ADVANCED ULTRA-VIOLET (UV) AIRCRAFT FIRE DETECTION SYSTEM
VOL III - GROUND SUPPORT EQUIPMENT (GSE) FOR SYSTEM CHECK-OUT

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This technical report has been reviewed and is approved for publication.

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ADVANCED ULTRA-VIOLET (UV) AIRCRAFT FIRE DETECTION SYSTEM
VOLUME III - GROUND SUPPORT EQUIPMENT (GSE) FOR SYSTEM CHECKOUT

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**Abstract:**
The objective of this program was to utilize ultra-violet (UV) radiation technology to provide advanced means of detecting fire hazards more reliable and more rapidly than current thermally activated continuous cable type system. This volume, Volume III of three volumes, provides detail information on the Ground Support Equipment (GSE) for automatic and manual checkout of the system.
The work reported herein was performed in accordance with Air Force Contract F33615-77-C-2029 under the direction of the Fire Protection Branch (AFWAL/POSH) of the Fuels and Lubrication Division, Aero Propulsion Laboratory, Air Force Wright Aeronautical Laboratories, Wright-Patterson Air Force Base, Ohio, under Project 2348, Task 01, Work Unit 02, with Mr. G.T. Beery and Mr. T.A. Hogan, AFWAL/POSH, as Project Engineers.

This report is the result of utilizing ultra-violet (UV) radiation technology in the development and flight testing of an advanced aircraft fire detection system.

The contractor was General Dynamics, Fort Worth Division, Fort Worth, Texas. Mr. R.J. Springer, Program Manager, directed the efforts of P.H. Lang, W.B. Kirk, B.B. Witte, D.C. Nelson, and J. Phillips. The overall effort was under the supervision of Mr. C.E. Porcher, Manager, Propulsion and Thermodynamics Section. Graviner Ltd./HTL Industries, General Dynamics subcontractor, accomplished the design, fabrication, environmental testing and support for the flight test phase of the program. Graviner/HTL's efforts were directed by Mr. S.P. Robinson who was supported by J.J. Sheath and D.J.V. Smith. Sacramento Air Logistics Command (SM-ALC) provided the F-111 aircraft and support for the flight test phase of the program. Mr. B.W. Nichols, SM-ALC Engineering, coordinated the flight testing at McClellan Air Force Base.

This report describes the results of work conducted during the period of 15 December 1977 to 26 October 1981.

This is Volume III of three volumes. Volume I describes the overall work of the program which includes the results of the flight test phase. Volume II contains a description and details of the system circuit and software design. Volume III contains a description and details of the Ground Support Equipment (GSE) which is used as a fault diagnostic maintenance tool.
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<td>GSE</td>
<td>Ground Support Equipment.</td>
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<tr>
<td>CCU</td>
<td>Computer Control Unit.</td>
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<td>CWU</td>
<td>Crew Warning Unit.</td>
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<td>LRU</td>
<td>Line Replaceable Unit.</td>
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<tr>
<td>RAM</td>
<td>Random Access Memory.</td>
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<tr>
<td>ROM</td>
<td>Read Only Memory.</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>United States of America.</td>
<td></td>
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<tr>
<td>RUNP</td>
<td>Run Program from Location 0000.</td>
<td></td>
</tr>
<tr>
<td>UV</td>
<td>Ultra Violet.</td>
<td></td>
</tr>
<tr>
<td>PROM</td>
<td>Programmable Read Only Memory.</td>
<td></td>
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<td>MRD</td>
<td>Memory Read Line.</td>
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<td>Chip Select 1.</td>
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<td>Chip Select 2.</td>
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<td>Input/Output.</td>
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SUMMARY

The Ground Support Equipment (GSE) described herein is a portable automatic manual check-out unit for the Advanced Fire Detection System (AFDS).

It performs three basic functions. Firstly, it reads out the stored data from the AFDS gathered during a flight. Secondly, it checks the operational capability of the AFDS and finally it identifies faulty line replaceable units.

This report is divided into the following sections:

Section 1 is the Introduction.

Section 2 is a Systems Design Description and describes functionally the Hardware and Software.

Section 3 is the Systems Method and describes the Hardware and Software in detail.

Section 4 is the Operating Instructions.

Section 5 contains the Conclusion.

From the four major sections it can be seen that the GSE has been designed successfully. This is not to say that the GSE could not have been designed better.

Some circuitry duplication was necessary due to two independent sides of the Computer Control Unit, System A.

The microprocessor card was bought ready built. The major part of the interfacing circuitry was wire-wrapped on two dual size eurocards for ease of modifications and there were many.

Several problems were encountered with the software. One of the major problems was that there was no clear cut ending to the particular test devised. Problems were also encountered due to the lack of microprocessor equipment. Finally, some problems also arose when the GSE was operated in the U.S.A. during the CCU flight trials.

It was proposed that for production the specification of the GSE would change, which would result in the GSE being simplified. If the production quantity is small then the undesired functions are removed from the GSE software and if the production quantity is large then redesign the GSE.
1.0 INTRODUCTION

In order that the Advanced Fire Detection System (AFDS) can be checked out on a regular maintenance basis, it is necessary to provide some form of Ground Support Equipment (G.S.E.) for test.

The AFDS has its own built-in test system but cannot identify a single failure on System A without a G.S.E.

Furthermore, the G.S.E. enables post-flight data, stored during flight, to be read directly from the AFDS.

The G.S.E. is a portable automatic/manual check-out unit for the Advanced Fire Detection System. It performs three basic functions; it reads out the stored data gathered during the flight, it checks the operation of the system and it identifies which Line Replaceable Unit (LRU) is faulty.

This report is a description of the detail implementation of the G.S.E. It is split into four major sections.

a) System Design

This section explains the functions of the G.S.E. for the following conditions:

Case 1 - When CCU is on aircraft.
Case 2 - When CCU is in laboratory.

A functional description of the G.S.E. hardware is given supported by a simplified block diagram. The software is discussed briefly, i.e. the object of each test performed on the CCU by the G.S.E. is given.

b) System Method

This section is split into two parts:

Hardware

The hardware is split into 17 functional parts and discussed.

Software

The overall design is discussed followed by a detailed description of each test.
c) Operating Instructions

d) Conclusions
2.0 SYSTEM DESCRIPTION

2.1 CCU - G.S.E. Connection and Operation

Cables 1 to 4 are custom-built to connect CCU to G.S.E. The same cables are used to test both Systems A and B.

Normally the CCU is on the Aircraft, and cables 1, 2 and 3 are used, but the CCU can be tested under laboratory conditions, in which case cable 2 is replaced with cable 4. The main differences between cables 2 and 4 are:

<table>
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<tr>
<td>1. Is an extension for the Aircraft cable form.</td>
<td>1. Is a Lab. support cable.</td>
</tr>
<tr>
<td>2. Powers G.S.E. from Aircraft Power supply.</td>
<td>2. Powers G.S.E. from bench power supplies.</td>
</tr>
<tr>
<td>3. Connects all sensors on Aircraft to G.S.E. input interface.</td>
<td>3. Has provision for connecting CWU and one dual or single U.V. sensor to G.S.E.</td>
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2.1.1 CCU on Aircraft

The sequence of connecting G.S.E. to CCU by cables 1 to 3 is shown in Figure 2-1. A complete set of operating instructions both in Manual Mode and Auto Mode is described in Appendix B.

Normally the G.S.E. is operated in Auto Manual in which case the operator ensures that:

a) G.S.E. IN/OUT switch is set to IN.
b) Auto/Manual key switch is set to Auto.
c) Set Power Switch to ON.
d) Press and Release "Start Button".
FIGURE 2-1 GSE CONNECTIONS SEQUENCE
Observe print out for results of the tests being performed. The print out will also show end of all tests when the paper is torn off.

When Manual Mode is selected, each test can be individually selected as long as certain rules are observed. The rules are described in Appendix B.

2.1.2 CCU on Bench

Figure 2-2 shows cable connections between G.S.E. and CCU. One of the main functions of cable 4 is to charge up the G.S.E. battery. It has additional connectors which enables it to be used for a bench checkout of system units. With this set-up the following tests cannot be conducted fully:

(a) Sensor Test
Because only one head can be connected.

(b) CCU Operating in Normal Mode
Although the CCU will be running in Normal Mode and respond to Fire and Fault Tests from the Crew Warning Unit, it can not detect real fire since simulated heads are connected to the CCU.

2.1.3 Ground Support Equipment

A simplified block diagram of the G.S.E. is shown in Figure 2-3. The G.S.E. contains a microprocessor system which controls all the interface circuitry to perform tests on the CCU. It also prints results of all tests on the printer.

Since the CCU (System A) consists of two microprocessor systems, the interface circuitry of the G.S.E. is duplicated to enable most tests to be performed in parallel. This results in a saving of approximately five minutes of CCU testing time. Since G.S.E. is common to both system A and system B, sufficient intelligence is built in to G.S.E. to recognize the system under test and perform tests accordingly.

The interface circuitry is divided into two equal sides which consist of:

(a) Complete control over CCU normal running and G.S.E. running mode.
NOTE: CABLE 4 CAN BE USED TO CONNECT THE 28V SUPPLY ONLY (CWU & DETECTOR HEAD NOT CONNECTED)

FIGURE 2-2 GSE CONNECTION, 28V SUPPLY
(b) Sensor input.
(c) CCU voltages and timing.
(d) Sensor simulation.
(e) CCU battery support.
(f) Power supply.

There are six tests performed by the G.S.E. and it may use one or more blocks of interface circuitry to perform each of the six tests. Five of these tests contain several sub-tests (e.g. for system A, 'Functional Test' contains 56 sub-tests).

The six tests are:
1 - Read data from CCU.
2 - Control Unit Tests.
3 - U.V. Head (Sensor) Tests.
4 - Parametric Tests.
5 - Functional Tests.
6 - Analyze data from CCU.

The G.S.E. can be operated in either Auto or Manual mode. In Auto mode the above tests are performed in the same sequence as they are listed above. However, in Manual mode the tests can be performed in any order, and any particular test can be repeated as many times as desired. Care should be taken to ensure Test 1 is always completed first, otherwise CCU data is lost. Consequently, data analysis test can not be performed. For this reason a key switch is used to set the G.S.E. in Auto mode when operated by non-skilled staff.

2.2 Description of Tests

A set of batteries housed in the G.S.E. support the RAM of CCU system A when the CCU is connected to the G.S.E. This is necessary because the battery support for system A is housed in system B.

2.2.1 Data Read

By putting the CCU into G.S.E. mode, the G.S.E. issues a command to perform a CCU housed test which dumps the RAM contents of CCU to G.S.E. This test takes approximately 25 seconds and initially it is performed on Side 1. If the CCU under test is System A, then the above is repeated for Side 2.
2.2.2 Control Unit Test

These are a set of four tests performed by CCU on itself but initiated by G.S.E.

The four tests are:

a) RAM - RETENTION A.
b) RAM - RETENTION B.
c) COMMON - LOGI.
d) RAM TEST AND SET.

The G.S.E. initiates these tests to be performed in the above sequence and monitors the results. If there is one or more failures then it is printed on the printer.

2.2.3 U.V. - Head (Sensor) Tests

This test determines the sensitivity of the U.V. heads. The U.V. emitters associated with each head are fired simultaneously for 10 seconds for Side 1. The pulses received from each head are counted and printed. With this information one of two conclusions can be drawn:

1) If the pulse count is less than 100 counts per 10 seconds then either the U.V. head has failed and must be replaced, or the emitter supply has failed.

2) If the pulse count is greater than 100 but less than 1000 then the U.V. heads need cleaning.

If the CCU under test is system A, then the above is repeated for Side 2.

2.2.4 Parametric Test

The object of this test is to monitor the CCU supply i.e. 5v supply; 320v Emitter supply. Also the 15 second emitter test and Time Share (167ms) times are monitored. The results are printed.

2.2.5 Functional Test

The object of this test is to confirm integrity of CCU hardware to respond to Fire and Fault conditions simulated by the G.S.E.
2.2.6 Data Analysis

The data received from CCU during the first test (i.e. data read) and the data received during the third test, i.e. U.V. Head (Sensor) tests is analyzed by this program and the results printed.
3.0 SYSTEM METHOD

The system is described under the sub-headings of Hardware and Software as follows:

3.1 Hardware

A simplified block diagram of hardware is shown in Figure 2-3. For any detailed reference to hardware see circuit diagrams in Reference 3-1.

The hardware is divided into seventeen main blocks. These are:

1. Microprocessor Card.
2. Printer.
5. Power Supply to CCU.
6. Battery support.
8. Set of Input Ports.
13. Head/Drive Control Side 1.
17. 25 second Timer.
3.1.1 Microprocessor Card

There were only two options available.
1) Custom built microprocessor card.
2) Buy a ready-made microprocessor card.

In both cases the processor card must be based on the RCA 1802 central processor unit so that it is compatible with the CCU.

To save time and money, it was decided to take Option 2. The microprocessor card selected is GRO430 low power single board computer supplied by "The Golden River Co.". The main features of the microprocessor card are:

1) 10K PROM/ROM
2) 2K RAM
3) PROM programmer on board
4) Total current typically 9mA.

For further details on the microprocessor card see Appendix A-1.

3.1.2 Printer

The printer selected is a Digitec Model 6410 with Option J, which provides 32 characters per line or 16 characters per line when selected.

The printer is manufactured by United Systems Corpn., U.S.A. For further details on the printer see Appendix A-2.

3.1.3 Cableforms

References 3-2, 3-3, 3-4 and 3-5 give all the details to manufacture cables 1 to 4. Installation system wiring is given in Reference 3-6.

The Amphenol connectors were selected to match those used on the CCU.

The Cannon connectors were selected due to easier delivery.

The cables were selected on the basis of being able to withstand worst operating conditions and yet produce a flexible cable form.
3.1.4 Power Supply Side 1 and 2

The G.S.E. is required to perform many similar functions to the CCU and thus employs the same power supply circuitry as the CCU. Also reference voltages of 8V and 5V are required to monitor the CCU voltages.

3.1.4.1 Power Supply Specification

Inputs

115V - 400 Hz - with a tolerance of +10% and -10%.
18 to 30V d.c.

Outputs

4.5V to 5.5V d.c.
310V to 340V d.c.
320V d.c. unregulated.
8V d.c. ) Reference Voltages with tolerances
5V d.c. ) of +5mV and -5mV.

3.1.4.2 Power Supply Description

A single transformer is employed to obtain the nominal 5.0V, 320V and 320V unregulated from 115V 400Hz.

Transient protection is provided at the input of the transformer by four transorbs and a series resistor capacitor arrangement.

The 5V and 320V are regulated by a series transistor method.

The 28V input is used to derive the 8V and 5V reference voltages. The former is derived by using a LM205 regulator and the latter is derived by using a LM340T 5V regulator.

The 5 volt supply is used to drive most of the G.S.E.'s electronics. The 320V supply drives the 16 UV photocells via the head/drive circuitry. The 320V unregulated supply drives the U.V. emitters associated with the photocells. The voltage monitoring circuitry uses 5 and 8V as its reference points. The 28v d.c. is further used to charge up the three Nickel Cadmium batteries that support the CCU RAM.

For Side 2, the 28v input and the 8 and 5V reference voltages are common to Side 1; but a separate input of 115v 400Hz and associated electronics are required.
The flexibility of the G.S.E. is increased by incorporating a 115V change-over arrangement for the printer, i.e. the printer is common to both sides and is initially supplied with 115V from Side 1 via a relay arrangement. The relay control is arranged such that if the 115V of Side 1 failed, then the printer will be supplied from Side 2.

3.1.5 Power Supply to CCU

The power supply to the CCU is routed via the G.S.E. This is necessary for a number of reasons:

1) The aircraft cableform carrying power to CCU is now connected to the G.S.E. This powers the G.S.E. to carry out tests on the U.V. heads.

2) In order to avoid corrupting the flight data it is necessary to hold the CCU in a power-off condition.

3) In order to perform certain tests it is necessary to have a complete control over the CCU.

Figure 3-1 shows a simplified diagram of the CCU power supply control. The power supply to the CCU is routed via a set of relay contacts. The operation of the relay is controlled by the microprocessor. Also the reset line of the CCU is controlled by another relay. The 28V is also routed via the G.S.E. but is not controlled. This arrangement gives the G.S.E. a complete control of the CCU.

3.1.6 Battery Support

If the CCU under test is system A then a 4 volt battery housed in the G.S.E. is required to support the CCU RAM when the G.S.E. is being connected to the CCU. The reason is that the battery support for system A is normally housed in system B, i.e. under the normal conditions system A is battery supported by system B via the Aircraft cableform. To make a complete CCU to G.S.E. connection it is necessary to connect the Aircraft cableform to the G.S.E., which results in the loss of battery support provided by the system B and consequently the flight data. For a correct G.S.E. to CCU connection, see Appendix B.

When the G.S.E. connection is complete, the result is that two sets of batteries are connected in parallel supporting the CCU RAM. The G.S.E. battery is routed to the CCU via a normally closed relay contact. This gives the G.S.E. the facility to disconnect the G.S.E battery support and test the CCU battery support system.
FIGURE 3-1  CCU POWER SUPPLY CONTROL DIAGRAM
Figure 3-2 shows a simplified diagram of the G.S.E. battery and its condition monitoring electronics.

The condition of the G.S.E. battery is monitored by a window detector. By pressing the TEST G.S.E. battery switch provided on the front panel, a Green Lamp adjacent to the G.S.E. switch illuminates if the G.S.E. battery condition is satisfactory. The window detector's limits are:

Lower Limit - 3.0V
Upper Limit - 7.0V

3.1.7 Input/Output Decode

The G.S.E. requires six input and five output ports. To meet this requirement an RCA CDP 1853CD N-bit 1 of 8 decoder is employed along with 6 two input NAND gates. One input of the NAND gates is connected to the Memory Read Line (WRD) of the microprocessor.

The input port is enabled by providing a low pulse to its output disable pin, while the output port is enabled by providing a low pulse on chip-select one (CS1) and a high pulse on chip-select 2 (CS2) simultaneously. The state of the memory read line decides whether an input or output port is selected.

Figure 3-3 shows a simplified diagram of the I/O port arrangement.

3.1.8 U.V. Head Simulation

The G.S.E. is required to perform a functional test on the CCU's U.V. Head/Drive circuitry. In order to achieve this requirement the U.V. heads of the CCU are simulated. Unlike the real U.V. heads which are ON LINE all the time that the CCU is powered on, the simulated heads can be brought ON LINE or OFF LINE as required.

Figure 3-4 shows a simplified diagram of the U.V. head simulation.

Eight sets of simulated heads are individually controlled by the microprocessor via the output ports. For Side 2 the above circuitry is duplicated.
FIGURE 3-2 BATTERY SUPPLY DIAGRAM
FIGURE 3-4 U.V. READ SIMULATION
3.1.9 **Head/Drive Control and Supply**

The CCU’s Head/Drive control and circuitry is duplicated in the G.S.E. This is necessary in order to test the U.V heads. Figure 3-5 shows a simplified diagram of the Head/Drive Control and supply circuit.

The control circuitry is driven by an oscillator of 250KHz. The 250KHz is divided down to give a train of pulses of period 896 us.

The train of pulses is used to interrupt the microprocessor every 832 us during U.V. Head Test. The circuit operates as follows:

a) The U.V. Head Test is performed on one side at a time.
b) The control circuit and the Head/Drive circuit are repeated eight times for each side.
c) The Heads are brought on line.
d) The U.V. emitter is enabled.
e) The U.V. Head fires and generates a positive edge pulse.
f) The positive edge pulse enables the control logic which generate two separate pulses. One is of duration of 2ms and it is used to remove the 320V supply from the U.V. photocell; the other is of duration 1ms and it is enabled on to the DATA BUS.
g) The U.V. photocell is brought back ON LINE and the above (section e and f) keeps occurring until the U.V. Head and emitters are disabled.

For Side 2 sections (a) to (g) are repeated.

3.1.10 **Voltage and Timing Monitoring**

The following CCU voltage lines and timing pulses are monitored by the G.S.E.

<table>
<thead>
<tr>
<th>Side 1</th>
<th>Side 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>320V DC</td>
<td>320V DC</td>
</tr>
<tr>
<td>5.8V DC</td>
<td>5.8V DC</td>
</tr>
<tr>
<td>Emitter Supply</td>
<td>Emitter Supply</td>
</tr>
<tr>
<td>15 second emitter test</td>
<td>15 second emitter test</td>
</tr>
</tbody>
</table>

COMMON TO BOTH SIDES.
FIGURE 3-5 HEAD/DRIVE CONTROL AND SUPPLY CIRCUIT
Check Point 1 (CH1)
Check Point 2 (CH2)
Check Point 3 (CH3)
Check Point 4 (CH4)
System Configuration

The voltages are monitored for lower and upper limit by the use of window detectors, the outputs of which are connected to a set of input ports. The check points one to four lines are of 28V DC. Figure 3-6 shows a simplified diagram of check points monitoring.

The 28V is potted down to 5.6V and connected to 5V regulated supply via a diode. Also the 5.6V is connected to the input ports via Schmitt inverter buffers.

The G.S.E. uses the system configuration (5.6V) line to determine whether it is testing system A or system B. The system configuration line is O Red with 5.6V Side 2 and connected to an input port. The O Red arrangement is desired because for system A the system configuration line is HIGH and for system B it is open circuit. Further there is no 5.6V side 2 in system B. The G.S.E. detection of system configuration is configured such that any one or both lines HIGH constitutes system A and if none are HIGH then system B. This type of arrangement was necessary due to the independent power supplies of the CCU.

3.1.11 25 Second Timer

Figure 3-7 shows the simplified diagram of the 25 second timer.

The timer is built of a single 556 dual monostable integrated circuit plus timing capacitors and resistors. It is arranged such that, normally the output is held HIGH. When the control logic triggers the timer, a negative going pulse of duration 10 millisecond is produced. This negative going pulse is used to reset the microprocessor program to start from location 0000.

3.2 Software

3.2.1 Over View

Figure 3-8 shows a simplified flow diagram of the G.S.E. software. The flow diagram is designed to
FIGURE 3-6 CHECK POINTS MONITORING DIAGRAM

FIGURE 3-7 25 SECOND TIMER DIAGRAM
FIGURE 3-8 GSE SOFTWARE FLOW DIAGRAM
perform tests on the CCU in a pre-determined sequence. The sequence is:

a) Since most of the tests will corrupt the RAM of the CCU, it is necessary for the G.S.E. to perform the Read CCU test first. (i.e. Retrieve the flight data from the CCU RAM).

b) If there is a failure in the CCU during the CCU TESTS, SENSOR TESTS or PARAMETRIC TEST then the FUNCTIONAL TESTS and the DATA ANALYSIS TEST shall be aborted. Also any failure in the PARAMETRIC TEST aborts the whole range of tests. This leaves either the CCU TESTS or the SENSOR TESTS to be performed after the READ CCU tests.

c) Flight Data retrieved during the READ CCU test is useful only if there is no fault in the CCU. The FUNCTIONAL TEST, tests out the CCU's ability to respond to FIRE and FAULT conditions and thus needs to be performed before the DATA ANALYSIS.

There are two other tests:

1. To determine whether or not the G.S.E. can communicate with the CCU. This test is always performed before tests (a) to (f).

2. To simulate the Heads and Emitter Test during normal operation of CCU.

3. To simulate the Heads and Emitter responses to the FIRE TEST and FAULT TEST switches when CABLE 4 is used.

3.2.2 The Microprocessor Card Utilization

The microprocessor card is a self-contained low power single board computer with its own utility program. The G.S.E. program is housed in four 2K by 8 bit U.V. PROMS (2716). The G.S.E. program is located at 0000 to 2000.

The utility program is located at 8000 to 83FF. The microprocessor card also has 2K RAM located at 4000 to 8000.

The G.S.E. program utilizes some of the subroutines from the utility program (teletype input and print subroutines) and it also uses the microprocessor cards RAM as a rough working area, e.g. The FLIGHT DATA retrieved is stored at this RAM.
The microprocessor card can RUN programs in two main modes, i.e.

1. Utility Mode.
2. Program Mode.

To RUN in Utility Mode the RUN line must be taken to ground momentarily. This forces the microprocessor to start RUNNING from location 8000.

To RUN in the Program Mode the RUN line must be taken to ground momentarily. This forces the microprocessor to RUN from location 0000.

**NOTE**

When the microprocessor card is in the program mode, the program can be arranged to jump into the UTILITY mode but the reverse is not possible.

For further details on the microprocessor card, see Appendix A-I.

3.2.3 *Note on the Start Up Condition*

At POWER ON, the G.S.E. has the following conditions:

1. No power is applied to CCU.
2. CCU reset line held LOW.
3. The EF3 flag of the Central Processor Unit is held LOW.

The G.S.E. program starts by disabling the INTERRUPT line; sets up the various registers of the CPU; activates the appropriate hardware to apply power to CCU; and releases the CCU reset line. Next the program examines the position of the G.S.E. IN/OUT switch. If the G.S.E. IN/OUT switch is at position OUT, then the program branches to perform the simulation of Heads and Emitter Test. This simulation also responds to the FIRE TEST and FAULT TEST switches when CABLE 4 is used. If the G.S.E. IN/OUT switch is at position IN, then the program looks for the state of the EF3 flag. (i.e. HIGH or LOW). The state of the EF3 flag is monitored because it allows the program to decide whether or not it has retrieved the FLIGHT DATA SIDE 1 (Note: for System A, there are two independent sides). This Hardware/Software arrangement of the G.S.E. is necessary because:

1. The CCU transmits the data serially; i.e. in the same format as a teletype.
2. In order to receive correctly the data transmitted by the CCU, the G.S.E. program jumps to the UTILITY program of the microprocessor card.

3. After all the data has been received by the G.S.E, the microprocessor card waits for further instructions which are not forthcoming. To escape from this UTILITY program condition, the RUNP line must be enabled, i.e. it must be taken to ground momentarily. This has the effect of starting the G.S.E. program from the beginning again. Hence, before DATA SIDE 1 is retrieved, the state of the EF3 flag is changed to HIGH. Consequently, when the program starts from the beginning, the second time, it is forced to branch to another part of the program, i.e. if it is System A, then retrieve DATA SIDE 2 or if it is System B then continue with the remaining tests. When DATA SIDE 2 has been retrieved, the program is forced to start from the beginning again and it proceeds to perform the remaining tests.

The remaining tests can be performed in AUTO or MANUAL mode. However, trained personnel can perform the tests in a different sequence when the G.S.E. is operated in MANUAL mode.

3.2.4 Tests Description

3.2.4.1 Simulate Heads and Emitter Response Time

This routine detects the type of system under test (e.g. System A or System B). The operation of this routine is synchronized with the CCU, i.e. at power ON the CCU performs an Emitter Test by firing its emitters and looking at the response from the U.V. heads.

NOTE

If the CCU under test is System A then the Emitter Test is always performed on SIDE 2 first.

The architecture of this routine is:

1. It waits until the CCU's emitter line side 2 is HIGH.
2. It fires all heads on Side 2, i.e. simulating the Heads.
3. It waits until the CCU's emitter line side 2 is LOW.
4. It resets the simulated Heads.

5. It waits until the CCU's emitter line Side 1 is HIGH.

6. It fires all Heads on Side 1, i.e. simulating the Heads.

7. It waits until the CCU's emitter line Side 1 is LOW.

8. It resets the simulated Heads.

9. It branches back to the beginning.

If system B is under test then it ships all operations regarding Side 2.

This routine is also used to test the CCU to respond to the FIRE test initiated by depressing the FIRE TEST switch on the Crew Warning Unit. When the FIRE TEST switch is pressed, the CCU fires all emitters. The routine detects this and fires all Heads simulating all Heads until the FIRE TEST switch is released. Consequently, the CCU resets its emitter line to LOW. The overall result is that the CCU responds with a FIRE CONDITION displayed on the CWU. In order to get out of this routine; it is necessary to set the G.S.E. IN/OUT switch to 'IN' and start the program again from location OOOO, i.e. take the RUNP line to ground momentarily. For full details on this routine see Appendix A-3.

3.2.4.2 To determine whether the G.S.E. can communicate with the CCU

The flow diagram is shown in Appendix A-4 and it is referred to as a block labelled PART I in Figure 3-8.

The object of this part of the program is as follows:

3.2.4.2.1 Initialize

"POWER ON" condition of the CCU.

HOLD CCU in Reset Mode, etc.

3.2.4.2.2 Print operating message

"GD/GRAVINER DFDS AUTO ROUTINE".

3.2.4.2.3 Test position of G.S.E. IN/OUT switch.
3.2.4.2.4 If G.S.E. IN/OUT switch is at position 'OUT' then the CCU is in normal mode and the G.S.E. program must branch to perform the "simulate Heads and Emitter response test" routine (see Section 3.2.4.1).

3.2.4.2.5 If the G.S.E. IN/OUT switch is at position 'IN' then it must proceed to test the status of the EF3 flag.

3.2.4.2.6 If the status of EF3 is LOW then branch to Read data from CCU test otherwise proceed to determine whether or not the G.S.E. can communicate with the CCU.

The object of this part of the program is:

a) To determine whether the CABLE FORMS (one of three) are connected properly between CCU and the G.S.E., i.e. the G.S.E. can communicate with the CCU.

b) To determine and print SYSTEM CONFIGURATION, i.e. SYSTEM A or SYSTEM B.

c) For SYSTEM A a PASS status will allow the G.S.E. PGM to proceed to PART 2, i.e. the communication path is confirmed. A FAILURE status will print the following message:

"NO G.S.E. - CCU PATH.
CHECK CABLE 1 OR REPLACE CCU"

**NOTE**

During this condition, three faults are possible:

1. CCU Faulty.
2. Cableforms not connected properly.
3. Cableforms faulty.

It is recommended that in the event of the above failure, the Cableforms be checked (pin to pin connection). Reconnect the G.S.E. to CCU connections and repeat the test. If the failure condition still exists, and the cableforms were found to be correct then, the CCU must be assumed FAULTY. Hence the CCU must be sent to GRAVINER LIMITED for detailed analysis.

d) For SYSTEM A, four PASS/FAIL status conditions are possible:

1. SIDE 1 & 2 PASS.
2. SIDE 1 & 2 FAIL.
3. SIDE 1 PASS, SIDE 2 FAIL.
4. SIDE 1 FAIL, SIDE 2 PASS.
Occurrence of Condition '1' will allow the program to proceed to the remaining tests.

Occurrence of Condition '2' will not allow the program to proceed to the remaining tests.

It will also print the same failure message as in Section 3.2.4.2.6(c).

Occurrence of Condition '3 & 4' will not allow the program to proceed to the remaining tests if the G.S.E. is in AUTO mode, but it will allow the program to proceed to the remaining tests if the G.S.E. is in MANUAL mode. Also it will print the following messages:

SIDE 1 PASS )
SIDE 2 FAIL )

OR

SIDE 1 FAIL )
SIDE 2 PASS )

along with the failure message as in Section 3.2.4.2.6(c).

This part of the program is implemented by issuing conditions to the CCU to perform an IDLE ROUTINE.

The IDLE ROUTINE is housed in the CCU software and when enabled, it sets the G.S.E. 1 and G.S.E. 2 lines of the CCU to HIGH.

These G.S.E. lines are monitored by the G.S.E. program (for both sides if System A) and consequently the above decisions are made.

For full details on this part of the program see Appendix A-4.

3.2.4.3 Read DATA from CCU

The object of this part of the program is to retrieve the FLIGHT DATA stored in the CCU RAM. Refer to Figure 3-8 (the dotted path 1) of the program is already described in Section 3.2.4.1. and 3.2.4.2.

The hardware is arranged such that the program is forced to follow (the dotted path 2), i.e. to retrieve DATA SIDE 1. The data is retrieved by
issuing the appropriate command to the CCU, to perform its 'SEND DATA OUT' routine. This is implemented in the following order:

1. Initialize the following:
   a) Memory code to LOW, i.e. store 00 at location 4000.
   b) Set EF3 flag to LOW.

2. Determine the type of system under test, i.e. System A or System B.

3. If the CCU is System A then set memory code to HIGH and proceed to 5.

4. If the CCU is System B then proceed to 5.

5.
   a) Issue commands to the CCU Side 1 to perform its 'Send Data Out' routine.
   b) Release the reset line of the CCU.
   c) Start the 25 second timer. (See note below).
   d) Jump to UTILITY program of the microprocessor card.

NOTE

As explained in Section 3.2.3., that in order to retrieve the data, the G.S.E. program must jump to the UTILITY program of the microprocessor card and in order to get out of the UTILITY, the RUNP line of the microprocessor card must be taken to ground momentarily. This is achieved by the 25 second timer, i.e. it takes approximately 23 seconds for the data transfer and 2 seconds later, the timer applies a short negative going pulse to the RUNP line of the microprocessor card.

6. Having retrieved data SIDE 1 the program starts from the beginning again and this time it follows (the dotted path 3).

7. If the CCU is type 'B' then the program proceeds to the remaining tests.
8. If the CCU is type A then the program performs
the following:

a) Set memory code to LOW, i.e. store 00 at location 4000.

b) Shift DATA from Side 1 to locations 4500-45FF.
(see note below).

c) Issue command to the CCU's Side 2 to perform its
'Send Data Out' routine.

d) Repeat as for Side 1 above.

9. Having retrieved the data from Side 2 the
program starts from the beginning again and
follows (the dotted path 4).

NOTE

The memory code is used to enable the program to
determine:

(i) That it has retrieved data from Side 1 and
the system under test is of Type B and thus
proceed to the remaining tests.

(ii) That it has retrieved data from Side 1 and
the system under test is of Type A and
consequently it must retrieve data from
Side 2.

(iii) That it has retrieved data from both sides
and thus proceed to the remaining tests.

For full details on this program see Appendix A-4.

3.2.4.4 The CCU Tests

The CCU tests are a group of four tests housed in
the CCU software. They are enabled one at a time.
The tests are:

(i) RAM Retention A.

(ii) RAM Retention B.

(iii) Common Logic.
NOTE

For System A, both sides must see a FIRE condition before it is displayed on the CWU.

Hence, this condition is 'AND'ed in the Common Logic of the CCU and the results displayed.

(iv) RAM Test and Set.

The object of these tests is to confirm the integrity of the CCU RAM and the Common Logic part of the CCU.

The tests are performed in the numerical order above.

Further, if there is a future condition, it is recorded at a pre-determined area of the RAM (i.e. in this case at locations 4003 to 4013). After each condition is tested, the PASS/FAIL record register is incremented by one. Tests (i), (ii) and (iv) are performed simultaneously on both sides and test (iii) is performed on Side 1, and then on Side 2. At the end of these tests the PASS/FAIL status is printed in coded format, i.e. a row of zeros is printed if all tests were correct. If there were a failure then a 'one' will be printed in the corresponding position. Appendix A-5 gives a full list of messages corresponding to the failures in the CCU.

Further details of the four tests are now given.

(1) RAM Retention A

The G.S.E. program sets up the conditions for the CCU to perform this routine. The object of this routine is to load hexadecimal numbers in to the CCU RAM. The numbers start at 0 and finish at FF, since the size of the CCU RAM is 256 bytes. (FF hexadecimal = 256 memory bytes). The numbers are located in the incrementing manner.

When all the numbers have been loaded the CCU raises a G.S.E. flag. The G.S.E. program waits for four seconds to detect this flag and proceeds to the next program.

(ii) RAM Retention B

RAM retention A & B are essentially one program. The first one sets up a pattern of numbers and the second checks that pattern after the power supply to the CCU was switched 'OFF' for five seconds.
Hence the G.S.E. program disables the power supply of the CCU for five seconds. Also the conditions are set to perform the RAM Retention B. It then waits for four seconds to detect the RAM Retention B completion flag and then proceeds to the next program.

(iii) **Common Logic**

Before this test is performed, it is necessary to confirm that the CCU is able to respond to FIRE and FAULT conditions. This is necessary since the Common Logic routine assumes that a fire or fault condition will be transmitted. Thus the G.S.E. puts the CCU in Normal mode and simulates the U.V. Heads in firing mode. It waits for six seconds and then checks whether or not the CCU is in FIRE condition. If the CCU fails to respond with a FIRE condition then the G.S.E. aborts the Common Logic test. Otherwise it creates a FAULT condition by failing the CCU by not simulating the U.V. Heads in firing mode during the CCU's first emitter test. If the CCU fails to respond with a FAULT condition, then the G.S.E. determines whether the CCU under test is type A or B. If it is type B then the Common Logic test is skipped.

The G.S.E. sets up the conditions for the Common Logic routine to be performed on one side at a time. Side 1 is performed first. The programs wait for results for about six seconds and then proceed to the next routine.

(iv) **RAM Test and Set**

The object of this routine is to see whether all the CCU's RAM locations are functional. It does so by loading and checking two sets of patterns and in the end it sets all memory locations to zeros. Again the G.S.E. sets up the conditions for this routine to be executed; waits four seconds for the result then proceeds to the last part of 'The CCU Tests' program.
3.2.4.4.1 CCU Test Summary

The purpose of the RAM retention A and B is to confirm the CCU's Battery support, i.e. its ability to retain the FLIGHT DATA when the CCU is 'POWERED OFF'. Should a failure occur then a 'CCU BATTERY LOW' message is printed as well as a 'One' in the row of zeros displaying where the failure occurred.

During the Common Logic test, three possible faults occur.

1. Inhibit Fail.
2. Fault Fail.
3. Fire Fail.

Each of these faults refer to certain parts of the CCU hardware. A skilled person with sufficient knowledge of CCU hardware can pinpoint the position of the fault.

The RAM test and Set confirms the integrity of the CCU RAM and then sets it to zero.

At the end, the PASS/FAIL codes are printed. They are also scanned for any failure condition.

If the G.S.E. is in AUTO mode and a failure condition exists, then a flag is set up. If the G.S.E. is in MANUAL mode with a failure condition, no flag is set up. This flag is used just before the Functional Test to determine whether or not 'The Functional Test' and 'Analyze Data Test' should be performed.

For full details on these tests see Appendix A-5, A-6, and A-7.

3.2.4.5 Sensor Test

The object of this is to determine:

1. The sensitivity of the U.V. Head (i.e. the photocell).
2. That the U.V. Head and the connecting wires are correct and functional. This is achieved by duplicating the U.V. Head/Drive circuitry in the G.S.E. and by connecting the U.V. Heads to the G.S.E., i.e. the G.S.E. has complete control over the U.V. Head and Emitter supplies.
This routine switches the U.V. emitters 'ON' and counts the number of pulses received from the U.V. photocells for a period of ten seconds. For System A each U.V. Head consists of two photocells and two emitters. One photocell and one emitter refer to Side 1 of the CCU and the others to Side 2. Further, a maximum of 8 U.V. Heads can be connected to the CCU. However, the current CCU's are configured to use only five U.V. Heads. This means that sufficient intelligence must be built into the Sensor Test such that it only prints the results of the U.V. Heads that exist.

This is implemented as follows:

1. Initialize Registers, i.e. clear registers which will hold the pulse count; set up the address of the Interrupt subroutine.

2. Enable Interrupt, fire the Emitters Side 1 and jump to SELF LOOP.

3. The Hardware Interrupt occurs every 832 microseconds and the G.S.E. program jumps to the Interrupt subroutine. (See Section 3.2.4.5.1. for the Interrupt routine).

4. The program jumps out of the Interrupt subroutine and returns back to the SELF LOOP.

5. Procedures 3 & 4 are repeated for ten seconds whence the program jumps to Part 2 of the Sensor Test.

6. The emitters are switched 'OFF'.

7. A decision is made whether the counted pulses refer to SIDE 1 or SIDE 2.

8. It is determined whether the first head exists or not. If it exists then the counted pulses are converted to decimal numbers and printed. This operation is repeated for all the 8 U.V. Heads.

9. If the system under test is type A then re-initialize the registers. Fire emitters SIDE 2; enable the Interrupt and jump to SELF LOOP 2.

10. Operations 3 to 8 are repeated.

11. If the G.S.E. is in AUTO mode then proceed to the next test otherwise branch to the Manual Loop.
For details on this test see Appendix A-8.

3.2.4.5.1 **BCD to Decimal Conversion**

The object of this subroutine is to convert the number of pulses counted/10 seconds in Binary Decimal Code to Decimal Numbers. It is capable of converting a full 16 bit number, i.e. a max hex number of magnitude FFFF. This subroutine is implemented as follows:

1. Store the hex number to be converted in a 16 bit register (i.e. R3).

2. Clear and arbitrarily assign the decade order to 5 RAM locations where the converted number is to be held, as follows:

<table>
<thead>
<tr>
<th>RAW location</th>
<th>Assigned decade value</th>
</tr>
</thead>
<tbody>
<tr>
<td>4030</td>
<td>Ten Thousands</td>
</tr>
<tr>
<td>4031</td>
<td>Thousands</td>
</tr>
<tr>
<td>4032</td>
<td>Hundreds</td>
</tr>
<tr>
<td>4031</td>
<td>Tens</td>
</tr>
<tr>
<td>4030</td>
<td>Units</td>
</tr>
</tbody>
</table>

3. Read the least significant HEX digit, i.e. the least four bits.

4. Since the least HEX digit has a weighting of 'one'; test it for <, = & >10. If it is less than 10 add it to the UNIT decade, i.e. 10°. If it is equal to 10 then add one to the TENS decade:

   \((i.e. \ 10^1)\)

   If it is greater than 10 then add one to the TENS decade, subtract 10 from the tested value and add the remainder to the UNIT decade.

5. Read the second least HEX digit. This has a decimal weighting of 16.

6. Test it for zero.

   6.1 If equal to zero then do Step 7.

   6.2 If greater than zero then add 1 to the TENS decade and 6 to the unit decade.
6.2.1 Test both Unit and Tens decade for overflow i.e. Test Unit Decade for = or > 10. If it is equal to 10 then subtract 10 from the unit decade and add 1 to the Tens decade. If it is greater than 10 then subtract 10 from the Unit decade and add 1 to the Tens decade. Having tested the Unit decade, test the Tens decade applying the same analogy.

6.3 Decrement the read value and test it for zero.

6.4 Repeat Steps 6.1 to 6.4.

7. Read the third least HEX digit. This has a decimal weighting of 254.

8. Test it for zero.

8.1 If equal to zero then do Step 9.

8.2 If greater than zero then add 2 to the Hundreds decade; 5 to the Tens decade and 6 to the Unit decade.

8.2.1 Test the Units, Tens, Hundreds and Thousands decade for overflow. Same analogy as in Para. 6.2.1. is applied.

8.3 Decrement the read value.

8.4 Repeat Steps 7 to 8.4.

9. Read the most significant HEX digit. This has a decimal weighting of 4096.

10. Test it for zero.

10.1 If equal to zero then do Step 11.

10.2 If greater than zero then add 4 to the Thousands decade, 9 to the Tens decade and 6 to the Units decade.

10.2.1 Test the Units, Tens, Hundreds, Thousands and Ten Thousands decade for overflow.

10.3 Decrement the read value.

10.4 Repeat Steps 9 to 10.4.

11. Print the converted number.

Subroutines are written for the Units, Tens, Hundreds and Thousands decade overflow tests.
Figure 3-9 shows a flow diagram for the BCD subroutine. Appendix A-7 gives assembly listing as part of the Sensor test. This subroutine is also used by the Data Analysis Test.

3.2.4.5.2 The Interrupt Subroutine

The object of this routine is to count the number of pulses for 8 photocells in parallel for a period of 10 seconds. Further it must be able to distinguish that for a particular photocell; for the occurrence of two consecutive pulses only one is stored, i.e.:

Pulses arrived 101110 ) Photocell 1
Pulses stored 101010 )

The above process is repeated for all 8 photocells. If the ten seconds are not up then, the exit from this routine is to either SELF LOOP 1 or SELF LOOP 2 otherwise the exit is to part 2 of the Sensor Test.

This routine is implemented as follows:

1. Initialize.
2. Read all 8 photocells (i.e. Have any one or all of them fired).
3. Determine if a pulse occurred immediately before the current read cycle and apply the above logic two consecutive pulses.
4. If a valid pulse exists for any of the 8 photocells then increment the corresponding photocell pulse counter.
5. If 10 seconds are up then branch to PART 2 of the Sensor Test otherwise branch to either SELF LOOP 1 or SELF LOOP 2.

For full details on this routine see Appendix A-8.

3.2.4.6 Parametric Test

The object of this test is to confirm that the integrity of the CCU's power supply rails, i.e. 320V, 5.8V and the emitter supply. Further it confirms the 15 second emitter test.
HEXA-DECIMAL TO BCD CONVERSION SUBROUTINE.

**Figure 3-9** BCD SUBROUTINE DIAGRAM

40
The power supply monitoring is implemented by a set of window comparators. When the supply rails of the CCU go below or above their predetermined values (See Section 3.1.4) then a flag is raised. The Parametric Test detects this flag and prints the appropriate message. See Appendix A-5 for a whole list of messages.

As always, sufficient intelligence is built into this test so that both types of CCU's can be tested efficiently. If any failure is encountered during the power supply monitoring and if the G.S.E. is in AUTO mode then the remaining tests are aborted. However, if the G.S.E. is in the MANUAL mode then this test branches to the MANUAL loop.

The second part of this test is to confirm the integrity of the 15 second emitter test. The CCU energizes its emitters for one Time share period every 15 seconds and it looks for positive response from the U.V. Heads. If there is no response then the CCU reconfigures such that the offending U.V. Head is switched off line. If sufficient number of U.V. Heads fail then the CCU issues a FAULT condition.

The emitter test puts the CCU in Normal mode and observes for the emitter line to go HIGH. If it does not go HIGH within six seconds, then it issues an error message (See sample print out) otherwise it observes the Emitter Line to go LOW. If the Emitter Line does not go LOW within 180 ms then an error message is printed, otherwise it observes that the Emitter Line does not go HIGH for the next 14 seconds. At this stage it starts to observe the Emitter Line to go HIGH. If it does not go high within one second then an error message is printed.

This is repeated for Side 2 if applicable.

If the G.S.E. is in AUTO mode then occurrence of any failure aborts the remaining tests. If in MANUAL mode then branch to the Manual Loop. Below is a full list of error messages for the Parametric Test.

1. 5.6V SIDE 1 FAILED.
2. 5.6V SIDE 2 FAILED.
3. 320V SIDE 1 FAILED.
4. 320V SIDE 2 FAILED.
5. EMITTER FAILURE 01.
6. EMITTER FAILURE 02.
7. EMITTER FAILURE 03.
8. EMITTER FAILURE 04.
9. EMITTER FAILURE 05.
10. EMITTER FAILURE 06.
11. EMITTER FAILURE 07.
12. EMITTER FAILURE 08.
NOTE

Emitter failure codes 01, 02, 03 and 04 apply to SIDE 2 and 05, 06, 07 and 08 apply to SIDE 1. Further points marked 01 to 05 correspond to the type of Emitter Failure for SIDE 2. For SIDE 1 the points would go from 05 to 08. For full details on this routine see Appendix A-5 and A-9.

3.2.4.7 Functional Test

This test confirms the integrity of the CCU Head Drive/Supply circuitry. It is achieved by putting the CCU in normal mode and simulating the U.V. Heads in a predetermined sequence and observing the FIRE/FAULT response of the CCU. E.g. simulate a FIRE condition. If the CCU responds with a FIRE signal then the Head Drive/Supply circuitry corresponding to the simulated heads is functional. The Functional Test is divided into seven major tests. These tests are implemented in the following manner.

Initially the CCU RAM is cleared by performing the RAM Test and set routine. See Section 3.2.4.4. Put the CCU in Normal Mode and simulate the U.V. Heads during the CCU Emitter Test. If the CCU fails after the first Emitter Test then store a failure code (01) at location 4050 and increment the failure code Register, i.e. 4051.

NOTE

Locations 4050 to 4089 are used to store the PASS/FAIL status of the SUB-TESTS during the Functional Test. At the end of the Functional Test the PASS/FAIL statuses are printed (see sample print outs in Appendix B, Chapter 5). These codes are issued with the code decode list of messages to determine which part of the CCU's Head Drive/Supply circuit is faulty.

Let the CCU run for another five Time share periods and observe if a FIRE condition is generated. If a FIRE condition is generated then store a failure code at location 4051 and increment the failure code register, i.e. 4052. (Both sides of the CCU share the time to observe FIRE/FAULT condition, i.e. each one observes for 187 milliseconds in turn). See Figure 3-10.
FIGURE 3-10  TIME SHARE DIAGRAM OF THE CCU
The above is a set of initial tests. The following are a further set of seven tests. If the CCU under test is of type A then all seven tests are performed and if the CCU is of type B then tests four, five and seven are performed. The method of storing PASS/FAIL status is the same as for the initial tests.

Test 1

(a) Fire all Heads on SIDE 1 (i.e. simulate Heads).
(b) Hold Heads in standby mode on SIDE 2.
(c) Wait for 6 Time Share periods and then observe a FIRE condition.
(d) If a FIRE condition exists then there is a permanent fault in the Head Drive/Supply (or logic) circuitry on SIDE 2. If no FIRE condition exists then branch to Test 2.

Test 2

Repeat Test 1 except change all references of SIDE 1 to SIDE 2 and vice-versa.

Test 3

(a) Fire all Heads on SIDE 1 (i.e. simulate heads).
(b) Fire Head one on SIDE 2.
(c) Wait for six Time Share periods and observe for a FIRE condition.
(d) If FIRE condition exists then the Head 1 Drive/Supply and Logic circuitry is functional otherwise it is faulty.
(e) Reset Head on SIDE 2.
(f) Wait for six Time Share periods and observe for NO FIRE condition.
(g) If FIRE condition exists then the Head 1 Drive/Supply and logic circuitry is faulty otherwise it is functional.
(h) Repeat Steps (b) to (g) for remaining seven Heads.
Test 4
Repeat Test 3 except change all references of SIDE 1 to SIDE 2 and vice-versa.

Test 5
If tests one to four are successful then all Head Drive/Supply and logic circuitry is functional. The remaining tests (i.e. 5, 6 and 7) are concerned with confirming the CCU's ability to respond to the adjacency sets.

NOTE
In order to reduce the probability of a false warning given by the CCU, the U.V. Heads are arranged in a set of pairs to look for FIRE in a predetermined area. This pairing of U.V. Heads is termed as the Adjacency Sets. For further details on adjacency sets see Appendix A-1, Volume II.

Adjacency sets are as follows:
The suffix refers to SIDE 1 or SIDE 2, i.e. Head 11 = Head 1, Side 1.
1. Head 11; Head 22
2. Head 21; Head 32
3. Head 21; Head 12
4. Head 31; Head 22
5. Head 41; Head 82
6. Head 81; Head 42
Hence for test five:
(a) Fire Head 11 and Head 22 (i.e. simulate Heads).
(b) Wait for six Time Shares and observe for a FIRE condition.
(c) If FIRE condition exists then the particular adjacency set response is correct, otherwise faulty CCU. NOTE: This time is not the Head drive/supply circuitry at fault. It could be the Logic card or the software at fault.
(d) Reset Heads 1\(^1\) and 2\(^2\).
(e) Wait for six Time Share periods and observe for the FIRE condition to reset.
(f) If FIRE condition exists then the CCU can not respond to the particular adjacency set correctly otherwise it's functional.
(g) Repeat the steps (a) to (f) for the remaining adjacency sets.

**Test 6**

In this test illegal adjacency sets are enabled to confirm that the CCU shall not respond with a FIRE condition unless the correct set of Heads see the FIRE. The illegal adjacency sets are:

1. Head 1\(^1\); Head 3\(^2\).
2. Head 4\(^1\); Head 2\(^2\).

Hence:

(a) Fire Heads 1\(^1\) and 3\(^2\) (i.e. simulate Heads).
(b) Wait for six Time Shares and observe for a FIRE condition.
(c) If FIRE condition exists then the CCU is faulty otherwise it is functional.
(d) Reset Heads 1\(^1\) and 3\(^2\).
(e) Wait for six Time Shares and observe for FIRE condition.
(f) If FIRE condition exists then the CCU is faulty otherwise it is functional.
(g) Repeat steps (a) to (f) for the remaining adjacency sets.

**Test 7**

The object of Test 7 is to disable some Heads such that the CCU fails after it has performed its first emitter Test.
Sets of Heads to be disabled are:

1. Heads $1^1$, $2^1$ and Heads $1^2$, $2^2$.
2. Heads $2^1$, $3^1$ and Heads $2^2$, $3^2$.
3. Heads $4^1$, $8^1$ and Heads $4^2$, $8^2$.

(a) Reset CCU RAM to zero.
(b) Fire all heads except Heads $1^1$, $2^1$, $1^2$ and $2^2$ (i.e. simulate heads).
(c) Wait six seconds and observe for a FAULT condition.
(d) If a FAULT condition exists then the CCU is functional otherwise it is faulty.
(e) Repeat steps (a) to (d) for the remaining sets of Heads.

When the G.S.E. has gone through the above tests it prints out the PASS/FAIL statuses. During test one to seven, if any failure is encountered then the Functional Test is aborted immediately and the PASS/FAIL status printed, i.e. 56 zeros will be printed except for a single "1" which corresponds to the position of the program at which the CCU failed.

e.g. 00000000001000 ....... ) a total of 56 digits

The above print out is used with the PASS/FAIL messages to determine which part of the CCU is faulty, i.e. the zeros are read as 1 to 56 starting from the beginning of the top line. The messages are listed from 1 to 56. In the above example the program failed during Test 3 while testing for Fire response when all Heads fired on Side 1 and Head 4 fired on Side 2. This statement is directly the result of determining where the "1" appeared, i.e. 11th place and then reading decode message 11 (see Appendix A-5).

The last action carried out by this program is to reset the CCU RAM to zero and proceed to 'Analyze Data' test if the G.S.E. is in AUTO mode otherwise branch to Manual Loop.

For a full list of Failure messages see Appendix A-5. For full details on Functional Test see Appendix A-10.
3.2.4.8 Data Analysis Program

3.2.4.8.1 Summary

The purpose of the program is to analyze the data stored in the control unit as a result of a flight. This data breaks into two types, namely data that is analyzed and preserved as information and data that is used to determine the status of the control unit. It is used to inform the operator of a course of action to take.

The program also accesses counts from the 10 second U.V. read test program for the analysis.

The philosophy used is that whenever one fault in the data is encountered, an action is indicated by utilizing the printer and the analysis is aborted. This is so because software to cope with multiple failures would be prohibitively long due to the many combinations involved.

3.2.4.8.2 Control Unit Data

Data included in the control unit is as follows, and it is summarized on the memory map Figure 3-11.

Ref. (a) A time marker which is stored when the pilot pushes the fire test button and is used as an event reference, such that the point in the flight where an event occurred can be determined, since the pilot would record in his flight log the time that the button was pressed.

Ref. (b) Which heads in the system are on line and which are faulty, along with a time marker denoting when the last head failed.

Ref. (c) The status of adjacency sets (which is directly related to (b) according to the configuration hard wired into the system) and the time that an adjacency set has failed.

Ref. (d) An indent which indicated whether data has been stored by the system.
Ref. (e) A counter which is incremented on every occasion that the system recognizes that a head has caused a 'gate' to be filled (W count).

Ref. (f) Memory locations which store data indicating how near the system gets to a fire condition. These are constituted by levels 2 - 5 for a System A or levels 2 and 3 for System B. First level fire indication is indicated by (e) above. A single fire level indication consists of the latest time that this event occurred, the head or heads recording the "fire nearness" level and an accumulator storing the number of times that this level has been observed.

Ref. (g) An indication of which area indicates a fire when a first test event occurs.

Ref. (h) The time when the first fire starts to be observed by the system.

Ref. (j) An indication of which area indicates a subsequent fire event.

Ref. (k) The time when the first or subsequent fire extinguishes.

Ref. (l) The number of fires logged by the control unit.

Ref. (m) An error code and time marker recording a processor self shut down.

3.2.4.8.3 Program Operation

The following figures along with the program listings of Appendix A-11 describe the operation of the program.

Figure 3-12 lists the RAM memory of the G.S.E. computer board that it utilized by the data analysis program.
<table>
<thead>
<tr>
<th>X</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>40Gx</td>
<td>HOLD 1</td>
<td>HOLD 2</td>
<td>CARRY</td>
<td>OR</td>
<td>THEN</td>
<td>( T_e - T_{f} )</td>
<td>OR</td>
<td>( T_e - T_{f} )</td>
<td>COM</td>
<td>( \text{SIGN} )</td>
<td>TEMPORARY STORAGE AREA</td>
<td>LEVEL COUNTER</td>
<td>( \text{MP} )</td>
<td>( \text{DATA} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40Ax</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>40Bx</td>
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<tr>
<td>40Cx</td>
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<tr>
<td>40Dx</td>
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<tr>
<td>40Ex</td>
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<td></td>
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<tr>
<td>40Fx</td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>

4400 to 44FF = STORED CONTROL UNIT SIDE 1 DATA
4500 to 45FF = STORED CONTROL UNIT SIDE 2 DATA
4210 to 425C = HEAD COUNTS FROM 10 SECOND HEAD TEST PROGRAM

FIGURE 3-12 PROGRAM OPERATION
The program utilizes subroutines available in the GRUTIL software package, namely subroutine handling techniques, message printing and next to ASCII conversion routines. It also uses subroutines developed for the data analysis program.

Since many print outs require variables, the data is printed from a scratch pad area. When required during the program the scratch pad is wiped clean, which entails loading the pad with ASCII clear characters terminated with a character that the printer recognizes as returning the print size to small.

The data analysis program starts by performing various checks to determine whether data has been saved or whether the memory locations have been corrupted.

The check at PNT. 5 of Data Main Program 1 is a check carried out to determine whether hardware failures have occurred in the control units circuitry associated with the fire and fault switches. If this route fails to check out, the effect could appear in one of two areas, namely the circuit or the CCU and its associated circuit. The print out enables an appropriate decision to be made.

A check on system status is made, checking whether failures have occurred in flight, and checking print out failure mechanisms and times.

Adjacency set failures and head failures are looked for and if found, area of failures are printed along with the action required to rectify the problem.

Head pulse data (gathered during the 10 second head test program) is checked to determine whether emitter lines to all heads of one side are functional. This is done by observing that at least one head present for the given configuration has responded with a count of at least 128 pulses during the head test sequence. Failure to respond to this requirement is taken as an indication of failure of the emitter line and an action is printed.

Next to be analyzed is determined by the events that took place during the last flight. If a fire or fires have occurred, fire data is analyzed. If no fires are recorded, then the fire level data and background count is analyzed.
In the case of a fire, the number of fires is printed along with the area in which the first fire occurred and its start time relative to the time that the pilot depresses the CWU fire test button. The time at which the first (or subsequent) fire extinguishes along with the area in which the fire was last observed, is also computed and fed to the printer. All times are converted from increments representing head test periods, (14.8 seconds), to an approximate minute indication by dividing the computed results by 4 using the R4SHR routine. All times printed are first treated to blank out leading zeros to make reading easier.

If no fires occur, the program path analyzes background (W) counts and fire level (or nearness to fire) data.

This data is listed in tabular form with column headings of LEVEL, COUNT, TIME and HEAD.

The program accesses the appropriate level count, converts this into a BCD number, then to an ASCII format suitable for transmission to the printer. It also blanks off leading zeros. The result is then stored in the appropriate scratch pad locations, such that when the pad is written to the printer it appears in the appropriate column.

For second level up to fifth level data, the time of the event is also processed relative to the time that the pilot's fire test button is depressed. BCD conversion, zero blanking and conversion to ASCII format is again utilized along with program which allows the push button time polarity to be displayed. i.e. if the event occurs before the pilot depresses the CCU fire test button, then the event time is printed as a negative time. The head column displays heads which have been responsible for the fire event levels.

At the completion of either background analysis, or the fire analysis program, according to whether the unit is running in manual or automatic mode, the program operation will return to the manual loop until control is recovered by depressing the G.S.E. start button.
4.0 OPERATING INSTRUCTIONS

The operating instructions are shown in Appendix B.

NOTE
Appendix B is a copy of the G.S.E. operating manual.
5.0 CONCLUSIONS

As supported by the preceding sections and the appendices the G.S.E. design has been successful.

The hardware for the G.S.E. is shown to be duplicated sections of the CCU, such that any simulation carried out by the G.S.E. is identical to that of the CCU. The major part of the G.S.E. electronics was built on two dual size eurocards which were wire wrapped because of the very short time scales required to complete the G.S.E. design. The PCB's were designed such that it did not impose severe restrictions on modifications that would normally be expected during the design.

It was apparent during manufacture that the particular connectors used had long lead times from the suppliers and should be noted for the future.

The general design of the software presented a problem regarding data retrieval from the CCU. Because of the data transmission speed, the microprocessor had to use a utility program which gave rise to problems on start up, whereby the G.S.E. had to remember that data had been retrieved from sides A and B, otherwise the data was lost.

The first system was manufactured and pressed into service on the flight trials. It became apparent that minor design problems existed with the unit. The hardware and software problems were analyzed and solved.
REFERENCES

3-1 Graviner Ltd. Drawing; Circuit Diagram for GSE, No. 51659-062CD, Rev. D

3-2 Graviner Ltd. Drawing; Aircraft to G.S.E. Cable (No. 1), No. DSK 8601, Rev. B

3-3 Graviner Ltd. Drawing; Aircraft to G.S.E. Cable (No. 2), No. DSK 8602, Rev. B

3-4 Graviner Ltd. Drawing; Aircraft to G.S.E. Cable (No. 3), No. DSK 8603, Rev. B

3-5 Graviner Ltd. Drawing; Lab Support Cable (No. 4), No. DSK 8752, Rev. A

3-6 Graviner Ltd. Drawing; Advanced Fire Detection System Wiring, No. Z22004, Rev. D
APPENDIX A-1

MICROPROCESSOR CARD
APPENDIX A-1

This Appendix gives functional details on the Golden River GR0430 low power single board computer. Details down to circuit level can be obtained from:

Golden River Company Limited,
Telford Road,
Bicester,
Oxfordshire OX6 OUL

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APPENDIX A-1

1. To operate the Golden River's GRO430 Low Power Microcomputer, the following minimum conditions should be established:

(a) Zero volt power line to Pin 1 of Edge Connector (E.C.)
(b) 8.0 volt to 12.0 volt power line to Pin 3 of E.C.
(c) Zero volt RS232 (Pin 7 of 25 pin "D") to pin 56 of E.C.
(d) RS232 data from terminal (Pin 2 of 25 pin "D") to pin 58 of E.C.
(e) RS232 data to terminal (Pin 3 of 25 pin "D") to pin 59 of E.C.
(f) One side of normally open switch to pin 56 of E.C.
(g) The other side of switch to pin 57 of E.C.

2. Check terminal settings as follows:

(a) 30 chars per sec (300 baud)
(b) Even parity
(c) 1 stop bit

If an alternative data rate is required under 2(a), refer to drawings for link selection.

3. Connect terminal and power supply. Operate and release switch.

The terminal should now print:

"GRUTIL VERS X.X"

If that happens, refer now to GRUTIL documentation.

4. Your terminal may require some or all of the following conditions:

(a) Pin 5 of "D" Connector to +5V (Pin 2 of E.C.)
(b) Pin 6 of "D" Connector to +5V (Pin 2 of E.C.)
(c) Pin 8 of "D" Connector to +5V (Pin 2 of E.C.)
(d) Pin 20 of "D" Connector to +5V (Pin 2 of E.C.)
APPENDIX A-1

1. The software is as per description for Ver 2.2 except for the following deletions:

   @M Command no longer available

2. All subroutine addresses listed are still valid.

3. Version 4 will run in any hardware with the following requirements:
   (a) I/O Port at Unit 6, EFL, EF2 ready lines
   (b) Program location $8000-$82EF
   (c) Program must be entered with X=PO
   (d) Interrupts are disabled by GRUTIL upon entry.
   (e) Minimum 30 bytes RAM must be available somewhere in system. GRUTIL will select upper most 30 bytes in Memory Map, out of valid functional memory.

4. Version 4 takes a little longer to start because of RAM locating routine.

5. New command available:

   ?R Dump all CPU register values at the time of entry to GRUTIL, except R0 and R1. Addresses are given showing the position of the RAM that GRUTIL has located for storage of these values.

6. The bug which prevented program loading at 10cps has been corrected.
1. Place an erased 2716 or 2758 PROM into position 0 (nearest the UART) with the same orientation as GRUTIL PROM (at other end of row).

2. Check that the PROM is 'clean' by doing a CRC check, which should give FFFF, e.g.
   *MO 400 (2758 Prom)
   *MO 800 (2716 Prom)

3. Load the data to be programmed into the PROM into RAM (Locations $4000 - $47FF) and perform a CRC check on RAM.

4. Apply 25.5 Volts ± 0.5 Volts to the test point connector, TPI. Restart system with RUN-U (connect pin 57 of edge connector to ground).

5. Use copy command to copy RAM data into PROM e.g.
   *M4000 0 400 (2758) (will take ≈60 seconds to complete)
   *M4000 0 800 (2716) (will take ≈120 seconds to complete)


7. Restart system with RUN-U (Connect pin 57 of edge connector to ground).

8. Perform CRC of PROM to check contents, e.g. MO 800 for 2716.
GOLDEN RIVER
GR0430 Low Power Single Board Computer

1. 1802 CMOS Central Processing Unit
2. 8 KB SRAM Read/Write Memory
3. Option for up to 16 Kbytes of erasable programmable or mask programmable ROM memory
4. Large I/O Capacity (up to 256 lines)
5. Complete with Liberty PROM easily to view
6. System UART Port on CPU Board
7. On-Board PROM Programming
8. Lower Power Design with low consumption typically 20mA
9. Easy to power with only single 5V to 20VDC input or regulated standard 5V ± 5%
10. Minimum size and weight system at 15 x 203 x 28mm (-6 x 8 x 1.1 in.)
11. Ledgerboard for easy paralleling
12. Wide operating temperature range -30°C + 80°C

UNIQUE I/O PHILOSOPHY
All CPU and MEMORY functions are concentrated on the GR0430 Single Board Computer which leaves the O E M free to design and implement the I/O structure for his particular application. The R + U Board can become a standard component for use in systems with subsequent reduced requirements. The I/O Ports are designed to interface with the bus of the GR0430 and can usually be implemented on a Single Side P.C.B.

Standard I/O Boards are available as follows:
(a) Fast Multipoint Device Board
(b) 32 Line-input board
(c) Mixed I/O Board with 4 UAR Ts and 8 Ports

DESIGN THEMES FOR GR0430 PRODUCTS
(a) Low Power and minimum power supply voltage constraints
(b) Concentration of CPU CONTROL SYSTEM on one board with user I/O on separate boards
GR0430 General Description

The GR0430 Single Board contains 2K bytes of static read only memory using low power CMOS RAM chips which at most times consume only 1mA leakage current. Sockets are provided for user program PROM of up to 8K bytes using Intel 2716 EPROMs, and the system monitor, GRUTIL, occupies a fifth position giving a total board capability of 10K bytes. When delivered the board contains a single Intel 2716B programmed with GRUTIL in the system PROM position.

The board has the facility to program the above 2 types of EPROM in one position on the board, without need for any special equipment other than a 25V ±1V external power supply. The new or erased PROM is inserted into the PROM location zero, and after applying 25V, the user can imagine that the first 1K or 2K (2756 or 2716 respectively) is Read/Write Memory. Single words or whole sections can be programmed at the rate of 80ms per location.

Also on board is a high speed asynchronous system port which may be connected to devices such as a Teletype ASR33, a Texas Instruments Silent 700 Terminals, or text V.D.U. at up to 960 characters per second. This port is designed as a system entry point and can be used as a monitor or maintenance position in the final O.E.M. application.

The 1mA power consumption of the GR0430 has been kept to an absolute minimum by use of low power CMOS technology, and by switching the NMOS EPROM's to "OFF" when not being accessed. As a result the absolute maximum power consumption of the board is around 40mA, by using certain software techniques, and taking a low speed jumper option on the board, the mean current requirement can be as low as 3mA typical. Also, since an on board regulator is used, a low cost alkaline cell such as a P93 battery can provide the system total electrical requirement.

In order to maintain high reliability, a minimum of discrete components have been used as follows:
18 Resistors
6 Ceramic Capacitors
4 Tantalum Capacitors (rated 10V. run at 5V)
7 Silicon diodes
7 Transistor Packages
2 Crystals

In addition, apart from hardware and fittings, a total of 46 integrated circuits in due in line packages are soldered into the board. The two PROM sockets bring the total component count to 96 items. The number of inter connects is approximately 1200.

The board is normally low soldered and hence has protective green epoxy screen to both sides.

Functional Block Diagram

---

**Diagram:**

1. EDGE CONNECTOR
2. 25V
3. PROGRAMMABLE MEMORY
4. Programmer
5. SYSTEM INTERFACE
6. 2522 INTERFACE
7. 8080 CPU
8. SYSTEM HARDWARE
9. CONTROL BUS
10. DATA BUS
11. ADDRESS BUS

---

68
The CPU used on GRO430 is RCA's powerful CMOS 8-bit CPU1802, which contains on a single LS1 chip, 164 transistors and is packaged in a 40-pin DIL package. The CPU contains 16 general purpose 16-bit registers which may be used as program counters, stack pointers and as scratch pad locations (data registers) for 2 bytes of data. An 8-bit accumulator and an overflow bit, an arithmetic point, and registers to interrupt control complete the CPU's principal features. The powerful but simple interrupt facilities make provision of a large number of interrupt lines unnecessary, hence maintaining a simple hardware configuration.

**APPLICATIONS**

GRO430 has definite advantages in the following areas over other SBC/MBI approaches:

- **Specific I/O Requirement:** GRO430 allows user to define I/O structure and functions.
- **Low Power:** e.g. dual-winding, four-wire applications - typically 10mA consumption.
- **Onboard:** On-board PROM programmer makes GRO430 a good investment as PROM program.
- **Wide Temperature Range:** Many SBC boards do not operate below 0°C. Due to use of CMOS technology, this board operates from -30°C to +60°C.
- **Light Weight:** Minimum power supply removes need for bulky weighty transformers and low reliability electrolytic capacitors.

**UTILITY PROGRAM**

The utility program GRO430 can be run within minutes of unpacking provided a terminal is available. Start operation by pressing reset and a solid "--" will be issued.

```
000000 XXXX YYYY Dump memory X bytes from location X
111111 XXXX XXXX Y... Load the string of hex characters into mem starting at location X
222222 XXXX YYYY Start Program operation at location X
333333 XXXX YYYY Performs CRC check on Y bytes starting at location X
444444 YYYY YYYY Performs 1 check on memory for Y bytes at a time
555555 YYYY YYYY Performs 2 checks on memory for Y bytes at a time
666666 YYYY YYYY Performs 4 checks on memory for Y bytes at a time
777777 YYYY YYYY Performs 8 checks on memory for Y bytes at a time
888888 YYYY YYYY Performs 16 checks on memory for Y bytes at a time
999999 YYYY YYYY Performs 32 checks on memory for Y bytes at a time
```

Plus more functions e.g. 3P 'M 8M etc. 16 routines are also available for use by the user program.

**SOFTWARE DEVELOPMENT**

Software development is best done using the facilities of a full manufacturer's development system. Resident assembler, debugger, and program debuggers greatly reduce the development time to a result in efficient machine code. Using GRO430, the development engineer can easily write and programs in machine code, but for non-trivial applications over ten tests, this is a very development-orientated approach.

GOLDEN RIVER - A COMPANY PROFILE

Golden River is an independent British Company operating from a modern manufacturing base in Swindon. The company has a strong background in the Traffic Data Collection Area and holds a dominant share of the market with dual authorities and Central Government for traffic counting equipment...
Specifications

Word Size:
Instruction: 8 bits, 16 bits or 24 bits Data: 8 bits

Instruction Set:
9 basic instructions: Control, memory reference, register operations, carry, active operations, branch instructions and I/O control. 256 operation codes total.

Auxiliary I/O
2 single bit input lines EF3 and EF4. 1 testable output line Q.

Utility Program
1,2756 PROM ready programmed with GRUTIL
Golden River Utility Program Vers. X.X.

On Board Programming Facilities
1 Position for 2716 or 2756 Programming. 50mA Programming time per PROM. 25V +/4 supply @ 30mA for programming.

Oscillator:
Basic Instruction Cycle 6.5 µs (Typically 99% of cycles will be 6.5 µs).
Cycling Time (m/s):
Optional Jumper Line 104 µs (For very low power operation).

Memory Adressing:
PROM: 0000-1FFF (2716 PROMS)
0000-0FFF (2756 PROMS)
0000-7FFF (1822 PROMS)
PLUS 8000-83FF (2716 SYS PROM)
8000-85FF (2756 SYS PROM)
RAM: 2K BYTES 4000-47FF
PLUS 128 BYTES 8000-85FF

Memory Capacity:
As above, off board memory not available.

I/O Addressing:
Each desired I/O Unit has unique code of 8 bits which is strobed from data bus. Direct capacity of 256 input, 256 output ports.

System Ports:
Designed to monitor port for the final OEM system
Asynchronous 7 bit ASCII Port 10cps to 9600cps add/ even parity.
Negative Supply generated from incoming signal
DMA Operations:
Special DMA cycles to input or output. Maximum transfer rate 150,000 c.p.s. 2 lines provided for DMA in & DMA out.

Interrupts:
Single vectored interrupt line provided. Maximum response time 6.5 µs

I/O Interface:
All signals 5V CMOS compatible

System Clock:
24,576,000 MHz or 153,600 Hz Jumper Selectable

Connections:
60 Way 0.1" P.C.B. connector with keyway at position 54. Single sided connections assigned.

Control Lines:
Run U causes vectored reset to the Utility Program at location $8000. Run P causes vectored reset to the User Program at location $0000.

Compatible Processing Systems:
Specify Vers 4J System 4E for cards and Modules.

Physical Characteristics:
Size: 157 x 203 x 25mm (6.20 x 8.00" x 1.00"
Weight: 225g (8 oz)

GOLDEN RIVER COMPANY LTD
50 Ford Road Bureau Outliers England Telephone Bures 67551 Fax 675346

LEADERS IN ELECTRONIC INSTRUMENTATION
APPENDIX A-2

This Appendix gives full details on the printer "DELTIGA-6400 series.

WARNING

This instrument is designed to prevent accidental shock to operator when properly used. However, no instrument design can render the instrument which is used carelessly. Therefore, this manual must be read carefully and completely prior to the initial measurements. Failure to do so can result in a serious or fatal accident.


Shock hazard shall be considered to exist at any part involving a potential of between 42.4 volts peak and 40 kilovolts peak in the following cases:

A. If the current through faulted circuit is not less than 500 ohms at 500 milliseconds after 0.003 second.

B. If the current through a faulted circuit is not less than 500 ohms at 500 milliamperes at 0.2 second.

C. If the current through a faulted circuit is not less than 500 ohms in 100 milliseconds at 0.1 second.

D. If the time required for the current through a load of not less than 500 ohms to decrease to 5 milliamperes is between 0.63 and 0.8 second and the total quantity of electricity passed through the load up to that time exceeds 4 milliampere-seconds.

E. If the time required for the current through a load of not less than 500 ohms to decrease to 5 milliamperes is between 0.03 and 0.1 second and the total quantity of electricity passed through the load up to that time exceeds 757.350T+ 1 milliampere-seconds, where T is the time in seconds.

NOTE: Ambulance attendants might enter when potentials more than 40 kilovolts peak are present.

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SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE.
APPENDIX A-2

WELCOME
Welcome — from United Systems Corporation. Thank you for choosing the DigiTec 6400 Series alphanumeric printer. Your continued satisfaction with DigiTec products is important to us; so this manual has been prepared to promote a clear understanding of the instrument, its capabilities and its proper use. Please follow these instructions to ensure optimum performance from, and your continued satisfaction with, your 6400 Series printer.

UNPACKING AND INSPECTION
Examine the shipping carton and the printer for any evidence of damage to the instrument. If there is any indication of damage, file a complaint immediately with the carrier.
Save the shipping carton and packing materials for future storing or shipping of the instrument.
Should there be no sign of damage, proceed with the instructions in this manual. Read the Shock Hazard warning on the inside of the front cover to avoid injury due to electrical shock.
If the instrument must be returned, contact the factory for prior approval. Give a full explanation of the reason and, if a malfunction is involved, the mode of operation in which it occurred.
Upon receipt of approval, ship in the original carton (or otherwise sufficiently packaged to prevent damage in shipment) PREPAID to your nearest authorized service center.

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1. INTRODUCTION

1.1 General Description

The DigiTec S400 Series alphanumeric printers are small, desktop printers that print top-to-bottom like a person normally reads. They combine the benefits of microprocessor technology with United Systems experience as a leading manufacturer of digital printers.

Model 6410 interfaces to your system through a serial format and Model 6420 has an 8-bit parallel bus interface. Both models print 64 different letters, numbers and symbols in a 5x7 matrix controlled by the standard ASCII code. The electrostatic printing technique provides quiet, reliable operation and a high-contrast printout that is easy to read.

The 6400 Series designer-styled cases make an attractive addition to any system. In addition, special colors and your own identification are available in OEM quantities.

1.3 Options

Option "J", Option "J" provides 32 characters/line capacity in place of the standard 21 columns.

1.4 Technical Assistance

United Systems Corporation offers assistance, if necessary, in solving application problems. We also encourage inquiries concerning special applications and custom-designed systems.

1.5 Specifications

<table>
<thead>
<tr>
<th>ELECTRICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 6410 Inputs/Output</td>
</tr>
<tr>
<td>RS-232-C</td>
</tr>
<tr>
<td>Max. logic 1: -15 V to 0 V (open circuit)</td>
</tr>
<tr>
<td>Space logic 0: 0 V to 15 V</td>
</tr>
<tr>
<td>20 mA Current Loop</td>
</tr>
<tr>
<td>Max. logic 1: current ON</td>
</tr>
<tr>
<td>Space logic 0: current OFF (open circuit)</td>
</tr>
<tr>
<td>Low: 0.45 V max, 1.6 mA typical</td>
</tr>
<tr>
<td>High: 24 V/mm, 30 V/apparent</td>
</tr>
<tr>
<td>Eject Out</td>
</tr>
<tr>
<td>Low: 0.2 V min, 0.5 V max, 0.1 mA</td>
</tr>
<tr>
<td>High: 2 V min, 5 V max, 0.1 mA</td>
</tr>
<tr>
<td>Std. Data Inputs and Test Input</td>
</tr>
<tr>
<td>Test Input Pulse Width: 100 μs min</td>
</tr>
<tr>
<td>Isolated 20 mA Current Loop</td>
</tr>
<tr>
<td>Optically coupled</td>
</tr>
<tr>
<td>Input Buffer</td>
</tr>
<tr>
<td>Holds one line</td>
</tr>
<tr>
<td>Power</td>
</tr>
<tr>
<td>115 or 230 Vac to 15 VA, 50/400 Hz</td>
</tr>
<tr>
<td>Operating Ambient</td>
</tr>
<tr>
<td>0' to 50' C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GENERAL SPECIFICATIONS</th>
<th>PHYSICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printer Life</td>
<td>Printhead: 3 million lines</td>
</tr>
<tr>
<td></td>
<td>Stylus: 500,000 lines, 20 characters each</td>
</tr>
<tr>
<td>Printhead</td>
<td>5 x 7 dot matrix, Electro-sensitive type</td>
</tr>
<tr>
<td>Characters</td>
<td>Height: 2.3 mm</td>
</tr>
<tr>
<td></td>
<td>21 characters per line (32 per line optional)</td>
</tr>
<tr>
<td>Print Speed</td>
<td>2 lines/second</td>
</tr>
<tr>
<td>Paper</td>
<td>Electro-sensitive, 100 ft (approx. 3000 inches)</td>
</tr>
<tr>
<td>Dimensions</td>
<td>7.8 in. x 2.875 in. x 5.375 in.</td>
</tr>
<tr>
<td>Weight</td>
<td>35 lbs</td>
</tr>
<tr>
<td>Interface Connector</td>
<td>EIA Standard (Canoe #00-25P)</td>
</tr>
</tbody>
</table>
2. PANEL FUNCTIONS

1. Power ON Indicator
2. Paper Advance, thumbwheel, turn towards rear to advance paper.
3. Tear Bar/Window
4. Paper Feeder Release: lifts stylus, releases paper feeder mechanism so paper can be pulled out of printhead.
5. Paper Spindle

FRONT PANEL

REAR PANEL

6. Input Connector
7. Power Cord (115/230 Vac selector and fuse are located inside the case)
8. Paper roll on spindle

3. STARTUP

This section explains how to apply power to your Digitec 6400 Series printer and how to load paper in the printhead. Your printer will then be ready for operation.

---

CAUTION

The printer should be operated ONLY with paper installed to prevent possible damage to the printhead.

---

3.1 Power

The Model 6400 Series printer can be operated on either a 115 Vac or a 230 Vac power line.

It is normally shipped for 115 Vac unless specified for 230 Vac. If 230 volt operation is needed, you must follow this procedure.

1. Remove the four screws, one in each corner, on the bottom of the printer case.
2. Lift the front of the case up and let it pivot backwards to rest on the table.
3. The fuse is located in the lower right-hand corner, looking from the front. 115 Vac operation requires a 1/4 amp, 125 volt fuse. 230 Vac operation requires a 1/8 amp, 250 volt fuse.
4. Lift the black power cord and notice the zero-ohm-resistor jumpers underneath. The position of these jumpers selects either 115 Vac or 230 Vac operation (insulated wire may be used instead of the resistors). The positions are as follows.

Figure 1. 115/230 Volt Selection

---

IMPORTANT

Be sure the proper rated fuse is installed for the power line rating selected. 115 Vac requires a 1/4 amp, 125 volt fuse. 230 Vac operation requires a 1/8 amp, 250 volt fuse.
3.2 Paper Loading

The 6410 Series alphanumeric printers are shipped with a roll of paper installed to prevent damage to the printhead during shipment. To load a roll of paper into the printer, follow this procedure:

**CAUTION**

The paper is electrically conductive. It should not be allowed to contact the printer's circuits when the unit is plugged in.

1. Turn the printer ON.
2. Place a roll of paper on the Paper Spindle. Both the spindle and a roll of paper are contained in a plastic bag shipped with the printer.
3. Place the loaded spindle into the slots in the Paper Spindle Bracket. The loose end of paper should come off the bottom of the roll and up towards you.
4. Make sure all paper from a previous roll is removed from the printhead. To remove leftover paper, turn the Paper Advance dial.
5. Pass the end of paper down into Slot A in the top of the printhead.

**NOTE:** NEVER put new paper into the printhead until ALL paper from the previous roll is removed.

4. MODEL 6410 INTERFACING

Your Model 6410 alphanumeric printer provides a choice of two basic types of interfaces for data communications in the serial character/serial bit mode. 1) RS-232-C and 2) 20 mA current loop. The design of your data transmitting device determines which interface your printer requires.

Through the framework of these two basic interfaces, operation of your 6400 Series printer is controlled by eleven-bit serial binary words. These binary words include control characters coded as defined by the widely-accepted American Standard Code for Information Interchange (ASCII). The Model 6410 printer accepts a single, fixed word format.

We normally ship the Model 6410 printer set up for the RS-232-C interface at a data rate of 110 baud. But you may easily change this setup in the field to satisfy your own requirements. This section contains the information necessary to adapt your printer's input to your specific application and to make the proper interface connections to input connector J4.

4.1 Input Connections

The connections to input connector J4 of your 6410 printer are defined by Table 1 below.

Examples that illustrate the connections for each type of interface follow the table. Keep in mind that the 20 mA current loop mode may be wired for either teletype or solid-state transmitters.

RS-232-C transmitting should not exceed 70 feet in length. In 20 mA current loop applications, a number of printers may be connected in series across the transmitter. When this is done, you must add up the total voltage drops of each printer in the series (1.8V nominal each) to determine the voltage required from your transmitter to maintain a proper current level of 20 mA in the loop.

**NOTE:** For this function to operate, the Received Data line must be in the Low Logic state.

---

**Table 1: Connector J4**

<table>
<thead>
<tr>
<th>PIN NO</th>
<th>ASSIGNMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Protective Ground</td>
</tr>
<tr>
<td>2</td>
<td>Received Data</td>
</tr>
<tr>
<td>3</td>
<td>Transmit Loop Input</td>
</tr>
<tr>
<td>4</td>
<td>Transmit Loop Return</td>
</tr>
<tr>
<td>5</td>
<td>Test Pin. Logic 0 (Ground) on</td>
</tr>
<tr>
<td>6</td>
<td>External Receiver Current Source</td>
</tr>
<tr>
<td>7</td>
<td>Signal Ground</td>
</tr>
<tr>
<td>8</td>
<td>Received Line Signal Detect (logic 1)</td>
</tr>
<tr>
<td>9</td>
<td>Auxiliary I/O Line (specials only)</td>
</tr>
<tr>
<td>10</td>
<td>gormhanicental current</td>
</tr>
<tr>
<td>11</td>
<td>20 mA Current Loop</td>
</tr>
</tbody>
</table>

---

For the function to operate, the Received Data line must be in the Low Logic state.

APPENDIX A-2
APPENDIX A-2

Fig. 2 illustrates portions of the printer circuits that associate with each pin of connector J4.

■ EXAMPLE: 20 mA current loop interface to type 33ASR Teletype only.

![Diagram of 20 mA current loop interface]

■ EXAMPLE: RS-232C Interface

■ EXAMPLE: Solid-state transmitter interface

■ NOTE: Signal level specifications for this application are:

<table>
<thead>
<tr>
<th>MAX.</th>
<th>MIN.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>15V</td>
</tr>
<tr>
<td>LOW</td>
<td>0.5V - 15V</td>
</tr>
</tbody>
</table>

(LOW TO MARK)
4.3 Input Formats

The Model 6410 alphanumeric printer has a fixed, 11-bit word format as follows:
- One START bit
- Seven ASCII data bits
- One PARITY bit (not checked)
- Two STOP bits

4.4 Data Transmission Timing

The timing relationship between the transmitted data rate and the ability of your Model 6410 printer to receive and print the data is determined by two factors: 1) the speed in bits/second (Baud rate) of the serially transmitted data, and 2) the speed with which the printer can print one line of data. You must ensure that the transmitter does not send data faster than the printer can print it.

Your Model 6410 printer operates in the ASYNCHRONOUS mode at either of two baud rates: 110 baud or 300 baud. This section contains instructions on how to operate your printer in the asynchronous mode and how to select the baud rate that suits your application.

4.4.1 Asynchronous Operation

The maximum number of data characters transmitted between print commands must not exceed the number of characters per line that the printer records, or some of the data may be lost. The baud rate of the transmitted data and the duration of a print cycle determine this relationship. Your 6400 Series printer operates at a rate of 2 lines per second, which means that 500 ms is required to print one line of data (the print cycle duration). The baud rate depends on your transmitter.

NOTE: Print commands (ASCII OA) may not be transmitted faster than once every 500 ms.

In asynchronous operation, you must supply the proper timing to ensure that the transmitted rate of each line of data maintains a correct timing relationship with your printer.

If the time required to transmit one line of data is equal to or greater than the time required to complete one print cycle (500 ms), no special consideration need be given to the timing of your printing system.

EXAMPLE: At a rate of 110 baud, one eleven-bit data character requires 100 ms of time; so one complete line of 21 characters allows ample time for one print cycle to be completed. The transmitted stream of data may flow without interruption.

If the time required to transmit one line of data is less than the time required for the printer to print one line (500 ms), you need to give special consideration to the timing of your printing system or some of the data may be lost. This can be accomplished by inserting the proper number of STOP bits between data characters to occupy the full interval.

EXAMPLE: At a rate of 300 baud, one eleven-bit data character requires 37 ms of time. If one line of data contains only ten characters (370 ms), the complete line will have been transmitted before the print cycle is finished.
APPENDIX A-2

4.4.2 Baud Rate Selection

A plug-in jumper is provided on the printer's circuit board for selecting either 110 baud or 300 baud data transmission rates. This jumper location is shown in Figure 4:

Figure 4. Baud Rate Jumper Location

The jumper positions are as follows:

- **110 baud**: Select this position when your printer is to be used at 110 baud. The control characters and data are internally converted to 300 baud baud.
- **300 baud**: Select this position when your printer is to be used at 300 baud. The control characters and data are transmitted at 300 baud.

5. MODEL 6420 INTERFACING

Your Model 6420 alphanumeric printer provides an eight-bit, parallel interface for data communications in the serial character/parallel bit mode.

Through the framework of this interface, operation of your 6400 Series printer is controlled by eight-bit character binary words. These binary words include control characters coded as defined by the widely accepted American Standard Code for Information Interchange (ASCII).

This section contains information necessary to make the proper connections to the printer's input connector J4, and an explanation of the ASCII code as it applies to your Digitel 6400 Series printer.

5.1 Input Connections

The connections to input connector J4 of your Model 6420 printer are defined by Table 3. Keep in mind that you can operate your printer in either of the two modes, asynchronous or 5 synchronous. These two operating formats are explained in greater detail in Section 5.7. Examples that illustrate connections to your printer follow the table.

Table 2. ASCII Table

<table>
<thead>
<tr>
<th>Control Function</th>
<th>Hex</th>
<th>Char</th>
<th>Hex</th>
<th>Char</th>
<th>Hex</th>
<th>Char</th>
<th>Hex</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRINT</td>
<td>0A</td>
<td>20</td>
<td>01</td>
<td>30</td>
<td>02</td>
<td>40</td>
<td>03</td>
</tr>
<tr>
<td>DATA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOLD</td>
<td>07</td>
<td>23</td>
<td>08</td>
<td>24</td>
<td>09</td>
<td>25</td>
<td>0A</td>
</tr>
<tr>
<td>&quot;CE&quot;</td>
<td>13</td>
<td>26</td>
<td>14</td>
<td>27</td>
<td>15</td>
<td>28</td>
<td>16</td>
</tr>
<tr>
<td>&quot;N&quot;</td>
<td>18</td>
<td>29</td>
<td>19</td>
<td>30</td>
<td>20</td>
<td>31</td>
<td>21</td>
</tr>
<tr>
<td>BOLD</td>
<td>0F</td>
<td>2A</td>
<td>10</td>
<td>2B</td>
<td>11</td>
<td>2C</td>
<td>12</td>
</tr>
<tr>
<td>FACE</td>
<td>17</td>
<td>2D</td>
<td>13</td>
<td>2E</td>
<td>14</td>
<td>2F</td>
<td>15</td>
</tr>
<tr>
<td>OFF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

ASCII in the 6400 Series Printers

Table 2 defines the printed characters and control functions that are produced by the partial ASCII code in the 6400 Series alphanumeric printers. The hexadecimal numbers given in the table are easier to handle than the larger binary ASCII numbers that the printer uses and are easily converted to binary when required.

The 6400 Series printers can be terminated, flow-controlled, or line-controlled as shown in the following table.

**Table 3. Connector J4**

- **Eight-line data input TTL positive true**
- **STR is TTL negative true (logic 0)**
- **STR pulse width 15 us min**
- **Busy Out positive true (logic 1)**

---

*For use with the Digitel 6400 Series printers.*
5.2 Data Transmission Timing

You can choose either asynchronous or synchronous operation for your Model 6420 printing system. In asynchronous operation, the transmitted data rate is not directly controlled by the printer. In synchronous operation, the transmitted data rate is directly controlled by the printer. Figure 6 is a timing diagram of your Model 6420 printer.

![Figure 5. Model 6420 Interface](image)

![Figure 6. Timing Diagram](image)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Application</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{LA}$</td>
<td>Delay time, $STR$</td>
<td>Min: 10 ms, Max: 40 ms</td>
</tr>
<tr>
<td>$T_D$</td>
<td>Delay time, input to $BUSY$</td>
<td>50 ms</td>
</tr>
<tr>
<td>$T_B$</td>
<td>Busy time per bit</td>
<td>200 ms</td>
</tr>
<tr>
<td>$T_L$</td>
<td>Busy time per line</td>
<td>500 ms - 530 ms</td>
</tr>
<tr>
<td>$T_V$</td>
<td>Data valid time</td>
<td>Min: 1 ms, Max: 20 ms</td>
</tr>
<tr>
<td>$T_{PW}$</td>
<td>Pulse width time, $STR$</td>
<td>15 ms</td>
</tr>
</tbody>
</table>

When $STROBE$ goes True, two things happen:

1. Data will be latched into printer between 15 ms and 40 ms later.
2. Busy will become valid 50 ms later (maximum).
5.2.1 Asynchronous Operation
You can operate your printing system in the asynchronous mode if you observe two basic rules:
A. Characters (8-bit parallel bytes) must be transmitted no faster than 3500 characters/second with each pulse period no less than 500 ms.
B. Print cycle command pulses must be no less than 500 ms duration.

5.2.2 Synchronous Operation
You can operate your printing system in the full synchronous mode by using pin 4 (BUSY OUT). BUSY OUT supplies a logic 1 pulse (POSITIVE logic) every time an 8-bit data word is received by the Model 6420. This is a 230 μs pulse to interrupt the transmitter from sending any more data until the printer is ready to receive it. A longer (500 ms) pulse is also sent out from this pin every time a PRINT command is received by the printer.

5.3 ASCII in the 6400 Series Printers
Table 4 defines the printed characters and control functions that are produced by the partial ASCII code in the 6400 Series alphanumeric printers. The hexadecimal numbers given in the table are easier to handle than the longer binary ASCII numbers that the printer uses and are easily converted to binary when required.

6. SERVICE INFORMATION
This section contains schematics, parts location pictorials and a parts list to assist those who are technically qualified to use this information.

Table 4. ASCII Table

<table>
<thead>
<tr>
<th>Control Function</th>
<th>Hex</th>
<th>Char</th>
<th>Hex</th>
<th>Char</th>
<th>Hex</th>
<th>Char</th>
<th>Hex</th>
<th>Char</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRINT</td>
<td>0A</td>
<td>SPACE</td>
<td>30</td>
<td></td>
<td>0</td>
<td></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>DATA*</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td>31</td>
<td></td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>BOLD</td>
<td>0E</td>
<td></td>
<td>23</td>
<td></td>
<td>32</td>
<td></td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>FACE</td>
<td></td>
<td></td>
<td>24</td>
<td></td>
<td>33</td>
<td></td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>&quot;ON&quot;</td>
<td>%A</td>
<td></td>
<td>25</td>
<td></td>
<td>34</td>
<td></td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>BOLD</td>
<td>0F</td>
<td></td>
<td>26</td>
<td></td>
<td>35</td>
<td></td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>FACE</td>
<td></td>
<td></td>
<td>27</td>
<td></td>
<td>36</td>
<td></td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>&quot;OFF&quot;</td>
<td></td>
<td></td>
<td>28</td>
<td></td>
<td>37</td>
<td></td>
<td>57</td>
<td></td>
</tr>
<tr>
<td></td>
<td>29</td>
<td></td>
<td>38</td>
<td></td>
<td>39</td>
<td></td>
<td>58</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2A</td>
<td></td>
<td>3A</td>
<td></td>
<td>40</td>
<td></td>
<td>59</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2B</td>
<td></td>
<td>3B</td>
<td></td>
<td>41</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>2C</td>
<td></td>
<td>3C</td>
<td></td>
<td>42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2D</td>
<td></td>
<td>3D</td>
<td></td>
<td>43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2E</td>
<td></td>
<td>3E</td>
<td></td>
<td>44</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2F</td>
<td></td>
<td>3F</td>
<td></td>
<td>45</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Will also print without an OA command whenever a total of 32 characters are received. With Option "J", 32 characters per line, do not send a line feed (OAH) after 31 characters. Otherwise, the automatic line feed and the one last transmitted will cause your printer to line feed twice. After 31 characters, you may send a "SPACE" character to make 32 characters to get an automatic line feed.
PARTS LIST

The following parts list contains the electrical (and some mechanical) components of each subassembly of the Model 6400 Series alphanumeric printers.

Under DESCRIPTION, the type of each capacitor and resistor is given by these codes:

**CAPACITORS**
- A = Aluminum
- C = Ceramic
- E = Electrolytic
- M = Mica
- P1 = Polyester
- P2 = Polystyrene
- P3 = Metallized Polycarbonate
- T = Tantalum

**RESISTORS**
- C = Carbon
- F = Film
- V = Variable
- W = Wire-wound

### MODEL 6410

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
<th>USC Number</th>
<th>Vendor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete Assembly</td>
<td></td>
<td>05-18790-01</td>
<td>LSC</td>
</tr>
<tr>
<td>C1.2</td>
<td>C 0.05 mf. 100 V</td>
<td>56-10215S503XP1</td>
<td>Centralia UC Series</td>
</tr>
<tr>
<td>C3</td>
<td>AE 2500 mf. 50 V</td>
<td>56-15604N150N50</td>
<td>Sprague Type T1/A</td>
</tr>
<tr>
<td>C4-6, 9, 10, 18</td>
<td>T 15 mf. 50 V</td>
<td>56-12711D15N50</td>
<td>Nippon, DA138s</td>
</tr>
<tr>
<td>C7</td>
<td>E 1000 mf. 16 V</td>
<td>56-10215S100N13</td>
<td>Sprague Type 503U</td>
</tr>
<tr>
<td>C8</td>
<td>E 220 mf. 16 V</td>
<td>56-12020-227N18</td>
<td>Sprague Type 503D</td>
</tr>
<tr>
<td>C11</td>
<td>M 100 pf. 500 V</td>
<td>56-10210A101M5</td>
<td>Elginco DK Series</td>
</tr>
<tr>
<td>C12</td>
<td>M 30 pf. 300 V</td>
<td>56-10210A250U3</td>
<td>Elginco DM Series</td>
</tr>
<tr>
<td>C13</td>
<td>M 24 pf. 500 V</td>
<td>55-10210A244J45</td>
<td>Elginco DM Series</td>
</tr>
<tr>
<td>C14</td>
<td>15-80 pf</td>
<td>56-18956-09</td>
<td></td>
</tr>
<tr>
<td>C15, 17</td>
<td>.01 mf. 25 V</td>
<td>56-12731A104N35</td>
<td>Siemens, B45134</td>
</tr>
<tr>
<td>C16</td>
<td>5.67 mf. 50 V</td>
<td>56-12731A479N3</td>
<td>Siemens, B45134</td>
</tr>
</tbody>
</table>
## APPENDIX A-2

### MAIN BOARD (continued)

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
<th>USC Number</th>
<th>Vendor</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1-5, 9, 10</td>
<td>Power diode, 100 PIV</td>
<td>40-07787-01</td>
<td>Fairchild, 1N4000 Series</td>
</tr>
<tr>
<td>D6</td>
<td>Zener diode, 8.3 V</td>
<td>40-09219-06</td>
<td>Schott, 5Z-6 5A</td>
</tr>
<tr>
<td>D7, 8</td>
<td>Signal diode</td>
<td>40-09239</td>
<td>Motorola, 1N4154</td>
</tr>
<tr>
<td>F1</td>
<td>Fuse, 1/4 A, Slow-Blow</td>
<td>52-09309-02</td>
<td>Buss, MDL-1/4 A</td>
</tr>
<tr>
<td>F2</td>
<td>Fuse, thermal</td>
<td>52-16830-006</td>
<td>Micro Devices, 60961</td>
</tr>
<tr>
<td>IC1, 2</td>
<td>Voltage regulator</td>
<td>40-16079</td>
<td>Fairchild, 78M24UC</td>
</tr>
<tr>
<td>IC2, 2</td>
<td>Voltage regulator</td>
<td>40-16501</td>
<td>Fairchild, 78M05C</td>
</tr>
<tr>
<td>IC4</td>
<td>Hex inverter</td>
<td>40-15955</td>
<td>Motorola, MC14049BCP</td>
</tr>
<tr>
<td>IC5</td>
<td>National Semi. DM8230AN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC6</td>
<td>Opto-isolator</td>
<td>40-14875</td>
<td>Monsanto, MCT8</td>
</tr>
<tr>
<td>IC7</td>
<td>Voltage regulator</td>
<td>40-18772</td>
<td>Motorola, MC3491</td>
</tr>
<tr>
<td>IC8</td>
<td>8-segment display driver</td>
<td>07-18753</td>
<td>Intel, P8748-8</td>
</tr>
<tr>
<td>Q1-7</td>
<td>Power transistor</td>
<td>40-15168</td>
<td>Motorola, MJE701</td>
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<tr>
<td>Q8</td>
<td>Signal transistor</td>
<td>40-11575</td>
<td>GE, 2N5172</td>
</tr>
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<td>Q9, 10</td>
<td>Signal transistor</td>
<td>40-04233-05</td>
<td>GE, 16A565-5</td>
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<tr>
<td>Q11</td>
<td>Signal transistor</td>
<td>40-06952</td>
<td>Fairchild, 2N3450</td>
</tr>
<tr>
<td>Q12</td>
<td>Power transistor</td>
<td>40-14164</td>
<td>Motorola, MJE800</td>
</tr>
<tr>
<td>R1</td>
<td>C, 5.6 kΩ, 1/4 W, 5%</td>
<td>55-10101H-035R6</td>
<td>IRC, GBT-1/4</td>
</tr>
<tr>
<td>R2</td>
<td>C, 27Ω, 1/4 W, 5%</td>
<td>55-10101H-0027</td>
<td>IRC, GBT-1/4</td>
</tr>
<tr>
<td>R3. 8</td>
<td>C, 47kΩ, 1/4 W, 5%</td>
<td>55-10101H-0047</td>
<td>IRC, GBT-1/4</td>
</tr>
<tr>
<td>R4, 9, 12, 15, 16</td>
<td>C, 1kΩ, 1/4 W, 5%</td>
<td>55-10101H-0001</td>
<td>IRC, GBT-1/4</td>
</tr>
<tr>
<td>R5</td>
<td>C, 150Ω, 1/4 W, 5%</td>
<td>55-10101H-150</td>
<td>IRC, GBT-1/4</td>
</tr>
<tr>
<td>R6</td>
<td>200kΩ, 1/4 W, 5%</td>
<td>55-10101H-220</td>
<td>IRC, GBT-1/4</td>
</tr>
<tr>
<td>R7</td>
<td>C, 4.7 kΩ, 1/4 W, 5%</td>
<td>55-10101H-003R7</td>
<td>IRC, GBT-1/4</td>
</tr>
<tr>
<td>R10, 14</td>
<td>C, 33kΩ, 1/4 W, 5%</td>
<td>55-10101H-003</td>
<td>IRC, GBT-1/4</td>
</tr>
<tr>
<td>R11, 17-23</td>
<td>C, 10kΩ, 1/4 W, 5%</td>
<td>55-10101H-010</td>
<td>IRC, GBT-1/4</td>
</tr>
<tr>
<td>R13</td>
<td>C, 22kΩ, 1/4 W, 5%</td>
<td>55-10101H-022</td>
<td>IRC, GBT-1/4</td>
</tr>
<tr>
<td>S1</td>
<td>Switch, illuminated rocker</td>
<td>43-18724</td>
<td>C &amp; K, CK5101</td>
</tr>
<tr>
<td>T1</td>
<td>Transformer, power</td>
<td>42-17685</td>
<td>USC</td>
</tr>
<tr>
<td>Y1</td>
<td>Crystal, 2.8 MHz</td>
<td>40-17829</td>
<td>Valtec, VM6-HC18</td>
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### MISCELLANEOUS

<table>
<thead>
<tr>
<th>Reference</th>
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<tbody>
<tr>
<td>Paper</td>
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<td>19-17210</td>
<td>USC</td>
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<tr>
<td>Paper Spindle</td>
<td></td>
<td>22-17971</td>
<td>USC</td>
</tr>
<tr>
<td>Connector, 25-pin male</td>
<td></td>
<td>51-09174-01</td>
<td>Canon, DB-25P</td>
</tr>
<tr>
<td>Power Cord</td>
<td></td>
<td>53-18738</td>
<td>Beiden, 17256</td>
</tr>
<tr>
<td>Printhead</td>
<td></td>
<td>47-18726</td>
<td>Pana sonic, EYP-106012LU</td>
</tr>
<tr>
<td>Case top</td>
<td></td>
<td>30-18705</td>
<td>USC</td>
</tr>
<tr>
<td>Case bottom</td>
<td></td>
<td>30-18706</td>
<td>USC</td>
</tr>
<tr>
<td>Jumpers, zero-ohm</td>
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<td>50-07657</td>
<td>Erie, 333</td>
</tr>
<tr>
<td>Jumpers, plug-in</td>
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<td>51-18194</td>
<td>Berg, 65474-002</td>
</tr>
<tr>
<td>J3</td>
<td>Printhead connector</td>
<td>51-18731-15</td>
<td>Wagner Elec. 335</td>
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<tr>
<td>J4</td>
<td>Lamp for power switch</td>
<td>52-09346</td>
<td>Cannon, DB-25S</td>
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<tr>
<td>25-pin female connector</td>
<td></td>
<td>51-09174-02</td>
<td>Wagner Elec. 335</td>
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</tbody>
</table>

### MODEL 6420

All other parts are the same as on the Model 6410 printer

### MAIN BOARD

<table>
<thead>
<tr>
<th>Component</th>
<th>Reference</th>
<th>Description</th>
<th>USC Number</th>
<th>Vendor</th>
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</thead>
<tbody>
<tr>
<td>Complete Assembly</td>
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<td>06-18730-02</td>
<td>USC</td>
<td></td>
</tr>
<tr>
<td>No G11</td>
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<td>No D7</td>
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<td>No IC5, 8</td>
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<td>IC6</td>
<td>Microprocessor</td>
<td>07-18869</td>
<td>Intel, P8748-8</td>
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<tr>
<td>No R17</td>
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</tr>
<tr>
<td>R17</td>
<td>C, 47 kΩ, 1/4 W, 5%</td>
<td>86-10101H-047</td>
<td>IRC, GBT-1/4</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX A-3

U. V. HEAD & EMITTER SIMULATION FLOW DIAGRAM
APPENDIX A-3

Head & Emitter Simulation

START

A or B

GSE2 SIDE2

Yes

GSE2 SIDE1

No

EMITTER SIDE2 HIGH

Yes

FIRE HEADS BOTH SIDES

No

EMITTER HIGH

Yes

RESET HEADS BOTH SIDES

FIRE HEADS SIDE1

GSE2 SIDE1

Yes

GSE2 SIDE2

No

RESET HEADS SIDE2

GSE2 SIDE2

NO

RESET HEADS SIDE1

No

THIS ROUTINE SIMULATES HEADS & Emitter TESTS.

(i) WHEN CCU RUNE NORMALLY

(ii) " " " " " WITH LAB SUPPORT CABLE.
APPENDIX A-4

CCU-GSE COMMUNICATION FLOW DIAGRAM
Start

Clear Locations 4000 - 4040

Issue Command To Do IDLE
   RTN Both Sides Release
   CCU Reset Line

Give 3 Second Delay

Side 1
   Fail or Pass
       Pass
       System A or B

   Print" --- System R---"

Side 2
   Pass or Fail
       Pass
       Side 1
       Pass or Fail

       Fail
       Print" Side 1 Fail
       Side 2 Pass" No
       Communication Path
       Established GSE - CCU
       Check Integrity Cable 1
       Connections or Replace CCU

   Fail
       Side 1
       Pass or Fail

       Print" Side 1 Fail
       Side 2 Pass" No
       Communication Path
       Established GSE - CCU
       Check Integrity Cable 1
       Connections or Replace CCU

CONTINUFD 93
Print Side 1&2 Failed
No Communication Path
Established GSE CCU
Check Integrity Cable 1
Connections or
Replace CCU

Print System B
No Connection Path
Established GSE - CCU
Check Integrity
Cable 1 Connections
or Replace CCU

Auto/Man

Man

Branch to Manual Loop

Set LF3=1
Set MEMCODE Address to 4000

System A or B

A

Set MEMCODE = 1 4002

B

Issue Command to Retrieve Data Side 1 Reset CCU
Start Time to Start PGM From Beginning (0000) After Data Has Been Retrieved
Jump To Utility
Start

DIS INT Apply Power To CCU

Is EF3 = 1? Yes

Is MEMCODE = 1? No

Point R4 To Call RTN
Point R5 To Return RTN

Is GSE In/Out Switch In? No

Auto/Man Yes

Jump To Control Unit Tests

Yes

Jump Into MAN Loop

Set MEMCODE = 0

Shift Data Side 1 To Memory 4500 - 45FF
Reset Issued Command To Retrieve Data Side 1
Reset Timer Command Issue Command to Retrieve Data Side 2 Reset CCU
Start Timer To Start PGM From 0000 Jump To Utility

Is Lab Support Cable Used? No

Print Message 53

Yes

Release CCU Reset Line 1e Out 7 # 14

Print Message 54

CONTINUED
Release CCU Reset Line ie OUT 7 # 14

Is GSE2 Side 1 High?

Yes

Fire All Heads Side 1 ie Out 3 # FF

No

Is GSE2 Side 1 Low?

Yes

Reset All Heads Side 1

No

System A or B

A

Is GSE2 Side 2 High?

No

Fire All Heads Side 2 ie Out 4 # FF

Is GSE2 Side 2 Low?

Reset All Heads Side 2 Out 4 # FF

CONTINUED
Start

Initialize R2 To Free RAM (4040) SEC R2

Apply Power To CCU And Do Not Hold It In Reset Mode ie Out ; # 14

Is GSE Control In?

Yes

Is EF3 = 1?

Yes

Point R4 to CALL RTN Point R5 To Return RTN Set X = 0

No

Hold CCU In Reset Mode ie Out 7 # 10

Issue Command To Do IDLE RTN Both Sides Release CCU Reset Line

Give 3 Seconds Delay

Side 1 Pass or Fail

Fail

Pass

Print Message 1 & 3
Long Branch To Part 2

System A or B

System A or B

CONTINUED 99
APPENDIX A-5

LIST OF ERROR CODES
This appendix consists of two parts. Both parts list a set of error messages. These messages are used to decode any failure conditions during the 'CCU Test' and the 'Functional Test'. The first digit in the PASS/FAIL coded print out corresponds to the first error message.

PART 1 refers to the CCU Test
PART 2 refers to the Functional Test.

## PART 1

<table>
<thead>
<tr>
<th>Message Number</th>
<th>RAM Location</th>
<th>Error Message</th>
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<tbody>
<tr>
<td>1</td>
<td>4000</td>
<td>Indicates System A for Data Retrieved</td>
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<tr>
<td>2</td>
<td>4001</td>
<td>Adjacency Fail</td>
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<td>A/P Ident Not Available</td>
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<td>8</td>
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<td>SIDE 1 COM-LOGIC PART 1 ABORT</td>
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<tr>
<td>9</td>
<td>4008</td>
<td>SIDE 1 INHIBIT FAIL</td>
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<td>10</td>
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<td>SIDE 1 COM-LOGIC PART 2 ABORT</td>
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<td>11</td>
<td>400A</td>
<td>SIDE 1 FAULT FAIL</td>
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<tr>
<td>12</td>
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<td>SIDE 1 FIRE FAIL</td>
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<td>13</td>
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<td>18</td>
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<td>19</td>
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<td>4050</td>
<td>First Emitter Test Failed</td>
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<td>Fire Occurred Immediately After Emitter Test</td>
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<td>4</td>
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<td>Test 3 Head 1 (Lit 7) Side 2 Operate Failed</td>
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<td>Test 3 Head 4 (Lit 4) Side 2 Operate Failed</td>
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<td>GD/GRAVINER DFDS AUTO TEST ROUT N</td>
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<td>SYSTEM A</td>
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<td>NO GSE - CCU PATH</td>
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<td>CHECK CABLE</td>
<td>OR</td>
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<td>REPLACE CCU</td>
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<td>TEST ABORT</td>
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<td>SIDE 1 &amp; 2 FAILED</td>
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<td>SIDE 1 PASS</td>
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<td>SIDE 2 FAIL</td>
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<td>14-29</td>
<td>Messages 14-29 are no longer used.</td>
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<td>GRAVINER DF DS F-III CONFIRMED</td>
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<td>31</td>
<td>ADJACENCY FAIL</td>
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<td>CONTROL UNIT TESTS COMPLETE</td>
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<td>REPLACE CCU</td>
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<td>Message 34 not used</td>
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<td>START CONTROL UNIT TESTS</td>
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<td>START UV-HEAD TEST</td>
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<td>START PARAMETRIC TEST</td>
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<td>START FUNCTIONAL TEST</td>
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<td>FUNCTIONAL TEST COMPLETE</td>
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<td>Message 44 Not used</td>
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<td>START READ CCU TEST</td>
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<td>READ CUU TEST COMPLETE</td>
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APPENDIX A-6

CCU TEST FLOW DIAGRAM
Start

Point R4 To Call RTN
Point R5 To Return RTN
Set Address And Jump
To Print Message 2
Set Address And Jump
To Print Message 35
R9 = 4000

Read A/C Adjacency
Config. Side 1 ie 44D7

Does it
Indicate F-111
ie EO

Yes

B

System
A or B

A

Read A/C Adjacency,
Config. Side 1 ie 45D7

Does it
Indicate F-111
ie EO

No

Set Address And
Jump to Print
Message 30

Set RA = 4401
RB = 4501
SEX RD
OR Location
4501-3 ie LDN RB
IRX OR IRX
OR STR RB
SEX RA LDN RA
IRX OR IRX
OR STR RA

System
A or B
Set R9 to 4003
Reset previous
Command issue
Command to do
RMRNA release
Reset of CCU
Give 3 secs delay

Is GSEi side 1 high?

Store 01 via R9
ie at 4003

INC R9 ie R9 = 4004

System A or B

B

Read GSE 1 side 2

A

OR locations
4503 and 4403
Store result at
4403 ie LDN RB
OR STR RA

LDN RA XRI # A5

Branch IF
L=0 ie LBN2

Store code ie LD1
#01 STR R9 INC
R9 INC R9
Set address and
jump to print
message 31
Set address jump to
print message 8
Is GSE1 Side 2 High?

Yes

INC R9 ie R9 = 4005

Switch Off 115V OF CCU

Reset RMRNA Issue RMRNB Give 4 Sec Delay Apply Power to CCU Give 3 Sec Delay

Read GSE Side 1 & 2

Are GSE 1 Or 2 Side High?

Yes

INC R9 ie R9 = 4000

System A or B

B

A

No

Store 01 via R9 ie At 4004

No

Store 01 via R9 ie At 4005
Hold CCU in Reset Mode. Put CCU in GSE Mode.

Set Address And Print Message 61. Set R9 = 4010.

System A or B

A

Issue Command To Do Common Logic Release Reset Of CCU.

Set Delay Timer To Zero ie R6 = 0000

Side 1 Is GSE 2 High?

Yes

Give 20ms Delay INC R9

No

Does Fire O/P Indicate Fire?

Yes

Store 01 via R9 ie At 4008

INC R9 ie R9 = 4009

No

Store 01 via R9 ie 4007 INC R9

INC R6

Are 3 Seconds Up?

Yes

Set Timer To Zero ie R6 = 0000

No
APPENDIX A-6
SHEET 6 OF 13

Side 1
Is GSE1 High?

Yes
Give 20ms Delay INC R9

No
Are 3 Seconds Up?

Yes
Store 01 via R9 te 4009
INC R9 INC R9

No
INC R6

Does Fault O/P Indicate Fault?

Yes
Store 01 via R9 te At 400A

No
INC R9 te R1 = 400B

Does Fire O/P Indicate Fire?

Yes
Store 01 via R9 te At 400B

No
INC R9 te R1 = 400C

Set Delay Timer To
Zero te R6 = 0000

Side 2
Is GSE2 High?

Yes
20ms Delay INC R9

No
INC R6

Are 3 Seconds Up?

No
Yes

116
Store 01 via R9 1e 400C INC R9

Does Fire O/P Indicate Fire?

Yes

Store 01 via R9 1e At 4000D

No

INC R9 1e R9 = 400E

Set Delay Timer To 1e R6 = 0000

INC R9 1e R9 = 400F

Does Fault O/P Indicate Fault?

Yes

Store 01 via R9 1e At 400F

No

117
Does Fire O/P Indicate Fire?

Yes

Store 01 via R9 ie At 4010

No

INC R9 ie R9 = 4011
Reset Issued Common Issue RMTAS
Hold CCU in Reset Mode
1 Second Delay
Release Reset Of CCU
Give 3 Second Delay
Read GSE1 Side 1

Is GSE1 Side 1 High?

No

Store 01 via R9 ie At 4011

Yes

INC R9 ie R9 = 4012

System A or B

A

Read GSE1 Side 2

Is GSE1 Side 2 High?

No

Store 01 via R9 ie At 4012

Yes
Reset Issue Command
Hold CCU In Reset
Mode
Set R9 = 4003
LDA R9

LDB

Set Address and Jump
To Print Message 14

LDA R9

LDB

Set Address and Jump
To Print Message 15

LDA R9

LDB

Set Address and Jump
To Print Message 16

LDA R9

LDB

Set Address and Jump
To Print Message 17
LDA R9

LBZ

Set Address and Jump To Print Message 26

LDA R9

LBZ

Set Address and Jump To Print Message 18

LDA R9

LBZ

Set Address and Jump To Print Message 22

LDA R9

LBZ

Set Address and Jump To Print Message 19

LDA R9
APPENDIX A-6
SHEET 11 OF 13

LBZ
Set Address and Jump To Print Message 20
LDA R9

LBZ
Set Address and Jump To Print Message 28
LDA R9

LBZ
Set Address And Jump To Print Message 21
LDA R9

LBZ
Set Address And Jump To Print Message 29
LDA R9

LBZ
Set Address And Jump To Print Message 22
LDA R9
LBZ
Set Address And Jump To Print Message 23
LDA R9
LBZ
Set Address and Jump To Print Message 24
LDA R9
LBZ
Set Address and Jump To Print Message 25
Set R9 = 4003
Set R9 LDFA
OR IRX 03 And 04
OR IRX Reg D And 04
OR IRX Reg D And 05
OR IRX Reg D And 06
OR IRX Reg D And 07
OR IRX Reg D And 08
OR IRX Reg D And 09
OR IRX Reg D And 0A
OR IRX Reg D And 0B
OR IRX Reg D And 0C
OR IRX Reg D And 0D
OR IRX Reg D And 0E
OR IRX Reg D And 0F
OR IRX Reg D And 10
OR IRX Reg D And 11
OR IRX Reg D And 12
BZ

Set Address and Jump To Print Message 33

Auto/Man

Branch Into Test Select Loop

Branch To Head Test
APPENDIX A-7

SAMPLE ASSEMBLER LISTING FOR TESTS
APPENDIX A-7

DATA ANALYSIS

SAMPLE ONLY

```
0000 0
0000 1
0000 1
1300 F812B31
1803 F807A31
1806 D31
1807 1
1807 F81FB901
180B F866A01
160E F840B21
1311 A21
1812 D01
1813 1
1813 D483EE181A302E:0014 SEP P4,*83EE,*A++4) BR HOP1
181A 5354415254204401:0015 T START DATA ANALYSIS,**8A
1821 415441204144E1:0015
1828 4C59349538A1:0015
182E 6CFA081
1831 3A461
1833 F844B11
1836 F845BA1
1839 F800A8A1
183D EB1
183E 721
183F 5A1A81
1842 F8001
1844 3A3E1
1846 F8DI9A1
1849 D91
184A 2BF311
184D 5R1
184E F845B1
1851 F801A81
1855 F8A51
1857 3A631
1859 72FB851
185C 3A631
185E F808A51
1861 32CE1
1863 1
1863 DD41
1865 F83E183E30801:0041 *83EE,*A++4) BR HOP2
186B 44415441204E4F1:0042 T DATA NOT SAVED SIDE ++0R0
1872 54205341545441:0042
1879 20534494520441:0042
1880 D483EE40ED1:0043 HOP2: SEP P4,*83EE40ED .. FROM WRITE PAD
1885 D0483EE1888D304:0044 PNT21 SEP P4 SEP P4,*83EE,*A++4) BR HOP3
188C A81
188D 44415441204E4F1:0045 T DATA ANALYSIS TEST ABDOT ++0AA8A
1894 414C5553453201:0045
189B 5445534204421:0045
18A2 4F52540A8A1:0045
18A3 6BFA041:0046 HOP3: IMP 3 ANI=04 .. TEST FOR AUTO/MAN
18AB CAL5861:0047 LBH=MAN
```
1967 0E5245504C414311095 40E,T,PEPLACE CCU 40F0A0A8A
196E 45204343550F0A11095
1975 0A8A1 0095
1977 1 0096
1977 C01851 0097 PNT2 LBR PNT2
197A C0197D1 0098 PNT7: 00C01970
197D 1 0099
197D 1 0100
197D 1 0101 ******DELAY ROUTINE******
197D 1 0102 FOR DELAY BETWEEN PRINT OUTS
197D 1 0103 USES P0 AS PGM COUNTER
197D 1 0104 RETURNS TO R3 CONTROL
197D 1 0105 USES RE AS COUNTER
197D 1 0106 ORG#1F65
1F65 D31 0107 OUTOF: SEP P3
1F66 1 0108 ENTER HEPE>>>>>>>>>
1F66 F8FFBEAE1 0109 M1UPΦ PH_', PE PLO PE
1F6A 2E53A6A1 0110 PLUS: DEC RE GHI PE BNZ PLUS
1F6E 30653 0111 BR OUTOF
1F70 1 0112
1F70 1 0113
1F70 1 0114 ******FIRST ENTRY TO ALL DATA ANALYSIS******
1F70 1 0115 IF PROGRAMME IS RUN IN ISOLATION**
1F70 1 0115 ORG#1CFO
1EF8 671 0116 OUT
1EF9 101 0118 #10 ASSUMES SET UP TO X=P=0
1EFA F82348B5 0119 LDI#B3 PHI R4 PHI R5
1EEF F87A41 0120 LDI#F7 PLO R4
1F01 88FAA51 0121 LDI#FA PLO R5
1F04 C018001 0122 #:C01800
1F07 1 0123 END
0000

? F,H,L,V=
APPENDIX A-8

SENSOR TEST FLOW DIAGRAM
Start

UV Sensor Test Selected

Yes

Set Address And Print Message 2 Set Address And Print Message 36
DIS INT

Set Interrupt Sub-Routine Address 21
Clear Registers Used To Count Pulses ie R3-R8
Fire Emitters Side 1
Set Q = 0 Enable Interrupt Store F1 in Loc 4013

Part 2 Of Head Test

Switch Off Emitters Side 1
Switch Off Emitters Side 2
Transfer Conts. Of Register to RAM

Clear Head Counter ie R9 = XX00

Point RB To Assemble Message Area RB=4600
Does Q = 1?

Yes

Assemble Side 2

No

Assemble Side 1

Read Location 4013 via R3 SHL and Store via R3

Is This Head Supposed To Be Printed LBNE?

Yes

Do BCD Conversion

INC Head Counter i.e. R9

Assemble UV Head

INC Printable Counter i.e. R7 Add #30 And Assemble

Assemble # of Pulses

No

Move To Next Set Of Sensor Pulses

Have Done 8 Heads

Yes
Point R 4 To CALL RTN
Point R 5 To RETURN RTN
Set Address To Print
Messages Assemble

Does Q = 1?

System A or B

Set R To Int Address
Clear Reg R 3 To R 8
Fire Emitters On Side 2
Set Q = 1
Enable Interrupt Store
EI In Loc 4013

Set To Address And Jump
To Print Message 40

Auto/Man

Man

Auto

Set Address And Branch
To Do Parametric Test

Set Address And Branch
To Manual Loop

APPENDIX A-8
SHEET 3 OF 3
(SENSOR TEST)
Start

Save Present Status
  ie DF D etc

Is
Q = 1?

Read Pulse Side 1

Test if Fwd
Consecutive Pulses

Head 1
Fired

Add 1 to Counter 1
  ie R3

Head 2
Fired

Add 1 To Counter 2
  ie R4

Head 3
Fired

Add 1 To Counter 5
  ie R5

Head 4
Fired

Read Pulse Side 2

Yes

No

Yes

No

Yes
APPENDIX A-8
SHEET 2 OF 2
(INTERRUPT SUBRTN)

Add 1 To Counter 4
e R6

Head 5
Fired
Yes

Add 1 To Counter 5
e R7

Head 6
Fired
Yes

Add 1 To Counter 6
e R8

Head 7
Fired
Yes

Add 1 To Counter 7
e R9

Head 8
Fired
Yes

Add 1 To Counter 8
e RA

INC 10 Sec Counter
e RB

Are 10
Secs Up?
Yes

Set RO To Part 2 Of
10 Sec Test

No

Restore Saved Status

Jump Out Of INT To PGM
Pointed By RO

Long Branch To Part 2 Of 10 Sec Test
APPENDIX A-9

Yes

Is 350v line side 1 OK?

No

Print "350v SIDE 1 FAILED"
Set Q=1

No

Is Q=1

Print "TEST ABORT"

Auto / Man

Auto

Man

Long Branch To Manual Loop

Do Emitter Test
EMITTER TEST

START

Set RC=0000
RD=0000, RE=0000,
RF=0000, Reset Q=0

System Aor B

A

Release Reset of
C.C., i.e., Set to X R3
Out 7#54

Jump To
Subrtn 2

Jump To
Subrtn 2

Jump To
Subrtn 2

Print "Emitter Failure1
TEST, ABORT"

Auto / Man

Auto

Cont. pg. V

Long Branch To
Manual Loop.
APPENDIX A-9

Return From Subrtn 2
ie When GSE 2=High

Yes

is Q=1

No

is GSE 2 Side 2 High

Yes

Inc. RF GHI RF

No

D=80 ie 167ms

Yes

Print "Emitter Failure 2 TEST ABORT"

No

Inc. RD Subrtn 2

Inc. RD Subrtn 2

Inc. RD Subrtn 2

Inc. RD Subrtn 2

Inc. RD Subrtn 2

Inc. RD Subrtn 2

Inc. RD Subrtn 2

Auto / Man

Man

Auto

Print "Emitter Failure 3 TEST ABORT"

Reset Q=0

Auto / Man

Man

Auto

Long Branch To
Manual Loop

Cont. pg V

148
Return From Subrtn 1 (when GSE 2 Side 1 HIGH):

- **Q = 1**
- **GSE 2 Side 1 HIGH**

**Inc RE GHI RE**

- **No** (i.e., GSE = 80, i.e., 167 ms)
  - **Yes**
    - **Print "Emitter Failure 6 TEST ABORT"**
    - **Auto / Man**
    - **Long Branch to Manual Loop**

**Man**

**Auto**

**Set Q = 1**

**Inc RC Subrtn 1**

**Print "Emitter Failure 7 TEST ABORT"**

**Man / Auto**

**Long Branch to Manual Loop**
SUBRTN 1

ENTRY POINT

Exit To Main PGM

Set RB=0000

ISGSE2 Side1High
   Yes
   Jump To Main PGM at Point XX or YY
   No
   Inc GHI RB RB

Yes
   D=FF
   No
   GLO RB

No
   D=FF
   Yes

FOR SUBRTN 2, REPEAT ABOVE EXCEPT CHANGE ALL REFERENCES OF SIDE 1 TO SIDE 2. ALSO CHANGE POINT XX TO YY

FOR ASSEMBLY LISTING AND OBJECT CODE
SEE APPENDIX A-7
APPENDIX A-10

FUNCTIONAL TEST FLOW DIAGRAM
Start

Is Functional Selected? Yes

Point R2 To Free RAM (ie R2 = 4040)

SEX RD

Issue RMTAS Command And Reset CCU

Give & Test 3 Sec Delay Is It Up?

Yes

Hold CCU in Reset Mode (ie Out 7 = 10)

Give 1 Sec Delay

Break GSE4 Line (ie)
Make CCU Run Normally (ie Out 7 = 54) And
Reset CCU

Is GSE2 Side 1 High?

Yes

Give 3 Sec Delay

No

Is Delay of 0.55 Sec Up?

Yes

No

Is 3 Sec Up?

Yes

No
APPENDIX A-10
SHEET 2 OF 13

Read 1/P Port 7 ie
Has Fault Occurred

Has Fault
Occurred?

Yes

Print "Change CCU (XX)" Stop

No

Is Delay of .835
Sec?

No

Print "Change CCU (10)" & Branch To
Data Analysis

Yes

Read 1/P Port 7 ie INP7

Has Fire
Occurred in CCU?

No

Print "Change CCU (11)"
& Branch To Data Analysis

Yes

System
A or B

A

Start Test 1

B

Is GSE2
Side 1
High?

No

Give 0334 Sec Delay

Yes

Fire Heads Side 1?

No

Give 0835 Sec Delay

Yes

Print "CCU Failed ( )"
Branch To Data Analysis

No

Is 0334 Sec Delay Up?

Yes

0334 Sec Delay Up?

Give 0835 Sec Delay

Is 0835 Sec Delay Up?

Read 1/P Port 7
APPENDIX A-10
SHEET 3 OF 13

Has CCU Issued A Fire?

Switch Off Heads Side 1

Test 2

Is GSE2 Side 2 High?

Give 0334 Sec Delay

No

Is 0334 Sec Delay Up?

Yes

Print "Change CCU ()" Branch To Data Analysis

No

Fire Heads Side 2

Give 0835 Sec Delay

Is 0835 Sec Delay Up?

Yes

Read I/P Port 7

Has CCU Issued Fire?

Print "Change CCU ()" Branch To Data Analysis

No

Switch Off Heads Side 2

Test 3

Set R7 = 08FC
Set R8 = 403F
Set R9 = XX00

LDN R7
STR R8

Is GSE2 Side 1 High?

Give 0334 Sec Delay

157
Is 0334 Sec Delay Up?

Print "Change CCU ( )" Branch to Data Analysis

Switch Heads Side 1

Read A/C Configuration
  i.e. LDN R8 INC R9 SHL STR R8

Is DF Set Is This Head Supposed To Fire?

Yes

Read Head No. i.e LDN R9

SM1 #01

Is D = 0? LBZ

Yes

Fire Head 1 Side 2

No

SM1 #01

Is D = 0? LBZ

Yes

Fire Head 2 Side 2

No

SM1 #01

Is D = ? LBZ

Yes

Fire Head 3 Side 2

No

SM1 #01

Is D = 0? LBZ

Yes

Fire Head 4 Side 2

No

SM1 #01

Is D = 0? LBZ

Yes

Fire Head 5 Side 2

No

SM1 #01
Give 1 Second Delay

Is 1 Second Up?

Read 1/P Port 7

Has CCU Issued Fire?

Print "Change CCU ( )" Branch To Data Analysis

Reset Head(s) Side 1 & 2

Give 1 Second Delay
Read Head No. ie LDN R9

Is D = 0?
LBZ

Yes

Is D = 0?
LBZ

Yes

Is D = 0?
LBZ

Yes

Is D = 0?
LBZ

Yes

Is D = 0?
LBZ

Yes

Is D = 0?
LBZ

Yes

Is D = 0?
LBZ

Yes

SM1 #01

Yes

Fire Head 1 Side 1

Fire Head 2 Side 1

Fire Head 3 Side 1

Fire Head 4 Side 1

Fire Head 5 Side 1

Fire Head 6 Side 1

SM1 #01

No

SM1 #01

No

SM1 #01

No

SM1 #01

No

SM1 #01

No
Fire Head 3 Side 1
Fire Head 2 Side 2

Jump To SUBRTN 1
ie SEP R1

Reset Heads Both Sides

Jump To SUBRTN 1
ie SEP R1

Fire Head 4 Side 1
Fire Head 8 Side 2

Jump To SUBRTN 1
ie SEP R1

Reset Heads Both Sides

Jump To SUBRTN 2
ie SEP R2

Fire Head 8 Side 1
Fire Head 4 Side 2

Jump To SUBRTN 1
ie SEP R1

Reset Heads Both Sides

Jump To SUBRTN 2
ie SEP R2

Test 6

Point R9 to 4080
Fire Head 1 Side 1
FireHead 3 Side 2
Give 1 Sec Delay

Is Fire Indicated?

Yes

No

164
INC R4
Reset Heads Both Sides
Fire Head 4 Side 1
Fire Head 2 Side 2
Give 1 Sec Delay

Is Fire Indicated?

Yes

Print Result & Failure Messages & Jump To Data Analysis POM

No

INC R9
Reset Heads Both Sides

Test 7

Hold CCU In Reset Mode
R5 = SUCHTM To Fire Heads To Fail CCU Due To Adjacency Failure

R4 = Adjacency Failure
Head Firing Sequence
Set RF(0) = 03
Reset Heads Both Sides
DLC RF
Do RAM Test & Set RTN
Hold CCU In Reset Mode
Give 4 Sec Delay
Allow CCU To Run In Normal Mode
Fire Heads 3, 4, & 8 (During 2nd & 3rd Loop Fire Heads 1, 4 & 3 And 1, 2 & 3 Respectively)
Give 3 Sec Delay

Is Fault Indicated?

No

Label Fail

Yes

INC R9
Hold CCU In Reset Mode

Reset Q Hold CCU In Reset Mode
Branch Back To Main PGM

Is System A or B?

A

Read GSE2 Side 2 AMI #10

# 0

BNZ

Fire Heads Side 2

Read GSE2 Side 2 AMI #10

= 0

BZ

# 0

Reset Heads Side 2

Read GSE2 Side 1 AMI #40

# 0

BNZ

Fire Heads Side 1

Read GSE2 Side 1 AMI #40

= 0

BZ

# 0

Reset Heads Side 1
APPENDIX A-11

DATA ANALYSIS FLOW DIAGRAM
APPENDIX A-11

Syntax:

START (1) (2) INTO SCART CH (USE LEVEL COUNT)
CONVERT (1) (2) TO RED FROM, APPLY ZERO BLANKING
RESULT, STORE RESULT IN DATA AREA OF SCART PAD
PRINT LINE FROM SCART PAD

SYSTEM A?

Y = SET?

N = SET OFF TO GET DATA FROM PDL 2

PRINT TO SECOND PDL LEVEL DATA

NEXT WRITE SCART PAD
DECODE AND WRITE RED DATA FROM RECEIVED DATA AREA TO SCART PAD
CALCULATE TIME OF EVENT RELATIVE TO PVT ORIGIN, WRITE RESULT (WITH SIGN)
CONVERT RESULT TO MINUTES AND CONNECT TO PVD (ZERO BLANKING, STORE RESULT)
CONVERT NUMBER OF LEVEL COUNT TO RED
APPLY ZERO BLANKING, STORE RESULT IN HOLE AREA SCART PAD
PRINT SCART PAD TO PRINTER

END OF LEVELS COMPLETE

COMPLET

FROM DATA

PRINT "END OF DATA ANALYSIS"

MANUAL MODE

RETURN TO MANUAL LOOP

PRINT "END OF ALL TESTS"

SYSTEM INTEGRITY CONFIRMED

REMovable PARING

Loop
APPENDIX A-11

LOAD HIGH END SEARCH PAD ADDRESS TO REGISTER

SINCE ASCII CODE CONFLICT EXISTS WITH NON-ASCII CODE?

ALL MEMORY LOCATIONS FILLED WITH ASCII CHARACTERS?

STICK HEAP AND/OR AT MIDDLE OF LINE

EXIT

RETURN TO CONFLICT CASE
EXIT FROM PRINT SUBROUTINE CHARACTERS

WHEN A STRING FINDS

GET UP TO DETECT END OF STRING

GET NEXT UNMATCHED CHARACTER

IS IT CODE?

IS NEW NON-ASCII CHARACTER

ASCII STRING FOUND TO ASCII

STICK RESULT IN MIDDLE SEARCH PAD ACCORDING TO PRINT?

ALL CHARACTER PRODUCED?

IS NON-ASCII CHARACTER DETECTED?

MARKER = ZERO?

STICK ASCII ZERO AT LOW MIDDLE SEARCH PAD LOCATION

EXIT
GRAVIERE
ADVANCED FIRE DETECTION
SYSTEM

OPERATION and MAINTENANCE MANUAL
Number MK.095

June 1980 (Revised Oct. 81)
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CHAPTER 1
INTRODUCTION

The Graviner Advanced Fire Detection System uses micro-processor controlled ultra-violet sensors to provide a very high level of detection validity even against a background of bright sunlight.

The equipment is used to detect fires in aircraft engine nacelles, and two systems are provided. System A is mounted on the left side and has dual sensor heads and dual micro-processors to give a high level of 'cross-checking' under fire conditions, and to give continued valid operation even if one or more items in the system fail. System B is mounted on the right side and has single sensor heads and a single micro-processor.

Both systems comprise up to eight detector heads (five installed in F111), a Computer Control Unit (CCU), and share a common Crew Warning Unit (CWU). In addition, a Ground Support Equipment (GSE) is used for pre-flight and post-flight checks.

Features include continuous self-checking of the sensors and the processors plus both a FAULT and a FIRE indicator on the CWU. If self-checks indicate that a system will not be able to satisfactorily indicate a fire, the FAULT indicator illuminates, warning the operator. A FIRE indication will not be given if there is a fault in the system.
ADVANCED FIRE DETECTION SYSTEM

FIG. 1-1 UNITS OF EQUIPMENT
CHAPTER 2

ABRIDGED SPECIFICATION

Response

The system indicates a fire when a detector head is exposed to a fire for 1 second or more. Full sunlight falling on the sensor does not affect its sensitivity.

Sensor Failure

System A: Both sensors in a detector head have to fail before a fault warning is given, and if the sensors are part of an adjacent pair, then a fault warning will not be given until all four sensors have failed.

System B: A fault warning is only given if the sensor that fails is the only one covering a fire area.

Detector Heads

Each detector is sealed against contamination and can withstand up to 260°C for an indefinite period. The connector has a life expectancy of 1000 hours at this temperature.

Computer Control Unit

Monitors up to eight detector heads continuously and actuates the Crew Warning Unit. Has the ability to bypass faulty sensor inputs and in type A systems to maintain processing using one channel if one of the dual processing systems fail.

Crew Warning Unit

Provides warning lamps and test buttons for use by the aircrew.

Ground Support Equipment

Portable unit to automatically access stored data from the aircraft and to check out the system.

Power Requirements

System A: 102-124V, 380-420Hz at 300mA Max. 16-29V d.c. at 230mA max. for CCU plus 15mA for CWU.

System B: 102-124V, 380-420Hz at 150mA max. 16-29V d.c. at 250mA max. for CCU plus 15mA for CWU.

GSE: Obtains supplies from aircraft, but 16-29V d.c. at 20mA required for bench recharging of internal battery.
ADVANCED FIRE DETECTION SYSTEM

Dimensions and Weight

CCU: 285mm deep, 198mm high, 115m wide nominal (11.1 x 7.8 x 4.5 in.). Weight
system A = 3.72kg (8.2 lb), system B = 
3.3 kg (6.04 lb).

Head, System A: 105mm wide, 60mm high,
75mm deep (4.2 x 2.4 x 3 in.). Weight = 
0.19kg (0.42 lb) each.

Head, System B: 70mm wide, 60mm high,
75mm deep (2.76 x 2.4 x 3 in.). Weight = 
0.11kg (0.24 lb) each.

CwU: 146mm wide, 47mm high, 119mm deep
(5.75 x 1.85 x 4.7 in.). Weight = 0.65kg 
(1.37 lb). Unit is shared by both systems.

GSE: 385mm deep, 465mm wide, 377mm high
(15.16 x 18.31 x 14.84 in.). Weight = 
17.77kg (36 lb) including cables.
CHAPTER 3

INSTALLATION CHECKS

Before replacing the engines in the nacelles, proceed as follows:

(1) Check that the wiring has been carried out according to drawing No. 222004. Clean each sensor bulb with metal polish. Avoid touching the bulbs after cleaning.

(2) Fit the Crew Warning Unit and the two Computer Control Units into the aircraft. The thicker cable from the aircraft cable form is connected to system A CCU (Part No. 53813-203).

(3) With the aircraft ground power on, switch on the 115V a.c. and 28V d.c. circuit breakers for the equipment. Check that the FAIL indicators on the CWU do not illuminate.

(4) View the detector heads in each engine nacelle and check that the emitters flash every 15 seconds. Check that when the FIRE DET TEST button is pressed on the CWU in the cockpit the emitter flashing rate increases (2 people needed).

(5) Carry out a full check using the Ground Support Equipment as described in 'Pre-Flight Checks' (5-1).
CHAPTER 4
GROUND SUPPORT EQUIPMENT

The GSE is a portable automatic check-out unit for the aircraft equipment. It performs 3 basic functions; it reads out the stored data gathered during the flight, and it checks the operation of the system and identifies which line replaceable unit (LRU) is faulty.

The flight data is stored in RAM's in the CCU and a battery back-up in system B CCU keeps the RAM data refreshed when the aircraft supplies are switched off. To ensure that the RAM data is not lost when the GSE is connected, a refresh battery is contained in the GSE and is connected to the CCU via cable 1. Note that the GSE must always be connected to system A CCU first and that cable 1 must be connected before the aircraft cable-form is disconnected from the CCU. The cables are stored in the top cover.

To ensure that the RAM refresh battery in the GSE is fully charged, cable 4 is plugged into cable No. 2 socket and the 28V wires in the cable are connected to a bench 28V supply when the GSE is not in use. The battery should be charged for at least 3 hours prior to use. Before carrying out any tests, always verify that the battery is satisfactory by pressing the GSE BATTERY TEST button and checking that the adjacent indicator illuminates. If the lamp does not illuminate, reconnect the GSE to the 28V bench supply.

Always check the quantity of paper on the printer roll. Red lines on the printer show the roll diameter at which the roll should be changed. To load the paper, refer to fig. 4-1 and proceed as follows:

1. Open the viewing window by turning the catches and then hinging the window to the right.
2. Press the Paper Feed Release Button and remove the existing paper.
3. Insert the paper spindle into a new roll of paper (Electro-sensitive) and place the spindle into the slots in the Paper Spindle Bracket. The loose end of paper should come off the bottom of the roll and up towards the operator.
4. Pass the end of the paper down into slot A in the top of the printhead.
5. Feed the paper into slot A while turning the Paper Advance Thumbwheel towards the rear of the printer. The paper automatically cycles through the printhead and out of slot B.
6. Hinge the viewing window to the left and latch into position by turning the two catches.
FIG. 4-1 PAPER THREADING
At any time the paper can be pulled through the printer by holding the Paper Feeder Release Button down.

The GSE will only operate fully when the GSE switch is set to IN. When the switch is set to OUT, the inputs and outputs are isolated from the GSE internal circuits. By reconnecting the aircraft cable form to the CCU, normal operation of the aircraft equipment can be obtained with the GSE still connected to the GSE connector on the CCU.

For standard flight testing, the GSE is operated in the AUTO mode. The MANUAL routine selection position of the keyswitch enables each test to be individually selected, as long as certain rules are observed, as follows:

(1) Turn key switch to Manual.

(2) Depress start button.

**NOTE:** Having printed the opening messages the printer will print:

MANUAL MODE-----------SELECT TEST?-----------'X'

(3) Select DATA READ program. Having read the data printer will print message 'X' again.

(4) Select Control Unit tests. Having performed and printed results the printer will print message 'X' again.

(5) Select UV Head Tests. Having performed and printed results the printer will print message 'X' again.

(6) Select Parametric Test. Having performed and printed results the printer will print message 'X' again.

(7) Select Functional Test. Having performed and printed results the printer will print message 'X' again.

(8) Select Data Analysis Test. Having performed and printed results the printer will print message 'X' again.

(9) Power off and disconnect cables as for AUTO MODE if the above tests are not to be repeated.

The four indicators marked '1, 2, 3, 4' provide additional diagnostic information if a fault develops. They are used only when cable 1 of the GSE is connected (the aircraft cable form is connected straight to the CCU), and the GSE switch is set to IN.
ADVANCED FIRE DETECTION SYSTEM

INDICATOR FUNCTION

1 2  Illuminate alternately at the time sharing rate (each on for 167ms) to show that the time sharing is operational.

3 4  Indicator 3 illuminates when side 1 emitter operates (every 15 seconds) and indicator 4 illuminates when side 2 emitter operates.

The main features of the RAM print-out are identified in fig. 4-2.

In addition to its use when recharging the GSE battery, cable 4 has additional connectors which enables it to be used for a bench check-out of system units. The connections are shown in fig. 4-3.

NOTE: CABLE 4 CAN BE USED TO CONNECT THE 28V SUPPLY ONLY (CWU & DETECTOR HEAD NOT CONNECTED)

FIG. 4-3 CABLE 4 CONNECTIONS
ADVANCED FIRE DETECTION SYSTEM

Indicates valid data follows

Main timer operation code
00 00
Hi Lo

Time of or Error code causing opposite processor shut-down

Time when FIRE DET TEST button was pressed
00 00
Lo Hi

Fire, level 5
00 00 00 00
Lo Hi Store
Time last
Count event

Fire, level 4
00 00
Hi Store last
event
Time

Error code causing self-shut-down

Time of shut down
00 00
Lo Hi

First fire time
00 00
Lo Hi

Adjacency set where 1st fire occurs
00 00
Lo Hi

Background count
00 00 00
Hi Lo head failure

Time of last head failure
00 00
Hi Lo head ref.

Adjacency set of subsequent or last fire

Time when last fire ended
00 00
Lo Hi

FIG. 4: MAIN FEATURES OF RAM PRINT-OUT
CHAPTER 5
OPERATIONAL PROCEDURES

1. Pre-Flight Checks

These checks ensure that the equipment is fully functional before a flight test is started. Proceed as follows:

(1) Switch on the aircraft circuit breakers for the engine fire control system and run the equipment on ground power for 30 minutes; this ensures that the RAM refresh batteries in system B CCU have sufficient charge to hold stored data.

(2) Ensure that the GSE has been on charge for at least 3 hours immediately prior to use. Press the GSE BATTERY TEST button and check that the adjacent indicator illuminates (GSE refresh battery is charged). Check that there is sufficient paper on the printer paper roll. If necessary, replace the roll (see Chapter 4).

(3) Connect the GSE to the CCU of system A (Part No. 53813-203), starting with cable 1 and then connecting as shown in fig. 5-1.

WARNING: WHEN THE AIRCRAFT PLUG IS REMOVED FROM THE CCU, AC POWER IS PRESENT ON THE EXPOSED CONNECTIONS OF THE AIRCRAFT PLUG.

(4) On the GSE set the POWER switch to ON and check that 115v side 1 and 115v side 2 power rail indicators illuminate, noting that with system B only side 1 indicator will illuminate. Set the GSE switch to IN, ensure that the AUTO/MANUAL keyswitch is at AUTO and press the START PROGRAM button. The flight data print-out will be meaningless but will show how many good detector heads are available. Verify that there are no equipment faults indicated on the rest of the print-out.

(5) Reconnect the aircraft cable form to the CCU of system A and repeat the connections and checks of (3) and (4) above for the CCU of system B (Part No. 53813-204).

2. Cockpit Check

With the equipment power on, the following checks must be made prior to a test flight:

(1) Press the FAIL IND TEST button on the Crew Warning Unit (CWU) and check that the left and right FIRE DET FAIL indicators illuminate.
FIG. 5-1 GROUND SUPPORT EQUIPMENT CONNECTIONS

ADVANCED FIRE DETECTION SYSTEM

GSE CONNECTION - FIRST STAGE

GSE CONNECTION - FINAL STAGE

NOTE
ALWAYS CONNECT TO SYSTEM A CCU FIRST.
(2) Press the FIRE DET TEST button and record the time at which it was pressed. Check that the left and right FIRE indicators illuminate.

**NOTE:** The FIRE DET TEST button can be pressed at any time during a flight to check the circuit but the time at which the button is pressed must be recorded on every occasion. This provides the datum time for the stored flight data.

3. In-Flight Operation

If a fire occurs during the flight, the appropriate FIRE button will illuminate (LEFT or RIGHT).

For future analysis, the equipment records the time and sensor inputs for all fire or 'near-fire' events in relation to the time when the FIRE DET TEST button was last pressed.

4. Post-Flight Checks

**CAUTION:** THE FOLLOWING CHECKS MUST BE CARRIED OUT WITHIN A FEW HOURS OF THE AIRCRAFT LANDING. THE TIME IS DETERMINED BY THE CHARGE ON AN INTERNAL BATTERY; IF THE BATTERY DISCHARGES BEFORE THE CHECKS TAKE PLACE, ALL THE FLIGHT DATA WILL BE LOST. WITH A FULLY CHARGED BATTERY THE DATA WILL BE HELD FOR UP TO 8 HOURS BUT FOR SAFETY IT IS RECOMMENDED THAT THE CHECKS ARE MADE WITHIN 2 HOURS OF LANDING.

Proceed as follows:

(1) Remove power from Fire Detection System as follows:
   (a) Break CCU/CWU 28V DC Breaker
   (b) Break AC system A or system B Breakers as appropriate

**NOTE:** System A has two AC Breakers

(2) Ensure that the GSE has been on charge for at least 3 hours immediately prior to use. Press the GSE BATTERY DET button and check that the adjacent indicator illuminates (GSE refresh battery is charged). Check that there is sufficient paper on the printer paper roll. If necessary, replace the roll (see Chapter 4). Set the GSE switch to IN, ensure that the AUTO/MANUAL keyswitch is at AUTO, and that the POWER switch is OFF.

**NOTE:** There is an instruction label on the GSE giving connection and operating information.

(3) Connect cable 1 from GSE socket 1 to the GSE plug on the CCU of system A (Part No. 53013-203).
ADVANCED FIRE DETECTION SYSTEM

CAUTION: TO ENSURE THAT THE STORED DATA IS NOT LOST, SYSTEM 'A' CCU MUST ALWAYS BE CHECKED BEFORE SYSTEM 'B', AND CABLE 1 MUST ALWAYS BE CONNECTED BEFORE THE AIRCRAFT CABLE-FORM IS DISCONNECTED FROM THE CCU.

(4) Complete the connection between the GSE and CCU as shown in fig. 5-1. Note that the aircraft cable form to system A CCU is thicker than that to system B CCU. Make AC Breakers followed by DC Circuit Breakers.

(5) On the GSE set the POWER switch to ON and check that the adjacent power rail indicators illuminate, noting that with system B only one 115V Indicator will illuminate (not side 2). If the indicators do not illuminate check the aircraft circuit breakers.

(6) Press the START PROGRAM button. The GSE will start to print out the stored RAM data. There are two tables of data from system A and one from system B. After the RAM data the GSE will perform a series of tests. If the tests are satisfactory an appropriate print-out will result. If a fault is present, the print-out will indicate which LRU should be replaced. Typical print-outs are shown in fig. 5-2. Total test run time in automatic mode is typically 7½ minutes.

(7) On the CWU (cockpit) press the FIRE DET TEST and then the FAIL IND TEST buttons. Check that the appropriate indicators illuminate.

(8) When the checks on system A have been completed satisfactorily, disconnect the aircraft cable form from the GSE extension cable and reconnect it securely to the A/C PLUG on system A CCU. Disconnect the GSE PLUG cable (cable 1) from system A CCU.

(9) Repeat procedures (2) to (8) for system B (Part No. 53813-204).

(10) After checking and carefully reconnecting both units, carry out a cockpit check of the CWU to ensure that the connections are satisfactory.

/ Note. System B may be checked out in isolation by carrying out procedures (2) to (8) for system B only, however data retained in system A will be lost.
ADVANCED FIRE DETECTION SYSTEM

FIG. 6-2 TYPICAL GSE PRINT-OUTS

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ADVANCED FIRE DETECTION SYSTEM

CHAPTER 6
SYSTEM DESCRIPTION

The units of the system are shown in fig. 6-1, and a simple block diagram in fig. 6-2.

1. Sensors

The sensors used are Graviner developed units which give a signal when exposed to ultra-violet (UV) radiation at frequencies below those in solar radiation; hence they discriminate against sunlight. Within the operating spectrum of the sensor there is still sufficient UV radiation from the flames.

When the sensor operates, an avalanche action occurs and the increase in current is detected at the Computer Control Unit (CCU). The 320V sensor supply is then switched off to allow the sensor to recover, and then switched on again. If the UV sensor avalanches four times or more in three successive 167ms gating periods then a fire condition is computed.

In the dual system (system A), two sensors are mounted on each detector head and are controlled in a time-share arrangement. A fire condition will only be computed if both sensors avalanche four times or more in each of three successive gating periods per side.

In certain parts of the installation two detector heads view the same area. This is termed adjacency, and the processor checks that all sensors covering a particular area give a similar output under fire conditions. The heads which provide adjacency outputs are given in Table 6-1. The outputs of both sides of a detector head and adjacent heads are fed via an AND system to give the greatest certainty of a fire condition. If a fault condition exists in any sensor, the output will change to an OR system so that valid fire warnings will still be given even when up to three of the four sensors (two system A detector heads) covering an area fail. The approximate positions of the sensors in the engine nacelle is shown in fig. 6-3.

<table>
<thead>
<tr>
<th>Fire Area</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor No.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

TABLE 6-1
ADJACENCY

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FIG. 6-1 GRAVIER ADVANCED FIRE DETECTION SYSTEM – F111
FIG. 6-3 APPROXIMATE POSITION OF SENSORS
To ensure that the sensors are operating correctly, each has an adjacent UV emitter which is activated every 15 secs while the equipment is operating. In system A, the side 1 emitters are energised simultaneously and the processor checks the output from every side 1 sensor. The side 2 emitters are then energised and the processor checks every side 2 sensor. If a sensor is found to be faulty, the processor arranges to disregard its output when computing a fire condition.

2. **Computer Control Unit (System A)**

The CCU contains two microprocessor systems each with their own power supplies. Each processor controls one sensor in every dual detector head but each is interconnected so that the fault status of the sensors, the processors themselves, and the associated electronics can be verified. The power supplies are completely separate so that if one fails half the system is still available to detect fires.

The CCU operates in a continuous series of 167ms periods, as indicated in fig. 6-4.

A random access memory (RAM) keeps a record of all sensor 'counts' (number of gate periods in which 4 or more avalanches took place), sensor and processor status, etc. To retain the information when the aircraft supplies are switched off, a rechargeable RAM refresh battery is contained in the CCU of system B which supplies the two RAM's in system A and the one in the system B CCU.

3. **Computer Control Unit (System B)**

The CCU contains a single microprocessor only. However, it will take note of adjacency conditions (table 6-1). The same self-checking facilities are incorporated as in system A.

4. **Crew Warning Unit**

The CWU has FIRE and FAULT indicators for two installations (system A, LEFT engine and system B, RIGHT engine). In addition, it has test buttons for both the FIRE and FAULT indicator circuits.

5. **Ground Support Equipment**

The GSE is connected into the aircraft system by cables. It provides an automatic print-out of the RAM contents so that the time of a fire, the number of fires, etc, can be quickly ascertained. The RAM also provides a mass of other data which will be used as an aid to future designs. The GSE is also used to give a comprehensive check-out of the aircraft equipment. These include a CCU test, a sensor test, a parametric test (power supplies, etc), a functional test, and finally a data analysis. The print-out indicates when tests are satisfactory and also identifies failures down to LRU level.
FIG. 6-4 TIME SHARING
ADVANCED FIRE DETECTION SYSTEM

FIG. 6-5 FRONT PANEL LAYOUT.
MAINTENANCE

1. Detector Heads

Each time that an engine is removed from the aircraft, inspect and clean all the detector heads (both sensors and emitters) in that nacelle with metal polish.

If a sensor fault is indicated, before replacing the appropriate detector head, check for cleanliness. When a head has been either cleaned or replaced, repeat the GSE check to ensure that the sensor is operational and there is no wiring fault.

After 1000 flying hours, the detector heads should be replaced.

2. Crew Warning Unit

Replace the indicator lamps in the CU periodically according to the aircraft maintenance schedule.

3. Ground Support Equipment

If the battery test indicator does not illuminate when the button is pressed and the GSE has just been on charge, check the battery indicator.

Periodically connect one end of cable 4 to cable No. 2 socket and the appropriate wires at the other end to 115V a.c. and 28V d.c. bench supplies. Set the POWER switch to ON and check that the appropriate indicators illuminate.

A partial indication that Ground Support Equipment is functional may be obtained by pressing and releasing the start program button on the GSE front panel.

The printer should respond with the message:

SYSTEM B
NO GSE - CCU PATH
CHECK CABLE 1 OR REPLACE CCU
TEST ABORT.