICS

Automatic Test Equipment for Concorde Avionics

MARCONI - ELLIOTT AVIONICS SYSTEMS LIMITED



Foreword

It is now more than a decade since the Management of Elliott Flight Automation, aware of the increasing complexity of avionics testing, set up a specialist product Division to develop automatic test systems. The Division was established both to provide this specialist function to support the Company's avionic products and also to compete in markets for general-purpose and multi-system automatic test equipment.

The Division has been in the forefront of the development in computer-controlled automatic test systems and has established a reputation for high quality, advanced technology products fully compatible with the United Kingdom and United States military requirements.

The technology developed provides greater flexibility in test capability than previous generations of equipment, and thus automatic test equipment hardware for a particular problem now costs less and has much greater scope for extension of application. The Company believes these considerations to be immediately relevant to airlines and that the automatic test equipment described in this proposal to support the Elliott/SFENA Automatic Flight Control System for the Concorde offers considerable technical benefits and economies to airlines. The ATE is offered with the full confidence that it will enhance the Company's reputation in the field of civil avionics.

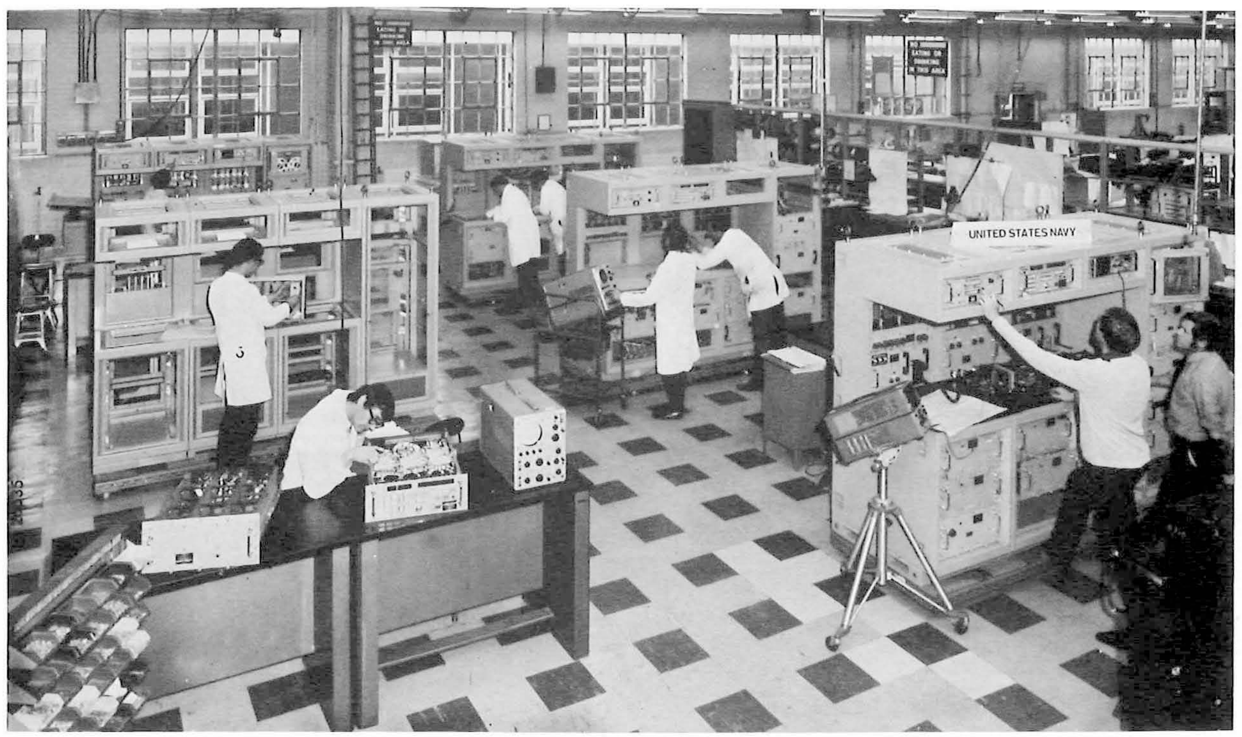
W.H. Alexander
Director, Marconi-Elliott Avionics

12 Years in Automatic Test Equipment

ARB Approval

Total Capability: **Design**
Manufacture
Programming
Service

ATE Commissioning Area



Automatic Test Equipment

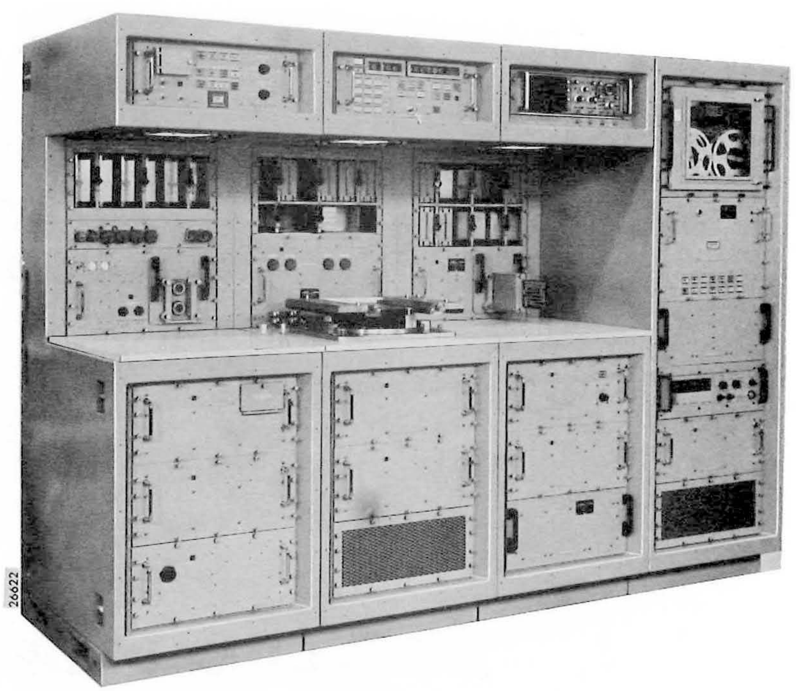
TECHNICAL PROPOSAL

- Hardware
- Operational Procedures
- Unit Under Test Software
- Technical Support
- ATE Spares
- Training

for CONCORDE

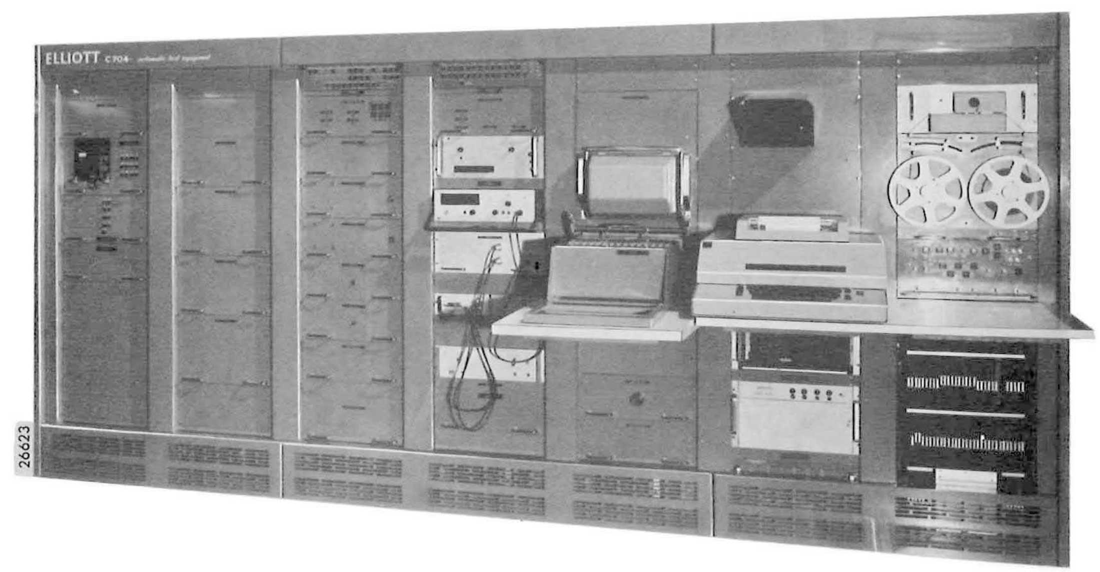
Project Milestones
Computer Controlled ATE for USN

MONTH O	**Contract Award**	2 LRU's Fault Diagnosis to Card Level 34 Cards Functional Test Self Test Fault Diagnosis to Card Level
MONTH 11	**First Delivery**	Service Test Model Initial LRU Programs
MONTH 22	**Acceptance**	All Programs Completed and accepted. 5th Test Set Delivered.
MONTH 23	**Peak Deliveries**	4 Test Sets in one month.
MONTH 27	**Completion**	14th Test Set Delivered.



ATE for Nimrod Avionics

General Purpose	33 LRU's	Flight Control System Inertial Navigation System Routine Dynamic Display Wind Computing Mission Analysis System
Computer Controlled		General Purpose 8K Core Store Alphanumeric Display
Operational	3 Locations	On site engineering support Program update service Multi-shift working.
Availability	2750 Hours	In first machine year.



Factory Automatic Test Equipment

Installed at Rochester

2 Years - No production time lost
Testing Avionics Modules.
24 hour shift working.

Batch Testing

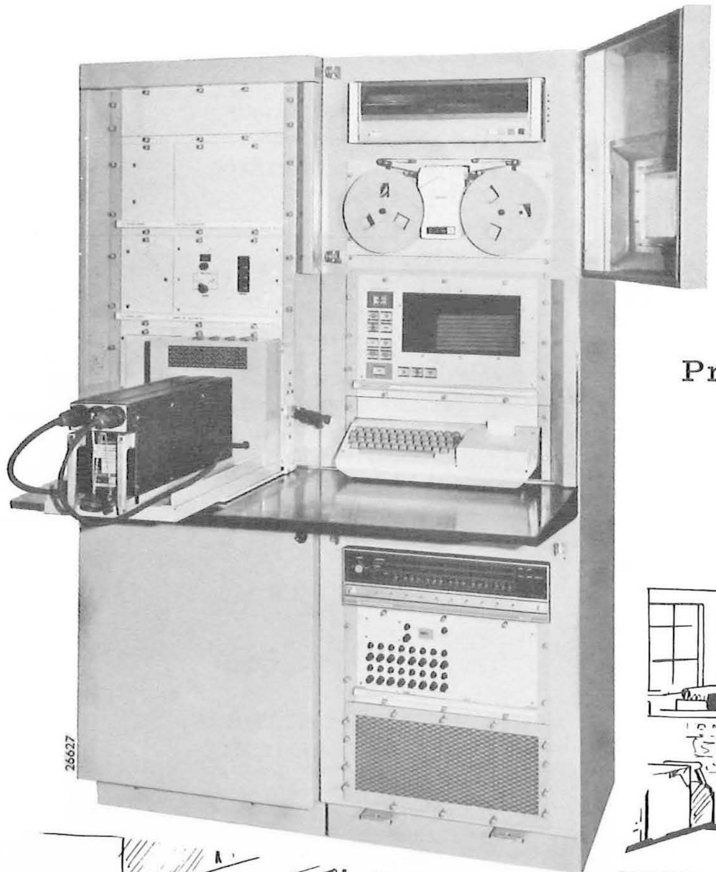
27 Units and Cards
Printed Docket for re-work.

Magnetic Tape Store

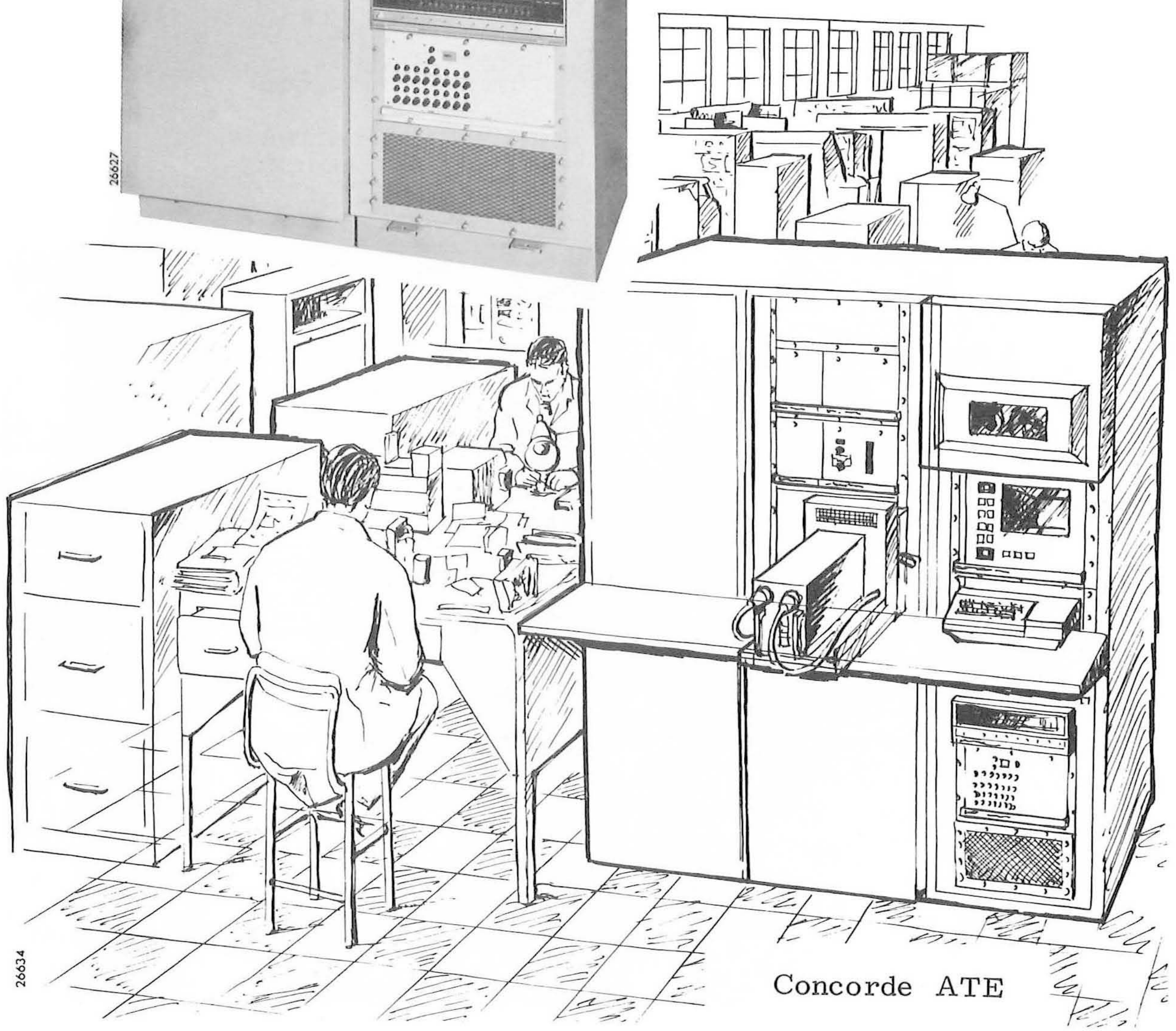
On demand Programs
Diagnostic to component level
Select on Test Routines.

Contents

Pre-Production Flight Control System ATE



Pre-production ATE



Concorde ATE

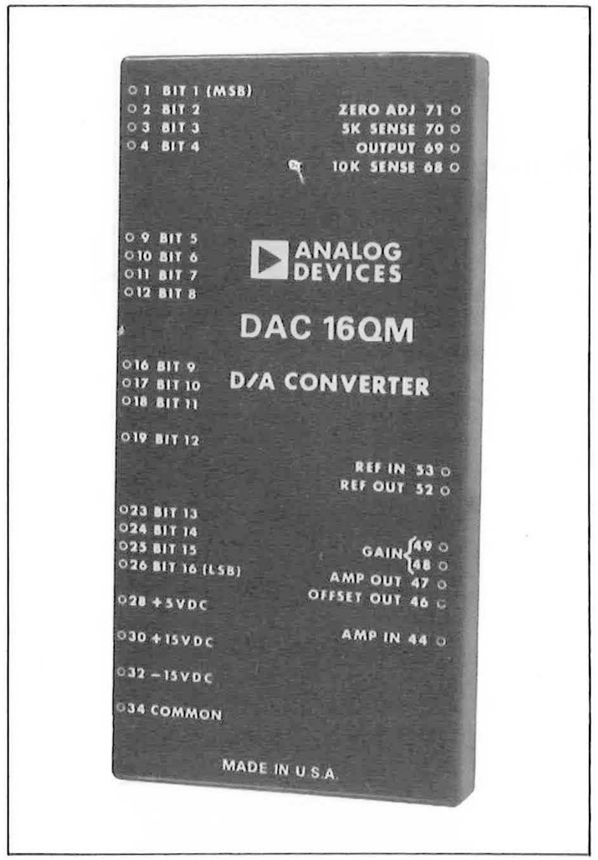
Features of the System

Advanced Technology ATE

Complex Waveform Generation and Analysis by Integrated Computer Control

COMPUTER CONTROL

- Mini Computer
- 8K Core Store
- 16 Bit Parallel Operation
- 1·2/ μS Access Time
- Calculation of ordinates to Function Generator
- Analysis of Data from Sampling Volt-meter
- Controls Peripherals
- Manipulation of Test Program
- On Line Test Program Preparation
- On Line Editing

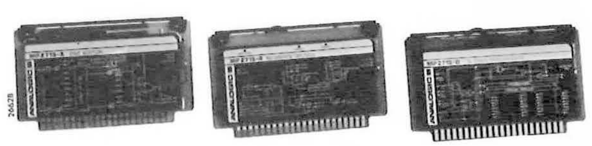


FUNCTION GENERATOR

- dc to 100kHz
- 14 Simultaneous output signals
- Xtal Controlled Frequency
- Programmable Waveshape
- Modulated Carrier
- 3 Wire Synchro Signals
- Trigger for Coherent Sampling

SAMPLING VOLTMETER

- Measurement of Convential Parameters
- Coherent Sampling
- Random Sampling
- Frequency and Time Measurement
- Phase Measurement
- Distortion Measurement
- Harmonic Analysis
- Synchro Measurement



PERIPHERALS

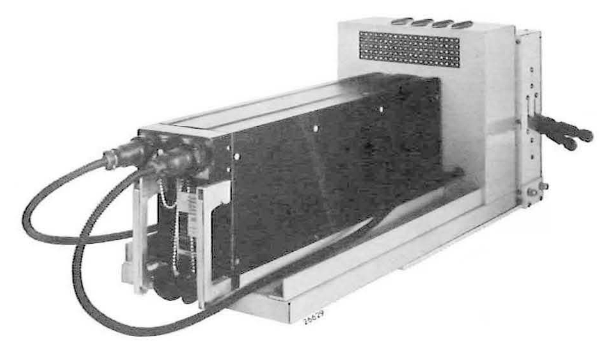
- Alpha Numeric Display
- Tape Reader and Handler
- 24M Bit Disc Store
- Keyboard
- Mosaic Printer
- Punch

MAN MACHINE INTERFACE

- Minimal Controls
- Illuminated Controls and Indicators
- Legible Alpha Numeric Display
- Standard Keyboard to Input Data
- Hard Copy Printout
- Automatic or Step by Step Control
- Manual Control

UNIT UNDER TEST INTERFACE

- Rigid
- Easily and positively located
- Rapid Removal
- Replaceable ATE Interface
- Access to Unit Under Test
- Forced Air Cooling
- Signal Monitoring Panel



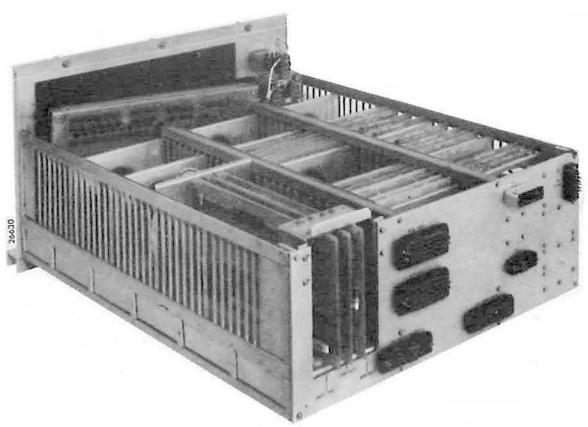
UNIT UNDER TEST SOFTWARE

- IDEAL Language
  A high level subset of ATLAS
- Simple to read
- Simple to write
- English message to operator
- Many mod states in one program
- Rapid access to disc

```
TEST 56203 $
SET UP, 'SAMPLING VOLTMETER', (VOLTAGE - RMS), RANGE 100 $
CLOSE, 62 $ COMMENT, THIS CONNECTS HB-43 TO SAMPLING VOLTMETER $
READ, 'SAMPLING VOLTMETER', FILTERED $
COMPARE, 'M', UL 29, LL 24, UNITS VAC $
GO TO, 56900, IF NO GO $
DISPLAY MESSAGE, CHECK TEST LAMP IS ON.  PRESS GO/NOGO $
WAIT FOR, MANUAL INTERVENTION, STOPPING $
GO TO, 56900, IF NO GO $
OPEN, 62 $
TEST 56204 $
SET UP, 'SAMPLING VOLTMETER', (VOLTAGE), RANGE 1 $
CLOSE, 116 $ COMMENT, CONNECTS ZA-37 TO SAMPLING VOLTMETER $
READ, 'SAMPLING VOLTMETER', FILTERED $
COMPARE, 'M', UL 400, UNITS MVDC $
GO TO, 56900, IF NO GO $
OPEN, 116 $
TEST 56205 $
CLOSE, 127 $ COMMENT, CONNECTS ZA-3 TO SAMPLING VOLTMETER $
READ, 'SAMPLING VOLTMETER', FILTERED $
COMPARE, 'M', UL 400 $
GOTO, 56900, IF NO GO $
OPEN, 127 $
TEST 56206$
SET UP, 'SAMPLING VOLTMETER' (VOLTAGE) RANGE 100 $
```

MECHANICAL CONSTRUCTION

- Filtered cross flow cooling
- Lightweight Chassis
- Telescopic Slides
- Front Access for Maintenance
- Units operational in extended position
- Ergonomically designed
- RFI Protection



ELLIOTT

RELIABILITY

- Over 300 Hrs. between failures
- Reduction in Hardware
- Use of MSI
- High Quality Components
- Printed Wired Boards
- Advanced Bonded Chassis

MAINTAINABILITY

- Preventative Maintenance minimised
- Interchangeability of identical modules
- Automatic Self Check
- Automatic Self Test
- Functionally Designed Cards

Maintenance Manual

- Automatic Calibration Routine
- Minimal Support Equipment

RELIABILITY is a quantative characteristic

PREDICTABLE in design

ASSUREABLE in production

MEASUREABLE in test

MAINTAINABLE in the field

Flexibility of Extension

SOFTWARE

- Depth of Diagnosis
- Analogue Modules
- Artificial Feel Computer
- Air Intake Control
- Throttle Control
- Master Warning
- Flight Data Acquisition

SOFTWARE/HARDWARE

- Digital Units
- Digital Modules
- Air Data Computer

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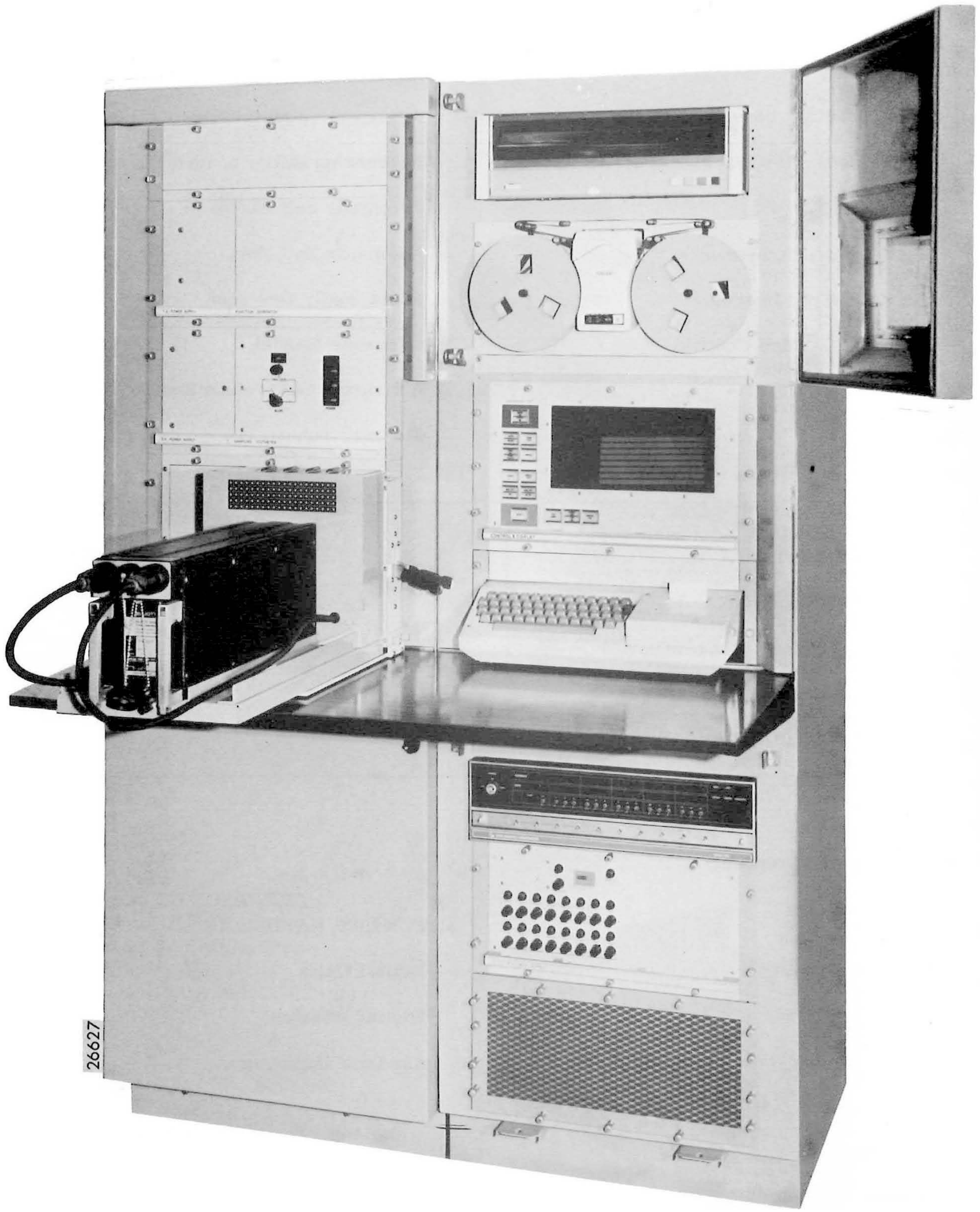


Application of the ATE

Value of Ownership

The value of ownership of Concorde Automatic Test Equipment is fourfold in regards to Avionic Systems. By its application an airline will:-

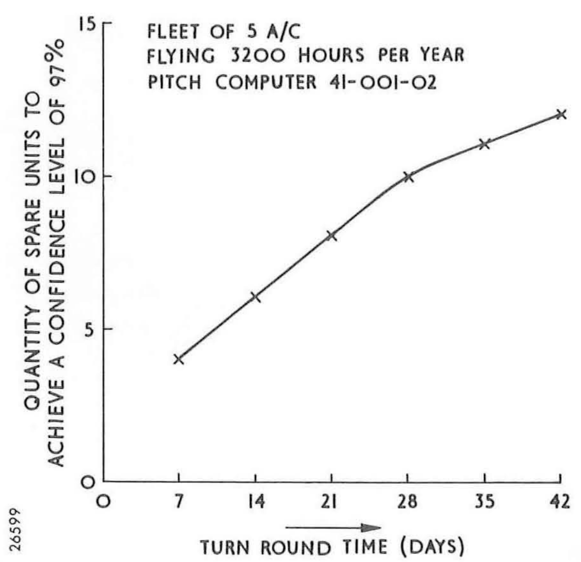
- ☐ be capable of rapidly filtering Line Replaceable Units removed from the aircraft.
- ☐ decrease the time required for modification embodiment.
- ☐ rapidly and accurately diagnose faults.
- ☐ obtain the maximum advantages from the modular construction of the components of avionics systems.

Any one of these virtues will increase the availability of useable spares and hence their utilization, and, while maintaining a satisfactory confidence level of spares availability, decrease the investment and spares holdings.

Rapid Filter. It is fair to assume that, despite the existence of Built-In Test Equipment, the pressures on Line-Maintenance Teams to turn aircraft around quickly will result in justified removals being not more than 70% of the total removals. The availability of automatic test equipment will ensure that unnecessary removals can be rapidly detected and returned quickly to Flight-Line Stores.

Modification Embodiment. To ensure spares availability during the embodiment of modifications, speed in testing components of avionics systems after modification is vital, and turn-round times similar to those for repair of units can be easily achieved when properly programmed automatic test equipment is available. A test program up-date service is available to ensure that the ATE is capable of testing units after the incorporation of modifications. In the case of Elliott/SFENA units it is proposed that an edit tape is supplied and costed as part of the modification kit.

The Speed of Fault Diagnosis, and of retest and certification after unit repair, which can be obtained from the use of automatic test equipment will substantially reduce "mean times to repair". This in turn will reduce the total turn-round time of a unit, and hence reduce the number of spares required. The effect of turn-round time on spares holdings is indicated in the graph.



Obtain maximum advantages of Modular Construction

The total advantages of the modular construction of the components of Avionics Systems can be achieved only when a faulty module can be detected easily, quickly and accurately; the faulty module changed by plugging in, and the expensive Unit Under Test rapidly retested, recertified and returned to Flight Line Stores.

It is felt that a total turn-round time of 7 days (including logistics times) is achieveable when automatic test equipment is available, whereas the use of manual test equipment will require total turn-round times of 21 days or longer. This difference in total turn-round times will considerably reduce the number of spare units required to maintain an airline's required confidence level of spares availability.

In the following example assume that:-

(a) a confidence level of not less than 97% is required.

(b) failures will be random.

(c) an airline will fly 3200 hours per year per aircraft.

(d) the fleet size is 5 aircraft.

(e) the demand rate for a spare will be calculated from:-

$$D = \frac{N.F.T}{MTBTR \times 365}$$

where D = Demand rate
N = number of equipments in the aircraft
F = Fleet flying hours
MTBTR = mean time between total removals (including unjustified removals)
T = turn-round time in days

(f) Since removals are assumed to be random, by the application of the Poisson distribution:-

$$A_{(ND)} = \sum_{x=0}^{N-1} e^{-D} \frac{D^x}{X!}$$

where A denotes the availability per cent

(g) That the demand rates are based on 7 and 21 days turn-round times

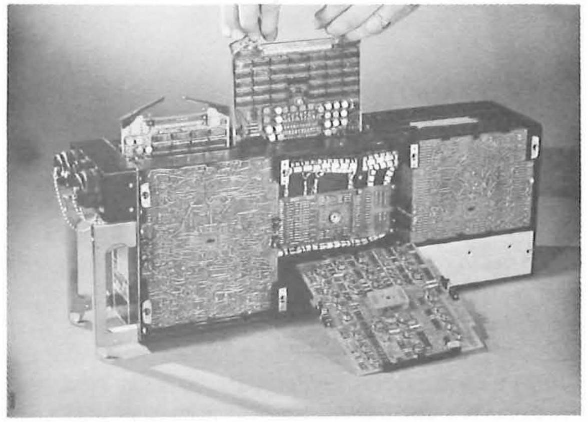
Part Number	Name	MTBTR	Qty 7 Days	Qty 21 Days	Unit Price*	Total Saving
41-001-02	Computer	630 hours	4	8	£26,000	£104,000
40-001-02	Computer	630 "	4	8	£26,000	£104,000
47-002-02	Computer	1000 "	4	6	£23,000	£ 46,000
42-001-02	Computer	1210 "	3	5	£14,000	£ 28,000

* Prices are given for the purposes of this example only to indicate the effect that automatic test equipment can have on investment. They are given without prejudice to any which may be negotiated in the future.

From these four examples it will be seen that cost of Automatic Test Equipment can be quickly absorbed in the savings of spares investment.

TEST REQUIREMENT

A study of the individual test specifications for the units comprising the Concorde Flight Control System indicates that these units can be tested using a low frequency analogue ATE system. In cases where logic testing is required (i.e. for the Item Computer) the types of test to be performed are solely combinational logic such that the input/output logic states can be considered as discrete d.c. levels.



ELLIOTT/SFENA UNIT REQUIREMENTS

The eleven ELLIOTT/SFENA units studies are manufactured using similar technologies. Although the individual test requirements of each unit may vary in detail there is a commonality in basic Power supply, types of measurement and a.c./d.c. stimulus requirements. A breakdown of the overall requirement for all eleven units is listed below:

Power Supplies

*115V/400Hz single phase 200VA
*26V/400Hz/0° single phase 15VA
26V/400Hz/25° single phase 5VA
(Reference phase 115V/400Hz supply)
26V 1800Hz single phase 5VA
*+28V d.c. 3A
±15V d.c. 300mA
±12V d.c. 300mA

*These supplies are required to be variable for margin tests on certain units.

The AC power supplies are generated in the Frequency Converter Unit. D.C. supplies are generated in the UUT Power Supply Unit.

A.C./D.C. Stimuli

A.C. and D.C. signal conditioning representative of fixed level, ramp and step functions are required for unit testing. The varying parameters of these signals are:

A.C. Stimuli

Amplitude - from mV to 20V r.m.s.
Frequency - from 400 to 1800Hz
Phase - 8°, 25°, 35°, 180°, 188°, 205°, 215°) Reference phase 26V/400Hz/0°

D.C. Stimuli
Amplitude - from mV to ±30V

Miscellaneous Stimuli

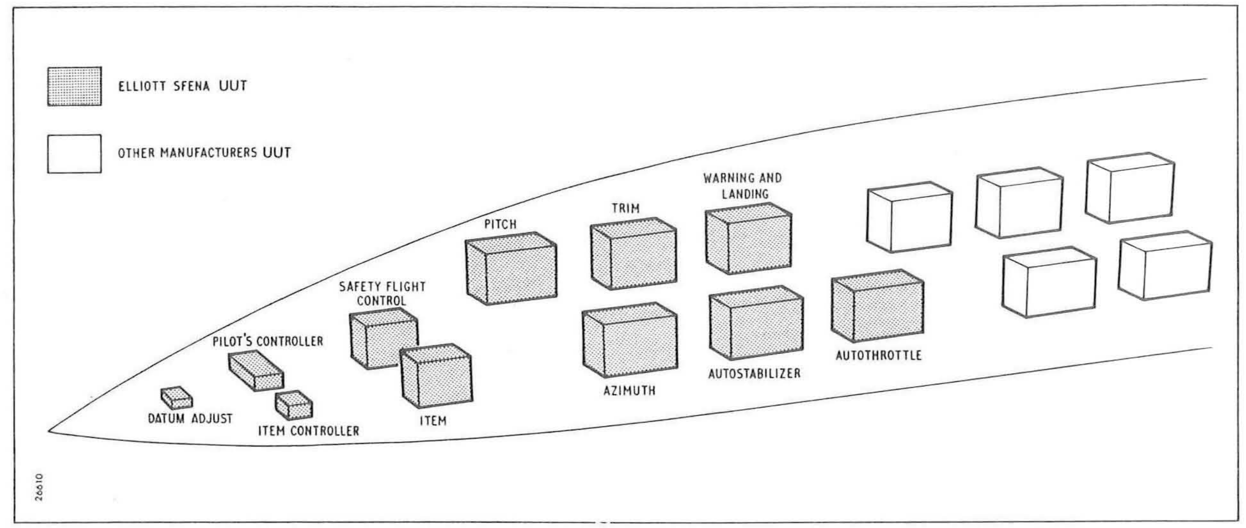
3 wire 26V/400Hz synchro control transmitter 0-360 Degrees angular rotation

Measurement

The various types of measurement to be recorded from signals output by units under test are:-

D.C. Volts	:	range mV - 30 volts
A.C. Volts	:	range mV - 125 volts frequency 80Hz - 5KHz
Resistance	:	range 0 - 10M ohms
Current	:	A.C./D.C. range mA - 3.5 Amps
Phase	:	range 0 - 180°
Period	:	range 0 - 40 seconds
Frequency	:	range 0 - 5KHz
Harmonic Distortion		
Synchro Position	:	range 0 - 360 Degrees (3 wire and 2 wire 26V/400Hz synchro)

All measurements are performed by the Sampling Voltmeter. This is at least an order more accurate than the most stringent requirement required for testing any of the eleven UUTs for each parameter measured.



UNIT TESTING

Generally the number of facilities required for testing a unit is proportional to the number of input/output signal lines. The unit under test is connected via an adaptor unit to the interface of the ATE. Each adaptor unit contains resistive loads and other components associated with the unit testing. In addition it is the means of connecting all U.U.T. input/output signal lines via reed relays to the ATE stimulus and measurement units. The Pitch Computer, for example, has approximately 400 input/output lines resulting in an estimated requirement for 640 reed relays for the switching of signals between the ATE and UUT when performing 1100 functional tests.

In general the unit on test will require more than one signal stimulus to be applied at any instant when performing a specific functional test. For the eleven units considered the worst case simultaneous stimulus requirement is for 9 off different signal levels to be applied to the Unit Under Test. Two function generators capable of providing up to 14 simultaneous outputs, each output being separately programmable in amplitude, frequency and waveshape, adequately meets the simultaneous signal requirement of any of the listed units. In addition 4 A.C./D.C. buffer amplifiers are provided to extend the output voltage/current capability of any function generator output.

Some UUTs are required to be cooled during testing, cooling air at 60lb/hour/100W is supplied by small fans mounted in the associated UUT adaptor.

Unit Title	No. of relays	No. of Tests
Pitch Comp.	640	1100
Azimuth Comp	487	1857
Warning & Landing Comp.	250	1268
Autostabiliser Comp.	600	1032
Autothrottle Comp.	385	473
Electric Trim Comp.	290	355
Safety Flight Control Comp.	450	500
ITEM Comp.	400	350
Datum Adjust Unit	85	200
Pilots Control Unit	390	325
ITEM Comp. Unit	110	300

The table lists the estimated number of reed relays and functional tests for each unit.

ATE Workload

The following assessment of workload is for the testing of eleven Elliott/SFENA units. The proposed ATE utilises computer integrated instrumentation which is capable of rapid measurement and stimulus. All test programs are stored on a magnetic disc providing access in milliseconds, reducing program search times almost to zero. The above features combined with an efficient man machine interface lend the system to high speed testing.

TESTING TIMES

The times and number of tests quoted are backed by automatic testing experience of analogue flight control systems, and the assistance of the AFCS design engineers.

Test specifications for the main units/computers have been studied in detail and the times are quoted with a high level of confidence. At the time of writing, specifications for ITEM and the Safety Flight Control computers have not been finalised, however the times are quoted with a reasonable degree of confidence that they can be achieved.

The times take into account the number and type of tests, time delays and recovery time of the UUT after completion of a test.

A considerable saving in time is made by taking measurements of the Command and Monitor lines almost simultaneously. These tests are carried out as two separate items on manual equipment, however it is possible to combine the tests and still maintain the correct sequence.

Time allowed for interfacing occupies valuable testing time and must therefore be kept to a minimum. The interfacing includes handling of the UUT, adaption to the ATE interface, program loading and initiation of testing. The proposed adaptors facilitate rapid connection and removal, minimising handling time. Programs are readily available from the disc store, eliminating program loading time.

UNIT/COMPUTER	QUANTITY/ AIRCRAFT	MTBTR (Hrs)	FUNCTIONAL TESTS/UNIT	ESTIMATED TESTING TIME /UNIT (Hrs)	UNITS TESTED/ AIRCRAFT/YR. AFTER REMOVALS	AFTER REPAIR	TOTAL	TOTAL TESTING TIME/ AIRCRAFT/ YEAR (Hrs.)
Pitch	2	630	1100	4.3	10	7	17	73
Azimuth	2	630	1857	5.0	10	7	17	85
Autothrottle	2	1210	473	1.0	5.2	3.6	8.8	8.8
Autostabiliser	2	1000	1032	1.6	6.4	4.4	10.8	17.3
Electric Trim	2	1400	355	1.9	4.6	3.2	7.8	14.8
Warning and Landing	2	1400	1268	1.3	4.6	3.2	7.8	10.2
Safety Flight Control	2	1210	500	1.2	5.2	3.6	8.8	10.6
ITEM	2	2000	350	0.8	3.2	2.2	5.4	4.3
Pilots Controller	1	575	325	1.5	5.6	3.9	9.5	14.2
ITEM Controller	1	3000	300	0.4	1.0	0.7	1.7	0.7
Datum Adjust	1	1830	200	0.1	1.8	1.2	3.0	0.3

Utilisation

The calculations within this section assume the following conditions:

(a) 3200 hours/aircraft/year

(b) 70% of removals are justified

(c) A working week is 40 hours

(d) 50 weeks in a year

(e) ATE Availability is 100%

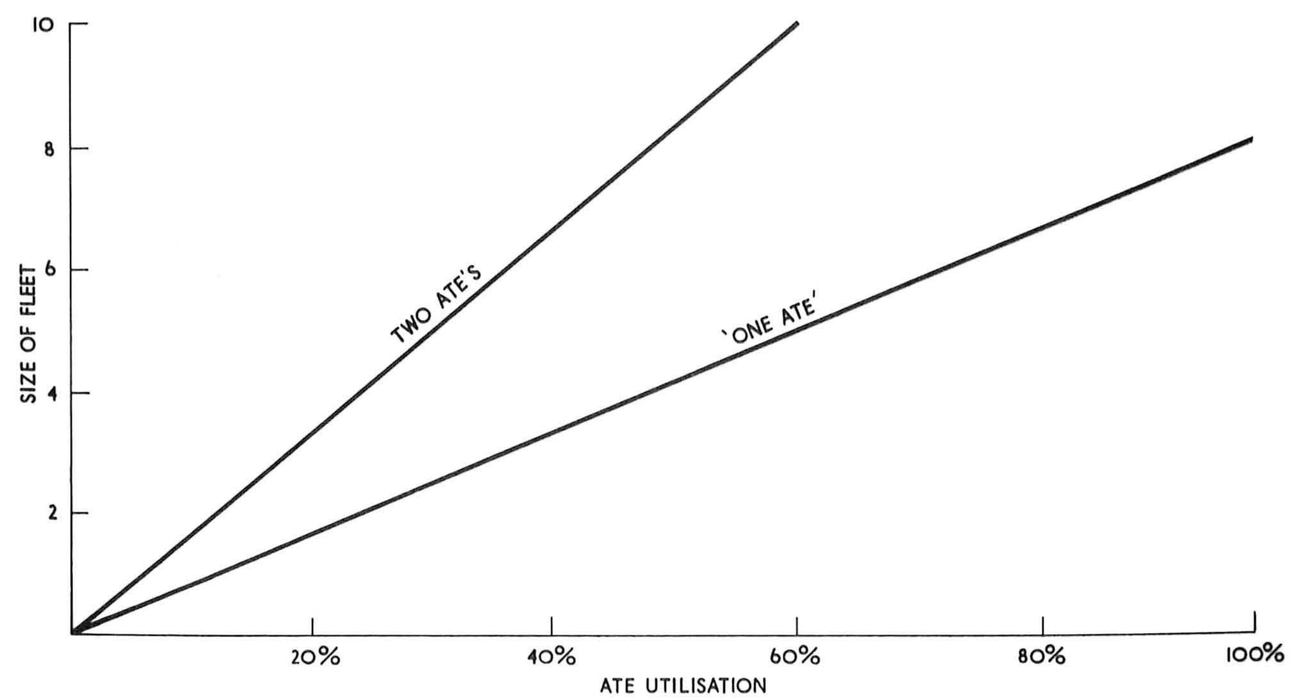
Applying the figures quoted in the table it is possible to calculate the total number of units tested.

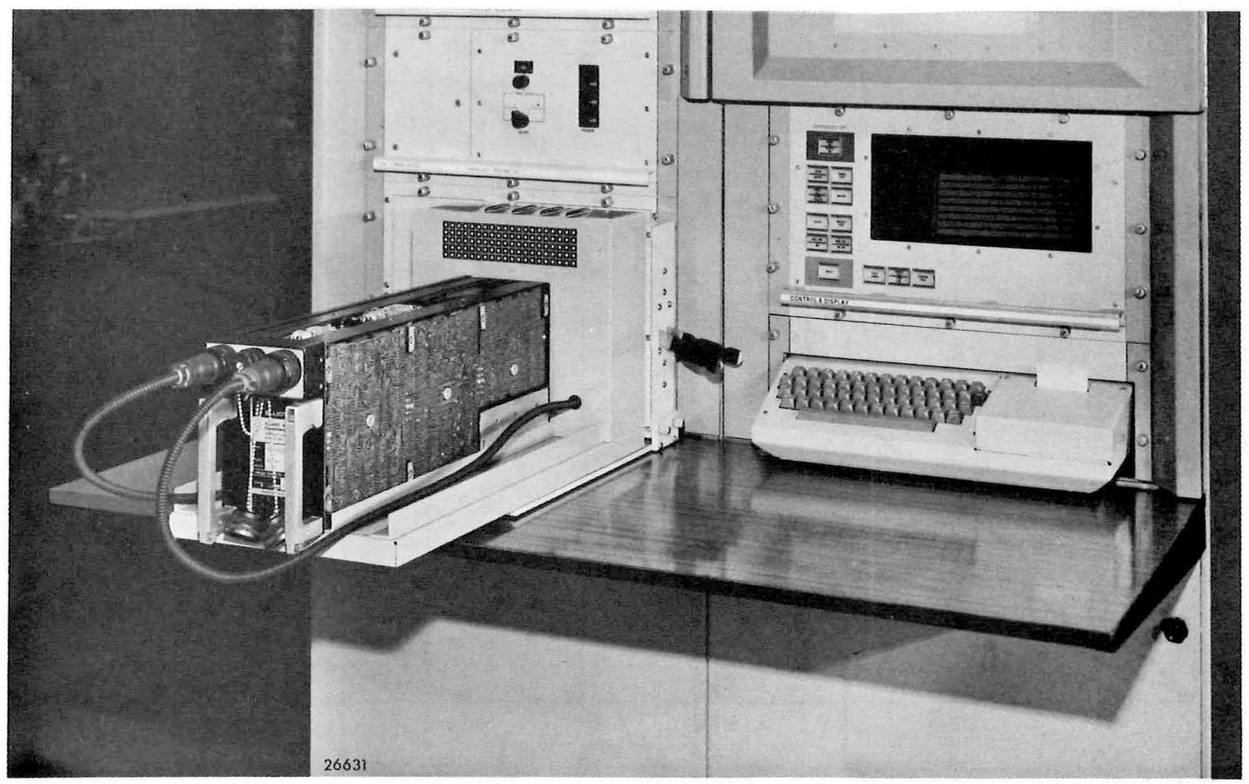
It is assumed that all nineteen units, eleven different types, are tested on the ATE 'after removal' and subsequently 'after repair'. Failure of units after repair places a further workload on the ATE not accounted for in the calculations.

The total testing time required for the units of one aircraft is 240 hours. Taking a sample of five aircraft, the requirement becomes 1200 hours with a possible 2000 hours available.

It is a known fact that the ATE cannot be utilised for 100% of available time. Utilisation is dependant on many factors, including the operator, customers maintenance policy, queuing factor and spares availability.

The ATE requirement is presented in graphical form, showing the required utilization of the ATE's against fleet size in order to test the eleven ELLIOTT/SFENA units.





Operators Controls and Displays

Simplicity of Operation

Modes of Operation

AUTO

In the Auto mode testing proceeds continuously with Program Control obeying all GO decisions. The test sequence stops on NO-GO with the measurement and limits displayed. In a diagnostic program the operator can decide, if the failure indicated is marginal, to proceed with testing or further diagnose the indicated failure.

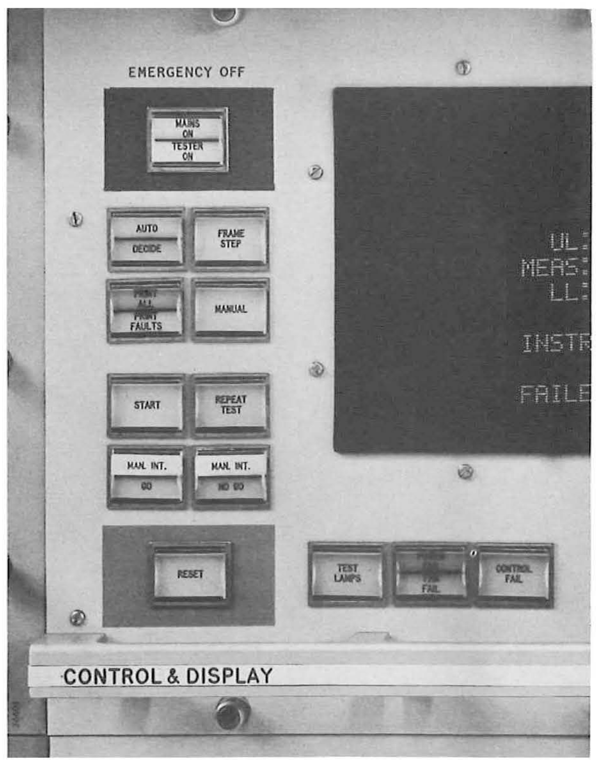
MANUAL

A list of key characters is displayed on operation of the Manual Mode control. These characters when input on the keyboard enable:

Statements to be assembled and executed in 'Ideal'.
Statements to be edited in a Test Program and the program re-compiled.

New tape copies of test program to be punch

Single frames to be set up and repeated to exercise instrumentation and interface link within the ATE for fault location.



MULTI-MODE

Optimum modes of control are provided for:

Functional and Diagnostic Testing
Program Proving
Fault Location during Self Test

DIRECT CONTROL BY ILLUMINATED PUSH BUTTONS

Simplifies Mode changing
Indicates Mode Selected
Leads Operator through Control Sequence by indicating in WHITE an enabled control.

ALPHA NUMERIC DISPLAY

Indicates Point Reached in Program
Displays Test Status
Provides Direct Instructions to Amplify or Replace Test Manuals

KEYBOARD

Data can be entered for:
Indication of Serial Number and Modification State
Selection of Tests
Panel Meter Readings
Program Editing

SINGLE TEST OR DECIDE

In the Single Test mode the test sequence stops on each test limit statement. The test sequence can then be restarted in three ways.

Repeat

The computer searches back to the nearest Test Entry point and repeats the test up to the Test Limit Statement.

GO or NO GO

The program will continue either down the main routine or into the diagnostic routine.

Frame Step or Statement Step

The program is advanced a single statement at a time. This allows direct comparison with the program as written in 'Ideal'.

Displays

The Unit Under Test Interface and the Controls and Displays are conveniently grouped for an operator to select mode or test procedure whilst making adjustments to the Unit Under Test.

ALPHA NUMERIC DISPLAY

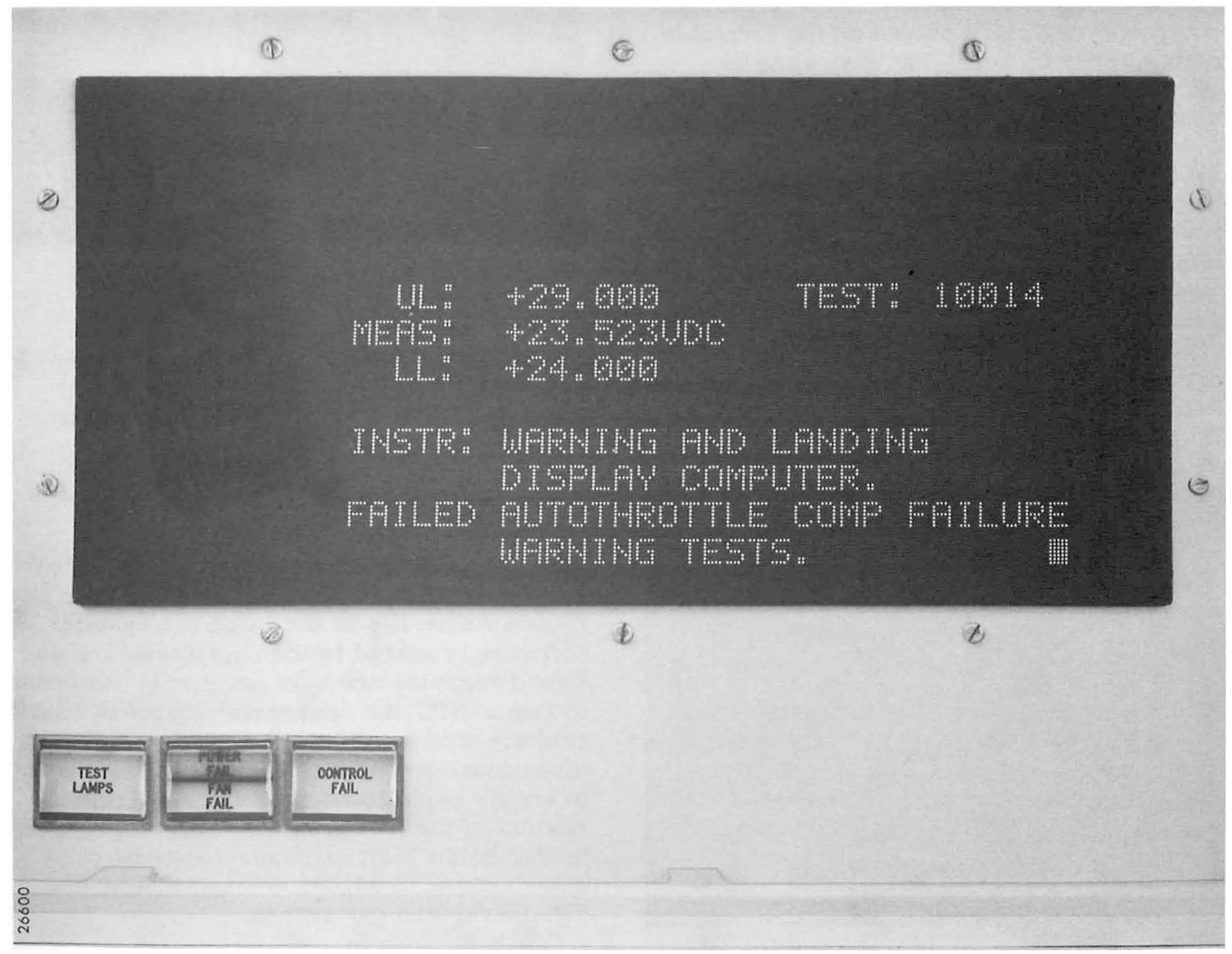
The Alpha-numeric display is capable of displaying a total of 256 characters arranged in eight lines of 32 characters each. A brightness of 50ft lamberts at a contrast ratio of 20 : 1 allows visibility in direct sunlight. The display is angled to give 'straight-on' viewing by the operator at the unit under test interface.

KEYBOARD

The keyboard provides a full alpha-numeric capability on typewriter layout. The keyboard and printer slide into a recessed housing to allow easy removal of the bench top for servicing of the computer and power supplies.

PRINTER

A mosaic dot printer provides a permanent test record in a full Alpha-numeric set of up to 20 characters per line. The UUT type and serial number, test results and diagnostic information can be provided in any desired format.

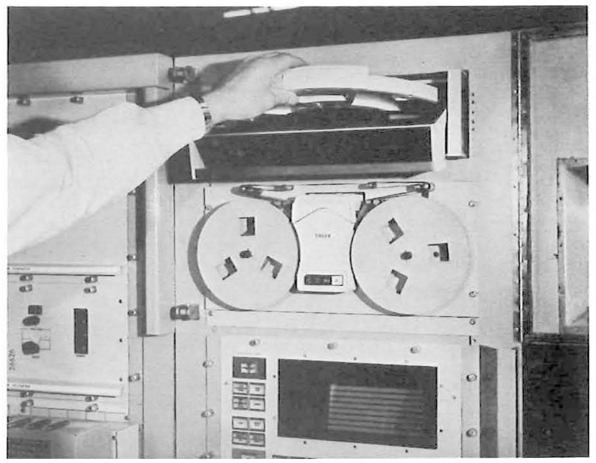


On Demand Programs

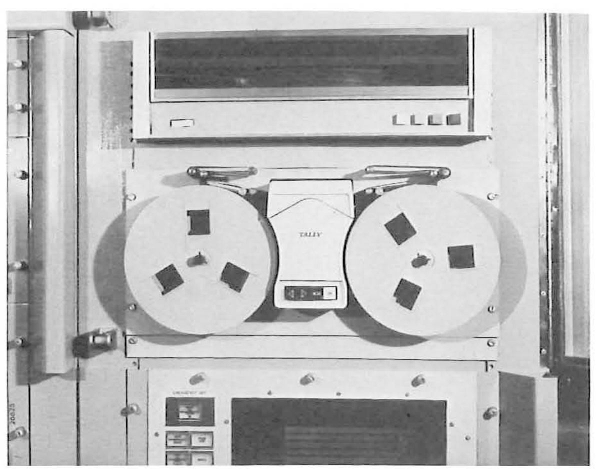
REPLACEABLE DISC PROGRAMMING

The System Software - Interpreter Program, 'Ideal' Edit, and Self Test Programs - and Flight Control System Test Programs are held on a Magnetic Disc file of 24 megabit capacity. To load a disc the load switch is operated; the cover opened after 10 seconds; a magnetic cartridge placed on the turntable and the cover closed. The disc runs to operating speed in 50 seconds after the Run Switch is made.

The Disc Handling Executive Program is permanently stored in the computer and provides all facilities for loading the system software and Test Programs. As the Program is loaded into core a parity check is made to ensure system integrity. A hard-wired Write Protect facility prevents corruption of program on the Disc but allows Editing in the Manual Mode.



The magnetic disc system provides access to any Test Program, Self Test program or Editing Program within 135 milliseconds.



TAPE READER AND HANDLER

The Tape reader is used to load Test Programs and Program Modifications onto the Disc file. Where a disc file is not fitted the system software is stored in the computer core and Test Programs are held on spools. In order to test a UUT the appropriate spool is loaded onto the tape handler mechanism. A bi-directional fast search facility is provided to enable rapid location of the required section of the test program. The program loader holds 750ft of Paper Tape and provides access to 90, 000 8 bit characters at 500 characters per second.

Mechanical Features and ATE/UUT Interface

Mechanical Features

MODULAR CONSTRUCTION

To provide an ATE system which is adaptable to various tasks and which is readily extended to encompass extra UUTs and extensions to testing policy (for instance, fault diagnosis or sub module testing) a modular system of construction has been developed.

The system utilises:

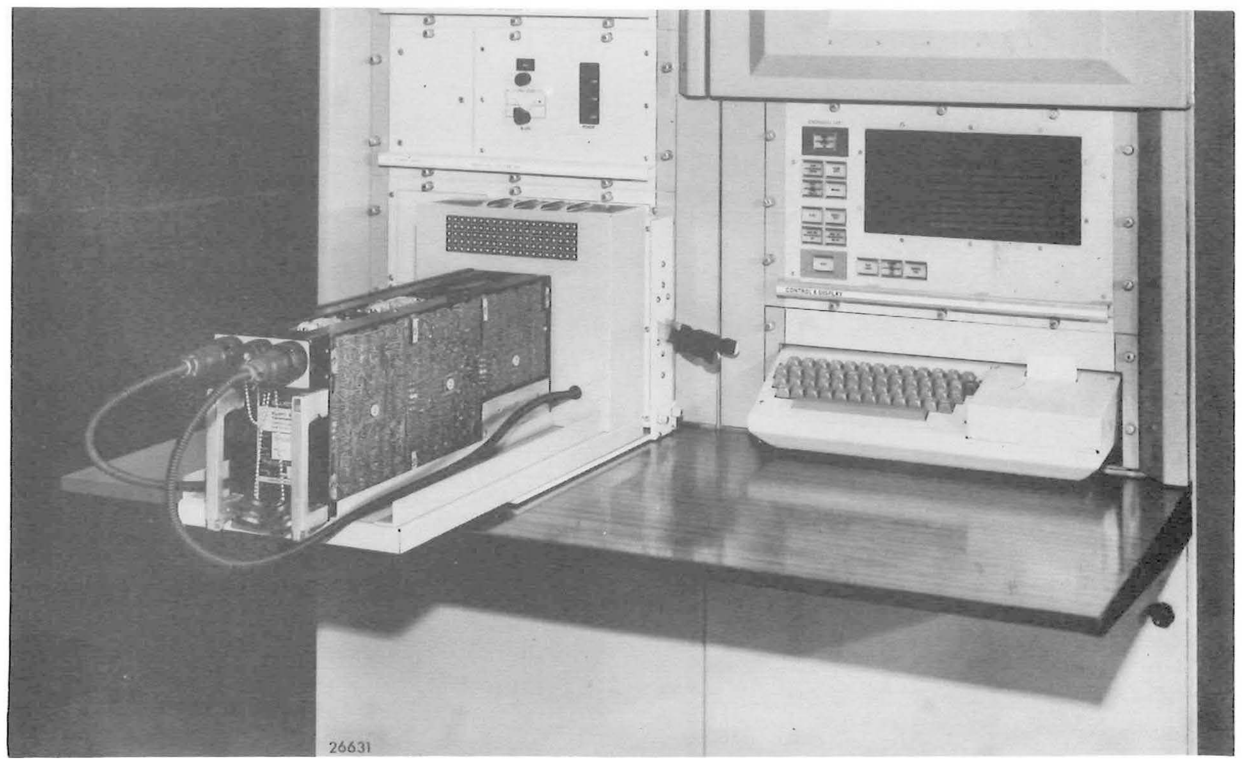
- Standard 19 inch P.O. racking.
- Standard Chassis design.
- Standard plug in modules.
- Functional test units which are self contained.
- RFI and EMI interference protection
- Telescopic slides on all UUTs.
- Cross-flow cooling system.

HUMAN ENGINEERING FACTORS

The human engineering factors of the man machine interface are a paramount factor in design of ATE.

Special attention has been given to the operator participation in the test procedure to provide:

- Maximum access to unit under test.
- Close proximity of UUT to controls.
- Ease of Interfacing UUT to ATE.
- Rapid selection of test progr^ms.
- Ergonomically designed controls and displays for important functions.
- Wide angle viewing of display screen.
- Eases of maintenance, all maintenance may be undertaken from the front of the ATE.



ATE/UUT Interface

RANGE OF ADAPTORS

Azimuth Computer	40-001-01
Pitch Computer	41-001-01
Autothrottle Computer	42-001-01
Autostabiliser Computer	47-002-01
Electric Trim Computer	49-004-01
Display Computer	51-002-01
Item Computer	59-017-01
Safety Flight Control	49-020-01
Datum Adjust	20-002-03
Pilots Control Unit	20-001-02
ITEM Control Unit	25-001-01

The list of test subjects being considered will all be mounted in individual adaptor units. The adaptor units are the interface between the UUT and the ATE and contain the interconnections necessary to allow the full flexibility of stimulus and measurement routeing. It is not envisaged that active components will be mounted in adaptors.

The adaptors will utilise the unit aircraft rack mounting features to secure the unit to the adaptor.

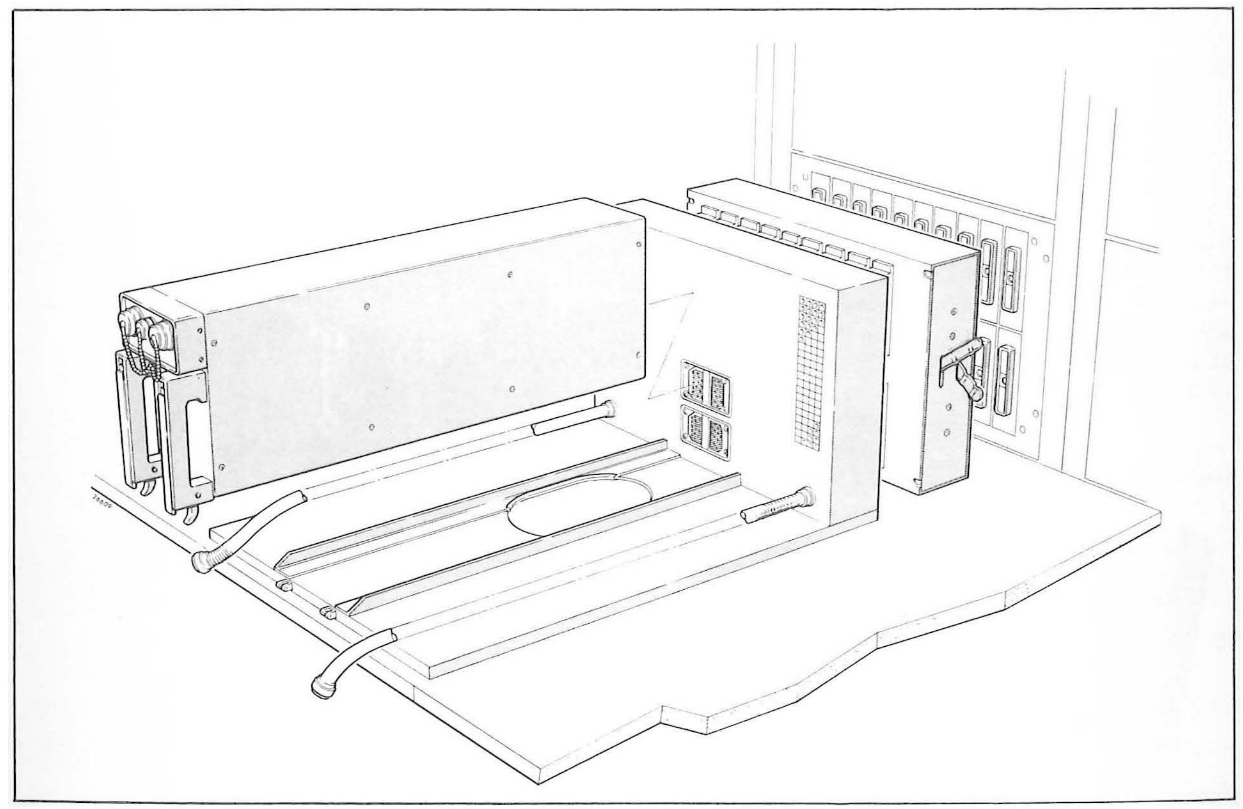
The adaptors also provide:

- Monitor points.
- Mechanical keying to ensure adaptor - UUT compatibility.
- Electrical keying to ensure adaptor - test program compatability.
- Common connector format for connection to LSU.
- Guides for aligning adaptor to interface.
- Mounting for passive electrical loads.
- Fans for cooling UUT.

UUT INTERFACE

All UUTs are interfaced to the tester via the Line Switch Unit. Design features:-

- Single lever operation to electrically 'make' adaptor to tester.
- Zero-force cam operated connectors. (life - 20,000 plus matings).
- Mechanical interface unit with cam operating mechanism.
- Replaceable cable connector assemblies.
- Monitor points for stimulus and measurement lines.
- Accessable patching to effect rapid modification to accommodate changes to the build standard of UUT.



LINE SWITCH MODULES

The Line Switch Unit is a standardised design. It contains an interface unit to receive instructions from the control complex and the stimulus circuits for operating the relays.

The relays are bistable and require power only when it is desired to change the relays state.

The relays are housed in replaceable modules of three types which contain either:-

- 50 dry reed relays
- 50 mercury wetted relays
- 22 power relays

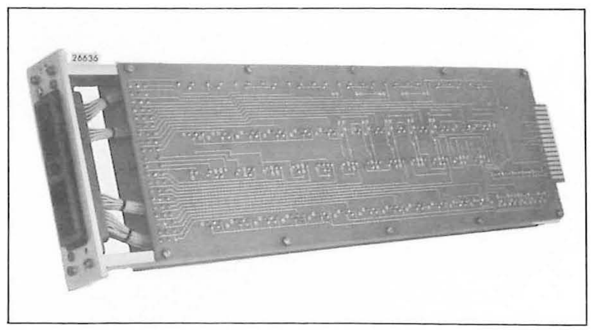
Special purpose modules are also available:-

- Solid state switching module (for demodulating AC carrier signals)
- Programmable decade resistance module
- Programmable decade capacitance module.

All modules are mechanically interchangeable in the Line Switch Unit. The module designs incorporate:-

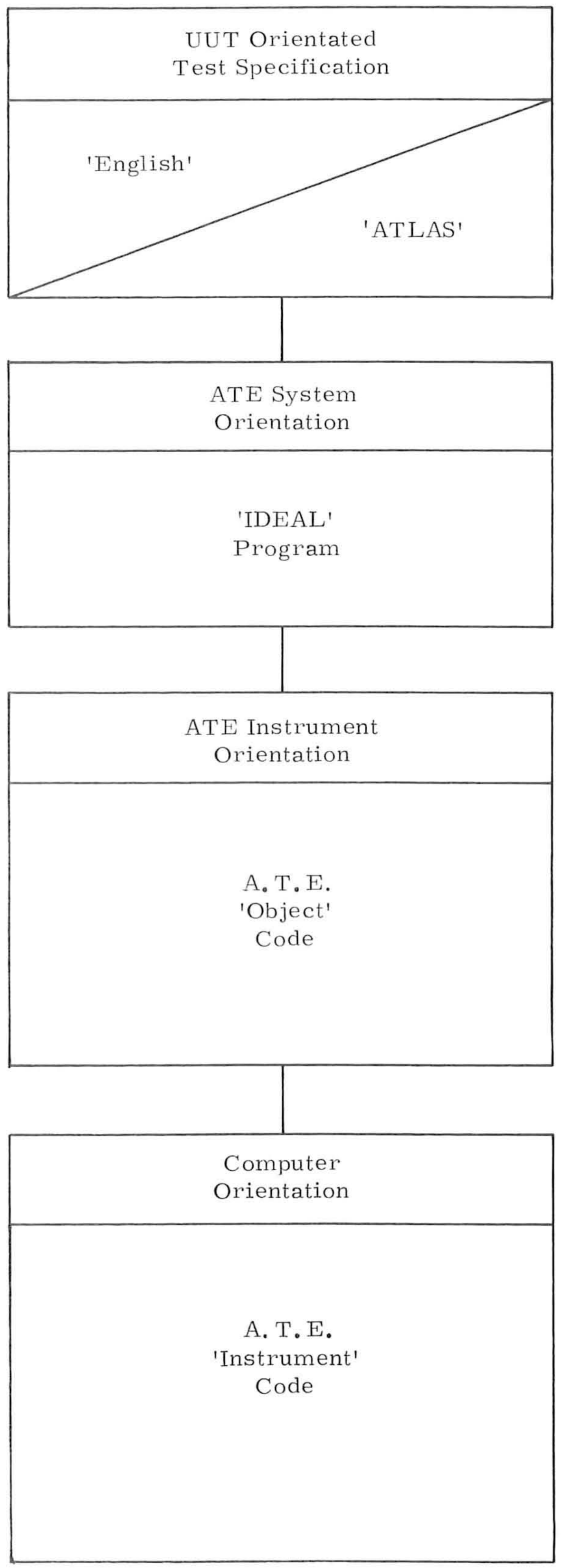
- Minimal circuit resistance
- Minimal circuit capacitance
- Minimal inter-circuit cross talk

The Line Switch Unit can accommodate a total of 18 such modules, in addition to the two 156 way stimulus and measurement sockets for connection of the ATEs functional test unit instrumentation.



Software

Software System



The basic specification for the UUT is defined in the manufacturer's performance specification which may be written in plain English or Atlas. Both these languages are problem orientated and describe the testing philosophy in engineering terms.

The Manufacturer's test specification will be examined for ambiguity and incompleteness as the first step towards its implementation by the Automatic Test Equipment (ATE).

To enable the performance specification to be aligned to the ATE System it is necessary to include the allocation of the ATE Source and Sensor resources into the specification.

This has to be a simple operation and the resulting procedure easily understandable. To this end the 'Ideal' program Language has been developed and it is into this language that the test specification is translated.

High level language Test Programs in 'Ideal' are converted into a code suitable for inputting to the ATE's Executive Software On line. This intermediate stage (object code) has a high density binary format which can be either stored on punched tape and entered from the Tape Handler or held in a backing disc store and read directly into the ATE when required.

This 'Object' code contains both triggering instructions for Master Program Routines and self contained routines for implementing the test procedure.

The ATE Computer contains a program called the Interpretive Master Program (IMP). It performs all the 'Real-time' Executive Routines of the ATE, including outputting the routines which control the Functional Test Units (FTUs) as directed by the Test Program.

Any data transmitted to an FTU is returned and verified in the computer for correctness of format thereby giving a high level of confidence of correct parameter demand.

All arithmetical routines are evaluated in the computer under the control of the Master Program.

Data Aquisition

Initial test information is derived from the appropriate Test Specification by examination of the individual unit circuit drawings together with other relevant data.

Assimilation of this Data will require liaison with the Elliott-SFENA consortium, through Flight Controls Division which is, together with ATE Division, a member of the Rochester establishment.

Such liaison will allow rapid and accurate modifications to the specifications to be agreed so that more efficient test programs can be written. Each modification will have the Prime Equipment Manufacturer's approval.

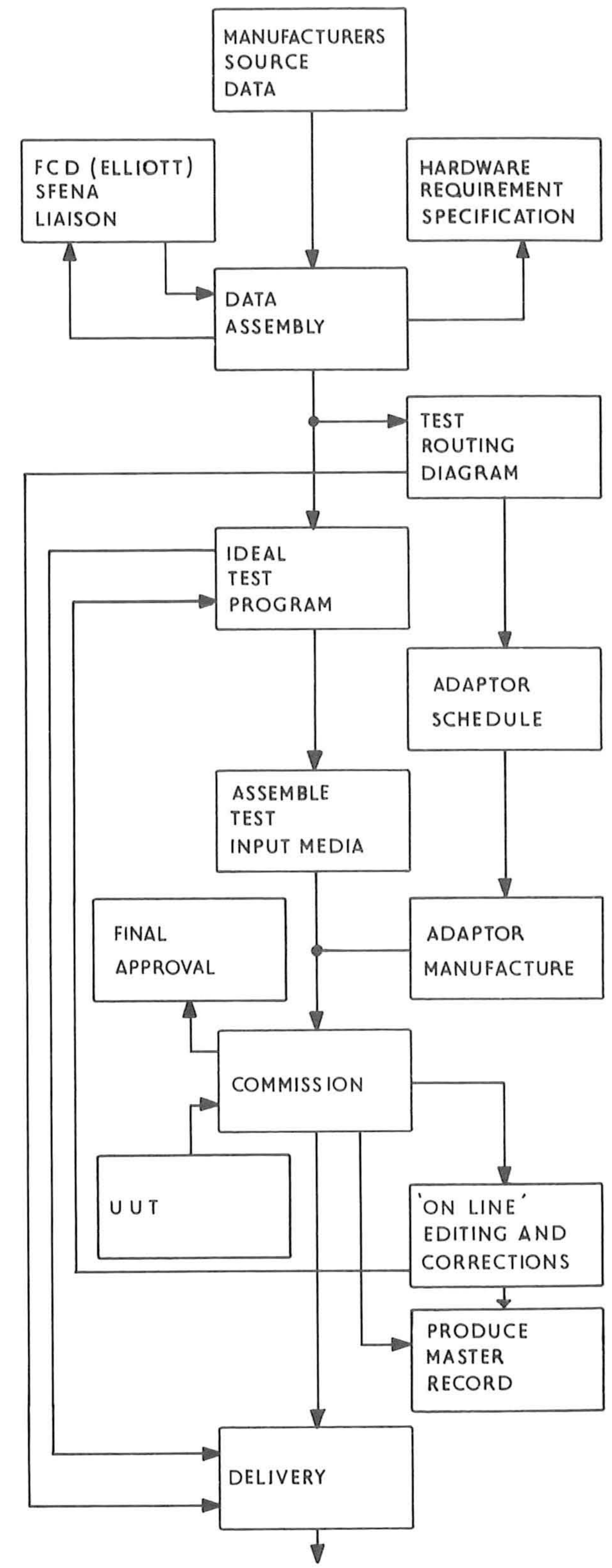
The interface between the Test Specification and the ATE hardware is the Test Program, written in 'Ideal'. 'Ideal' is an easily readable language which expresses the stimulus and measurement requirements of a UUT in terms orientated to the parameters of the ATE.

In parallel with the program writing Test Routeing Diagrams will be generated. These record the interconnections of the ATE and the UUT, including any loads etc. which may be located in the Adaptor.

These diagrams are orientated to the FTU's as datum and form the basis for the Adaptor Unit Wiring Schedule.

Assembly of the Ideal Program either on a remote computer facility or in the ATE's computer system will result in an 'Object Code' program. Assembly can be achieved with the ATE computer whether or not the disc facility is provided.

The test program is shown to be compatible with its source specification during the commissioning phase when it is run together with its adaptor against a previously calibrated UUT on a proven ATE.



Test Routine Flow Diagram.

Program Proving

During the proving of a Test Program there are inevitably problems which have to be resolved. These problems fall mainly into the areas of ATE orientation and errors in Source documentation.

OPERATIONAL MODES

To reduce 'on line' running time in tracing errors, a clear identification of Tests at which the program may be re-entered is available in the Program language. Examination of the suspect area can then be carried out either in the Automatic or Decide Mode of operation of the ATE or in more detail by means of the Frame Step facility.

DECIDE MODE

If the problem is time dependent, then with the ATE in Decide Mode repeated samples of analogue signals can be displayed on each measurement instruction.

Repeat Test Mode

A single signal condition may be re-cycled by demanding the Repeat Test Mode whereby the ATE automatically repeats the test routine from the last nominated Test Entry point.

PROGRAM EDITING

Detailed examination of the routine may require the 'Ideal' Test Program to be altered. With the 'on line' edit and compile programs the Test Programmer has the facility to manipulate his program using the existing ATE computer and 'in house' Disc and Line Printer peripherals, allowing both 'trial' and 'permanent' editing.

To change a Test Program as a trial, the Statement to be modified is approached in the Frame Step mode where each statement is referenced and its number displayed. On arrival at the required point in the program, depression of the Manual Switch displays a list of instruction characters and their meanings. Selection of the appropriate character will allow the programmer to insert valid 'Ideal' statements into the operation routine. Re-pressing the Manual Switch returns the program to the testing sequence as modified.

To incorporate a permanent change to the program, the Manual Switch enables a further instruction letter to be called up, thereby displaying the first few instructions on the display of the program to be modified. By demanding the tests, statements and characters required the program is changed and re-assembled. Re-running of the Program this time has to be from the beginning of the group.

SAFETY MEASURES

To minimise the possibility of a test subject accidentally being damaged during testing, various precautions are built into the Software system.

To ensure correct selection of Test Program, Adaptor and UUT there is an electrical key in the form of a unique electrical resistance measurement to be called up by the appropriate program. This combined with the individual UUT Adaptor mechanical plug keying ensure a correct test system.

To eliminate the initial commissioning routeing problems the Test Program is monitored in a 'Dry Run' mode. The program parameters are measured on the UUT sockets without the UUT connected and any faults corrected.

To aid rapid diagnosis of a discovered fault a number of monitor points are available in the adaptor. They are provided at the discretion of the test programmer.

SELF CHECK

Test failures may possibly be due to ATE failures and to differentiate between these and genuine test failures Self Check routines are provided. These enable a rapid 'on line' verification of the FTU's status. Failure of Self Check will lead automatically to a Self Test entry point from which Self Test and ATE fault diagnosis will proceed automatically once the operator has replaced the UUT and its adaptor with the appropriate Self Test adaptor.

Documentation

Test Software data is published in the "Programming Manual" and the series of manuals relating to UUT testing e.g. "Operating Instructions : Azimuth Computer Testing"

Programming Manual

This includes the specification for 'Ideal' program language and gives instructions for translating test procedures written in 'Atlas' to 'Ideal' test language. It also gives instructions for processing test programs in 'Ideal' to produce 'ATE Object Code' test tapes.

Operating Instructions : UUT Testing

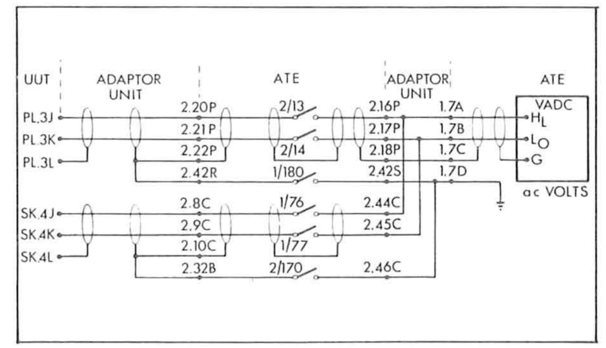
This series of manuals provides detailed information and instructions relating to each UUT test procedure.

Step-by-step instructions for fitting adaptor and UUT, and for program selection.

The test program in 'Ideal' test language is provided with cross references to the 'Atlas' test procedures in the UUT overhaul Manual. Test Routeing diagrams are also provided.

Routeing Diagrams

Signal Routeing is presented as a series of drawings in a clear, handlable size. They show the electrical path progressing from the ATE function to the UUT socket via the associated Line Switches showing any components which are mounted in the Adaptor Unit together with diagramatic representation of wire type, screening, etc.



Programming Language

The 'Ideal' language has been designed to be aligned as near as possible to the 'Atlas' language whilst also being related to the particular instruments of the ATE. The language is as readable as possible enabling engineers to understand the procedures without any specialist knowledge of computers or of ATE. It has a logical format which is readily converted into codes suitable for direct input to the ATE on line.

PREAMBLE AND PROCEDURE

The 'Ideal' language allows a Test Program to be written which may include a Preamble and Procedural section.

The Preamble allows the Programmer to 'Define' labelled Procedures, Messages and Functions. These may contain variable parameters according to the data declared in the procedure.

The procedure is a series of statements built up from a standard list of verbs, nouns and modifiers. The procedural section contains the information required for the previously defined preamble and contains the instructions to implement the program.

Vocabulary

The standard list of verbs, nouns and modifiers allow individual manipulation of specific FTUs.

Examples of meaningful words are 'Set Up' 'Close', 'Open', Display', 'Read', 'Compare', etc.
which result in the FTU action as written.

Other words have an executive action and operate as written. Such are 'Go-To', 'Wait For', 'Calculate', 'Remove' etc.

Comment

The Comment facility is purely an operator's aid providing extra information which the operator may find informative and useful but which is ignored by the assembly process because it is not instruction to the ATE.

Manufacturers Test Specifications

Type No. 51-002-01 | Spec No. TS 51-002-01

Unit Title: Warning and Landing Display Computer | Issue A

Test No.	Test Procedure	Value	Tolerance	AL
5.6	AUTOPILOT FAILURE WARNINGS			
5.6.1	Autopilot failure warning Amber			
	Disconnect -15V and connect +15V to the following points:			
	HA-44 (A/P No. 2. F.W.)			
	The voltage at the following points and the state of the corresponding indicator lamps shall be:			
	Pin / Lamp / State			
	HB-9 A/P Red off	+28V	+1V -4V	
	HB-8 A/P Amber off	0V d.c	± 100mV	
	ZA-37	+0.4V	Max	
	ZA-41	+0.4V	Max	
5.6.2	Disconnect +15V and connect -15V to JB-5 (Land or Lock TRK Mode Selected Com) and to JB-28 (G/S Captured). The voltage at the following points and the state of the corresponding indicator lamps shall be:-			
	Pin / Lamp / State			
	HB-9 A/P Red off	0V d.c	± 100mV	
	HB-8 A/P Amber on	+28V	+1V -4V	
	HB-43 Test on	28Vrms	+1V rms -4V	
	ZA-37	+0.4V	Max	
	ZA-41	+15V	± 0.45V	
	ZA-3	+0.4v	Max	
5.6.3	Disconnect -15V and connect +15V to JB-5, JB-28 and JA-91. The voltage and the state of the corresponding indicator lamps shall be:			

Ideal Test Procedure

```
TEST, 56101, ENTRY $ COMMENT, AUTOPILOT FAILURE WARNING TESTS, PTS REF, 5.6.1 $
OPEN, 27 $
CLOSE, 28 $ COMMENT, CONNECTS +15V to HA - 44 $
SET UP, 'SYM TRIGGER', COMPUTER $
SET UP, 'SAMPLING VOLTMETER', (VOLTAGE), RANGE 100 $
CLOSE, 54 $ COMMENT, CONNECTS HB-9 SAMPLING VOLTMETER $
READ, 'SAMPLING VOLTMETER', FILTERED $
COMPARE, 'M' UL 29, LL 24, UNITS VDC $
GOTO, 56900, IF NO GO $
DISPLAY, MESSAGE, CHECK A/P RED LAMP IS OFF.   PRESS GO/NOGO $
WAIT FOR, MANUAL INTERVENTION, STOPPING $
GOTO, 56900, IF NO GO $
OPEN, 54 $
TEST 56102$
SET UP, 'SAMPLING VOLTMETER', (VOLTAGE), RANGE 1 $
CLOSE, 57 $ COMMENT, CONNECTS HB-8 TO SAMPLING VOLTMETER $
READ, 'SAMPLING VOLTMETER', FILTERED $
COMPARE, 'M', UL 100, LL -100, UNITS MVDC $
GOTO, 56900, IF NO GO $
DISPLAY MESSAGE, CHECK A/P AMBER LAMP IS OFF.   PRESS GO/NOGO $
WAIT FOR, MANUAL INTERVENTION? STOPPING $
GOTO, 56900, IF NO GO $
OPEN, 57 $
TEST 56103$
CLOSE, 116 $ COMMENT, CONNECTS ZA-37 TO SAMPLING VOLTMETER $
READ, 'SAMPLING VOLTMETER', FILTERED $
COMPARE, 'M', UL 400 $
GOTO, 56900, IF NO GO $
OPEN, 116 $
TEST 56104$
CLOSE, 112 $ COMMENT, CONNECTS ZA-41 TO SAMPLING VOLTMETER $
READ, 'SAMPLING VOLTMETER', FILTERED $
COMPARE, 'M', UL 400 $
GO TO, 56900, IF NO GO $
OPEN, 112 $
TEST 56201$  COMMENT, PTS ref 5.6.2 $
OPEN, 113 $ COMMENT, DISCONNECTS +15V FROM JB-5 $
CLOSE, 43, 69 COMMENT, CONNECTS -15V TO JB-5 AND JB-28 $
CLOSE, 54 $ COMMENT, CONNECTS HB-9 TO SAMPLING VOLTMETER $
READ, 'SAMPLING VOLTMETER', FILTERED $
COMPARE, 'M', UL 100, LL -100 $
GOTO, 56900, IF NO GO $
DISPLAY, MESSAGE, CHECK A/P RED LAMP IS OFF. PRESS GO/NOGO $
WAIT FOR, MANUAL INTERVENTION, STOPPING $
GOTO, 56900, IF NO GO $
OPEN, 54 $
TEST 56202 $
SET UP, 'SAMPLING VOLTMETER', (VOLTAGE), RANGE 100 $
CLOSE, 57 $ COMMENT, CONNECTS HB-8 TO SAMPLING VOLTMETER $
READ, 'SAMPLING VOLTMETER', FILTERED $
COMPARE, 'M', UL 29, LL 24, UNITS VDC $
GO TO, 56900, IF NO GO $
DISPLAY, MESSAGE, CHECK A/P AMBER LAMP IS ON PRESS GO/NO GO $
GO TO, 56900, IF NO GO $
OPEN, 57 $
TEST 56203 $
SET UP, 'SAMPLING VOLTMETER', (VOLTAGE - RMS), RANGE 100 $
CLOSE, 62 $ COMMENT, THIS CONNECTS HB-43 TO SAMPLING VOLTMETER $
READ, 'SAMPLING VOLTMETER', FILTERED $
COMPARE, 'M', UL 29, LL 24, UNITS VAC $
GO TO, 56900, IF NO GO $
DISPLAY MESSAGE, CHECK TEST LAMP IS ON.   PRESS GO/NOGO $
WAIT FOR, MANUAL INTERVENTION, STOPPING $
GO TO, 56900, IF NO GO $
OPEN, 62 $
TEST 56204 $
SET UP, 'SAMPLING VOLTMETER', (VOLTAGE), RANGE 1 $
CLOSE, 116 $ COMMENT, CONNECTS ZA-37 TO SAMPLING VOLTMETER $
READ, 'SAMPLING VOLTMETER', FILTERED $
COMPARE, 'M', UL 400, UNITS MVDC $
GO TO, 56900, IF NO GO $
OPEN, 116 $
TEST 56205 $
CLOSE, 127 $ COMMENT, CONNECTS ZA-3 TO SAMPLING VOLTMETER $
READ, 'SAMPLING VOLTMETER', FILTERED $
COMPARE, 'M', UL 400 $
GOTO, 56900, IF NO GO $
OPEN, 127 $
TEST 56206$
SET UP, 'SAMPLING VOLTMETER' (VOLTAGE) RANGE 100 $
CLOSE, 112 $ COMMENT, CONNECTS ZA-41 TO SAMPLING VOLTMETER $
READ, 'SAMPLING VOLTMETER', FILTERED $
COMPARE, 'M', UL 15.45, LL 14.55, UNITS VDC $
GOTO, 56900, IF NO GO $
OPEN, 112, 43, 69 $
TEST, 56301 $ COMMENT, PTS ref 5.6.3 $
TEST, 56900, JUMP $
DISPLAY, MESSAGE, FAILS AUTOPILOT FAILURE WARNING TESTS $
GOTO, 57000 $
```

Computer Programs

SYSTEM PROGRAMS

The ATE computer store holds the various system programs when they are being run. If the disc option is implemented, all systems programs are stored on the disc and are called into store as required by the operator. The principal systems program is the Interpretive Master Program (IMP) which performs the on-line control of the ATE thus testing the UUTs. Other systems programs include the Compiler which translates test programs written in 'IDEAL' into the 'ATE object code' which is used as the input to the IMP, the Editor, the Self Check and the Self Test programs and the debug programs used during the commissioning of a new or modified test program.

THE POWER OF THE COMPUTER

As well as its role of controlling the ATE the Interpretive Master Program provides the real power behind the Function Generator and the Sampling Voltmeter. The Function Generator can produce waveforms of any shape which can be sensibly described in 64 ordinates including waves with programmed harmonic components up to the 16th harmonic. Each of these wave shapes may also be used to modulate a higher frequency carrier. The software can extract a wide range of physical parameters from a set of samples: DC voltage and current, AC peak, mean or rms voltage or current, resistance, frequency and periodic time and the phase angle between two waves of the same frequency. In addition the computer can extract the amplitude of the in-phase and quadrature components of the first sixteen harmonics of a fundamental by the use of Fourier Analysis techniques. The phase angle and total amplitude of these harmonics can be calculated by the computer from these measurements. An extension of the Fourier Analysis technique enables the total distortion of a nominally sinusoidal wave to be calculated automatically. These techniques have been shown to permit transfer function analysis, of d.c. and a.c. carrier systems, to be performed to the same accuracy as is achieved by specialised TFA instruments. Transfer functions can also be measured by cross correlating the output and input to the UUT. A pseudo-random binary sequence is employed as the UUT input.

CONTROL OF THE ATE

The operations performed by the ATE are determined by instructions from three different sources. The test programmer converts the test specification into IDEAL which is compiled to the object code of the ATE. The operator controls the way in which the tests are performed by operating the controls on the Control and Display Unit (CDU) and the keyboard. These two control sources feed information to the computer. The Interpretive Master Program is designed to implement these instructions by modifying the actions it performs while performing a test program. To enable the operator to control the ATE it is essential that he is given information about the progress of the test program. The IMP derives this information from the test program and the results of the tests performed and formats it before displaying it on the alpha-numeric display.

CONTROL OF THE INSTRUMENTS

The principal instructions in the test program are concerned with controlling the instruments of the ATE. The test programmer writes the instruction in IDEAL which is very English-like. This is converted into the object code which is carefully defined to minimise the amount of backing storage required without compromising the modular integrity of the IMP. The IMP interprets this data and causes the required subroutines to be obeyed, thus causing the instrument to generate or measure the required signal.

SEQUENCING OF TESTS

The IMP also interprets the variety of test program instructions which are concerned with the correct sequencing of the tests. These range from time delays and pauses of indefinite length to permit the operator to take some action (such as operating a switch on the UUT) to the test number and jump frames which alter the sequence in which tests are applied according to the state of the UUT. The IMP includes facilities to permit a wide variety of different build standards of a UUT requiring marginally different test specifications to be tested by a common test program.

Reliability and Maintainability

Optimum Quality

QUALITY IMPROVEMENTS BROUGHT ABOUT BY:

Full printed wiring boards and modular sub-assemblies.

Advance bonding techniques used in chassis design giving high strength/weight ratio, close tolerance and simplified construction.

Maximum use of cable forming on chassis and cabinet wiring.

Maximum use made of plated through holes to improve packaging.

Use of Computer Aided Design for artwork generation giving high accuracy - uniform layout.

Controlled soldering techniques.

Use of tywrapping to secure cable forms.

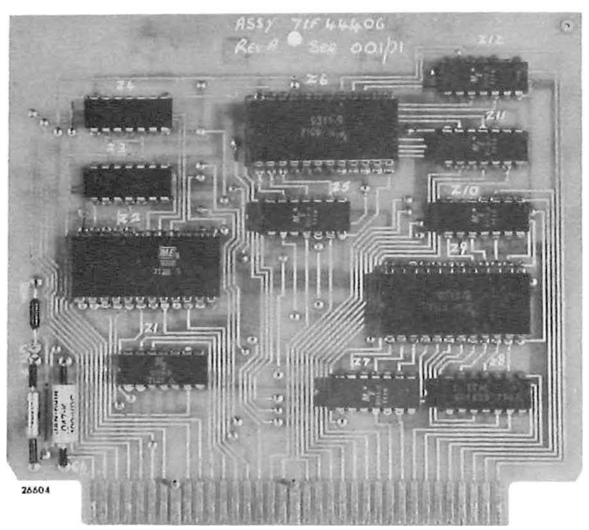
Production personnel working to fully documented process instructions.

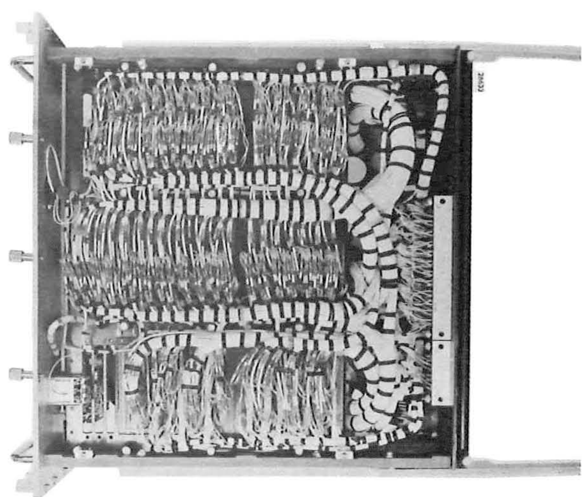
Cross flow cooling provides fresh air cooling to all chassis.

Use of Kynar shrink sleeves to give added support to conductors soldered to terminal posts of edge connectors.

Use of solder sleeves for terminating conductors and screen tails.

Use of standard white jacket cables, colour coded to assist Maintainability.





Quantative Reliability

HIGH RELIABILITY - is achieved by adherence to the following policy

Strict Quality Control of wire jointing processes.

Choice of High Quality Components under-run with special attention to their thermal and mechanical environment.

Use of Medium Scale Integration (MSI) giving improvement in overall reliability for a given functional complexity and improvement in packaging techniques.

Reduction in number of display tubes required by utilising an advanced Alpha-Numeric Display integrated into a single Plasma Display Matrix.

High Reliability Power Supply Modules as integral part of unit.

Use of Ground Plane techniques to improve noise immunity.

Use of High Noise Immunity Data Highway giving a reduction in number of transmission lines required.

Reduction in size and number of Interface cards by use of a serial data system utilising MSI components.

Advanced Electrostatic and Electromagnetic shielding to improve Noise Immunity, fully isolated sub-chassis to improve Common Mode Rejection.

Use of durable, low mating force, low contact wear connectors.

The QUANTATIVE RELIABILITY parameters of the equipment are:

Mean Time Between Failures (MTBF) = 312 hours

Mean Time to Repair (MTTR) = 60 mins.

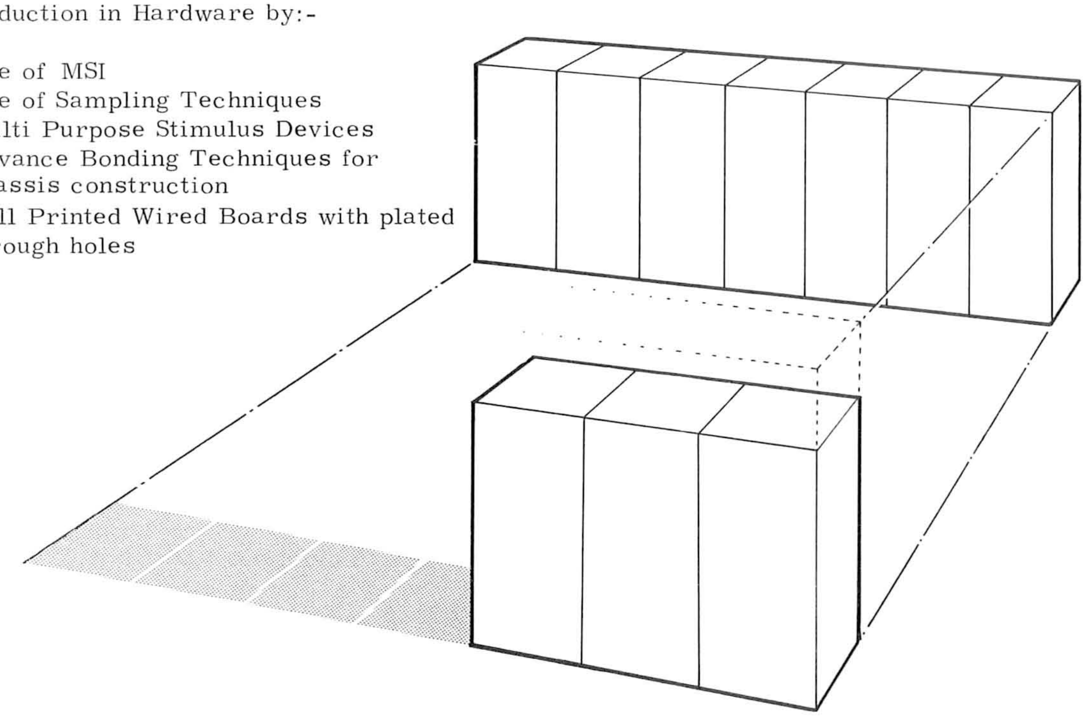
Equipment Availability $A = \dfrac{1}{1 + \dfrac{MTTR}{MTBF}}$

$= 0 \cdot 996$

$= 99 \cdot 6\%$

Reduction in Hardware by:-

Use of MSI
Use of Sampling Techniques
Multi Purpose Stimulus Devices
Advance Bonding Techniques for chassis construction
Full Printed Wired Boards with plated through holes



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On Demand Availability

Availability is Dependent upon Maintenance Procedures

	Maintainability Targets
Maintenance Simplicity	Adequate identification, visibility and accessibility of parts.
	Interchangeability of identical sub-assemblies.
	Limitation in number and variety of tools, accessories and support equipment.
Infrequent Maintenance	Fails safe and Fault limitation features in the design.
	Parts selected that require little or no preventive maintenance.
	Adequate tolerances provided which allow for use and wear throughout life.
	Corrosion prevention or control features.
Minimum Downtime	Rapid and positive detection of unit failures.
	Quick removal achieving ease of fault corrections.
	Rapid and positive adjustment calibration and verification of correction.

MAINTENANCE PHILOSOPHY

Maximum use will be made of automatic diagnostic self test routines to locate malfunctions quickly in order to reduce repair times, skill level and special support equipment.

The design of the ATE will be such as to allow automatic diagnosis to board or module level.

Repair of the ATE will be to replaceable board or module.

Self test routines can be stored and accessed quickly by selected keyboard operations with disc option fitted or direct from the self check program.

Limited amount of manual diagnosis required.

PREVENTIVE MAINTENANCE

No preventive maintenance will be required on the ATE other than routine servicing on electro mechanical peripherals of the control complex such as the tape reader, disc, printer, punch and air filters fitted.

Check calibration program carried out at 180 day intervals.

CORRECTIVE MAINTENANCE

Diagnosis is accomplished by self check and/or self test diagnostic routines.

The self test diagnostic program will isolate malfunctions to board, module, or a sub-assembly. Where an individual board or module cannot be indicated groupings with a maximum of four boards will be specified in the most probable order of failure.

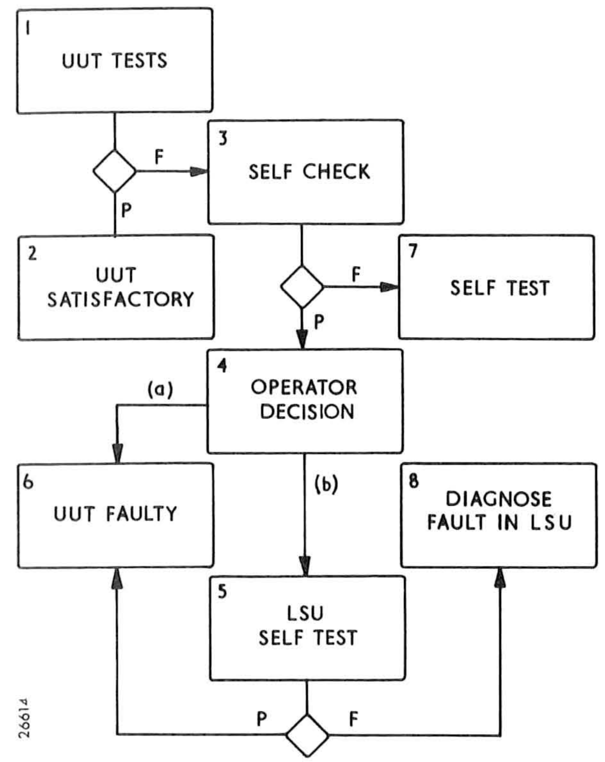
Diagnosis to a lower level in these additional areas will require secondary maintenance action.

The secondary action takes the form of manual diagnosis by the technician aided by circuit diagrams and information contained in the ATE maintenance manual.

Areas that will require some manual diagnosis are:

Power Supply Units
Chassis/Cabinet Wiring

Individual UUT Check



1 Connect UUT to ATE - Select Program - Test UUT
2 All Tests Pass - UUT Satisfactory - Remove UUT
3 UUT Tests Fail - Program Proceeds to Self Check Routines
4 Self Check Tests Pass - Stimuli and Measurement Units Satisfactory - Remove UUT Operator Decides -
(a) ATE Previously in Operation - No Similar UUT Failure Confidence in ATE Performance - UUT Faulty
(b) ATE Not Previously in Operation - Recent Similar UUT Failure - Suspected ATE Relay Fault
5 Carry Out Rapid 5 Minute Check of LSU by Selecting Program from Store
6 Line Switch Unit (LSU) Tests Pass - UUT Faulty - Repair Action
7 Self Check Tests Fail - Program Indicates Selection of Self Test Routeings - Diagnosis to FTU Board, Module or Sub-assembly
8 LSU Tests Fail - Immediate Diagnosis to Relay Module and Relay Failure

ATE Checkout

FAILURES WITHIN THE ATE RAPIDLY IDENTIFIED BY:

SELF CHECK

These routines arrange for stimuli to be routed back via the appropriate measurement system on detection of a failure by the test program.

Failures in Self Check will produce an indication of a selected entry into the Self Test Program.

PROGRAM MONITORS

These are written within the Interpretive Master Program and include:-

Continuous checks of all data transfers to verify that information received and stored by an IFU is the same as that transmitted from the control system.

Detection of any fault by the program monitor causes the Master Program to reset the ATE and provide a fault indication.

POWER SUPPLY FAILURE MONITORS

Failures of the system power supplies are detected and indicated by:

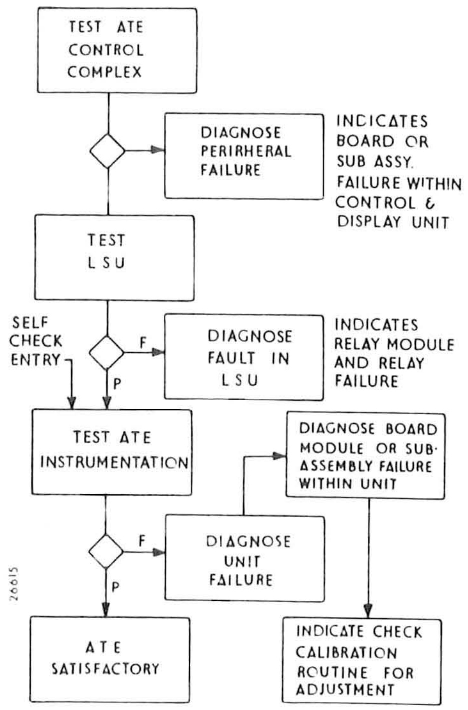
Power Fail Indication on the Main Control Panel

A specific supply failure indication on the system power supplies front panel

A logic signal will inform the computer of a supply failure in order to bring about a program and hardware reset condition.

Failures of the measuring system power supplies are indicated separately on the unit front panel.

SELF TEST



CONTROL COMPLEX SELF TEST

The Control Complex Self Test routines establish the integrity of, and perform fault diagnosis on the units of the Complex.

The program is stored and is designed to be accessed quickly via a selected operation of the keyboard.

Diagnostic routines will isolate faults to a unit of the Complex with further diagnosis to board level for the serial data transfer system.

Tests on all control functions to and from computer are checked and information on any failure showing type of error and data bit malfunction will be indicated.

INSTRUMENTATION COMPLEX SELF TEST

Tests on the ATE instrumentation provide for the adequate checking of all Functional Test Unit parameters identifying any faulty unit and diagnosing the malfunction to board or sub-assembly level.

The program consists of three main features:

Rapid and complete checkout of the Line-Switch Unit using a Self Test Adaptor designed only to test the relays. Indication of Relay Module and Relay Failure will be displayed.

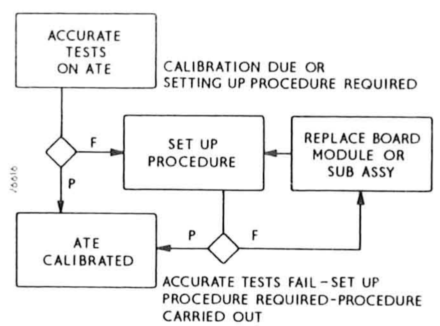
A comparison check of all FTUs one against another using an FTU routeing adaptor will provide a checkout of all parameters to fulfil an ATE operational test while using second opinions as necessary to isolate any malfunction first to the failing unit and then to indicate the faulty board, module or sub-assembly within that unit.

The program is constructed such that selected entry into the program is allowed to provide a direct link from Self Check failures.

Routines can be contained on the disc backing store and selected quickly when required.

Failure information will be indicated by the Display or Printer with references to the Maintenance Manual as necessary for detailed repair action.

CHECK CALIBRATION



Calibration will be carried out at 180 day intervals using a check calibration program.

A limited amount of external equipment will be used to calibrate selected units which are then considered as standards.

These are then used to calibrate the remaining units.

All units are calibrated via the UUT Interface to take into account any inaccuracies due to cabinet wiring.

After Sales Support

Support Policy

Marconi Elliott Avionics policy for the support of Automatic Test Equipment has been evolved from experience of supporting systems for military and civil customer on a world wide basis.

Support is of prime importance while the user is introducing the ATE into his maintenance unit and the Marconi Elliott Avionics policy is to provide an engineer at the users site for a period of one year after delivery.

Spares parts and factory repair service required during this first year are also included in the basic price. Technical Manuals to ATA Specification 101 and consistent with the maintenance and spares provisioning policy are provided.

Training courses can be arranged at Rochester for user personnel as required. Subsequent to the first year a spares package will be negotiated and a factory repair service and engineering service on a 'per diem' basis are available.

TRAINING

Training courses covering design theory, operation, maintenance and programming can be arranged to meet particular user personnel requirements, in terms of depth of treatment.

A general course of four weeks duration is recommended. This course would take place at Rochester about three months before delivery.

The course provides a theoretical background to the system hardware and software design, and includes practical instruction in operating and maintenance procedures.

This course also allows user personnel to be familiarised with the technical manuals, and UUT test procedures. The course syllabus is shown as follows.

Course Syllabus

(1) Introduction

(2) Description of Test Set

(3) Location and Purpose of Individual Sub-assemblies

(4) Theory of Operation (Block diagram level):

- (a) Control Complex
- (b) Peripheral Control
- (c) Measurement and Stimulus Units
- (d) Power Supplies

(5) General Operating Procedures (including practical demonstrations and experience)

(6) UUT Testing:

- (a) Tape Preparation
- (b) Test Programme and Adaptor for all UUT's.
- (c) Practical work testing all UUT's.

For each UUT the test requirements will be discussed and the student will be informed of the test methods, facilities of the ATE and the test programmes employed to meet these requirements. Emphasis will be placed on special and complex testing procedures and procedures where manual interventions are required.

(7) Theory of Operation (circuit diagram level) of Control Complex:

- (a) Tape Handler/Reader
- (b) Disc Backing Store
- (c) Computer
- (d) Keyboard and Printer
- (e) Control and Display Unit

(8) Theory of Operation (circuit diagram level) of Stimulus and Measurement Units:

- (a) Function Generator
- (b) Sampling Voltmeter
- (c) Scaling Unit
- (d) Line Switch Unit

(9) Theory of Operation (circuit diagram level) of Power Supply Units:

- (a) System Power supply Unit
- (b) UUT d.c. Power Supply Unit
- (c) UUT a.c. Power Supply Unit

(10) Fault Diagnosis, Maintenance and Repair

- (a) Self Check Program
- (b) Fault Indications
- (c) Self-test Programmes and Procedures
- (d) Check Calibration Programmes and Procedures
- (e) Routine Maintenance Procedures
- (f) Removal and Replacement of Units and Modules
- (g) Fault diagnosis, Calibration and Maintenance Procedures (Practical)

TECHNICAL SUPPORT ON-SITE

An engineer is provided for one year after delivery to support user personnel in system operation and maintenance.

This engineer will also assist user personnel in developing up-dated test software if required, all will provide a close link with Automatic Test Equipment Division and Flight Controls Divisions engineering design personnel at Rochester.

Engineering support of this kind ensures trouble-free introduction of ATE into the users service.

In addition, this technical support provides extensive informal training to user personnel to supplement any formal training and the information and instructions provided in the technical manuals.

SPARES

All ATE spares required during the first year after delivery are included. Maintenance policy for the ATE is to diagnose faults to replaceable board or module level.

A spares package of these items will be negotiated with the user and supplied at the end of the first year. A factory repair service for faulty boards and modules is provided. This repair service operates with an average turn round time of one month.

TECHNICAL MANUALS

Technical manuals conforming to ATA Specification 101 are provided, comprising an Operation Manual, a series of individual manuals for each UUT giving operating instructions for testing the particular UUT, a Maintenance Manual, an Illustrated Parts Catalogue and a Programming Manual.

Contents of Technical Manuals

OPERATION MANUAL

Chapter 1 Description and Operation	Leading particulars: location and purpose of units: general mechanical description: block diagram level electrical description: front panel controls and indicators. Maintenance philosophy: self check: self test check calibration.
Chapter 2 Operating procedures	General operating instructions, i.e. switch on: fit adapter: connect UUT: program selection, use of display and indicators.
Chapter 3 Servicing	Routine servicing, recognition of elementary faults: lamp replacement: fuse replacement etc.

OPERATING INSTRUCTIONS: AZIMUTH COMPUTER

Chapter 1 ATE Operating Instructions	Step-by-step instructions for fitting adaptor and UUT, program selection, and any instructions particular to the UUT.
Chapter 2 'IDEAL' Language Test Program	Test program in 'IDEAL' test language with cross references to ATLAS test procedures in UUT Overhaul Manual. Test Routeing Diagrams.

Similar manuals for each UUT are provided as follows:-

OPERATING INSTRUCTIONS: TRIM COMPUTER

OPERATING INSTRUCTIONS: AUTO STABILIZER COMPUTER

OPERATING INSTRUCTIONS: AUTOTHROTTLE COMPUTER

OPERATING INSTRUCTIONS: WARNING AND LANDING COMPUTER

OPERATING INSTRUCTIONS: PITCH COMPUTER

OPERATING INSTRUCTIONS: AFCS PILOTS CONTROL UNIT

OPERATING INSTRUCTIONS: ITEM COMPUTER

OPERATING INSTRUCTIONS: ITEM CONTROL UNIT

OPERATING INSTRUCTIONS: SAFETY FLIGHT CONTROL COMPUTER

OPERATING INSTRUCTIONS: DATUM ADJUST UNIT

Contents of Technical Manuals-continued

MAINTENANCE MANUAL

Chapter 1 Descriptions and Operation	Complete functional description of the ATE, commencing with system orientated functions progressing down to functions within the TRU's. The text will be complemented by block diagrams, board and unit interconnection diagrams.
Chapter 2 Trouble shooting	Fault diagnosis information related to the use of the self check/self test program data provided in the form of tables. These tables will relate messages on the display to probable faulty boards or modules and cross refer to illustrations in the Illustrated Parts Catalogue to enable faulty board or module to be physically located and replaced. In the event of the replacement of the board/module not clearing fault, indications of probable areas of faulty cabinet/unit wiring will be given and relevant illustrations will be referred to. In minor areas where the self check/self test program cannot diagnose to a faulty board or module (in accordance with maintenance philosophy) manual diagnosis procedures will be provided.
Chapter 3 Servicing	Data will be provided in the form of tables to relate manual procedures, connecting external equipment etc. to the check calibration program.
Chapter 4 Removal and Installation	
Chapter 5 Adjustment/Test	Token leaves referring to Chapters 2 and 3.
Chapter 6 Inspection/check	General statement covering inspection of the general condition of the equipment.
Chapter 7 Cleaning/Painting	Token leaf covering general maintenance.
Chapter 8 Repair	Detail procedures to cover replacement of TRU's or modules where any special technique is required. Detailed procedures for replacing connectors where crimping or special techniques are required.

ILLUSTRATED PARTS CATALOGUE

Introduction	List of suppliers, with codes
Chapter 1	Numerical Index
Chapter 2	Detailed parts list. Exploded views. Illustrations and lists will only provide details to the level required for board or module replacement. Data will not be provided for repair of board and modules.

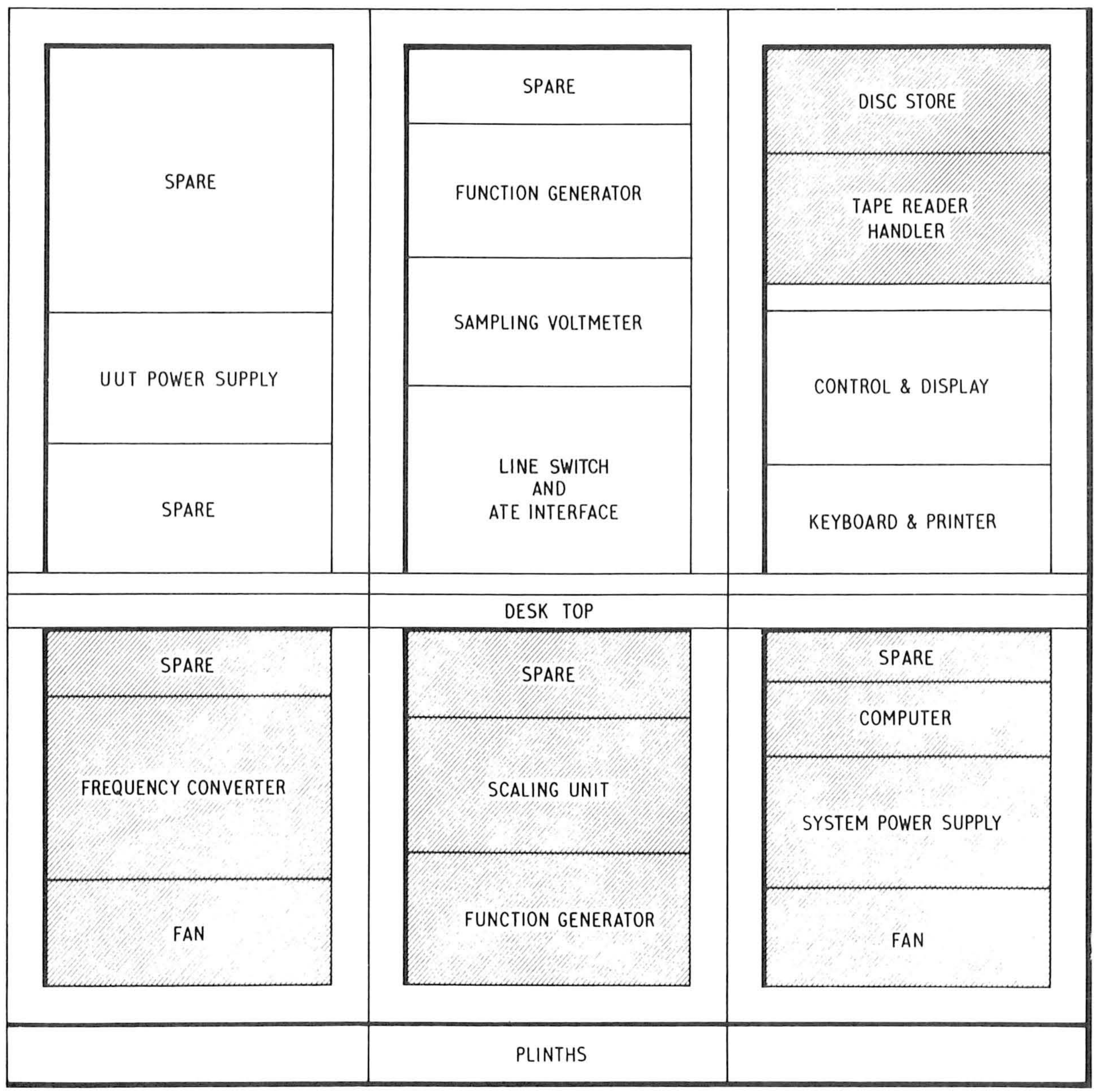
PROGRAMMING MANUAL

Chapter 1 Ideal Program Language	Specification for 'Ideal' program language.
Chapter 2 Programming	Instructions for translating test procedures written in 'ATLAS' to 'IDEAL' test language. Instructions for processing test programs in 'IDEAL' test language and producing UUT test tapes using the ATE.

Technical Specification

ATE Layout

Shaded Areas Denote RFI Covers



Control Complex

SYSTEM ENVIRONMENTAL CONDITIONS

Temperature range Operating:	$+ 10^{o}$ C to $+ 44^{o}$ C
Temperature range Storage:	$- 10^{o}$ C to $+ 50^{o}$ C
Relative Humidity:	30% to 80%

THE CONTROL COMPLEX

The Control Complex is housed in the extreme right-hand cabinet of the ATE. It consists of a Control Computer, a Control and Display Unit, a Printer and Keyboard, a Punched Tape Reader and Handler and a System Power Supply Unit. In addition a multi-test program storage facility is provided in the form of a magnetic disc store.

Control Data and Measurement Results are passed between the Control Complex and the Test Complex via a serial data highway system which operates between the Master Multiplex Unit (MMU) located in the Control and Display Unit and the IFU's associated with each programmable unit in the ATE Test Complex.

THE CONTROL COMPUTER

The main function of a computer in an automatic test equipment is to control various Functional Test Units (FTU) that comprise the ATE from data defined by the test program input. It also makes calculations and comparisons between the measured value and limits set by the test program, determining whether the Unit Under Test (UUT) is satisfactory.

Several subsidiary functions necessary to the running of the ATE are associated with this main function.

These include:-

Reading the test program data into the computer, searching and verification which is necessary in order to find and load the correct section of the program.

Selecting output of results and instructions either directly from the test program data or from measurements taken. Suitably processing all results measurements and instructions.

Controlling man-machine interface instructions initiated by the Operator. Controlling display and keyboard servicing routines.

Using a computer simplifies the hardware of the ATE and renders test programming simple and powerful.

THE COMPUTER

The computer is a modern fast 'mini' computer selected because it is suitable for controlling Automatic Test Systems. Ability to handle input/output data and its computing ability are of equal importance.

The following major features are considered necessary:

16 bit parallel operation general purpose
Single address
Four accumulators
Interrupt by automatic interrupt source identification
Direct and autonomous data transfer
8192 words core store (expandable up to 24K)
$1.2 \mu S$ core store cycle time.

CONTROL AND DISPLAY UNIT

The alpha-numeric display is capable of displaying a total of 256 characters arranged in eight lines of 32 characters each. The display operates on the gas discharge principle similar to a nixie tube - each character being made by illuminating the appropriate dot matrix for that particular character. The dot matrices are 7 dots high and 5 dots wide. The scan rate is 85 ch/sec and the brightness is 50 ft lamberts at a contrast ratio of 20:1.

The control functions are as follows:-

PRINT ALL/PRINT FAULTS, RESET, START, FRAME STEP, AUTO/DECIDE, MANUAL, TEST LAMPS, REPEAT TEST, GO/MAN INT, MAINS ON/TESTER ON, POWER FAIL/FAN FAIL, CONTROL FAIL

KEYBOARD

The keyboard provides a full alpha-numeric capability on typewriter layout and employs:

53 keys - operating pressure 3 oz.
2 key roll over protection
Life of keys 20 x 10^8 operations
ASC II coded output
Positive TTL logic

DATA TRANSFER

The serial data transfer system, interfacing the computer with the signal generator and measurement Functional Test Units (FTU), is divided into three sections; the Computer Interface, the Serialiser, and the FTU together form the Master Multiplex Unit (MMU) which is located within the Control and Display Unit. IFU's are mounted adjacent to their respective FTU's. Using a serial system minimises cabinet wiring and improves reliability. The amount of control logic required is considerably less than that for a comparable parallel arrangement, so that reliability is further improved and power consumption reduced.

PERFORATED TAPE READER AND HANDLER

This unit provides access to approximately 2.0 Megabit of information at 500 characters/second. A bidirectional fast search facility is provided to enable rapid location of the required section of the test program at 1200 characters/second.

The test program are held on spools that are loaded onto the tape handler mechanism.

Specification:

Speed: Unidirectional	500 Characters/second
synchronous: Bidirectional	300 Characters/second
fast search:	1200 Characters/second
Perforated tape	1 in. wide, 8 track
Spools:	7 ½ in. NAB spools
Capacity:	1000ft. 0.0025 in. Mylar 750 ft. 0.004 in. Paper

SYSTEM POWER SUPPLIES

The system power supply unit is made up of two power supply modules providing + 5 volts and + 28 volts to the system.

Each module is over and under voltage protected and has over current protection. If any supply is outside ±5% of its nominal voltage tolerance, the complete power supply system is switched off by SCRs. Remote indication of a shut down is provided on the Control and Display Unit. Indication of individual supply failure is provided on the front panel of the system power supply unit.

MOSAIC PRINTER

A mosaic printer is provided to give a permanent record of test results and important maintenance instructions. The

information to be printed is defined in the test program.

The printer has full alpha numeric capability.

Printing speed	50 ch/sec
Throughput	1 line per sec.
Line Width	20 Characters.

TAPE PUNCH

A Tape Punch is included as an additional facility for the recording of test results. This punch is capable of punching paper or mylar tape.

Brief Specifications:

Punching speed:	80 characters per sec.
No. of tracks:	5, 6, 7 or 8 hole tape ISO standard
Tape Material:	Paper or Mylar
Reel Capacity:	1000 feet

Note ...
If the ATE computer is to be used for Test Program assembly off-line a punch is required to produce the Tester Tape.

THE BACKING STORE

Software is stored on a standard magnetic disc. This provides rapid computer access to any part of any test program, and permits the flexible operating system described in this document to be employed on the ATE. As the range of tasks allocated to an ATE is increased the disc can be replaced simply by operating a switch and then withdrawing one disc from the mechanism and inserting the replacement before returning the switch to its original position.

DATA DENSITY

Bit density	200 bits per inch
Track density	100 tracks per inch
Bit Transfer rate	1562kHz
Recording Mode	Double Frequency

CAPACITY

per disc	24 000 000 bits
per track	60 000 bits
per sector	7 500 bits

ACCESS TIME

Rotation	1500 r.p.m.
Average latency	20 millisecs.
Head positioning typical, track-to-track	12 millisecs.
typical, average	60 millisecs.
maximum, track-to-track	15 millisecs.
maximum, average	70 millisecs.

POWER

Drawn from the computer	+ 15V d.c. - 15V d.c.
Instantaneous peak load	7 amps
Worst Case Average	4 amps

Size

Width	19in rack mounted
Height	7 inches
Depth	$22\frac{7}{8}$inches
Weight	35 pounds

WARM UP

Typical warm up and acceleration time	50 secs.
Decelleration time	10 secs.

Test Complex

THE SAMPLING VOLTMETER

The sampling voltmeter is a programmable 'sample and hold' strobing voltmeter, capable of making instantaneous voltage amplitude measurements on UUT waveforms. The voltage measurement point in time may be delayed over a controlled range following a measurement - enabling trigger or a computer generated measurement point.

Where waveforms under test are derived from the Function Generator, the measurement - enabling trigger is supplied by the Function Generator. Where a waveform under test is not derived from the Function Generator, the measurement-enabling trigger can either be obtained from the waveform under test within the sampling voltmeter, or from an externally supplied trigger. The voltage measurement 'point in time', with respect to the measurement-enabling trigger is programmable.

SPECIFICATION

DC VOLTAGE

Full scale ranges:	±1V, ±10V, ±100V, ±1000V
Resolution:	1 part in 2^{15}
Accuracy (24 hours)	±0·01% of full scale
(6 months)	±0·02% of full scale
Temperature co-efficient:	±0·0025% of f.s.d. 7^{o} C.
Input Impedance:	10M ohm
Common mode voltage:	±500V max.
Common mode rejection:	100dB d.c. to 50Hz with 100 ohm in either lead
Filtering:	Digital

AC VOLTAGE

Full scale peak ranges:	1V, 10V, 100V, 1000V
Resolution:	1 part in 2^{15}

Accuracy (all ranges):

DC - 1kHz	±0·04% f.s.d.
1KHz - 10kHz	±0·35% f.s.d.
10KHz - 50kHz	±0·80% f.s.d.
50KHz - 100kHz	±1·80% f.s.d.
Temperature co-efficient	±0·006% f.s.d./^{o}C up to 50kHz
Input resistance:	10M ohm
Common mode voltage:	±500V max.
Common mode rejection:	100dB at 50Hz with 100 ohm in either lead

RESISTANCE

Full scale ranges:	1k ohm, 10k ohm, 100k ohm, 1M ohm, 10M ohm.
Resolution:	1 part in 2^{14}
Accuracy:	
1, 10, 100k ohm ranges:	±0·03% f.s.d.
1M ohm range:	±0·07% f.s.d.
10M ohm range:	±1·20% f.s.d.
Temperature co-efficient:	±0·002% f.s.d./^{o}C.

PHASE

Frequency range:	0·5Hz to 100kHz
Amplitude range:	1 to 500V full accuracy
Accuracy:	±0·4^{o} maximum ±0·1^{o} minimum
Input Impedance	
Signal:	10M ohm
Reference:	10M ohm
Measurement Time:	
Below 100Hz	<5 cycles
100Hz to 100kHz	1 sec at 100Hz Decreasing to 10ms at 100kHz

MEASUREMENT DELAYS

Unlocked mode, Measurement delay increments:	200ns, 2µs, 20µs 200µs, 2ms, 20ms
Delay	(1 to 1024) x (delay increments) in steps of 1.
Accuracy:	± 2% of delay
Delay Jitter:	0·05% of delay

FREQUENCY PERIOD

Frequency range:	0·5Hz to 1MHz
Accuracy:	One part in 10^{5}
Maximum Measurement Time:	20ms above 10Hz Below 10Hz the time taken for measurement is 2 cycles maximum.
Amplitude range:	1V to 500V
Input Resistance:	10M ohms
Common mode voltage:	500V

FOURIER ANALYSIS

Frequency range:	0·5Hz to 100kHz
Amplitude range:	1 to 500V for full accuracy
Signal input resistance:	10M ohm
Common mode voltage:	500V
Measurement modes:	In phase component, quadrature component.
Accuracy	
DC - 10kHz	±0·75% of f.s.d.
10kHz - 50kHz	±1·2% of f.s.d.
Harmonics	Up to 16th

DISTORTION

Frequency range:	0·5Hz to 100kHz
Signal amplitude range:	1 to 500V for full accuracy
Signal input Impedance	10M ohm
Common mode voltage:	500V
Measurement mode:	r.m.s. value of residue after removing fundamental
Accuracy	
DC - 10kHz	±1·5% of f.s.d.
10kHz - 50kHz	±2·4% of f.s.d.

SYNCHRO MEASUREMENT

Frequency:	All standard synchro frequencies between 0·5Hz and 100kHz.
Amplitude ranges:	1V, 10V, 100V, 1000V, pk
Resolution:	1 point in 2^{15}
Input resistance:	10M ohms
Common Mode voltage:	±500V max.
Common Mode Rejection:	100dB at 50Hz with 100 ohms in either lead
Positional measurement accuracy:	<± 2 minutes of arc.

THE FUNCTION GENERATOR

The Function Generator is a general-purpose stimulus unit capable of generating d.c. and a.c. signals, modulated signals and phase related signals simultaneously. The number of outputs can be increased depending on Customer requirements.

The Function Generator contains 2 DAC's and 2 HM's. The two HM's can be switched directly to a DAC to obtain a fixed or variable reference signal. Each output may be used direct for low current and simultaneously through a Buffer Power Amplifier for high current.

In addition to the DAC's and HM's 4 Sample and Hold amplifiers are available to provide independent d.c. signals. These amplifiers are 'set' in turn by the analogue output of a DAC which cycles the amplifiers continuously.

The Function Generator generates signals with waveform, frequency, and amplitude independently variable. Trigger signals are provided to externally synchronise the Sampling Voltmeter. The Function Generator output signals are isolated from the ATE Power Supplies.

SPECIFICATION

Waveforms: d.c., Sine, Square, Ramp, Triangular, Special, Synchro Position, Synchro Rate

Voltage Range		Max. No. of outputs
d.c.	± 10V	7 off
a.c.	0 to 7·07V r.m.s.	4 off
Synchro	(26V r.m.s.)	1 off
Special Waveforms	± 10V peak	4 off
Resolver		1 off

Resolution

DAC	0·3mV
H.M.	5mV
Synchro	4 minutes

Accuracies (at 25°C)

DAC	0·005% F/S
H.M.	0·02% F/S
Synchro	± 3 minutes

Temperature Coefficient	0·0012% /°C max.	
Frequency Range 0 to 100kHz		CW or modulated
Modulation Frequency Range 0 - 10 kHz		
Special Waveforms	As defined by 64 equally spaced ordinates	
Output Impedance	10^{-4} ohms	
Output Current	100mA	4 off
	3mA	4 off
Output Current (with amplifier)	500mA	2 off
Reference	Int or Ext	

Ext Ref	± 10V
Frequency 0	to 10kHz

NOTE:

The total number of simultaneous outputs are restricted to seven per Function Generator. Two Function Generators are provided in the ATE

As synchro stimuli can be measured by the sampling voltmeter to better than 2 minutes of arc, a measure and correct technique can be employed to further increase accuracy.

THE LINE SWITCH UNIT

Mercury wetted relays, dry reed relays and heavy duty relays, required to switch LF signals, are arranged in sub-modules, both ends of each relay being available at the ATE output connectors. Connection from the ATE to the UUT is made through an Adaptor Unit which provides facilities for patching between FTU's, the Line Switch, and the UUT, and contains any required UUT loads. Also available at the ATE output connectors are the inputs and outputs of the FTU's.

The Line Switch Unit contains 10 Mercury Wetted Relay modules, 6 Dry Reed Relay modules and 1 Heavy Duty Relay module to the following specifications.

Mercury Wetted Relay Module

No. of Relays per Module	50
Line Current Maximum	5 amps
Line Current Switching Maximum	2 amps or 100VA
Relay Contact Resistance	20m ohms
Repeatability	± 2m ohms (over life) (10^9 Operations)
Maximum Voltage Switching	500 Volts
Maximum Voltage Open Circuit	1000 Volts

Interelectrode Capacitance & Insulation Resistance	Capacitance and Insulation Resistance of the Switching circuit depends upon the routeing of the total wiring centred within the Line Switch Unit.
	Relay Interelectrode Capacitance - 30pF max.
	Relay Insulation resistance - 1000M ohms min.

Dry Reed Relay Module - General Purpose

No. of Relays per Module	50
Line Current Maximum	1 amp
Current Switching	1 amp at 20V or 20VA
Voltage Rating (Switching)	150 Volts Maximum
Voltage Rating (Open Circuit)	350V maximum

Heavy Duty Relay Module

No. of Relays per Module	22
Line Current Maximum	10 amps
Current Switching:	10A at 28V
Voltage Rating (Switching):	130V maximum
Voltage Rating (Open Circuit):	500V maximum

U.U.T. POWER SUPPLY

The U.U.T. Power Supply drawer contains the fixed d.c. power supplies required for the units under test.

Five P.S.U. modules are contained in this drawer and the following voltages are generated:-

+28V +15V +12V -12V -15V

+28V P.S.U.

Output Voltage	+28V
Regulation	±0·05%
Output Current	5A
ripple and noise	0·5 mV p-p

+15V P.S.U.

Output Voltage	+15V
Regulation	±0·05%
Output Current	2A
ripple and noise	0·5 mV p-p

+12V P.S.U.

Output Voltage	+12V
Regulation	±0·05%
Output Current	2A
ripple and noise	0·5mV p-p

-12V P.S.U.

Output Voltage	-12V
Regulation	±0·05%
Output Current	2A
ripple and noise	0·5mV p-p

-15V P.S.U.

Output Voltage	-15V
Regulation	±0·05%
Output Current	2A
ripple and noise	0·5mV p-p

All modules contain over-voltage crowbar protection and re-entrant current limiting.

SCALING UNIT

This unit contains the following items:

Multiplying Amplifiers

These amplifiers are used to increase the available output voltage range of the Function Generator. 4 Amplifiers are supplied.

Multiplying constant	x5
Output Voltage Range	±45V peak
Accuracy	±0·2%
Output Current	100mA max.
Frequency range.	d.c. -10kHz.

Phase Generators

U.U.T's require the generation of 400Hz signals at various phases. These phases are generated on the phase generator boards from the 115V 400Hz supply.

Output voltage	3·5V r.m.s.
Accuracy	± 2%
Phase Angles	0^{o} 8^{o} 35^{o} 180^{o} 188^{o} 205^{o} + 215^{o}
Phase accuracy	$\pm 1^{o}$

FREQUENCY CONVERTER

This unit provides the 115V 400Hz required for the U.U.T's from the 240V 50Hz mains Input.

Input voltage 240V 50-60Hz single ∅
Output voltage 400Hz single ∅
Output Frequency tolerance ±1%
Output Voltage tolerance ± 3%
Power Output 500VA at 0·7 P.F. lagging
Distortion 3% total

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A GEC-Marconi Electronics Company

**AUTOMATIC TEST
EQUIPMENT DIVISION**

MARCONI-ELLIOTT AVIONICS

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