EI

8-channel flow monitor & flow computer

TCS
TCS
TCS
TCS

system

6000

6436
6437

technical
manual

6436 & 6437

EIGHT-CHANNEL FLOW MONITOR & FLOW COMPUTER

TECHNICAL MANUAL

Date : Nov 87

Issue: 1; Rev B

Part No: HA 076904 U003

Turnbull Control Systems Limited
Broadwater Trading Estate Worthing Sussex BN14 8NW
Telephone Worthing (0903)205277
Telex 87437

CONTENTS

SECTION		PAGE
1	General Description	1.2
1.1	Introduction	1.2
1.2	Features and General Description	1.2
1.3	Mechanical Structure	1.6
1.3.1	Rack-Mounting	1.8
1.3.2	Bin-Mounting	1.8
1.3.3	Panel-Mounting	1.8
1.3.4	Universal Packaging System	1.8
1.4	Daughter Board Functional Descriptions	1.8
1.4.1	Front-Panel Board	1.8
1.4.2	Central Processor Board	1.11
1.4.3	Memory Board	1.11
1.4.4	Analogue Processor Board	1.12
1.4.5	Input/Output Boards	1.13
1.4.6	+5V Power Supply Board	1.14
1.4.7	+12V, -5V, -12V Power Supply Board	1.14
1.4.8	Fuse Board	1.14
1.5	Technical Specification	1.15
1.5.1	Operator Displays	1.15
1.5.2	Operator Controls	1.16
1.5.3	Analogue Inputs	1.19
1.5.4	Analogue Outputs	1.20
1.5.5	Pulse Inputs	1.21
1.5.6	Digital Inputs (6437 only)	1.22
1.5.7	Digital Outputs	1.22
1.5.8	Flow Calculation Characteristics	1.23
1.5.9	Flow Totalisation Characteristics	1.25
1.5.10	Power Supplies	1.26
1.5.11	Communications	1.27
1.5.12	Physical Specification	1.29
1.6	Order Sheet	1.30

CONTENTS

SECTION PAGE

2 Installation 2.1

2.1 General Requirements 2.1

2.2 Power Supply Connections 2.3

2.3 Internal Switch Settings 2.3
  2.3.1 Memory Isolation Plug 2.3
  2.3.2 Analogue I/O Processor Board Internal Status Switches 2.5

2.4 Plant and Other External Connections 2.8
  2.4.1 Power Supplies 2.8
  2.4.2 Pulse Input 2.8
  2.4.3 Analogue Inputs 2.8
  2.4.4 Analogue Outputs 2.9
  2.4.5 Digital Outputs 2.9
  2.4.6 Serial Data Bus 2.9

2.5 Instrument Power-up Sequence 2.10
  2.5.1 Power-up from Initial Unprogrammed State 2.10
  2.5.2 Power-up from a Previously Programmed State 2.10
  2.5.3 Indication of Power-up 2.10

2.6 6436/7 Hardware Diagnostic Facilities 2.11
  2.6.1 Watchdog Timer 2.11
  2.6.2 Standby Battery Check 2.12
  2.6.3 Instrument Diagnostic Messages 2.15

2.7 Use of the 6436/7 with 4-20mA Input Signals 2.24

CONTENTS

SECTION		PAGE
3	6436/7 Functions and Applications	3.2
3.1	Functional Overview	3.2
3.1.1	Input Conditioning	3.3
3.1.2	Flow Rate Calculation	3.3
3.1.3	Alarm Condition Calculations	3.4
3.1.4	Totalisation Calculation	3.4
3.1.5	User Background Program	3.5
3.2	Input Signal Processing	3.5
3.2.1	Input Filtering	3.6
3.2.2	Input Linearisation	3.6
3.2.3	Input Ranging	3.6
3.2.4	Input Signal Default Values	3.8
3.3	Flow Rate Calculation	3.8
3.3.1	Flow Rate Calculation General Considerations	3.9
3.3.2	Orifice Plate Metering	3.20
3.3.3	The Gilflo Meter	3.23
3.3.4	Turbine Meter	3.25
3.3.5	Further Use of the Flow Rate Calculation	3.27
3.4	Alarm Routine	3.29
3.4.1	Introduction	3.29
3.4.2	Entering Alarm	3.29
3.4.3	Leaving Alarm	3.29
3.4.4	Disabling Alarms	3.30
3.4.5	Manual/Automatic Alarm Acknowledge	3.30
3.4.6	Alarm Displays	3.30
3.4.7	Alarm Outputs	3.30
3.4.8	Alarm Information Access via Serial Data Link	3.30
3.5	Flow Rate Totalisation	3.31
3.5.1	General Considerations	3.31
3.5.2	The Displayable Total	3.32
3.5.3	Pulse Output Totaliser	3.34
3.6	Software Structure	3.36
3.6.1	The Data Base	3.36
3.6.2	Flow Calculation	3.36
3.6.3	Programming	3.37
3.6.4	The System Tasks	3.37
3.6.5	Forth Words Specific to the 6437	3.40

CONTENTS

SECTION		PAGE
4	Programming the 6436/7 via the Hand Held Terminal	4.2
4.1	Programming Terminal Characteristics	4.2
4.2	Parameter Entry Procedures	4.4
4.2.1	Terminal Initialisation	4.4
4.3	Instrument Command Parameters	4.6
4.3.1	Functional Description	4.6
4.3.2	Format Details	4.8
4.4	Channel Selection Parameter (CN)	4.16
4.5	Channel Command Parameters	4.17
4.5.1	Functional Description	4.17
4.5.2	Format Details	4.24

CONTENTS

SECTION		PAGE
5	Computer Supervision of 6436/7 Flow Computer	5.1
5.1	Serial Data Bus Hardware Installation	5.1
5.2	Serial Data Transmission	5.1
5.3	Communication Protocol	5.2
5.3.1	ASCII Protocol	5.2
5.3.2	Binary Protocol	5.6

LIST OF ILLUSTRATIONS

FIGURE	TITLE	PAGE
1.1	6436/7 Flow Monitor/Computer Hardware Schematic Block Diagram.	1.1
1.2	6436/7 Flow Monitor/Computer Internal Structure.	1.3
1.3	6436/7 Flow Monitor/Computer Fascia Diagram.	1.7
2.1	Plan View of 6436/7 with Internal Switches shown.	2.1
3.1	6436/7 Flow Monitor/Computer Data Movement	3.1
3.2	6436 & 6437 Software Functional Overview	3.34
4.1	Hand-held Terminal Keyboard Layout.	4.1
D.1	Relationship Between Current and Historic Alarms (AC and AH).	D.1
E.1	Compressibility Factors of Mean Bacton Gas	E.2

LIST OF TABLES

TABLE	TITLE	PAGE
1.1	Daughter Board Edge Connector Characteristics.	1.5
1.2	I/O Daughter Board Types and their Corresponding Board Identities.	1.9
1.3	Order Sheet.	1.28
2.1	Analogue I/O Processor Board Internal Status Switches S1 and S2 Functions.	2.4
2.2	RS422 Supervisory Serial Data Link Baud Rate Selections.	2.6
2.3	Diagnostic Messages and Fault Recovery Procedures.	2.13/14
3.1	Analogue Board Output Select (FP Bits 1,2)	3.15
3.2	Transducer Type (Digit B of FP)	3.16
3.3	Density Correction Select (Digit C of FP)	3.18
3.4	6437 FORTH Words	3.39
4.1	List of Command Parameter Data Formats.	4.3
4.2	List of Instrument Command Parameters and their Respective Mnemonics.	4.5
4.3	Analogue Output Board	4.7
4.4	Digital Output Board	4.7
4.5	Board Identities	4.9
4.6	Relationship Between the Transmitted UID and the Channel Accessed For two 6436/7 Instruments with the same Group Address.	4.12
4.7a/b	List of Channel Command Parameters and their Respective Mnemonics.	4.14/15
4.8	Binary Numbers and their Hexadecimal Equivalents.	4.24
4.9	List of the Available Input Channel Processing Functions.	4.25
4.10	List of Input Filter Time Constant Values.	4.25
4.10.1	Analogue Board Output Select (FP Bits 1,2)	4.26
4.11	FP Parameter Transducer Type Selection.	4.27
4.12	Density Correction Select Digit C.	4.28
4.13	Decimal Point Selection.	4.29
4.14	Borrowed Output Channel Selection (FL) Digit D	4.30
5.1	List of 6436/7 Parameter Mnemonics [C1 C2] for ASCII Protocol and Hand Held Terminal.	5.4
5.2	List of 6436/7 Parameter Numbers [PNOs], and their Respective Mnemonics for Binary Protocol.	5.5

APPENDICES

APPENDIX	TITLE	PAGE
A	Rear Connector Pin Functions	A.1
B	7600 Bin System	
	B6436 Rear Termination Assembly	B.1
	B6437 Rear Termination Assembly	B.3
C	7900 Single or Multi-way Sleeve Assembly for Microprocessor-Based Instrumentation.	C.1
	7436 Flow Computer Rear Termination Assembly.	C.7
	7437 Flow Computer Rear Termination Assembly.	C.13
D	Relationship Between 6436/7 Current and Historic Alarms (AC and AH).	D.2
E	Flow Rate Calculation Derivations.	
E.1	Orifice plate metering	E.1
E.1.1	Mass Flow Rate	E.1
E.1.2	Volumetric Flow Rate	E.1
E.1.3	Gas Density, Compressibility Factors	E.1
E.1.4	Finding the Density	E.4
E.1.5	Referenced Volumetric Flow Rate	E.5
E.2	Turbine Metering	E.7
E.3	Reference Conditions	E.7
F	Second Order Approximation Density Calculation Derivation	
F.1	Introduction	F.1
F.2	Basis of Method	F.1
F.2.1	Liquids	F.1
F.2.2	Gases and Steam	F.2
F.3	Calculation of Constants	F.3
F.3.1	Liquids	F.3
F.3.2	Gases and Steam	F.4
G	Example Set-up Sheet - 6436	G.1
	Example Set-up Sheet - 6437	G.2
H	Software Revision History	
	6436 Parameter Tables - Revision History	H.1
	6437 Parameter Tables - Revision History	H.2

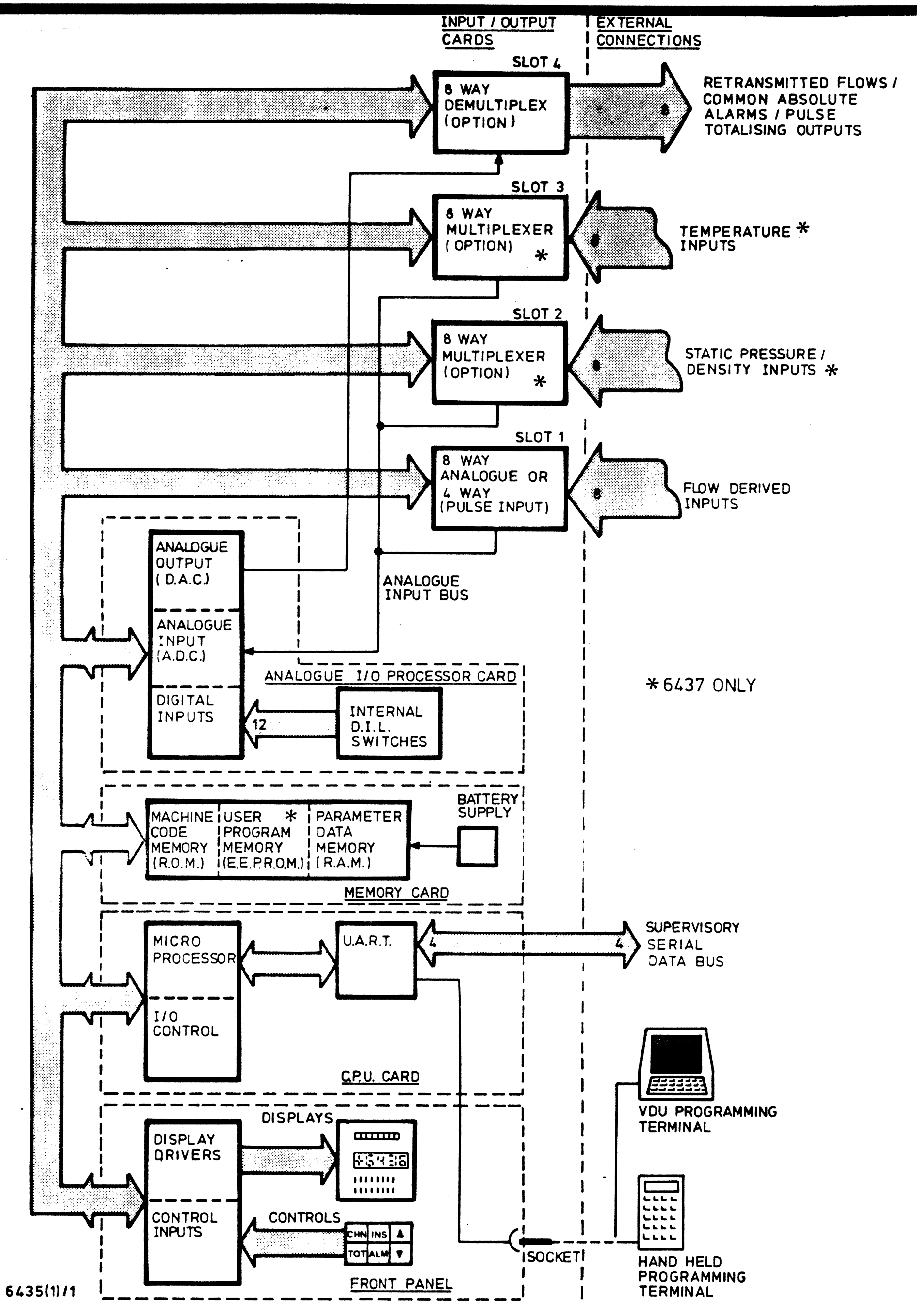


FIG.1.1 6436/7 FLOW MONITOR/COMPUTER HARDWARE SCHEMATIC BLOCK DIAGRAM

Section 1 GENERAL DESCRIPTION

1.1 Introduction

Model 6436 Flow Monitor and 6437 Flow Computer are fully compatible, both electrically and mechanically, with the Turnbull Control Systems Matric 6000 Range of modular control and instrumentation equipment.

As Systems components they plug directly into the model 7000 Rack unit or 7600 Bin unit for plant installation and integrate with the full capabilities of the range which includes modules for signal conditioning, actuator driving and centralised monitoring and control facilities.

The 6436 and 6437 instruments are also available housed within a 72mm DIN compatible sleeve for front of panel mounting in those applications where this is a requirement (See Appendix C).

The main difference between the 6436 and 6437 are:-

1) The 6436 has one input and one output slot, and is ideal for calculating simple uncompensated flow rates, using the calculation forms built into the instrument and selected via the hand held terminal. The 6437, on the other hand, can perform fully compensated flow calculations using Slots 2 and 3 (Fig 1.1) for optional pressure/density and temperature inputs. There is a choice of 32 standard calculation forms available in the 6437.

2) The 6437 implements a version of the programming language FORTH*. This allows the running of special user flow equations and powerful control programs not needed for the less complex applications intended for the 6436.

* FORTH is a registered trademark of FORTH INC.

Throughout this manual, the term '6436/7' is used when the information applies equally to both instruments. Otherwise, the individual model numbers are quoted specifically.

It is possible to upgrade a 6436 to a 6437, by changing the memory card, and by fitting extra input cards as required. These modifications must be carried out by TCS engineers.

1.2 Features and General Description

The features of the 6436/7 instrument are best described with reference to the schematic Block Diagram shown in Fig 1.1. It can be seen that the hardware structure is such that each of the instrument's separate functional blocks, namely:-

Front Panel Displays and Operator Controls,
Analogue Input/Output signals and
Digital Output signals

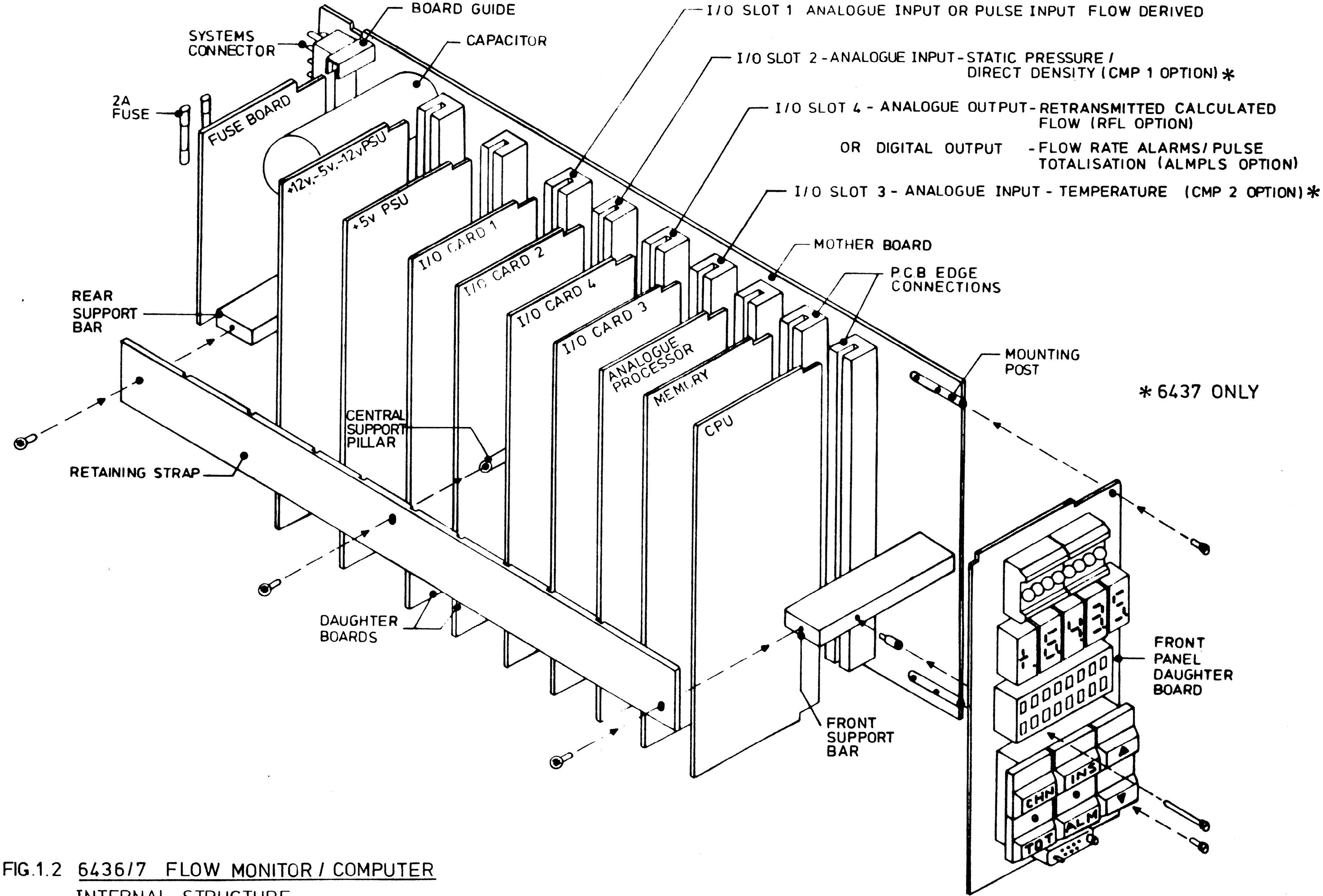


FIG.1.2 6436/7 FLOW MONITOR / COMPUTER INTERNAL STRUCTURE

6435(2)/2

are implemented as separate hardware blocks. Each of these functional blocks communicates with the Central Processor Unit (CPU) which controls the overall operation of the unit via the internal communication busses shown. The CPU itself contains the microprocessor which is the intelligent 'heart' of the device and it in turn has to communicate with a Memory block which stores the necessary set of calculation programs together with all the calculation parameters.

The Front Panel contains all the indicators and displays necessary to allow an operator to monitor any one of 8 Flow Lines. It also has six control push-buttons which allow the operator to display the calculated flow rate, the flow total or any of the analogue input signals used to calculate the flow rate. A socket is provided on the front panel for connection of the 8260 hand-held programming terminal (HHT) used to set up the flow rate calculation characteristics.

The 6437 has a resident 'question-and-answer' configuration program (CONFIG). This allows complex configurations to be set up easily, using a VDU terminal or computer plugged into the front panel socket. The HHT is best kept for simple configurations and to alter parameter values initially set up via CONFIG. The 6437 FORTH facility also allows special flow equations to be programmed, by the customer or by TCS.

Access to all the calculation parameters for monitoring or updating purposes is also possible by means of a second communication channel, intended for computer supervisory use, available via the rear connector.

The analogue inputs and outputs signal range is 0-10V but any analogue input can be programmed to accept a 1-5V range signal. When the AN-IN option is specified, the 6436/7 is fitted with an 8-Way analogue input card in slot 1 providing each flow monitoring channel with an input for the flow dependent (primary) variable, derived from the flow measuring element e.g. differential pressure across an orifice plate.

The pulse input signal ranges are 0-15V but can accept inputs down to 5V. When the PULSE-IN option is specified, the 6436/7 is fitted with a 4-Way pulse input board in slot 1. This provides the first four flow monitoring channels with an input from the flow dependent (primary) variables, derived from the flow measuring element e.g. frequency from a turbine meter.

The pulse input board, fitted when the PULSE-IN option is specified, also contains four digital input circuits. These are accessible only to the last four channels of the 6437 instrument, via its FORTH facility.

When the CMP1 option is specified the 6437 is fitted with an additional 8-Way analogue input board in slot 2 providing each channel with an input that is software selectable as direct density or static pressure for the flow calculation.

CONNECTOR NUMBER	CONNECTOR TYPE	DAUGHTER BOARD FUNCTION	POLARISING KEY POSITION
1	Double-sided	Central Processor Unit	39 - 40
2	Double-sided	Memory Mk 6 (007 - 6437) (014 - 6436)	40 - 41
3	Double-sided	Analogue Processor	19 - 20
4	Single-sided	8-way Analogue I/P (CMP2) - Slot 3	27 - 28
5	Single-sided	8-way Analogue O/P (RFL) 8-way Digital O/P (ALMPLS) - Slot 4	27 - 28
6	Single-sided	8-way Analogue I/P (CMP1) - Slot 2	27 - 28
7	Single-sided	8-way Analogue I/P 4-way Pulse I/P - Slot 1	27 - 28
8	Single-sided	+5V Power Supply	25 - 26
9	Single-sided	±12V, -5V Power Supply	14 - 15

Table 1.1 Daughter Board Edge Connector Characteristics

When the CMP2 option is specified the 6437 is fitted with an additional 8-way analogue input board in slot 3 providing each channel with an input to be used as temperature in the flow calculation.

With the RFL option specified (mutually exclusive with ALMPLS) an additional 8-way analogue output board is fitted in slot 4, providing each channel with a retransmitted flow rate output.

With the ALMPLS option specified (mutually exclusive with RFL) slot 4 is fitted with an 8-Way digital output board which provides an output, for each channel, that is software selectable on a channel by channel basis to be used as either a commoned absolute flow rate alarm or a pulse totalisation output.

1.3 Mechanical Structure

The Mechanical Structure of the 6436/7 is shown in Fig 1.2. Each of the functional blocks is implemented on a single printed-circuit board (pcb) which plugs into an interconnection or Mother board via pcb edge connectors. The Front-Panel pcb is connected to the Mother board via a 15 way single-in-line connector and is secured via two retaining screws and the front support bar. All the other daughter boards plug into 48 way pcb edge connectors except for a small fuse board at the rear of the module. This pcb carries the fuses and power supply protection circuitry and is connected directly to the Mother Board via soldered 'F' pins and is restrained by board guides. A large reservoir smoothing capacitor, C1, is situated behind the fuse board and mounted directly on the mother board.

The rear end of the Mother Board carries the 48 way male systems edge connector which plugs directly into the TCS racking connector system.

The connectors for the remaining daughter boards are provided with polarising clips to ensure that the boards are always inserted in the correct order. The daughter board connector characteristics are listed in Table 1.1. The 9 daughter boards are firmly held in the mother-board edge connectors by means of a restraining strap. This strap has lateral grooves for positive mating with each daughter board and is provided with three fixing screws. The front fixing screw is connected to the Front-panel support bar, the middle screw has a central support pillar in between I/O slots 2 and 3, and the rear screw has its own support bar which also supports the fuse board.

The complete set of daughter boards and the mother board slide into a 72mm sleeve assembly which is fitted with a front-panel fascia as illustrated in Fig 1.3. The fascia carries the cover for the HHT connection socket, and the metal catch-handle for module withdrawal. A metal clip mounted at the rear of the sleeve holds the complete assembly firmly in place.

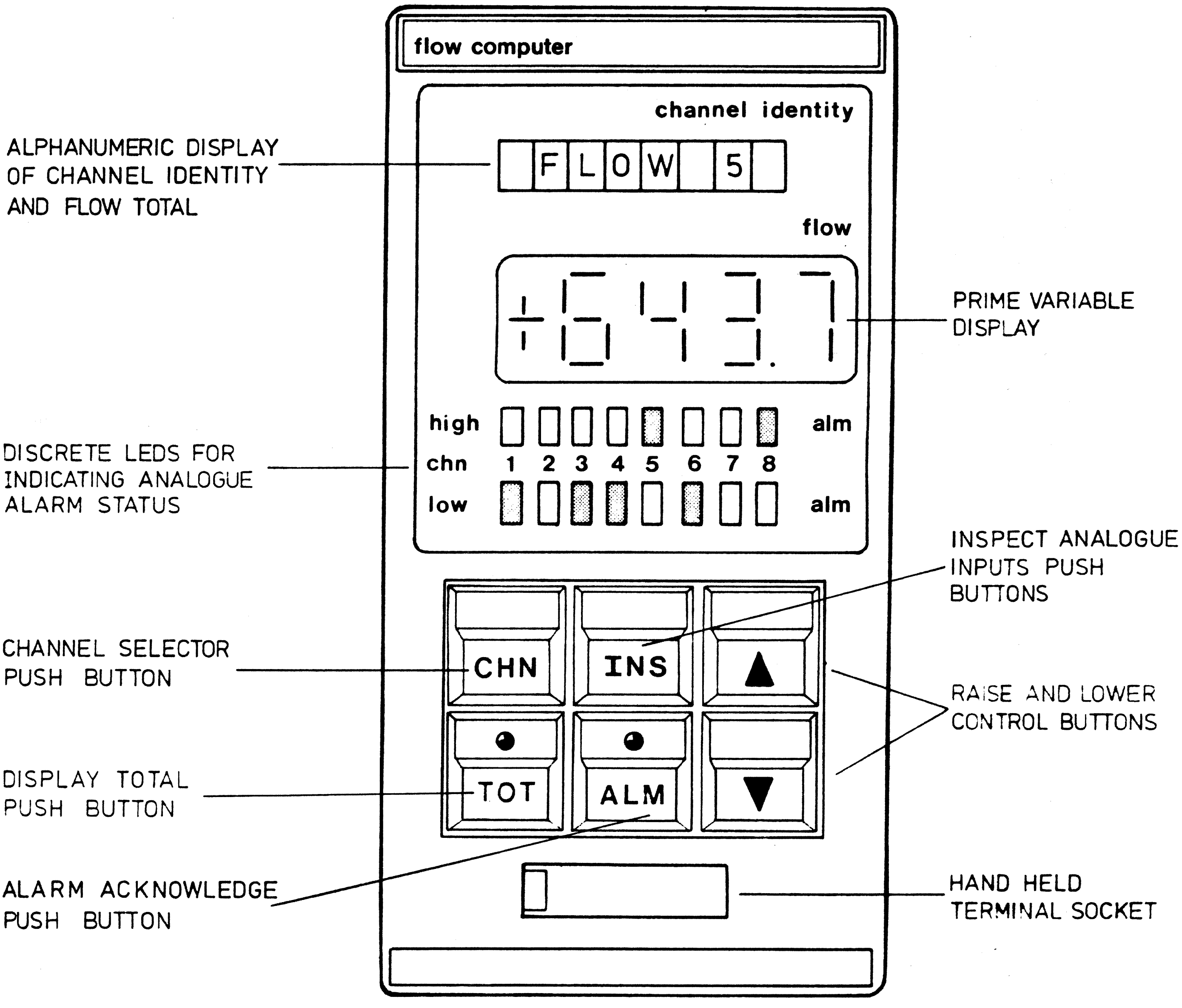


FIG. 1.3 6436/7 FLOW MONITOR/COMPUTER FASCIA DIAGRAM

6435(3)/3

1.3.1 Rack-Mounting

The 6436/7 may be rack mounted in the standard TCS type 7000 racking system. A 19" rack will house up to 6 units in their 72mm metal sleeves, though of course they can be mixed with other TCS matrix 6000 modules. A half width rack is also available, and this can hold up to 3 units. Rack wiring is carried out in the conventional manner, and a rack-wiring schedule may be prepared from the 6436/7 rear connector pin chart given in Appendix A.

1.3.2 Bin-Mounting

The 6436/7 instruments may be mounted in the TCS 7600 bin system, where the pins are wired to customer screw terminals. The system can be configured by referring to the B6436/7 rear termination assembly given in Appendix B.

1.3.3 Panel-Mounting

The 6436/7 can be used as a stand alone panel mounted instrument by using the 7900 single or multi-way sleeve assembly. In this case each instrument is provided with a rear termination assembly that contains the power supply and also gives access to all the module connections. The 7436/7 rear termination assembly is shown in Appendix C.

1.3.4 Universal Packaging System

The 6436/7 may be mounted in the TCS 7950 Universal Packaging System, which allows for powered or unpowered panel- or 19" rack-mounting of all TCS modules and Chessell recorders in any combination.

The 7950 Packaging System, instrument pins are wired to customer screw terminals using exactly the same pin-numbering scheme as in the 7600 bin system (see Appendix B). Full details of the 7950 Universal Packaging System are given in the 7950 Product Specification.

1.4 Daughter Board Functional Descriptions

Each of the daughter boards is described in turn to indicate its function within the basic 6436/7.

1.4.1 Front-Panel daughter Board (Assembly: AC 069452)

The front-panel daughter board holds all the indicator and display components together with the Operator Control push-buttons. The display components actually visible to the Operator can be seen from the fascia diagram of Fig 1.3 and consist of the following:-

a) Digital Readout

A 4 digit, orange, 7-segment LED display with sign and programmable decimal point positions for primary, secondary and tertiary analogue input indication in the range -9999 to +9999, flow total fractional part in the range 0 to +.9999 and calculated flow rate in the range 0 to +9999.

BOARD TYPE IDENTITY	NUMBER OF CHANNELS	BOARD DESCRIPTION	BOARD CATEGORY
00	8	0-10V non-isolated 1M impedance	Analogue inputs- Primary Inputs, (AN-IN) Secondary Inputs* (CMP1 Option) and Tertiary Inputs* (CMP2 Option)
01	-		
02	-		
03	-		
04	-		
05	-		
06	-		
07	-		
08	8	0-10V non-isolated with sample and hold	Analogue outputs- Retransmitted flow (RFL option)
09	-		
0A	-		
0B	-		
0C	-		
0D	-		
0E	-		
0F	-		
10	8	0-15V non-isolated, non-latched, 100k impedance	Digital inputs
11	4		Pulse inputs Primary inputs (PULSE-IN)
12	-		
13	-		
14	-		
15	-		
16	-		
17	-		
18	8	0-15V non-isolated, open-collector with 2k2 pull-up	Digital outputs- Common Absolute flow rate alarms/ Pulse totalisation outputs (ALMPLS option)
19	-		
1A	-		
1B	-		
1C	-		
1D	-		
1E	-		
1F	-	No board fitted	
			* Not 6436

Table 1.2 I/O Daughter Board Types and their Corresponding Board Identities

b) Alarm Status Display

Consisting of 2 horizontal rows of 8 red LEDs situated below the 4 digit readout. They indicate high and low flow rate absolute alarms. Current alarms flash in phase with the red LED in the ALM push-button if unacknowledged, and are on steady if acknowledged by an operator. Fleeting alarms flash out of phase with the red LED in the ALM push-button if unacknowledged, and disappear if acknowledged by an operator.

c) Identity/Diagnostic Display

Consisting of a row of 8 red 17 segment alpha-numeric LED displays situated above the 4 digit readout. Each digit can display the full 64 character ASCII set and is used to indicate channel titles and numbers, flow total integer part and instrument diagnostic messages.

The 6 Operator Control push-buttons are all of the momentary type and have the following functions:-

a) Channel Selection

1 non-illuminated push-button, CHANNEL (CHN), used in conjunction with the Raise/Lower push-buttons to select any one of up to 8 active channels for display.

b) Alarm Acknowledge

1 illuminated push-button, ALARM (ALM), with integral red LED, used to acknowledge an alarm condition on the currently displayed channel and a global Power Fail Alarm. The LED indicates the collected alarm status of all the active channels.

c) 2 Display Select Push-Buttons

1 non-illuminated push-button, INSPECT (INS), used in conjunction with the Raise/Lower push-buttons to select an analogue input of the currently displayed channel for inspection.

1 illuminated push-button, TOTAL (TOT), with integral yellow LED. This is used to select the integer part of the flow total of the currently displayed channel for inspection, and also to accept a total overflow alarm. If used with the Raise/Lower push-buttons then the fractional part of the flow total is also displayed. The LED indicates normal totalisation in progress for that channel when illuminated.

d) Function Selection

2 non-illuminated push-buttons Raise (▲) and Lower (▼) used in conjunction with the (CHN), (INS) and (TOT) push-buttons as described above.

The daughter board contains all the drive electronics associated with these displays and push-buttons and also carries the 7-Pin socket into which the 8260 HHT, or VDU terminal or computer, may be plugged.

1.4.2 Central Processor Daughter Board (Assembly: AC 069932)

The CPU daughter board contains the 16 bit microprocessor together with the associated support logic required for interrupt handling and for providing the necessary input/output decoding logic. A Universal Asynchronous Receiver Transmitter (UART) circuit and associated drivers are used to communicate with either the 8260 Hand-held programming terminal via the front panel socket, or with a supervisory system via the rear connector serial data bus.

The CPU card also contains a Watchdog timer circuit which monitors the microprocessor input/output functions. Upon detection of a failure all the Analogue outputs are 'frozen' and all front panel displays are cleared except for the eight character alphanumeric display at the top of the front panel.

1.4.3 Memory Daughter Board (Assembly: AC 076042)

The Memory daughter board is divided into three separate memory areas as follows:-

a) ROM Area

The ROM area contains the actual 6436/7 operating software.

b) RAM Area

The non-volatile RAM area contains the Instrument Data Base consisting of the Channel parameters and other variables. In the 6437 unit only it is also used to store User Application Programs created by editing the TCS FORTH high-level programming language.

c) EEPROM Area

The EEPROM memory can be used to store both the Instrument Data Base and User Application Program for additional security. Programs are always executed from RAM to allow on-line debugging and subsequent editing. Once the program has been checked out fully the CPU can transfer data from the RAM area into the Electrically Erasable PROM (EEPROM). Whenever the 6437 is subsequently powered up, or a sumcheck is detected, the CPU automatically copies the program from EEPROM back into the RAM area to allow program execution. The CPU can also copy data from the EEPROM area back into the RAM under operator control to permit further editing and dubugging cycles to be carried out. It should be noted that with issue 1 software 4078 bytes of User memory are available.

The RAM chips are made non-volatile by means of a standby battery supply circuit which powers them when the main supply has failed or undergoes a transient failure. A long-life Lithium primary cell is used for this purpose and the features of the supply circuit are as follows:-

a) Lithium Battery

The Lithium battery is not soldered directly to the memory board itself but is fitted to a separate battery board (Assembly: AC 076044) which is connected to the memory board via two 2-way plugs and sockets. This plug-on battery board is held in place by a board restraining bracket.

b) Battery Standby

When the battery board is disconnected to facilitate battery replacement, standby current to the CMOS RAM is supplied by a high value 'Supercap' fitted to the memory board. This capacitor will maintain the RAM in its non-volatile state for a minimum period of 20 minutes while the battery board is being replaced.

c) Battery Isolation Switch

The battery supply can be isolated from the RAM by means of switch SW1 (see fig 2.1). This might be done to conserve battery life when the 6436/7 is to be left unpowered for any great length of time. This switch is pushed in to connect the battery and pulled out to isolate the battery from the RAM.

1.4.4 **Analogue Processor Board** (Assembly: AC 069398)

The Analogue Processor Board provides a number of digital and analogue functions as follows:-

a) Digital Functions

The board contains 12 internal switches which are used to set up the 6436/7 communications channel characteristics and certain optional functions. Certain CPU buses are also routed through to the selected I/O slots 1 to 4 as necessary by logic on this board.

b) Analogue Functions

The board contains the circuitry necessary to provide an analogue output bus for driving 8-way Analogue Output cards when they are plugged into the I/O slots. It also provides an analogue input bus facility which is driven by 8-way Analogue Input cards when they are plugged into the I/O slots. In addition, circuitry is provided on the board which allows the CPU to check the battery voltage under dynamic loading conditions (See Section 2.6.2).

1.4.5 Input/Output Daughter Boards

The 6436/7 has 4 slots into which general-purpose daughter boards are plugged. These boards come in four basic categories, viz:-

a) Analogue input cards
b) Analogue output cards
c) Digital input cards
d) Digital output cards

The 6436/7 is supplied with either an analogue input card (AN-IN option) or a pulse/digital input card (PULSE-IN option) fitted in slot 1. The 6437 may have the CMP1 option (additional analogue input card in slot 2), and the CMP2 option (a further analogue input card in slot 3). The 6436/7 may have in slot 4 either the RFL option (analogue output card) or the ALMPLS option (digital output card).

The 6436/7 hardware has the ability to detect which type of card is plugged into each of the 4 I/O slots by monitoring a board identity which is pre-programmed onto each card. The 6436/7 software verifies that the correct type of card is plugged into each slot and can also distinguish between the 8 different types of card within each category. Table 1.2 lists the types of I/O boards currently available together with their corresponding hardware identity codes. The 4 types of I/O boards that can be fitted to the 6436/7 are described in the following paragraphs.

a) Analogue Input Daughter Board (Assembly: AC 069400)

This board multiplexes 8 non-isolated input signals in the range 0-10V onto the analogue input bus of the Analogue Processor card. Each channel is provided with an input network comprising a pull-down resistor, a 100 usec CR filter, and a 12V zener diode clamping circuit.

b) Pulse/Digital Input Daughter Board (Assembly: AC 075799)

This board accepts 4 non-isolated frequency/pulse input signals which are measured independently in the range 0-15 volts. This information is latched and presented directly to the processor card. Each channel is provided with an active input network comprising a 100usec CR filter, together with a pull down resistor to 0 Volts.

The board also contains four non-isolated, non-latched, digital input circuits which can be instantaneously accessed by the CPU control and address busses. Each input is provided with a 15V CMOS buffer circuit fitted with a 100K pull-down resistor to 0V.

c) Analogue Output Daughter Board (Assembly: AC 069402)

This board demultiplexes the 0-10V analogue output bus from the Analogue Processor card into 8 non-isolated output channels. Each output channel consists of a medium term sample-and-hold circuit and buffer amplifier stage capable of driving ±5mA signals.

d) Digital Output Daughter Board (Assembly: AC 069401)

This board contains 8 non-isolated digital latch circuits driven by the CPU control and address busses. The outputs of each latch are buffered by a 0-15V open-collector TTL gate fitted with a 2k2 pull-up resistor to the 15V supply.

1.4.6 +5V Power Supply Daughter Board (Assembly: AC 066518)

This board basically consist of a switching regulator circuit which draws its power from a 23-35 volt smoothed unregulated input and can supply up to 2.5A before current limiting. The board also contains the necessary logic circuitry to detect Power On and the Power Failure conditions and alert the CPU accordingly.

1.4.7 +12V, -5V, -12V Power Supply Daughter Board
(Assembly: AC 066519)

This board also draws its power from the 23-35 volt supply input and uses a monolithic regulator to produce the +12V supply rail. A -16V supply is also generated on the board by means of an inverting regulator circuit and the -12V and -5V supply rails are derived from this using two further monolithic regulators. All 3 of the regulators incorporate current limit and thermal shutdown facilities.

1.4.8 Fuse Daughter Board (Assembly: AC 069441)

This board is used to mount the main 2A supply fuse together with circuitry capable of blowing it in the event of any internal supply rail exceeding its voltage tolerance limit. In addition, the fuse board generates a regulated 15V supply for the Watchdog and other digital outputs, while a spare 2A fuse is also mounted on the board for convenience (See System 6000 Installation Guide section 5.2).

1.5 Technical Specification

1.5.1 Operator Displays

a) Digital Readout (for Calculated Flow Rate, primary secondary and tertiary analogue input and indication of the Flow Total fractional part).		4 digit, orange LED display with sign and decimal point programmable to 4 positions:- ±.9999 ±9.999 ±99.99 ±999.9 or none i.e. ±9999
b) Flow Rate Alarm status display	:	2 rows of red LEDs programmed to indicate for each channel:- (i) Acknowledged HI/LO Flow rate alarm present when steady (ii) Un-acknowledged HI/LO Flow rate alarm (current or fleeting) when flashing
c) Identity/ diagnostic display	:	Row of 8 red 17 segment alphanumeric LEDs capable of displaying 64 character ASCII set to indicate:- (i) Channel Numbers/ Channel Names (ii) Flow Total integer part (iii) Instrument diagnostic messages

1.5.2 Operator Controls

a) Channel Selection : 1 momentary, non-illuminated push-button CHANNEL (CHN)

- (i) When used in conjunction with (CHN), the Raise (▲) push-button increments the channel number at each depression i.e. from 1 through 8 and back round to 1 again.
- (ii) When used in conjunction with (CHN), the Lower (▼) push-button decrements the channel number at each depression i.e. from 8 through 1 and back round to 8 again.

The channel number is displayed on the upper alpha-numeric readout as long as the (CHN) button is depressed and the corresponding channel name is displayed once the button is released.

b) Alarm Acknowledge : 1 momentary illuminated push-button ALARM (ALM) used to acknowledge an alarm condition on the currently displayed channel. If a module power fail warning is indicated this can be cleared by pressing the (ALM) button.

All un-acknowledged alarms cause the (ALM) LED and the specific channel alarm LED to flash. The channel alarm LED will flash in phase with the (ALM) LED if the un-acknowledged alarm is current and will go on steady when it is acknowledged.

b) Alarm Acknowledge (contd.)		The channel alarm LED will flash out of phase with the (ALM) LED if the un-acknowledged alarm is fleeting and will be extinguished when it is acknowledged.
c) Display selection	:	2 momentary push-buttons 1 illuminated TOTAL (TOT) and one non-illuminated INSPECT (INS) (i) The (TOT) button when pressed causes the integer part of the flow total for that channel to be displayed on the upper alphanumeric display, with the channel number displayed on the digital readout. If the (▲) or (▼) push-buttons are pressed in conjunction with (TOT) the digital readout will display the fractional part of the flow total. If a flow total count roll over warning is indicated this can be cleared by pressing the (TOT) button for that particular channel.

c) Display selection (contd.)

(ii) The (INS) push-button, used with the (▲) or (▼) push-buttons allows an operator to inspect any of the analogue inputs for that channel, by causing the digital readout to advance or reverse respectively through a circular list of calculated flow and primary, secondary and tertiary analogue variables. The upper alpha-numeric display shows the corresponding input number.

1.5.3 Analogue inputs

a) Number of Inputs : 8 direct non-isolated inputs as standard plus 16 optional inputs (6437 only).

b) Input Functions : Slot 1, inputs 1 to 8 for Flow derived signals.
Slot 2, inputs 1 to 8 for static pressure/ direct density signals (CMP1 option) (6437 only).
Slot 3, inputs 1 to 8 for Temperature signals (CMP2 option) (6437 only).

c) Input signal Levels : Direct inputs are 0-10V range; (inputs may be 1-5V, selected by software).

d) Resolution : 12 bit binary ADC (.025%) hardware applied to inputs.

15 bit binary representation obtained after digital input filtering and signal averaging giving resolution of 1 digit in 9999.

e) Accuracy : ±1 LSB (typ) of DAC.
This appears as:-

±1 digit of reading for 0-4000 range,
±2 digits of reading for 0-8000 range,
±3 digits of reading for 0-9999 range,
- after input filtering.

f) Sampling Rate : ADC samples each input every 496ms.

g) Input Impedance : 1 Mohm pull-down to 0V on all inputs

h) Input Signal Processing : Linear (normal or inverse), Normalised square root,
Type J, K, T, S, R, E, B thermocouples or Platinum resistance thermometers.
Up to five types of user specified linearisation per instrument.

1.5.4 Analogue Outputs

a) Number of Outputs : 8 optional direct non-isolated outputs.

b) Output Functions : Slot 4, outputs 1 to 8 for Retransmitted Calculated Flow Rate (RFL option).

c) Output Signal Levels : Direct outputs are 0-10V range.

d) Output Circuit Type : Medium-term analogue sample-and-hold circuits preceded by DAC.

e) Output Resolution : 12 bit binary (.025%) giving minimum analogue voltage steps of 2.5mV.

f) Accuracy, 0-10V Output : ±1 LSB (typ) of DAC.

g) Sample and Hold : DAC updates each output every 496ms.

h) Output Drift Rate under Watchdog Failure Conditions : 0.5mV/sec maximum (equivalent to 1% of full scale in 3 minutes).

i) Output Drive Capability : ±5mA.

1.5.5 Pulse Inputs

a) Number of Inputs	: 4 direct non-isolated inputs to counters positive edge triggered (count up only).
b) Channel Functions	: Slot 1, only channels 1 to 4 are flow derived inputs.
c) Input Frequency Range (Range software selectable)	: 0.0001Hz to 10kHz
d) Input Waveform	: Square wave to maximum frequency. Pulse train with minimum pulse width 15usec.
e) Input Voltage Levels	: 5V to 15V = logic 1 0V = logic 0 with hysteresis of 200mV.
f) Accuracy	: Average rate measured to 0.025% of reading. No pulses missed. Crystal timebase ±0.01%
g) Input Sampling Rate	: Each input sampled every 496ms for frequencies greater than 10Hz. Approx T for frequencies less than 1Hz (where T is the input signal period).
h) Input Impedance	: 100kohm pull-down to 0V gives (150uA logic one current).
i) Input Signal Processing	: Linear (normal or inverse). User specified linearisation functions.

1.5.6 Digital Inputs (6437 only)

a) Number of Inputs : Four non-latched, non-isolated inputs, channels 5 to 8 only.

b) Channel Functions : In slot 1 only it is instantaneously accessible by CPU control and address busses, via the 6437 FORTH facility.

c) Input Voltage Levels : 15V = logic one
0V = logic zero

d) Input Impedance : 100kohm pull-down to 0V (gives 150uA for logic one).

e) Sampling rate : Inputs sampled every 496ms.

1.5.7 Digital Outputs

a) Number of outputs : 8 optional non-isolated outputs plus Watchdog.

b) Output Functions : Slot 4, outputs 1 to 8 are Pulse Totalisation outputs but are software selectable to function alternatively as commoned flow rate alarms (ALMPLS option).

c) Output Voltage Levels : 15V = logic one
0V = logic zero.

d) Output Drive Capability : 2k2 open-collector pull-up to +15V supply, maximum logic zero sink current = 16mA.

e) Output Update Rate : Each channel alarm output is updated every 496ms.

1.5.8 Flow Calculation Characteristics

The calculation performed by the 6436/7 has several optional parts but in its most general form can be represented as shown below.

NOTE: The 6436 does not include a DCT facility

$$FL = 1C \times 2C \times \begin{Bmatrix} 1V \\ \text{or} \\ \sqrt{1V} \end{Bmatrix} \times \begin{Bmatrix} DCT \\ \text{or} \\ \sqrt{DCT} \end{Bmatrix}$$

(The use of square root extraction for the Primary Variable and/or DCT is dependent on the type of Primary device in use.)

Where DCT is the 'density correction term' shown below:

$$DCT = \begin{cases} 2V \\ \text{or} \\ \frac{1}{SG} \times \frac{TO}{PO} \times \frac{2V+PA}{3V+TA} \times \frac{XO}{Zf} \\ \text{or} \\ 3C\,\frac{1+5C.1E\text{-}2.(2X+PA-PO)+6C.1E\text{-}5.(2X+PA-PO)^{**}2}{1+7C.1E\text{-}3.(3X+TA-TO)+8C.1E\text{-}7.(3X+TA-TO)^{**}2} \\ \text{or} \\ \text{term1} + \text{term2} \end{cases}$$

(Density signal directly available from in-stream Densitometer)

(Density inferred from Temperature and/or Static Pressure input signals)

```
IF    2X < 3C
THEN  term1 = (2X+5C).6C
ELSE  term1 = 0

IF    2X ≥ 4C
THEN  term2 = (3X+7C).8C
ELSE  term2 = 0
```

NOTE 1: '2V' and '3V' are measured plant variables whose interpretation varies depending on which DCT is used.

NOTE 2: Default constants '2K' and '3K' may be used instead of measured variables, where appropriate, and this is also under the control of the user.

a) Algorithm Sampling Period : 496ms.

b) Calculated Flow Range : 0 to 9999 Engineering units.

c) Primary (Flow derived) Input Range : 0 to 9999 Engineering Units.

d) Secondary and Tertiary Input Ranges : -9999 to 9999 Engineering Units.

e) Input Filter Range : 0-60 secs.

f) Input Signal Pre-Processing : One of 16 functions including square root and linearisation.

g) Transducer Types : Differential pressure type (orifice plate, venturi nozzle etc.), Linear differential pressure type (e.g. Gilflo meter), any linear output devices e.g. Turbine or Vortex meter.

h) Density Correction : Direct density input or density inferred for gases using Temperature and Pressure inputs.

1.5.9 Flow Totalisation Characteristics

A) Displayable Total

a) Algorithm Sampling Period : 2 secs.

b) Displayable total capacity : 99,999,999 (8 digit integer flow total automatically rolls over when full).

c) Direct totalised : No pulses missed.

d) Crystal timebase accuracy : ±0.05%

e) Lowest Totalisable calculated flow : 0.01 units/day

f) Highest totalisable flow rate : 9999 units/sec.

g) Total clear/ pre-load : Via the HHT (using the 1B and 2B parameters)
or via the SSDL (using the 1F and 2F parameters)
or via the CONFIG program (6437 only).

B) Pulse Totalisation

a) Algorithm Sampling Period : 2 secs.

b) Pre-multiplier range : 000.0 to 999.9

c) Direct totalised : No pulses missed.

d) Crystal timebase accuracy : ±0.05%

e) Lowest totalisable calculated flow : 0.01 units/day

f) Highest totalisable flow rate : 9999 units/sec.

g) Value per pulse : 0000 to 9999.

h) Maximum pulse rate : 4 Hz.

i) Total clear : Internal accumulator is automatically cleared when the Displayable Total is pre-loaded or cleared.

1.5.10 **Power Supplies**

a) Input Voltage : 20-30V DC recommended operating range (may be unsmoothed, full-wave rectified AC). 19-35V DC absolute maximum input limits.

b) Input Current : 550mA without hand-held terminal at 28V DC 650mA with hand-held terminal at 28V DC.

c) Input Fuse Rating : 2A.

d) Internal Supply Rails :

Nominal Voltage	Voltage Tolerance	Current Limit
+12V	±0.5V	200mA
+ 5V	±0.25V	2.5A
- 5V	±0.2V	200mA
-12V	±0.5V	300mA

e) Power Failure Detect Threshold : when input voltage falls below 16.5 ±2V.

f) Memory Standby Battery Characteristics : Lithium type.

: 3.0V nominal output at 160mAh.

: 8-10 year shelf life typical.

: 5 year life typical on continuous standby.

g) Output supply Characteristics : 15V DC ±0.5V at 100mA max.

1.5.11 Communications

a) No. of Communication Channels	: 2 serial ports.
b) Type	: Full duplex.
c) Functions	: (A) Dedicated data link via the front panel for the hand-held, or VDU programming terminal.
	: (B) Multi-drop data link (RS422) via the rear connector used by a supervisory computer.

(A) Hand-Held Terminal Link

a) Transmission Standard	: 2 wire RS 232/V24 (±12V).
b) Data Rate	: 300 baud.
c) Character Length	: 10 bits made up of:- 1 start + 7 data + 1 parity (even) + 1 stop.

(B) VDU Programming Terminal Link

a) Transmission Standard	: 2 wire RS232/V24 (±12V).
b) Data Rate	: Up- or down-loading parameters:- 300 baud. Programming:- Selectable from 110, 300, 600, 1200, 2400, 3600, 4800 or 9600 baud.
c) Character Length	: 10 bits made up of:- 1 start + 7 data + 1 parity (even) + 1 stop.

(C) Multi-drop Supervisory Link

a) Transmission Standard : 4 wire RS422 (0-5V).

b) Line Impedance : 120-240 ohm twisted pair.

c) Line Length : 4000 ft max. (at 9600 baud).

d) No. of Instruments/Line: 16

e) Data Rate : Selectable from 110, 300, 600, 1200, 2400, 3600, 4800 or 9600 baud.

f) Character Length

(i) ASCII mode - 110 Baud : 11 bits made up of:- 1 start + 7 data + 1 parity (even) + 2 stop.

(ii) ASCII mode - 300 to 9600 Baud : 10 bits made up of:- : 1 start + 7 data + 1 parity (even) + 1 stop.

(iii) Binary mode - 110 Baud : 12 bits made up of:- 1 start + 8 data + 1 parity (even) + 2 stop.

(iv) Binary mode - 300 to 9600 Baud : 11 bits made up of:- 1 start + 8 data + 1 parity (even) + 1 stop.

1.5.12 Physical Specification

a) Mechanical

(i) Width : 72mm.

(ii) Height : 142mm.

(iii) Depth : 300mm.

(iv) Weight : 1545g (Basic Unit)

+45g (AN-IN option)
or
+65g (PULSE-IN option)

+45g (CMP1 Option)
+45g (CMP2 Option)

+37g (ALMPLS Option)
or
57g (RFL Option).

b) Environmental

(i) Operating Temperature : 0 to 50°C.

(ii) Storage Temperature : -20 to +50°C.

(iii) Humidity : 5% to 90% non-condensing.

1.6 Order Sheet

DESCRIPTION	ORDER CODE
8 Channel Flow Monitor with 8 Channel Flow Computer with	6436 or 6437
8-Way Analogue flow inputs and fixed density correction calculation	AN-IN [1]
4-Way Pulse flow inputs and fixed density correction calculation	PULSE-IN [1]
Additional 8-Way Analogue input card providing: Either 1) Variable Direct density inputs OR 2) Variable Pressure inputs in compensation calculation for each channel	/CMP1 [3]
Additional 8-Way Analogue input card providing: Variable temperature in compensation calculation for each channel	/CMP2 [3]
Additional 8-Way Analogue output card providing: Re-transmitted calculated flow facility for each channel	/RFL [2]
Additional 8-Way Digital output card providing: Either 1) Common absolute flow rate alarms OR 2) Pulse totalisation outputs for each channel	/ALMPLS [2]

NOTES

[1] These two options are mutually exclusive.
[2] These two options are mutually exclusive.
[3] 6437 only.

EXAMPLE

6437/AN-IN/CMP1/CMP2/RFL - 8-Channel Flow Computer with temperature and static pressure inputs and retransmitted calculated flow

Section 2 INSTALLATION

2.1 General Requirements

The sequence of events for installing a 6436/7 in a system should be as follows:-

EITHER a) Ensure that a 72mm slot, fitted with a 48 way connector and all the correct mounting hardware, is available in a TCS 7950 Rack or 7600 Bin (See sections 1.3.1 and 1.3.2).

OR b) Ensure that a 7900/7435 Self-Powered Sleeve is available (See Section 1.3.3).

EITHER c) Ensure that an appropriate 24V DC supply is available and has been wired to the slot in the manner outlined in the System 6000 Installation Guide Section 5.

OR d) Ensure that the 7900/7435 Self-Powered Sleeve has been correctly wired to either a 110/240V AC mains supply or a 24V DC supply (See Appendix C).

e) Before sliding the instrument into the rack, Bin or 7900/7435/7950 sleeve check that all the internal switches have been set correctly as outlined in Section 2.3

f) Check that all the plant connections and other external inputs have been implemented correctly and that the signals are at the right levels as outlined in Section 2.4.

g) Power up the instrument in the manner outlined in Section 2.5.

h) The instrument can now be programmed with the Flow Calculation parameters following the instructions given in Section 4 and the user manual.

i) The 6436/7 may be used to monitor and totalise fluid flows using the transducer types and density correction methods as described in Section 3.

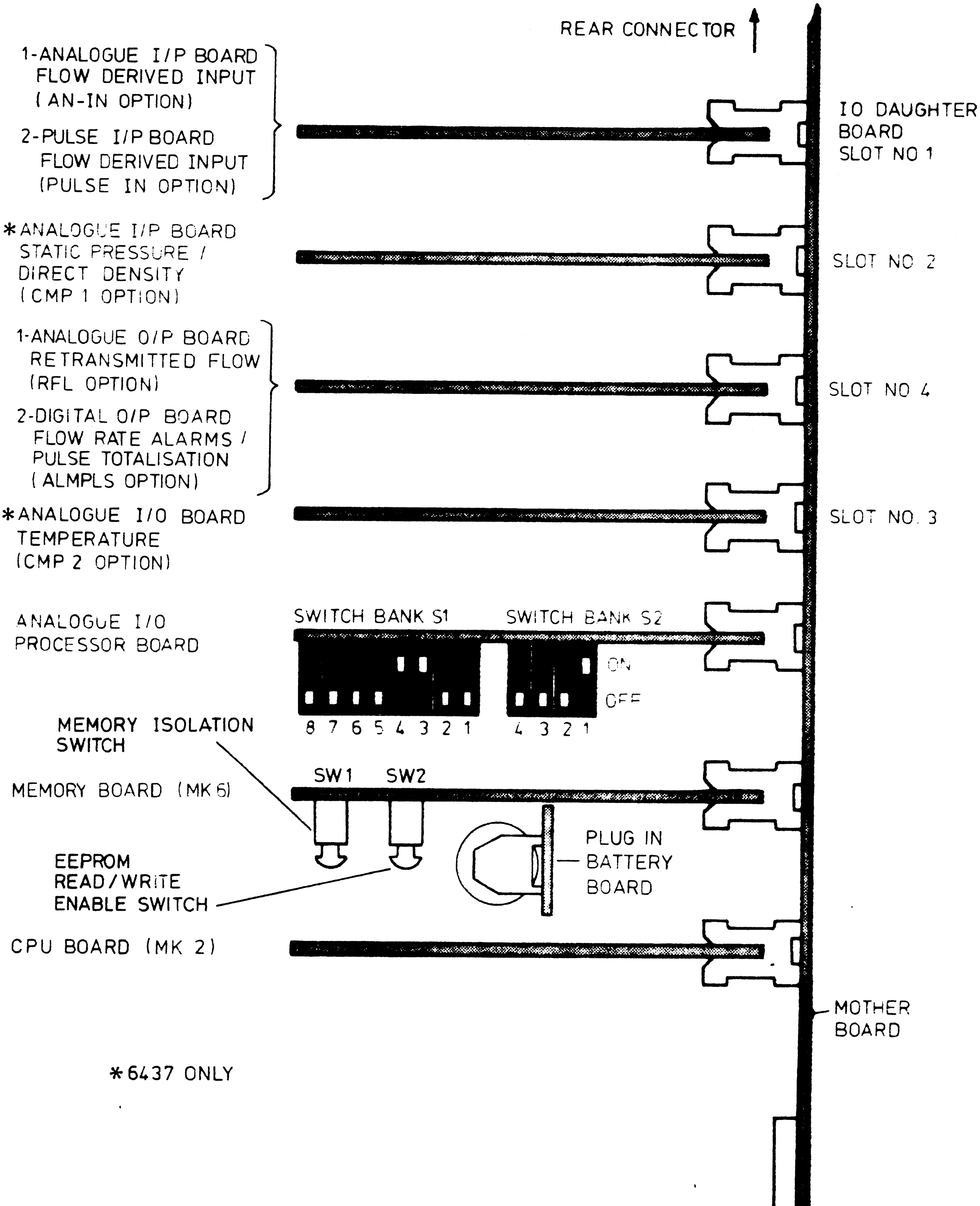


FIG 2.1 PLAN VIEW OF 6436/7 WITH INTERNAL SWITCHES SHOWN

6435(4)/4

2.2 Power Supply Connections

For a description of Power Supply connections including discussions of:

Basic Ground connections,
Connection of Separate 24V DC supplies,
Common Parallel Supply configuration,
Combination supply configuration
and External Ground connections

refer to the System 6000 Installation Guide Section 5.

2.3 Internal Switch Settings

Fig. 2.1 is a view of the 6436/7 looking down at the top of the sleeve and illustrates the relative positions of the various daughter boards and their associated internal switches.

2.3.1 Memory Board Switches

Fig. 2.1 shows that there are two ON/OFF switches situated along the top edge of the Mk 6 memory daughter board and their functions are as follows:-

a) Memory Isolation Switches

This switch, SW1, is situated furthest from the plug-in battery board and its function is to isolate the CMOS parameter memory from the standby battery supply. In normal operation this switch should always be pushed in to ensure that all the instrument parameters are stored safely when the external power supply is interrupted for any reason. When power is re-established the instrument will continue operation using the last set of stored parameters.

If the instrument is to be stored or left un-powered for any length of time without parameters programmed into the memory, then the switch can be pulled out to avoid draining the standby battery. It should be checked carefully that the switch has been pushed in before attempting to power up the instrument and start entering parameters. Note that whenever this switch is pulled out, all stored parameters will be stored for a minimum period of 20 minutes after which they will be lost. This storage period is to enable easy replacement of the plug-in battery board. (See Section 1.4.3).

BANK	SWITCH	'ON'	'OFF'	FUNCTION	
S2	1	UID Range: 8-F	UID Range: 0-7	Unit identifier (UID) select	
	2	Enable	Disable	I/O daughter board slot 2 enable (CMP1 option)	
	3	Enable	Disable	I/O daughter board slot 3 enable (CMP2 option)	
	4	Enable	Disable	I/O daughter board slot 4 enable (RFL/ALMPLS option)	
S1	1	Baud Rate Set By Switches 2, 3, 4	300 Baud (2, 3, 4 Don't Care)	Baud rate selection switches for RS422 supervisory serial data link	
	2	See	TABLE 2.2		
	3				
	4				
	5	High Speed Data Format (Binary)	Standard Data Format (ASCII)	Data Link Communication Protocol Selection	
	6	4	0	2^2	Totaliser Group Identifier (GID)
	7	2	0	2^1	
	8	1	0	2^0	

Table 2.1 Analogue I/O Processor Board Internal Status Switch S1 and S2 Functions

b) EEPROM Write Enable Switch

This switch, SW2, is situated closest to the plug-in battery board and it controls the Write Enable input of the EEPROM as follows:-

SW2 OFF (pulled out) = writing inhibited (read-only)
SW2 ON (pushed in) = writing enabled

If SW2 is OFF and the user attempts to copy an Application Program from RAM into EEPROM via the 'SAVE' utility, an error condition will be indicated, (see Programmable Instruments Programming Manual).

2.3.2 Analogue I/O Processor Board Internal Status Switches

Fig 2.1 shows that the Analogue I/O Processor daughter board carries a 4 way and an 8 way DIL switch situated along the top edge. These two switch banks S1 and S2 are used for setting up various internal functions within the 6436/7 to characterise it for a specific metering system application. The functions assigned to each of the switches contained within S1 and S2 are listed in Table 2.1 and are detailed below.

NOTE: The functions of most of the switches are related to the use of the supervisory serial data link (SSDL). Remote supervision and monitoring of TCS microprocessor-based instruments by an external intelligent device is discussed fully in the System 6000 Communications Manual.

a) Switch Bank S1 Functions

The switches on this bank are used to set up the RS422 supervisory data link as follows:-

Switch no. 1

If 'OFF', baud rate of 300 selected regardless of other switch positions. If 'ON', then baud rate set by switches 2, 3 and 4.

Switches no. 2, 3, and 4

These three switches select the baud rates at which the RS422 data link operates. See Table 2.2.

Switch no. 5

This switch is used to select one of two serial data link communications protocols for the instrument.

NOTE: All instruments on the RS422 data link must be using the same protocol.

SWITCH BANK	SWITCH NUMBER				BAUD RATE	NUMBER OF STOP BITS
	1	2	3	4		
1	OFF	X	X	X	300	1
	ON	OFF	OFF	OFF	110	2
		OFF	OFF	ON	300	1
		OFF	ON	OFF	600	1
		OFF	ON	ON	1200	1
		ON	OFF	OFF	2400	1
		ON	OFF	ON	3600	1
		ON	ON	OFF	4800	1
		ON	ON	ON	9600	1

X = Don't Care

Table 2.2 RS422 Supervisory Serial Data Link Baud Rate Selections

Switches no. 6, 7, and 8

In a large supervised control/instrumentation system many System 6000 instruments may be connected to the central computer via a single serial data link. In such a configuration each instrument must have some sort of unique address identity so that when the computer sends a message to a particular instrument, only the unit that has been pre-programmed with that identity will reply. When a 6436/7 is connected to the RS422 data link, it is addressed by the supervisory computer as 8 separate devices or units, each of which corresponds to an individual flow monitoring channel. The hardware of the 6436/7 allows up to 128 separate flow monitoring channels to be uniquely identified by means of a 7 bit binary address. The 4 least-significant bits of this address are called the Unit identifier (UID) and the 3 most-significant bits of this address are called the Group Identifier (GID). Conceptually, each flow monitoring channel within the 6436/7 is addressed as a separate unit so that the 6436/7 occupies up to 8 consecutive unit addresses. Consequently, the Unit Address Identifier requires only the top bit to be set in the 6436/7 while the bottom 3 bits are used by the computer to select which of the 8 flow monitoring channels are being accessed (see S2 no. 1). The 4 Group Identifier bits are selected by means of switches 6, 7 and 8 of switch bank S1.

The binary weighting of each switch can be seen from Table 2.1 to be as follows:-

$$\left.\begin{array}{l}\text{S1 no 8} = 1\\ \text{S1 no 7} = 2\\ \text{S1 no 6} = 4\end{array}\right\} \text{- when in the 'ON' position.}$$

Thus these 3 switches can be used to select a Group Identifier from 0 - 7.

b) Switch Bank S2 Functions

The switches on this bank are used as follows:-

Switch no. 1

This switch represents the most significant bit of the UID. A four bit UID allows 16 units to be addressed within a group. This switch places the 8 channels of a 6436/7 instrument in the upper or lower half of a group, thus :-

S2 no 1 OFF, UID = 0-7
S2 no 1 ON, UID = 8-F

Switch no. 2, 3 and 4

These are set to enable the optional I/O boards (if fitted) in slots 2, 3 and 4 respectively.

2.4 Plant and Other External Connections

Appendix A lists all the functions of the rear connector pins of the 6436/7. For correct operation of the instrument in a system it is necessary that external plant and equipment is connected up to it in the following manner.

2.4.1 Power Supplies

Connection of the 0V ref., 0V power and +24V supply rails of pins 2, 3 and 8 respectively are fully dealt with in the System 6000 Installation Guide Section 5.

2.4.2 Pulse Input

When a PULSE-IN option is specified, 4 flow monitoring channels of the 6436/7 are provided with a frequency/pulse input for the flow derived variables, using rear connector pins 10-13 inclusive. Pins 14-17 are for digital inputs. These inputs accept 0-5 to 15V signal levels as described in Section 3.2.3 (see also section 4.5.2 c) on the 1P Parameters).

NOTE: This option and the AN-IN option are mutually exclusive.

2.4.3 Analogue Inputs

When the AN-IN option is specified, each flow monitoring channel within the 6436/7 is provided with one analogue input for the flow derived variable, using rear connector pins 10 to 17 inclusive. These inputs accept 0-10V or 1-5V signal levels as described in Section 3.2.3 (See also Section 4.5.2 c) on the 1P, 2P and 3P Parameters).

NOTE: This option and the PULSE-IN option are mutually exclusive

When the CMP1 option is specified a second analogue input board is fitted to the 6437 in the slot 2 position. This provides an extra analogue input for each channel using rear connector pins 18 to 25 inclusive. These inputs are the secondary variables which may be interpreted as static pressure or direct density signals as shown in Section 3.3 B. (See also section 4.5.2 b) on the FP parameter). These inputs also accept 0-10V or 1-5V signal levels as described in Section 3.2.3 (See also section 4.5.2 c) on the 2P parameter). When this board is fitted, switch no. 2 of switch bank S2 must be in the ON position.

With the CMP2 option specified a third analogue input board is fitted to the 6437 in slot 3 providing each channel with one analogue input for temperature using rear connector pins 26-33 inclusive. These inputs accept 0-10V or 1-5V signal levels as described in Section 3.2.3 (See also Section 4.5.2 c) on the 3P parameter). When the board is fitted, switch no. 3 of switch bank S2 must be in the ON position.

2.4.4 Analogue Outputs

The RFL option, if specified, provides the 6436/7 with an analogue output card, fitted in slot 4, giving each channel one analogue output for retransmitted calculated flow rate. This option can also be configured to give each channel either commoned absolute flow rate alarms or flow totalisation pulse outputs (See Section 4.5.2.b on the FP parameter). These outputs are 0-10V signals and are brought out on rear connector pins 34 to 41 inclusive. When this board is fitted, switch no. 4 of switch bank S2 must be in the ON position.

NOTE: This option and the ALMPLS option are mutually exclusive.

2.4.5 Digital Outputs

When the ALMPLS option is specified, a digital output board is fitted to the 6436/7 in the slot 4 position. This provides a digital output for each channel using rear connector pins 34-41 inclusive. These outputs are used either as commoned absolute flow rate alarms or flow totalisation pulse outputs (See Section 4.3.2 d) on the CT parameter). The output signal logic levels are 0V and 15V with 15V representing the alarms safe condition and consist of open collector type TTL gates. Each output is provided with a 2k2 pull-up resistor to the +15V rail and can sink a maximum current of 16mA in the logical zero (alarm) state. When this board is fitted, switch no. 4 of switch bank S2 must be in the ON position.

NOTE: This option and the RFL option are mutually exclusive.

2.4.6 Serial Data Bus

For a full description of the Serial Data Bus, including discussion of:

Interface Connectors,
Cable Impedance and Termination
and Interface Signal Polarity

refer to the System 6000 Installation Guide Section 7.

2.5 6436/7 Power-Up Sequence

There are two possibilities that can occur when the 6436/7 is connected to an external power supply and these are as follows:-

2.5.1 Power-Up from Initial Un-programmed State

When a 6436/7 is first powered-up before any parameters have been programmed, the parameter storage area of the non-volatile memory will be empty. The first thing that the CPU does after the power-up sequence has been completed is to check the memory for stored sumcheck patterns. This sumcheck is only updated as parameters are entered into the memory so this check will cause a memory error condition to occur upon initial power-up. Consequently the CPU will force the instrument to behave as for MEMORY SUMCHECK FAIL conditions as described in Section 2.6.3 f) and 2.6.3 g).

In a 6437 instrument, there will be no background FORTH program installed. So when the sumcheck error has been cleared, the 'HALTED' error message will flash.

2.5.2 Power-Up from a Previously Programmed State

If the power supply to an instrument is interrupted during its normal working state then all the parameters will be stored in the non-volatile memory area provided that the standby battery is switched in circuit (see Section 2.3.1). Upon subsequent re-establishment of the power supply the CPU will verify the stored memory sumcheck values. This test should be carried out successfully and CPU will then return the instrument to exactly the same set of operating conditions as were present before the power interruption.

2.5.3 Indication of Power-Up

On establishing a power supply to a 6436/7 in either of the above cases 2.5.1 or 2.5.2 the message:-

PFAIL ER (Power Failure Error)

will be displayed. The message is intended simply to bring to an operator's attention the fact that totalising has been stopped for some undefined period of time and consequently that the stored flow totals may be inaccurate (See section 2.6.3 b)).

2.6 6436/7 Hardware Diagnostic Facilities

The 6436/7 incorporates a number of diagnostic facilities for continuously monitoring and checking the status of its hardware during operation. Each of these diagnostic facilities provides the following features:-

a) Indication and identification of the fault via the 3 operator interfaces, viz:-

   (i) Front-panel display indication
   (ii) Local indication via rear connector logic signal
   (iii) Remote indication via the serial data links.

b) Well defined shut-down procedures for each type of fault with the instrument taking up pre-determined operating conditions to maximise plant safety.

c) Automatic restart under certain transient fault conditions.

These diagnostic facilities are described in the following four sections.

2.6.1 Watchdog Timer

The CPU card incorporates a Watchdog Timer circuit which has to be refreshed periodically by the CPU to maintain correct operation as described in Section 1.4.2. If the CPU fails to refresh the Watchdog at the normal rate due to some fault condition, the following actions occur:-

a) All the Front-panel displays are extinguished except for the 8 character alphanumeric display at the top of the front panel which retains the last message displayed. This provides immediate visual indication to the operator.

b) The WATCHDOG TIMER logic output on pin 9 of the rear connector is reset from 15V to 0V to indicate the fault condition and will stay low as long as the fault persists. This feature allows the pin 9 output to be used for external alarm monitoring purposes or for switching in Manual back-up systems etc.

c) The 'sample and hold' circuitry associated with the 8 analogue outputs (See section 1.4.5 b) and Section 2.4.3) is forced into the 'hold' state so that they will retain the last voltage level set by the CPU before the Watchdog tripped out. Under these conditions the capacitors are not refreshed by the DAC and an output drift rate of up to 0.5mV/sec maximum may occur (equivalent to a drift of 1% of full scale in 3 minutes worst case).

As long as the Watchdog is tripped out a circuit automatically attempts to restart the instrument at approximately 10ms intervals using the same restart procedure as when the 6436/7 is first powered up. Consequently there are three possibilities that can occur after each restart attempt:-

(i) If the failure was due to a transient fault such as electrical noise and the memory has not been corrupted then the instrument will restart automatically as described in Section 2.5.2. The Watchdog output, pin 9, will then be set back to 15V by the CPU about 30ms after the restart occurs.

(ii) If the failure was due to a transient fault which has corrupted the memory, then the instrument will restart automatically as described in Section 2.5.1. The Watchdog output will again be reset to 15V after a 30ms period.

(iii) If the failure was due to a permanent hardware fault such as a damaged integrated circuit, then the CPU will not be able to refresh the Watchdog and the pin 9 logic output will remain at 0V.

2.6.2 Standby Battery Check

The memory daughter board incorporates a long life Lithium standby battery which powers the RAM circuits when the external power supply has failed or is interrupted for any reason (see Section 1.4.3). A comparator on the Analogue Processor board is monitored every 500ms and will indicate a failure if the battery voltage falls below 2.7 volts. Should a battery-fail be detected the CPU takes the following actions:-

a) All the unused decimal points on the front panel digital readout are flashed continuously to warn an operator of the battery condition.

b) The battery voltage low bit of the 'MD' status word, bit 11, is set to 1.

This state of affairs will continue until the battery on the memory board is replaced by a new unit. When the instrument is subsequently powered up the CPU immediately starts with a battery voltage test and, if this is successful, only the decimal point programmed via the 'FP' parameter for the displayed channel will be illuminated; the others will remain off.

It should be noted that if the memory isolation plug, PL1 of Figure 2.1 is inadvertently left out, the CPU will immediately detect this as soon as the instrument is powered up and it will behave as if the battery voltage were low.

INSTRUMENT FAULT	DIAGNOSTIC MESSAGE	FLOW DISPLAY	OPERATING MODE CHANGE	COMMAND PARAMETER STATUS INDICATION	ERROR RECOVERY PROCEDURE
Watchdog (hardware) failure	Undefined	Blanked	Analogue outputs frozen	All Comms disabled	Renew instrument
Front panel hardware fault	FP ERROR	Unchanged	HHT and push-buttons disabled	MD bit 6 set to 1	Renew front panel board
Pwr interruption detected	PFAIL ER	Unchanged	None	MD bit 9 set to 1	Set MD bit 9 to 0
I/O board 1 hardware fault (flow derived signal)	B1 HW ER	Unchanged (primary I/P shows Err)	Flow set to LR	S1 bit 12 set to 1 MD bit 12 set to 1	Renew slot 1 board
I/O board 2 hardware fault (secondary analogue I/P)	B2 HW ER	Unchanged (secondary I/P shows Err)	Default constant used in flow rate calculation	S2 bit 12 set to 1 MD bit 12 set to 1	Renew slot 2 board or set S2 no 2 off
I/O board 3 hardware fault (tertiary analogue I/P)	B3 HW ER	Unchanged (tertiary I/P shows Err)	Default constant used in flow rate calculation	S3 bit 12 set to 1 MD bit 12 set to 1	Renew slot 3 board or set S2 no 3 off
I/O board 4 hardware fault (RFL/ALMPLS options)	B4 HW ER	Unchanged	None	S4 bit 12 set to 1 MD bit 12 set to 1	Renew slot 4 board or set S2 no 4 off
Instrument parameter sumcheck failure	IP SC ER	Displays LR	Totalisation held and flow set to LR	MD bit 8 set to 1 >. set to * in parameter list	Re-enter corrupted parameters then set MD bit 8 to 0
Channel n parameter sumcheck failure (n = 1 to 8)	Cn SC ER	Displays LR	Totalisation held flow set to LR outputs frozen	ST bit 3 set to 1 MD bit 13 set to 1 >-. set to * in parameter list	Re-enter corrupted parameters then set ST bit 3 to 0 for CN
1-5V Analogue/Pulse I/Ps out of range (n = 1 to 8)	Cn OR ER	Unchanged (I/P>5.5 or HI I/P<0.5 or LI)	None	MD bit 10 set to 1 ST bits 0 set to 1 or 1 set to 1 or 2 set to 1	Restore analogue I/P signals to 1-5V range, Pulse I/P signals to HI, LI range.
Pulse I/P channel hardware fault (PULSE OPTION) (n = 1 to 4)	Cn PC ER	Displays LR (primary I/P shows Err)	Flow set to LR	ST bit 9 set to 1	Renew slot 1 board then set ST bit 9 to 0
Flow total count roll-over warning (n = 1 to 8)	Cn OVFLW	Unchanged	None	ST bit 7 set to 1	Set ST bit 7 to 0
Battery voltage low	None	Unused decimal points flash	None	MD bit 11 set to 1	Renew battery

TABLE 2.3 Diagnostic Messages and fault Recovery Procedures

(continued next page)

INSTRUMENT FAULT	DIAGNOSTIC MESSAGE	FLOW DISPLAY	OPERATING MODE CHANGE	COMMAND PARAMETER STATUS INDICATION	ERROR RECOVERY PROCEDURE
User flow equation (FLOWn) run time error (n = 1 to 8)	Fn EQ ER	Set to Zero	Flow set to zero	ST bit 11 set to 1	Check/amend flow equation program
User program (BGRND) sumcheck failure	PG SC ER	Unchanged	Program may halt	S1 bit 13 set to 1	Inspect and recopy program
User program (BGRND) run time error	RT ERROR	Unchanged	Program halts	S1 bit 13 set to 1	Correct program error
No user program (BGRND) running	HALTED	Unchanged	None	S1 bit 14 set to 1	Run a program

TABLE 2.3 (Continued) Diagnostic Messages and Fault Recovery Procedure

2.6.3 Instrument Diagnostic Messages

The 6436/7 software continuously monitors various functions within the instrument, apart from the Watchdog and Battery checking described in Sections 2.6.1 and 2.6.2. These additional diagnostic functions are listed in Table 2.3 where it can be seen that they have a number of common characteristics, viz:-

(i) Each monitoring function is capable of displaying a diagnostic message on the upper alphanumeric readout, e.g.

B2 HW ER

These messages will flash alternately with the name or identity of the channel currently being displayed on the front-panel.

(ii) Each of the diagnostics set various status bits in the instrument and Channel Command Parameters so that the condition of the 6436/7 can be monitored locally via the Hand-Held Terminal, or remotely via the serial data link.

(iii) Each of the diagnostics has a well-defined error recovery procedure allowing the operator to quickly identify and rectify a fault condition.

The 6436/7 hardware incorporates data input/output ports on the Front-panel, Analogue I/O processor, and Input/Output daughter boards of Section 1.4.1, 1.4.4, and 1.4.5 respectively. Before the CPU carries out a data transfer to or from any of these ports, the hardware itself is checked. This is done by connecting a bit from each output port back to a spare bit on the corresponding input port. The CPU then checks that these test bits can be set or reset correctly before each port is used for a data transfer. If any input/output port fails this hardware check the appropriate diagnostic message is displayed. All The diagnostic messages produced by the 6436/7 (shown in Table 2.3) are described briefly below.

a) Front-Panel Hardware Fault

When the CPU finds that it cannot communicate correctly with the data I/O ports on the front-panel board, it attempts to flash the diagnostic message:-

FP ERROR (Front Panel Hardware Error)

The calculated flow is unchanged but all the front-panel push-buttons and the hand-held terminal socket are disabled. The 'MD' parameter has bit 6 set to logic 1 and the only way to cure the fault is to replace the front-panel board itself with a new unit.

b) Power Interruption Detected

Whenever the 6436/7 is powered up it performs an initialisation routine one function of which is to set the power failure warning flag in the 'MD' status word. Therefore after any interruption of power to the 6436/7 (which would stop it totalising and render the flow totals inaccurate) the message:-

PFAIL ER (Power Fail Error)

is displayed. Table 2.3 shows that under this condition totalisation proceeds normally and bit 9 of the 'MD' status word is set to logic 1. The message will stop when the condition is acknowledged by resetting bit 9 of 'MD' to zero, or pressing the ALM button.

c) Input/Output Board 1 Hardware Fault

When a hardware fault is detected on the Analogue input board fitted to I/O Slot 1, the message:-

B1 HW ER (Board 1 Hardware Error)

is displayed. Attempting to display the primary variable '1V' (Flow derived input) by using the (INS) and (▲) or (▼) buttons will produce the message:- 'Err' on the 4 digit display. In this fault condition the primary variable '1V' is undefined but flow calculation and totalisation continue using the default constant '1K' in place of '1V' in the calculation. The 'S1' and 'MD' parameters have bit 12 set to logic 1. The fault is cured by replacing the faulty board in slot 1 with a new unit.

d) Input/Output Board 2 Hardware Fault (6437 only)

If an Analogue input board is fitted in the I/O slot 2 position (specified by the CMP1 option) and is enabled using S2 no 2 then if a hardware fault is detected, the message:-

B2 HW ER (Board 2 Hardware Error)

is displayed. Attempting to display the secondary variable '2V' (static pressure or density input) by using the (INS) and (▲) or (▼) buttons will produce the message:- 'Err' on the 4 digit display. In this fault condition the secondary variable '2V' is undefined but flow calculation and totalisation continue using the default constant '2K' in place of '2V' in the calculation. The 'S2' and 'MD' parameters have bit 12 set to logic 1. The fault is cured by replacing the faulty board in slot 2 with a new unit but the message may be inhibited by disabling the board using switch bank S2 no 2.

e) <u>Input/Output Board 3 Hardware Fault</u> (6437 only)

If an Analogue input board is fitted in the I/O slot 3 position (specified by the CMP2 option) and is enabled using S2 no 3 then if a hardware fault is detected, the message:-

B3 HW ER (Board 3 Hardware Error)

is displayed. Attempting to display the tertiary variable '3V' (temperature input) by using the (INS) and (▲) or (▼) buttons will produce the message:- 'Err' on the 4 digit display. In this fault condition the tertiary variable '3V' is undefined but flow calculation and totalisation continue using the default constant '3K' in place of '3V' if required in the calculation. The 'S3' and 'MD' parameter have bit 12 set to logic 1. The fault is cured by replacing the faulty board in Slot 3 with a new unit but the message may be inhibited by disabling the board using switch bank S2 no. 3.

f) <u>Input/Output Board 4 Hardware Fault</u>

When the RFL or ALMPLS options are specified, an Analogue or Digital output board respectively is fitted in the I/O slot 4 position and enabled using S2 no. 4. If a hardware fault is detected, the message:-

B4 HW ER (Board 4 Hardware Error)

is displayed. Since this board is used for optional retransmitted calculated flow or flow rate alarms/pulse totalisation, a hardware fault will not affect the calculated flow display, flow rate calculation or Totalisation. In this fault condition both the 'S4' and 'MD' parameters will have bit 12 set to logic 1. The fault is cured by replacing the faulty board in Slot 4 with a new unit but the message may be inhibited by disabling the board using switch bank S2 no. 4.

g) Instrument Parameter Sumcheck Failure

The 6436/7 maintains a separate sumcheck of the set of Instrument Parameters that are entered and stored in the non-volatile memory area. Any corruption of these stored parameters will cause the subsequently calculated sumcheck to differ from the stored sumcheck value. When the CPU detects this failure condition, the message:-

IP SC ER (Instrument Parameter Sumcheck Error)

is displayed. Table 2.3 shows that under these conditions Totalisation is held and the calculated flow rate 'FL' is forced to its low range value 'LR'. Bit 8 of the 'MD' instrument status parameter is set to logic 1 and all the instrument parameters will have the greater than sign (>) or decimal point (.) replaced by an asterisk (*) when read back via the hand held terminal or the supervisory data link using the ASCII mode of the communications protocol.

If the sumcheck error was due only to a transient memory corruption then it can be corrected by resetting bit 8 of the 'MD' parameter to logic 0. The Instrument Parameters should first be checked for possible corruption and re-entered where necessary. Flow calculation and Totalisation will then continue as normal.

If the sumcheck error was due to a permanent hardware fault it will not be possible to reset bit 8 of the 'MD' parameter and the operating conditions given in Table 2.3 will prevail. The error can, in this case, be corrected by replacing the memory board with a new unit.

h) Channel Parameter Sumcheck Failure

The 6436/7 maintains a separate sumcheck of each of the 8 sets of Flow calculation parameters that are entered and stored in the non-volatile memory area. Any corruption of these stored parameters will cause the subsequently calculated sumcheck to differ from the stored value. When the CPU detects this condition, the message:-

Cn SC ER (Channel n parameters Sumcheck Error)

is displayed. Where n is the number of the Channel which has the sumcheck error. Table 2.3 shows that under these conditions totalisation is held, the calculated flow 'FL' is forced to its low range value 'LR' and all analogue or digital I/O for that Channel is suspended. Bit 3 of the Channel status word 'ST' for Channel n will be set to logic 1 to indicate the sumcheck failure, and bit 13 of the 'MD' status word will also be set to logic 1. All channel parameters for channel n will have the greater than (>), minus (-) or decimal point (.) signs replaced by an asterisk (*), when read back via the hand-held terminal or supervisory data link using the ASCII mode of the communication protocol.

If the sumcheck error was due only to a transient memory corruption then it can be corrected by resetting bit 3 of the appropriate Channel 'ST' parameter to logic 0. The parameter list of Channel n should first be checked for possible corruption and re-entered where necessary. Totalisation, Flow Calculation and I/O will then be released from their suspended state and operation will continue as normal.

If the sumcheck error was due to a permanent hardware fault it will not be possible to reset bit 3 of the 'ST' parameter for Channel n and the operating conditions given in Table 2.3 will prevail. The error can in this case be corrected by replacing the memory board with a new unit.

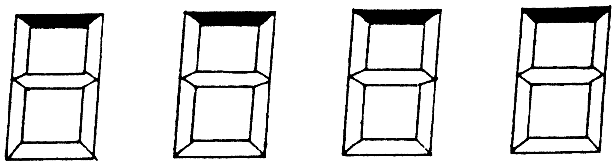
i) 1-5V Analogue Inputs Out of Range

The 6436/7 has the facility to program any of the analogue inputs of any active channel to accept 1-5V signals by setting Bit 0 of the appropriate status word ('1P', '2P', or '3P') to logic 1. When an input has been set up for 1-5V operation, the CPU checks that the signal level lies within range. For an input signal less than 1 volt the corresponding input variable is set to its minimum value (e.g. '1V'='1L'). For an input signal greater than 5 volts the input variable is set to its maximum value (e.g. '1V'='1H'). If the signal lies outside the range 0.5V - 5.5V the message:-

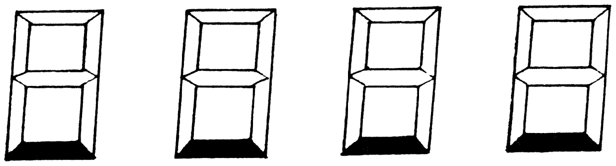
Cn OR ER (Channel n Out of Range Error)

is displayed, where n is the number of the Channel having one or more of its analogue inputs in the out of range condition. Table 2.3 shows that under these conditions the calculated flow rate display remains unchanged but attempting to display the out of range analogue input, using the (INS) and (▲) or (▼) buttons, produces the following:-

(i) If the input signal is greater than 5.5V, then only the top bars of each 7-segment display will be illuminated indicating 'input over-range' i.e.



(ii) If the input signal is less than 0.5V, then only the bottom bars of each 7-segment display will be illuminated indicating 'input under-range' i.e



It can be seen from Table 2.3 that while the out of range condition persists bit 10 of the 'MD' status word will be set to logic 1 and bit 0, 1 and/or 2 of the Channel 'ST' parameter (depending on which of the 3 analogue inputs for that channel are out of range) will also be set to logic 1. This fault can be corrected by restoring the analogue input(s) to a value within the range of 1-5V.

NOTE: If the 6436/7 is used with 1-5V signals or 4-20mA signals (with burden resistors) the out of range detection described above will indicate open circuit analogue inputs.

j) Pulse Input Channel Hardware Fault

When a hardware fault is detected on a particular channel of the pulse input board fitted to I/O Slot 1, the message:-

Cn PC ER (Channel n Pulse Card Error)

is displayed. Attempting to display the primary variable '1V' (Flow derived input) by using the (INS) and (▲) or (▼) buttons will produce the message:- 'Err' on the 4 digit display. In this fault condition the primary variable '1V' is undefined but flow calculation and totalisation continue using the default constant '1K' in place of '1V' in the calculation. The channels 'ST' parameter has bit 9 set to logic 1. The fault is cured by replacing the faulty board in slot 1 with a new unit and resetting bit 9 in the 'ST' parameter.

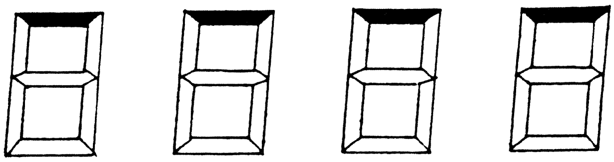
k) Pulse Inputs Out of Range Error

The 6436/7 has the facility to alarm out of range frequency/pulse inputs outside the HI,LI parameter range. When the CPU detects an input outside this range then the message:-

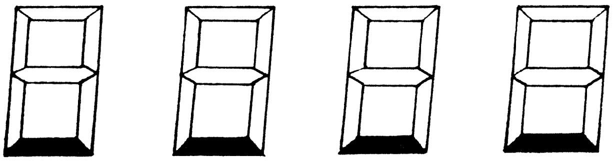
Cn OR ER (Channel n out of Range Error)

is displayed, where n is the number of the channel having its input in the out of range condition. Table 2.3 shows that under this condition the calculated flow rate display remains unchanged but attempting to display the out of range frequency/pulse input, using the (INS) and (▲) or (▼) buttons, produces the following:

i) If the input signal is greater than the high frequency range (parameter HI) then only the top bars of each 7 segment display will be illuminated indicating 'input over-range' i.e.



ii) If the input signal is less than the low frequency range (parameter LI) then only the bottom bars of each 7 segment display will be illuminated indicating 'input under-range' i.e.



l) Flow Total Overflow Detected

The 6436/7 maintains a flow total, in engineering units, of 8 digits i.e. maximum value of 99,999,999 engineering units. In the course of normal operation a flow total would be periodically cleared (e.g. at the end of a working shift etc.). Should the total be left to reach 99,999,999 it will automatically 'roll over' through zero and totalisation will continue uninterrupted. When this condition occurs the warning message:-

Cn OVFLW (Channel n Flow Total Overflow)

is displayed where n is the number of the Channel which has overflowed. Table 2.3 shows that under this condition normal operation is fully maintained and bit 7 of the Channel status word 'ST' for channel n will be set to logic 1. The message will stop when the condition is acknowledged by re-setting bit 7 of 'ST' to zero, or pressing the TOT button when set on the relevant channel.

m) User Flow Equation (FLOWn) Run Time Error

If a run time error occurs whilst one of the user flow equation programs (FLOWn in FORTH) is running, the diagnostic message:-

Fn EQ ER (Flow n Equation Error)

is displayed, where n is the affected channel number. Table 2.3 shows that the result of the flow calculation for that channel is set to zero while bit 11 of the channel status word 'ST' for channel n will be set to logic 1.

The fault is cleared by checking and amending the flow equation program FLOWn. Full details on writing FORTH programs are given in the TCS publication 'Programmable Instruments Programming Manual'. The 6437 User Guide describes how to install and run user flow equations, and gives a list of run time errors.

n) User Program (BGRND) Sumcheck Failure

The 6436/7 maintains a separate sumcheck of the user program (BGRND) stored in the non-volatile memory area. Any corruption of the stored program causes the subsequent calculated sumcheck to differ from the stored sumcheck value. When the CPU detects this failure condition, the message:-

PG SC ER (Program Sumcheck Error)

is displayed. Table 2.3 shows that under these conditions the user program may halt, depending on the precise nature of the program corruption, bit 13 of the channel status word 'S1' will be set to logic 1.

The error condition should be investigated by inspecting the program. If necessary the RAM area can be erased via the NEW command and the program recopied from EEPROM to RAM via the RECALL command. See 6437 User Guide.

o) User Program (BGRND) Run Time Error

When the 6436/7 software detects a run time error in the user program, the message:-

RT ERROR (Run Time Error)

is displayed. The program halts and bit 13 of the channel status word 'S1' will be set to logic 1. The error condition can be cured only by finding the error within the user program and correcting it.

A detailed error message can be obtained by connecting a VDU terminal (e.g. Epson PX-8) to the 6436/7 via the front panel socket, and logging in. Refer to the 6437 User Guide.

p) No User Program Running

When no user program is running, which may be deliberate or resulting from a fault condition, the following message is displayed:-

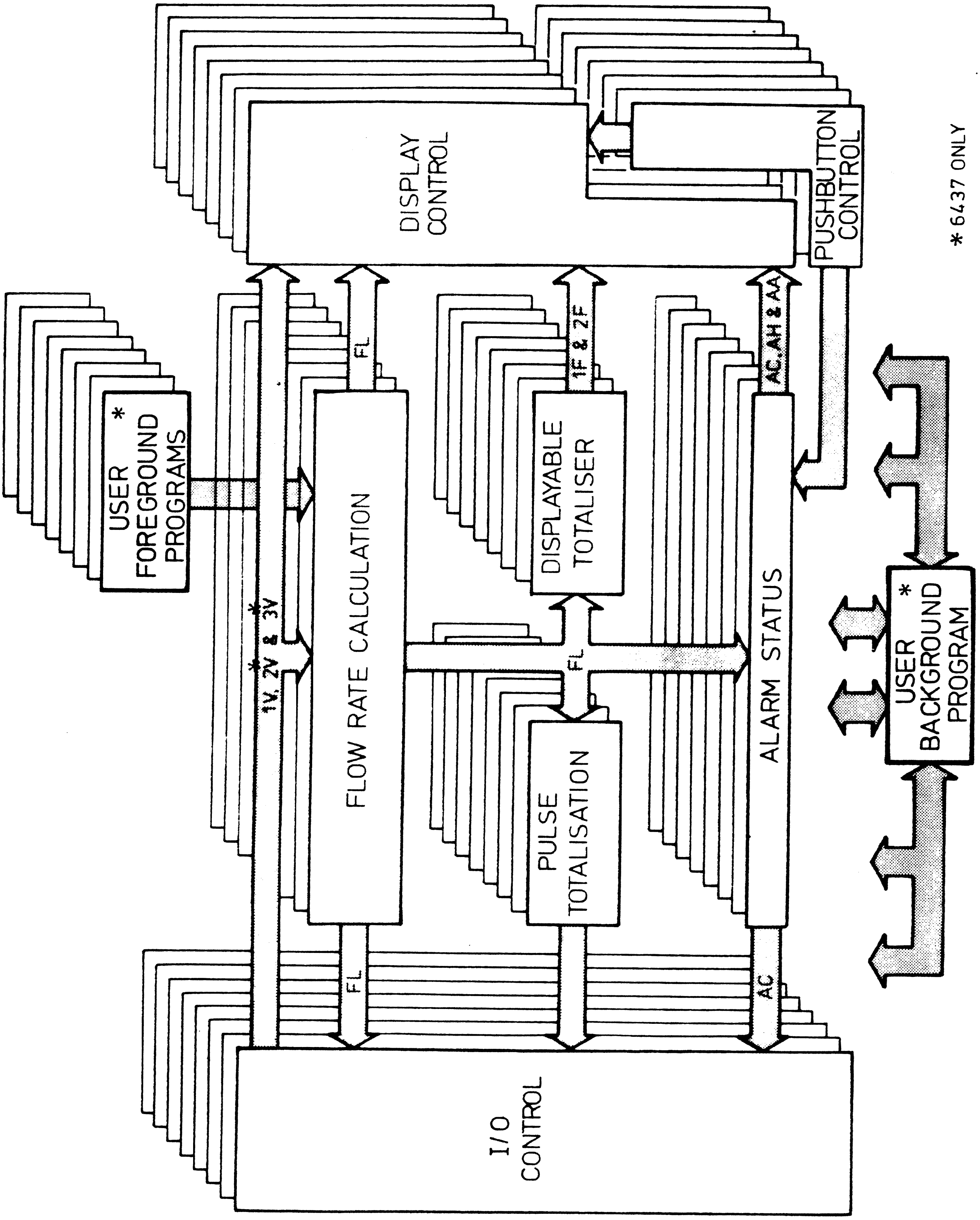
HALTED

The program halts and bit 14 of the channel status word 'S1' will be set to logic 1.

This message can be cleared by running a user program. To merely clear the message, a dummy program can be run (e.g. a BEGIN REPEAT indefinite loop).

2.7 Use of the 6436/7 with 4-20mA Input Signals

The 6436/7 has the facility to program any of the Analogue inputs of any active channel to accept 1-5V signal levels by setting Bit 0 of the 1P, 2P, or 3P status word for the appropriate channel to logic 1 (see section 4.5.2 c)). Once any input has been set up in this way it can be used with 4-20mA input signals provided that a 250 ohm precision resistor is used to convert this to a 1-5V signal. When these external resistors are used it is very important that they are connected in a manner that does not inject current into the 0V reference bus and so degrade the system 0V reference. See the System 6000 Installation guide Section 6.2. for a fuller description of the use of TCS instrumentation with 4-20mA Input signals.



* 6437 ONLY

FIG. 3.1 6436/7 FLOW MONITOR/COMPUTER DATA MOVEMENT

6435(5)/5

Section 3 6436/7 FUNCTIONS AND APPLICATIONS

3.1 Functional Overview

The 6436/7 implements eight flow monitoring channels, each with separately programmable characteristics. In explanation of the flow computer functions and discussion of its applications, it is only necessary to consider one active channel. Unless specifically mentioned all further discussions concerning a flow monitoring channel are generally applicable to any active channel.

NOTE: The 'S1' parameter determines how many of the 6436/7 channels are active (1-8) and should therefore be set up, via the 8260 Hand-held Terminal (HHT), VDU programming terminal (VDU), or supervisory serial data link (SSDL), on power-up from an un-programmed state (See the User Guide). The Channel parameter list of any inactive channel is not accessible via the HHT, VDU, or SSDL (using the ASCII mode of the communication protocol).

The 6436/7 performs two main functions:-

a) Calculation of instantaneous flow rate.

b) Totalisation of the calculated flow rate.

Figure 3.1 shows schematically these calculations together with some subsidiary and additional calculations, and the relationships between them. Each calculation (except for display and push-button control) is introduced below (Sections 3.1.1 to 3.1.4) and discussed in detail in the following sections (Sections 3.2 to 3.5).

The 6436/7 software structure and FORTH programming capability are discussed in Section 3.6.

NOTE: 6436/7 parameters may be individually keyed in digit by digit using the Hand-held Terminal plugged into the front panel of the instrument. Alternatively, (6437 only), the resident higher level question-and-answer configuration program (CONFIG) may be used to set up the instrument via a VDU programming terminal plugged in instead of the HHT. This is usually much simpler, especially for complicated configurations.

Throughout this section, when references are made to setting up parameters, these options should be borne in mind. The 6437 User Guide gives full details on the use of CONFIG.

3.1.1 Input Conditioning

The 6436/7 uses analogue or frequency input signal values as well as programmed constant data in the flow rate calculation. The analogue or frequency input signal values may be inspected using the front panel numeric display. The input conditioning calculation performs the function of converting the input signal into a suitable form for display and for the flow rate calculation. (See Section 3.2).

3.1.2 Flow Rate Calculation

This is the first major calculation block and its function is to perform the complete calculation of instantaneous flow rate (mass, or referenced volumetric) of the gas or liquid being metered.

As an alternative to selecting one of the 32 standard flow calculations resident in the 6437, users can write their own special flow equations in FORTH. These are called 'foreground programs'. User flow equations can take any form, and so the comments below referring to the standard flow calculations do not apply to them. Refer to the 6436/7 User Guide for details on writing, installing, and enabling FORTH flow equations.

A full description of the standard resident flow rate calculation is given in Section 3.3, but essentially it consists of 3 parts :-

a) The Scaling Factor term.

b) The Primary Variable term.

c) The Density Correction term (6437 only).

The flow rate is calculated by multiplying together these three terms.

Term a) is simply the product of two Scaling Factors.

Term b) is the Primary Input Variable '1V', but is optionally square rooted in accordance with the characteristic of the flow transducer used.

Term c) is the Density Correction term and may also be square rooted if necessary, in accordance with the characteristic of the flow transducer being used. The density correction term itself has four alternative forms:-

(i) Used when density is being directly measured continuously with an on-stream density meter.

(ii) Used when the density of a gas is to be inferred by measuring the temperature and static pressure of the flowing gas. (See Appendix E)

(iii) Used when the density of a non-linear fluid is to be inferred measuring the temperature and static pressure. (See Appendix F)

(iv) Used when conditional switching and manipulation of inputs are required (e.g. Tariff metering, dual head DP).

With this flexible calculation structure the 6436/7 may be used to calculate the mass and volumetric flow rate of liquids and gases being metered with a very wide range of transducer types.

Examples of flow rate calculations for various types of transducer are shown in Section 3.3 where the flow rate calculation is dealt with in detail. Section 3.3.5 shows an example of a process calculation which is not necessarily related to flow metering, implemented by a 6437.

3.1.3 Alarm Condition Calculations

The flow rate of the metered substance, calculated as described above, is compared with two alarm level settings. If the flow rate is found to be greater than the high alarm level or less than the low alarm level, the channel is said to be in high or low alarm respectively. The event of entry into high or low alarm is recorded so that the occurrence of a short-lived alarm condition (possibly not seen by an operator during its existence) does not pass unnoticed.

The function of the alarm condition calculation block is to generate and maintain indications of the current and historic alarm state. This is described in more detail in Section 3.4.

3.1.4 Totalisation Calculation

The two separate flow rate totalisation calculations are represented by the two central blocks of Fig 3.1. Both of the calculations are described here and discussed in detail in Section 3.5.

Two separate accumulators are maintained by this calculation and at every totalisation sample time they are both incremented by an amount that is proportional to the Flow rate. The basic increment quantities can also be predivided by scaling factors before being added into their respective accumulators. The increments are formed by using the current flow rate to calculate the quantity of the metered substance that has flowed since the last sample time. The displayed total automatically 'rolls over' when full.

The calculation for pulse output totalisation is only slightly more complex than for the displayable total. When the accumulator value exceeds a preset level, a pulse is produced at the digital output and the preset amount is subtracted from the accumulator. This accumulator is not displayable and, as it decreases with every pulse that is produced, does not 'roll over'.

One last feature of the totalisation calculation that should be noted is the low flow substitution facility. This provides two programmable constants, called the low flow threshold and the default flow rate. When the calculated flow rate falls below the low flow threshold, the default flow rate is used in the totalisation calculations. This allows, among other things, a low flow cut-off to be implemented.

3.1.5 User Background Program

The FORTH interpreter resident in the 6437 allows programs to be written not only for individual flow equations (foregound programs), but also for controlling events across the whole eight channels of the instrument (background programs).

At power up, a user program called BGRND is automatically run (if it is present in the instrument's memory). This is a background program that can call other stored programs, can access and update all the inputs, outputs, parameters, variables, and timers within the 6437's database, and so determine the overall actions of the instrument.

The User Guide gives details on how to install and use background programs. A library of these powerful programs has been developed by TCS for both specific and, with adaptation, more general applications.

3.2 Input Signal Processing

The 6437 may have up to three inputs in use for any given flow monitoring channel. Only one input, the Primary Variable, is possible for the 6436 model. There are essentially three functions performed by the signal processing calculation for each input namely:-

1) Input Ranging
2) Input Linearising
3) Input Filtering (Analogue Input only)

Fourteen Channel parameters are of interest here, four for each input, plus two specifically for pulse inputs ('HI', 'LI'):-

'1P', '1H', '1L' and '1V' for the Primary input
'2P', '2H', '2L' and '2V' for the Secondary input
'3P', '3H', '3L' and '3V' for the Tertiary input

The parameters in each group (e.g. '1P', '2P' and '3P') perform similar functions for each input. Taking one input as an example, '1P' controls the input conditioning calculations for the primary input and '1V' is the parameter which holds the final 'conditioned' value while '1H' and '1L' are ranging constants (in engineering units) used in the Input ranging calculation.

3.2.1 Input Filtering (Analogue Inputs only)

As part of the input processing calculation the Flow Computer can perform some digital filtering (signal averaging) on each incoming signal. This facility is of value if the input signal is likely to have superimposed noise. The filter time constant for each input is separately programmable in the range 0.2 to 60 secs using digit C of the '1P', '2P' or '3P' status words as appropriate.

3.2.2 Input Linearisation

Input signals must be in the range 0-10V or 1-5V. A 0-10V signal is being considered in this example. The signal might typically represent a temperature in the range 0-120°C, however the relationship between the real temperature and the voltage signal representing it is not necessarily linear. With 0V representing 0°C and 10V representing 120°C, an input of 5V does not necessarily represent 60°C. The 6436/7 has, as part of the input processing calculation, a routine to 'linearise' the input signal using tables stored in its memory. Several linearisation tables, mainly for thermocouple inputs, are stored as standard and one of them may be applied to an input signal by programming digit B of the '1P', '2P' or '3P' parameter as appropriate. See the User Guide. Various input conditioning (linearisation) functions are available and it should be noted that if required up to five customer specified linearisation tables may be included in the memory as an option.

3.2.3 Input Ranging

a) Signal Level Ranges

i) Analogue Inputs

The 6436/7 analogue input circuitry accepts signals in the range 0-10V and the input signal may be interpreted as having a span of 0-10V or of 1-5V. This second span is used when only a

4-20mA signal is available from the plant and is converted to a voltage signal using a precision 250 ohm burden resistor (See System 6000 Installation Guide Section 6.2). Each input is separately selectable as having an input span of 0-10V or 1-5V by programming Digit D of the '1P', '2P' or '3P' status word as appropriate. (See Section 4.5.2 c)).

NOTE: When a 1-5V signal is being used the input resolution is reduced by 60% (See Section 1.5.3).

ii) Pulse Inputs

The 6436/7 frequency/pulse input circuitry accepts signals in the range 0V for logic 0 and 5 to 15V for logic 1. The frequency range is from 0-10kHz and a capability of period measurement up to 10,000 secs.

For direct voltage free contact closure measurements the 6436/7 has a 15V, 100mA power supply available.

NOTE: There is no contact de-bounce circuitry on these inputs.

iii) Borrowed Inputs (Software-Patched Inputs)

The 6436/7 is capable of having any of its flow rate output channels software-connected to any other channel's input using digit D of the '1P' '2P' or '3P' status words as appropriate. (See Section 4.5.2 c)).

b) Ranging for Display and Calculation

Consider the example of a 1-5V signal representing a temperature in the range 0-80°C (the principle is the same for a 0 to 10V signal). The 6436/7 generates a display of the temperature from this 1-5V input signal using two ranging constants '3H' and '3L'. '3L' is programmed with the value of temperature that corresponds to an input signal of 1 volt (0°C) and '3H' with the value corresponding to a signal of 5 volts (80°C). The relationship between temperature and input voltage is, at this stage, assumed to be linear and consequently the 6436/7 can calculate and display the temperature that corresponds to any input, in the range 1-5V, by a process of linear interpolation. The decimal point position for the front panel display (and for the '3V' parameter as seen via the HHT or SSDL) is selected by programming digit A of the '3P' parameter (See Section 4.5.2 c) and Table 4.13).

3.2.4 Input Signal Default Values

Section 3.3.1 B c) outlines how either programmed constant data ('2K' and '3K') or plant derived input variable data ('2V' and '3V') may be selected for use in the density correction term of the flow rate calculation.

If programmed constant data is selected it is still necessary that the ranging parameters '2H' and '2L' and/or '3H' and '3L' and the correct decimal point position be set up for the constants '2K' and/or '3K' as they are used as 'substitute' input values.

If input variable data is selected, the constants '2K' and '3K' should be programmed with average values of the corresponding input variables. Under I/O daughter board hardware failure conditions (or if a 1-5V input falls below 1 volt) the constants are used by default, ensuring that a meaningful flow rate value is calculated, despite the hardware failure, until the fault is corrected (See Section 2.6.3 c) and 2.6.3 d)).

3.3 Flow Rate Calculation

This is the central calculation performed by the 6436/7 and it is discussed here in detail. Firstly some general considerations concerning the form and use of the equations implemented within the 6436/7 are discussed. This is followed by discussion of an Orifice Plate Metering application (though not using a specific numeric example). Lastly Turbine Meter and Gilflo Meter applications are considered by comparison with the Orifice Plate application.

NOTE 1: The 6436 does not have the density correction term (DCT) facility, and so the following discussion of the DCT applies only to the 6437.

NOTE 2: The FORTH facility in the 6437 allows user defined flow calculations to be employed, instead of the built in standard calculations. The following discussion applies only to the standard flow calculations, not to user defined ones, which may have any form capable of being programmed.

3.3.1 **Flow Rate Calculation General Considerations**

A) Equation Form

The General form of the flow rate calculation implemented within the 6436/7 is shown below:-

$$FL\ (computed) = 1C \ x \ 2C \ x \left\{ \begin{array}{c} 1V \\ or \\ \sqrt{1V} \end{array} \right\} x \left\{ \begin{array}{c} DCT \\ or \\ \sqrt{DCT} \\ or \\ 1/DCT \\ or \\ 1/\sqrt{DCT} \end{array} \right\}$$

where DCT is the Density Correction Term (set to unity in the 6436 instrument).

The DCT itself can take four forms:-

i) $DCT = 2V$ (Direct Density Form)

ii) $DCT = \frac{1}{SG} x \frac{TO}{PO} x \frac{2V + PA}{3V + TA} x \frac{XO}{ZF}$ (Inferred Density Form)

where
FL = Calculated Flow Rate
1V = Primary input
2V = Secondary Input
3V = Tertiary Input
TO = Reference Temperature (absolute)
PO = Reference Pressure (absolute)
SG = Relative Density (Specific Gravity)
TA = Offset to absolute zero from temperature measurement scale zero
PA = Offset to absolute zero from pressure measurement scale zero
1C = Scaling Factor
2C = Scaling Factor
XO = Base Compressibility (a value of 0 sets XO/ZF = 1)
ZF = Compressibility Factor (See Table 3.3)

(iii) $DCT=3C.\frac{1+5C.1E-2.(2V+PA-PO)+6C.1E-5.(2V+PA-PO)**2}{1+7C.1E-3.(3V+TA-TO)+8C.1E-7.(3V+TA-TO)**2}$

(Second Order Approximation Density Form)

where 3C = base density
5C,6C = pressure constants
7C,8C = temperature constants

```
iv)   DCT = term1 + term2  (Analogue Manipulation Form)

      where IF 2V < 3C
            THEN term1 = (2V+5C).6C
            ELSE term1 = 0

      and   IF 2V ≥  4C
            THEN term2 = (3V+7C).8C
            ELSE term2 = 0
```

This general form of the flow rate calculation is a convenient shorthand representation of the 32 possible calculation forms. Six of these possible calculation forms are listed below, applied to three main types of transducer:-

a) <u>Differential Pressure Types</u> - Orifice plate,

Venturi meter and Venturi nozzle

(i) $$FL = 1C \times 2C \times \sqrt{1V} \times \sqrt{2V}$$

(ii) $$FL = 1C \times 2C \times \sqrt{1V} \times \sqrt{\frac{1}{SG} \times \frac{T0}{P0} \times \frac{2V + PA}{3V + TA} \times \frac{XO}{ZF}}$$

b) <u>Linear Differential Pressure Type</u> - Gilflo meter

(i) $$FL = 1C \times 2C \times 1V \times \sqrt{2V}$$

(ii) $$FL = 1C \times 2C \times 1V \times \sqrt{\frac{1}{SG} \times \frac{TO}{PO} \times \frac{2V + PA}{3V + TA} \times \frac{XO}{ZF}}$$

c) <u>Velocity Type</u> - Turbine Meter or Vortex Meter

(N.B. Set SG = 1)

(i) $$FL = 1C \times 2C \times 1V \times 2V$$

(ii) $$FL = 1C \times 2C \times 1V \times \frac{1}{SG} \times \frac{TO}{PO} \times \frac{2V + PA}{3V + TA} \times \frac{XO}{ZF}$$

B) The Density Correction Term

a) Types of DCT

As shown in 3.3.1 A) the DCT has four distinct forms:-

(i) Direct Density Form

2V

This is used when density information is available directly from some form of on-stream density meter.

(ii) Inferred Density Form

$$\frac{1}{SG} \times \frac{TO}{PO} \times \frac{2V + PA}{3V + TA} \times \frac{XO}{ZF}$$

This form is used (when metering gases) to infer the density of the gas at line temperature and pressure by assuming that it behaves as a theoretical perfect gas, and then applying a deviation factor of XO/ZF.

(iii) Second Order Approximation Density Form

$$DCT=3C.\frac{1+5C.1E-2.(2V+PA-PO)+6C.1E-5.(2V+PA-PO)**2}{1+7C.1E-3.(3V+TA-TO)+8C.1E-7.(3V+TA-TO)**2}$$

This is an empirical method applicable to all fluids (liquids, gases, and steam). In the case of gases and steam, five values of density are required.

Second Order Approximation is often accurate over a wider range around base conditions than Inferred Gas Density. The method is discussed in Appendix F of this manual.

Note: When the resident 6437 configuration program (CONFIG) is used to set up the instrument, all the necessary constants for this method are calculated automatically by the program from the density data fed in. An example is given in the User Guide.

(iv) Analogue Manipulation Form

```
DCT = term1 + term2

where IF 2V < 3C
      THEN term1 = (2V+5C).6C
      ELSE term1 = 0

and   IF 2V ≥ 4C
      THEN term2 = (3V+7C).8C
      ELSE term2 = 0
```

This special form can be adapted to many kinds of flow manipulation. For example, addition, subtraction, and conditional selection of factored flows, with either low range clipped to zero, or high range cut-off. 2V and 3V may be real plant inputs, constants, or software patched outputs from other channels.

An example of the use of this Analogue Manipulation is given in the User Guide.

b) TA and PA in the Density Correction Term

TA is the 'Offset to Absolute zero from the temperature measurement scale zero'. In the inferred density DCT, temperature must be an absolute value e.g. in Kelvin, while for display purposes it is more convenient and useful to show the temperature on the more familiar Celsius (or Centigrade) scale. TA is added to, in this example, a Celsius measurement to give absolute temperature. Generally a flow measuring installation will be using either metric units (with TA of 273.2) or imperial units (TA of 459.7).

PA is the 'Offset to Absolute zero from pressure measurement scale zero'. Again an absolute value of pressure is necessary in the inferred density DCT while it is often required that gauge pressure be displayed. PA is the offset that is added to a pressure measurement to give the absolute pressure. Generally a flow measuring installation will be using either all gauge pressure sensors (PA will be local atmospheric pressure) or all absolute pressure sensors (PA should be set to 0). PA will be in Bars when temperature is in Celsius/Kelvin and Atmospheres when temperature is in Fahrenheit/Rankine.

c) Constants and Variables in the DCT

It is important to note that where the input variables '2V' and '3V' appear in these equations the constants '2K' and/or '3K' may be used instead. To illustrate this consider the first of the six basic equation forms (3.3.1 A a)(i)). With the constant '2K' selected instead of the variable '2V' it becomes:-

$$FL = 1C \times 2C \times \sqrt{1V} \times \sqrt{2K}$$

This would be the form to use for an orifice plate installation when density correction is not required.

Similarily, considering the second form of the equation (3.3.1 A a) (ii)), with the constant '3K' selected instead of the variable '3V' it becomes:

$$FL = 1C \times 2C \times \sqrt{1V} \times \sqrt{\frac{1}{SG} \times \frac{TO}{PO} \times \frac{2V + PA}{3K + TA} \times \frac{XO}{ZF}}$$

This would be the form to use for an orifice plate installation metering a gas, when density correction is required and the changes in density are being inferred by measuring the static pressure variations while the temperature is taken as being constant.

This facility to replace variables in the equations with constants extends the number of forms of the six basic equations (given in Section 3.3.1 A) to 18, each relevant to a different combination of primary and secondary transducer types.

C) Units System Changes

The calculated flow rate will normally be in units of Kg/s for mass flow measurements and in cubic metres/sec for volumetric flow rate. In many cases the flow rate may be required in other units and the differences may be in:-

a) Time units e.g. /minute or /hour flow rates to be displayed.

b) Unit multiples e.g. volumetric flow in litres/sec or 10's of cubic metres/sec.

c) Measurement scales e.g. mass flow rate in lbs/sec.

d) Basic measured quantity e.g. to display cost or energy equivalent of measured mass flow.

Such unit changes may be accomplished by inclusion of appropriate factors within the scaling factor term:- 1Cx2C.

NOTE: Acceptable time units ranges are /second, /minute /hour and /day. Other ranges may be used if the flow rate is not required to be totalised but displayed only.

D) Selecting the Calculation Form

The main use of the 'FP' parameter (Flow Processing) is to select which of the calculation forms is to be used, although certain bits have other functions.

In particular, bits 1 and 2 (in digit D), in conjunction with parameter CT, determine the form of the output for analogue output boards (See Table 3.1). They have no effect on digital output boards.

For digital output boards, it is the CT bit for each channel which determines which of the two possible output forms is used: 0 = alarm output, 1 = pulse output. See Section 4 for details of all parameters.

FP - Flow Processing (Read/Write)

Parameter Format 5 (4 hexadecimal digits)

Decimal Point				Primary Device Type				Density Correction Select				Analogue Output Select			
Bit 15	14	13	12	11	10	9	Bit 8	Bit 7	6	5	4	3	2	1	Bit 0
Digit A				B				C				D			

DIGIT	BIT	FUNCTION	
A	15-12	Decimal Point Position Select	0-4
B	11-8	Transducer Type Select (See Table 3.2)	0-9
C	7	Density Correction Select (See Table 3.3)	
	6		
	5	3V/3K Select in Calculation	0=3K Selected 1=3V Selected
	4	2V/2K Select in Calculation	0=2K Selected 1=2V Selected
D	3	Unused	
	2	Analogue Board Output Select (See Table 3.1a)	
	1		
	0	FORTH Flow Equation (FLOWn) Select	1 = FLOWn Selected 0 = Follows Digit B

Appropriate CT Bit (See Section 4.3.2 d)	FP Parameter Bit		Output Type
	2	1	
0	X	1	Flow rate alarm
0	0	0	Retransmitted flow
0	1	0	FORTH SETAN
1	X	X	Retransmitted flow pulse

(X = Don't Care)

Table 3.1 Analogue Board Output Select (FP Bits 1,2)

Transducer Type Digit Entry	Calculation Form	Typical Transducer	Config* Transducer Type No.
0	1C.2C.1V.DCT	Turbine Meter	3
1	1C.2C.1V.$\sqrt{\text{DCT}}$	Gilflo Orifice Meter	4
2	1C.2C.$\sqrt{\text{1V}}$.$\sqrt{\text{DCT}}$	Orifice Meter	5
3	1C.2C.$\sqrt{\text{1V}}$.DCT	Extra	7
4	1C.2C.1V.1/DCT	TU1	8
5	1C.2C.1V.1/$\sqrt{\text{DCT}}$	GI2	9
6	1C.2C.$\sqrt{\text{1V}}$.1/$\sqrt{\text{DCT}}$	OR1	10
7	1C.2C.$\sqrt{\text{1V}}$.1/DCT	EX1	11
8	1C.2C.1V	Uncorrected Flow	1
9	(Not used)		-
A	1C.2C.$\sqrt{\text{1V}}$	Uncorrected Flow	2

* As used in the 6437 configuration program 'CONFIG' detailed in the 6437 User Guide.

Table 3.2 Transducer Type Digit B of FP

a) Transducer Type

The 'Transducer Type' digit of 'FP' (digit B) determines which of the terms 1V and DCT are square rooted. An orifice plate calculation for example requires:-

$$\sqrt{1V} \text{ and } \sqrt{DCT}$$

while the calculation form required for calculating the flow rate through a gilflo type orifice has :-

$$1V \text{ and } \sqrt{DCT}$$

Table 3.2 shows the values that may be programmed in the 'Transducer Type' digit of 'FP' and the corresponding combinations of square rooted terms they select.

Density Correction Type Bit 6,7	Calculation Form
:0:0:x:x:	Selects DIRECT DENSITY DCT = 2X
:0:1:x:x:	Selects INFERRED GAS DENSITY DCT = $\frac{TO.(2X+PA)}{SG.PO.(3X+TA)} \cdot \frac{XO}{ZF}$ (Set SG to 1 for turbine meter) NOTE 1 IF XO is zero THEN XO/ZF =1 ELSE ZF is calculated ZF =1+b.(2X+PA)+c.(2X+PA)**2 b =[3C+(4C.3V)-(5C.3V**2)].1E-5 c =[6C+(7C.3V)+(8C.3V**2)].1E-8
:1:0:x:x:	Selects SECOND ORDER APPROXIMATION DENSITY CALC. DCT = 3C. $\frac{1+5C.1E-2.(2X+PA-PO)+6C.1E-5.(2X+PA-PO)^{**}2}{1+7C.1E-3.(3X+TA-TO)+8C.1E-7.(3X+TA-TO)^{**}2}$
:1:1:x:x:	Selects ANALOGUE MANIPULATION CALC. DCT = term1 + term2 IF 2X $<$ 3C THEN term1 = (2X+5C).6C ELSE term1 = 0 IF 2X $\geqslant$ 4C THEN term2 = (3X+7C).8C ELSE term2 = 0 Note: 2X, 3X represents either 2V or 2K, 3V or 3K dependent upon whether constants have been selected or not.

Table 3.3 Density Correction Select. Digit C of FP

b) Density Correction Term

Digit C of the 'FP' parameter determines the form DCT takes and this involves selecting:-

(i) The form of the DCT, i.e.:-

Direct Density,

or

Inferred Gas Density,

or

Second Order Approximation Density,

or

Analogue Manipulation.

See Table 3.3.

(ii) Whether the DCT term (selected as above) is to use input variables ('2V' and/or '3V') or constant data ('2K' and/or '3K').

3.3.2 Orifice Plate Metering

In this section the use of the 6437 with an Orifice plate is covered in detail. In the example considered, 'referenced' volumetric flow rate is calculated. That is the volumetric flow rate that would occur at the reference temperature and pressure (usually STP or NTP) corresponding to the measured mass flow rate. Gas density, in this example is calculated from the gas temperature and pressure. The referenced volumetric flow rate is given by:-

$$Qo = a.E.\frac{Pi}{4}.d^2. \sqrt{\frac{2}{ro(air)}} . \sqrt{Dp}. \sqrt{\frac{1}{SG}.\frac{TO}{PO}.\frac{P}{T}.\frac{ZO}{ZF}}$$

(See Appendix E for explanation for the terms used).

This equation is implemented in the 6437 Flow Computer as:-

$$FL = 1C.2C . \sqrt{1V} . \sqrt{\frac{1}{SG}.\frac{TO}{PO}.\frac{2V+PA}{3V+TA}.\frac{XO}{ZF}}$$

A channel of the 6437 would be set up to perform this calculation as follows:-

A) Input Signal Related Parameters

a) Primary input (Differential Pressure)

For differential pressure to be correctly displayed and used in the calculation:-

1H should be set to the maximum measurable differential pressure.

1L should be set to the minimum measurable differential pressure.

1P must have the correct decimal point position and signal voltage span selections set up. An input filter time constant would also be programmed here but no linearisation is required.

1V will now contain the correct differential pressure.

(1K should be programmed to zero.)

b) Secondary Input (Static Pressure)

For static pressure to be correctly displayed and used in the calculation:-

2H should be set to the maximum measurable static pressure.

2L should be set to the minimum measurable static pressure.

2P must have the correct decimal point position and signal voltage span selections set up. An input filter time constant would also be programmed here but no linearisation is required.

2V will now contain the correct static pressure.

2K should be programmed with the expected nominal value of 2V (see Section 3.2.4).

c) Tertiary Input (Temperature)

For Temperature to be correctly displayed and used in the calculation:-

3H should be set to the maximum measurable temperature.

3L should be set to the minimum measurable temperature.

3P must have the correct decimal point position and signal voltage span selections set up. An input filter time constant would also be programmed here and a temperature sensor linearisation will probably be required.

3V will now contain the correct temperature.

3K should be programmed with the expected nominal value of 3V (see Section 3.2.4).

B) Selecting the Calculation

a) The orifice plate characteristic is selected using the FP parameter digit B.

b) Using the FP parameter digit C, the inferred density form of the DCT is selected by setting bit 6 to 1. 2V and 3V are selected in the DCT instead of 2K and 3K by setting bits 4 and 5 respectively to 1 (See Tables 3.3 and page 3.15).

C) Programming Constants

a) If temperature is being measured in Centigrade then TA must be 273.2 while if temperature is being measured in Fahrenheit then TA must be 459.7.

b) If gauge static pressure is being measured then PA must be set to local atmospheric pressure while if absolute static pressure is measured then PA must be set to zero.

c) TO is the Reference Temperature, PO is the Reference Static Pressure. SG is the ratio of the density of the gas to the density of air (measured at TO and PO).

d) 1C x 2C must give the value of:-

$$a.E.\frac{Pi}{4}.d^2. \quad \sqrt{\frac{2}{ro(air)}}$$

D) Flow Rate Range Parameters

The calculated flow rate is held in the 'FL' parameter and, although its value will depend on how all the parameters mentioned above are programmed, its maximum value will be known when specifying the size of the primary transducer etc. 'FL' is displayed by the 6436/7 Flow Computer in the same way as analogue inputs and for the flow rate to be correctly calculated and displayed:-

HR should be set to the maximum measurable flow rate,
LR should be set to the minimum measurable flow rate,
FP should be used to set the decimal point position for the calculated flow rate,
FL will now hold the value of the calculated flow rate.

NOTE: If HR is set lower than the maximum measurable flow rate then for flow rates higher than HR the display will show HR i.e. higher flow rates are 'clipped'. To check that HR and LR are set correctly:

a) Temporarily set 1L to 1H, this forces the input variable 1V to its maximum value (maximum differential pressure).

b) Temporarily set 2L to 2H, this forces the input variable 2V to this maximum value (static pressure).

c) Temporarily set 3H to 3L, this forces the input variable 3V to its minimum value (minimum temperature).

d) Observe the calculated flow rate. Now increase HR by a factor of 10 (by modifying the decimal point position selected in the FP parameter) and re-examine the calculated flow rate. If it has increased then HR is too low and must be re-ranged.

3.3.3 The Gilflo Meter

This is a spring loaded, variable aperture orifice meter. Fluid flow through a Gilflo orifice produces a differential pressure across it which is proportional to the volumetric flow rate rather than to the square of the flow rate as with a normal Orifice Plate.

The 6437 may be set up to use such a linear orifice plate in much the same way as it is set up for use with a normal orifice plate. The example application discussed for the orifice plate in 3.3.2 is considered here for the Gilflo orifice and volumetric flow rate is given by:-

$$Qo = K \cdot \sqrt{\frac{1}{ro(air)}} \cdot Dp \cdot \sqrt{\frac{1}{SG} \cdot \frac{TO}{PO} \cdot \frac{P}{T} \cdot \frac{ZO}{ZF}}$$

(Where K is manufacturer supplied constant data)

This equation is implemented in the 6437 as:-

$$FL = 1C.2C \cdot 1V \cdot \sqrt{\frac{1}{SG} \cdot \frac{TO}{PO} \cdot \frac{2V+PA}{3V+TA} \cdot \frac{XO}{ZF}}$$

By comparison with the Orifice Plate example of 3.3.2, a channel of the 6437 would be set up to perform this calculation as follows:-

A) Input Signal related parameters

a) Primary input (Differential Pressure)

For differential pressure to be correctly displayed and used in the calculation:-

1H, 1L, 1P, and 1K should be set up in the same manner as for the orifice plate example of 3.3.2.

b) Secondary Input (Static Pressure)

For static pressure to be correctly displayed and used in the calculation:-

2H, 2L, 2P and 2K should be set up in the same manner as for the orifice plate example of 3.3.2.

c) Tertiary Input (Temperature)

For temperature to be correctly displayed and used in the calculation:-

3H, 3L, 3P and 3K should be set up in the same manner as for the orifice plate example of 3.3.2.

B) Selecting the Calculation

a) The Gilflo characteristic is selected using the FP parameter digit B (see Table 3.2).

b) The required DCT is selected in the same manner as for the example in 3.3.2.

C) Programming Constants

a) If temperature is being measured in Centigrade then TA must be 273.2 while if temperature is being measured in Farenheit then TA must be 459.7.

b) If Gauge static pressure is being measured then PA must be set to local atmospheric pressure while if absolute static pressure is measured then PA must be set to zero.

c) TO is the Reference Temperature; PO is the Reference Static Pressure. SG must be the ratio of the density of the gas to the density of air (at the conditions TO and PO).

d) 1C x 2C must give the value of:-

$$K \cdot \sqrt{\frac{1}{ro(air)}}$$

D) Flow Rate Range Parameters

The Flow rate High and Low range parameters HR and LR should be set and tested in the same manner as for the example in 3.3.2.

3.3.4 Turbine Meter

A Turbine meter has, as its output signal, a pulse train with the pulse rate proportional to the volumetric flow rate of the metered substance. The pulse train generated by a turbine meter cannot be fed directly into the analogue input card of a 6436/7 but must first be converted into a voltage signal proportional to frequency.

For a 6436/7 fitted with a pulse input card, the pulse train from the turbine meter must be isolated and conditioned to acceptable logic levels (e.g. using a TCS D401 unit). Also, the pulse train fed to the 6436/7 must be sufficiently regular to avoid erratic results.

The example application of 3.3.2 is considered here for the Turbine meter and volumetric flow rate is given by:-

$$Qo = k \cdot f \cdot \frac{TO}{PO} \cdot \frac{P}{T} \cdot \frac{ZO}{ZF}$$

(See Appendix E for explanation of terms)

This equation is implemented in the 6437 as:-

$$FL = 1C.2C \cdot 1V \cdot \frac{1}{SG} \cdot \frac{TO}{PO} \cdot \frac{2V+PA}{3V+TA} \cdot \frac{XO}{ZF}$$

By comparison with the Orifice Plate example of 3.3.2, a channel of the 6437 would be set up to perform this calculation as follows:-

A) Input Signal Related Parameters

a) Primary Input (Pulse Rate)

For pulse rate to be correctly displayed and used in the calculation:-

1H, 1L, 1P, and 1K should be set up by following the same procedure that is used for the differential pressure input in the orifice plate example of 3.3.2.

b) Secondary Input (Static Pressure)

For static pressure to be correctly displayed and used in the calculation:-

2H, 2L 2P and 2K should be set up in the same manner as for the orifice plate example of 3.3.2.

c) Tertiary Input (Temperature)

For temperature to be correctly displayed and used in the calculation:-

3H, 3L, 3P and 3K should be set up in the same manner as for the orifice plate example of 3.3.2.

B) Selecting the Calculation

a) The Turbine Meter characteristic is selected using the FP parameter digit B (see Table 3.2).

b) The required DCT is selected in the same manner as for the example in 3.3.2.

C) Programming Constants

a) If temperature is being measured in Centigrade then TA must be 273.2 while if temperature is being measured in Farenheit then TA must be 459.7.

b) If Gauge static pressure is being measured then PA must be set to local atmospheric pressure while if absolute static pressure is measured then PA must be set to zero.

c) TO is the Reference Temperature; PO is the Reference Static Pressure.

d) 1C x 2C must give the value of the meter k-factor as supplied by the meter manufacturer.

e) SG must be set to 1.0

D) Flow Rate Range Parameters

The Flow rate High and Low range parameters HR and LR should be set and tested in the same manner as for the example in 3.3.2.

3.3.5 Further Use of the Flow Rate Calculation

The flow rate calculation performed by the 6437 can be used for applications other than fluid flow rate monitoring. The four forms of DCT together with the facilities to select plant variable or constant data within the DCT and square rooting of the DCT and/or primary variable, allow many calculation forms. A simple example is considered here but the principle demonstrated is applicable to other forms of the 6437 flow rate calculation.

Engineering Units Analogue Multiplier

A single Channel of a 6437 (fitted with CMP1 and RFL option daughter boards) can be used as an engineering units analogue multiplier. Typically the output signal might be fed to the Process Variable input of a process controller.

Selecting the turbine meter characteristic and direct density DCT gives calculation form:-

FL = 1C x 2C x 1V x 2V

The analogue inputs will be 1V and 2V, the result, FL, can be output as an analogue signal (RFL option). Both the analogue inputs and the calculated output value may be inspected via the front panel, HHT or SSDL.

A channel of the 6437 would be set up to perform this calculation as follows:-

A) Input Signal Related parameters

a) Primary input (Signal 1)

For the analogue signal to be correctly displayed and used in the calculation:-

1H should be set to the maximum measurable signal value in engineering units.

1L should be set to the minimum measurable signal value in engineering units.

1P must have the correct decimal point position and signal voltage span selections set up. An input filter time constant would also be programmed here but no linearisation is required.

1V will now contain the correct engineering units value of the input signal.

1K should be programmed with the desired fall-back value of 1V

b) Secondary Input (Signal 2)

For the analogue signal to be correctly displayed and used in the calculation:-

2H should be set to the maximum measurable signal value in engineering units.

2L should be set to the minimum measurable signal value in engineering units.

2P must have the correct decimal point position and signal voltage span selections set up. An input filter time constant would also be programmed here but no linearisation is required.

2V will now contain the correct engineering units value of the input signal.

2K should be programmed with the desired fall-back value of 2V (see Section 3.2.4).

c) Tertiary Input

Without the CMP2 option board fitted and enabled, the value of the 3V parameter is undefined and is not accessible via the front panel (See section 3.2.4).

B) Selecting the Calculation

a) The Turbine Meter characteristic is selected using the FP parameter digit B (see Table 3.2).

b) Using the FP parameter digit C, the direct density form of the DCT is selected by setting bit 6 to 0. 2V is selected in the DCT instead of 2K by setting bit 4 to 1.

C) Programming Constants

1C x 2C would be programmed to give the value 1.0

3.4 Alarm Routine

3.4.1 Introduction

The 6436/7 performs alarm level checking on the flow rate for each flow monitoring channel. The alarm status information thus generated is accessible via the three main interfaces to the 6436/7 namely:-

a) The front panel displays
b) The optional digital output card
c) The HHT/SSDL/VDU programming terminal

Two basic types of information are produced:-

a) Current alarm status
b) Historic alarm status

and for both of these types, separate high and low alarm states are monitored. The Current and Historic alarm status of all active channels is collected together in the two instrument command parameters 'AC' and 'AH'. 'AC' is a read only parameter which holds the current alarm status (see Section 4.3.1 e)). The 'AH' parameter records the event of entry into an alarm state, so that should a channel enter and quickly exit an alarm state (a so called 'fleeting' alarm) a note of the alarm state is still made. (See Section 4.3.1 f)).

3.4.2 Entering Alarm

A channel is said to be in high alarm if the calculated flow rate, 'FL', has a value greater than that of the high alarm level parameter, 'HA'. Similarly a channel is in low alarm if 'FL' is less than 'LA'. On entering an alarm state the corresponding alarm bit for the channel (high or low) is set to logic one in the 'AC' and 'AH' parameters. The bit set in 'AC' is kept set to logic 1 while the condition alarm persists.

3.4.3 Leaving Alarm

The 6436/7 Alarm routine implements a hysteresis band of 0.5% of span above the 'LA' and below the 'HA' parameters. A high alarm state, for example, exists as soon as 'FL' is found to exceed 'HA'. The alarm state remains until 'FL' drops below 'HA' by at least 0.5% of the flow rate span. A similar argument applies to leaving a low alarm state (remembering that the hysteresis band is above 'LA'). On leaving an alarm state the 'AH' parameter is unchanged but the alarm bit (high or low) is set to logic zero in the 'AC' parameter and remains at logic zero until the alarm state re-occurs.

3.4.4 Disabling Alarms

Referring to the above two paragraphs it can be seen that if 'HA' is set to the same value as the maximum flow rate parameter, 'HR', then it is impossible for a high alarm condition to occur. Similarly if 'LA' is set to 'LR' it is impossible for a low alarm condition to occur.

3.4.5 Manual/Automatic Alarm Acknowledgement

The 'AA' parameter allows you to make the acknowledgement of each channel's alarms either manual or automatic.

With the appropriate AA bit (see Section 4) set to 0, the LED for that channel flashes on alarm until it is acknowledged (by pressing the ALM front panel button). With the AA bit set to 1, acknowledgement is automatic and LED flashing is avoided.

3.4.6 Alarm Displays

These are discussed in Section 1.4.1 b) and 1.5.2 b).

3.4.7 Alarm Outputs

If a digital output card is fitted in slot 4 (ALMPLS Option) and enabled then a digital output may be used as either a pulse totalisation output or as a commoned alarm output (See Section 2.4.4). The alarm output state is generated from the current alarm status parameter 'AC' and will be 0V if either a high or low alarm state currently exists for the channel otherwise it will be at 15V.

3.4.8 Alarm Information Access via HHT, SSDL, or VDU Programming Terminal

The 'HA' and 'LA' parameters for each channel are accessible via the HHT, SSDL, or VDU terminal for an operator to inspect or set. The current and historic alarm status of all active channels is available collected in the 'AC' and 'AH' parameters.

3.5 Flow Rate Totalisation

The Totalisation Calculation has already been introduced in the calculation overview (see 3.1.4); this section provides a detailed description of how to use the totalisation facilities.

3.5.1 General Considerations

The calculated flow rate of the metered substance is integrated, by the 6436/7 totalisation calculation, to give the total amount of the substance that has flowed through the metered line. Section 3.3.1 C) shows how the 6436/7 flow rate calculation can be used to calculate equivalent energy flow or even equivalent cost flow of a metered substance. Section 3.3.1 C) also shows how the units of mass or volume etc. of the calculated flow rate may be changed from one units system to another.

a) Totalisation Time Units

The units of time are significant when integrating the flow rate and though standard flow rate calculations yield results of mass or volume per second, it may be more convenient to display the flow rate with different time units. Section 3.3.1 C) shows how the time units may be changed as part of the flow rate calculation. Acceptable time units ranges are seconds, minutes, hours and days, and the totalisation calculations must be set to integrate the calculated flow rate with the correct time units by programming digit A of the 'ST' parameter (see Section 4.5.2 a)).

b) Low Flow Substitution

This facility is implemented using two constants: the low flow threshold parameter, 'FC', and the default flow rate parameter 'DF'. If the calculated flow rate, 'FL', falls below 'FC' then 'DF' is used instead in the totalisation calculations. This substitution does not affect the main display which still shows 'FL'. When totalising 'in default', bit 5 of the 'ST' parameter is set to logic one providing indication to a remote operator via the SSDL. The yellow LED in the (TOT) push-button is extinguished indicating that 'normal' totalisation is not taking place.

The most common use of this facility is to implement a low flow cut off for situations where a primary transducer signal is invalid at low flow values. 'FC' is programmed with a suitable low value and 'DF' is programmed to the required default value (typically 'LR') and in the invalid band below 'FC' totalisation continues with the defined value in 'DF'.

c) Totalisation Hold

Totalisation may be explicitly halted by setting bit 8 of the 'ST' parameter to logic 1. The yellow LED in the (TOT) push-button is extinguished indicating that 'normal' totalisation is not taking place.

3.5.2 **The Displayable Total**

The flow total, which consists of two parts, is formed by integrating the calculated flow rate, 'FL' and pre-dividing by a scaling factor parameter 'FT':-

1) An eight digit integer part which may be inspected via the front panel display (see section 1.4.1), HHT, SSDL, or VDU programming terminal.

2) A four digit fractional part which is available only via the front panel display and is provided for operator convenience to give confirmation of totalisation when low flow rates are being integrated.

The following sections describe how the flow total may be updated or inspected via the HHT, SSDL, or VDU terminal and finally the action of the totaliser when the flow total overflows is discussed.

a) Access to the Flow Total via the SSDL, HHT, or VDU Terminal

The eight digit flow total is inspected via the HHT, SSDL, or VDU terminal as two separate 4 digit command parameters '1F' and '2F'. It should be appreciated that the flow total is continually being updated within the instrument so that during interrogation of the '1F' and '2F' parameters the real total is changing. Some special action is necessary if a meaningful flow total is to be 're-constructed' from the two parameters and this is described below.

(i) Reading the Flow Total via SSDL, HHT or VDU Terminal

Each time the '1F' parameter is read, a copy of the current flow total is 'frozen' in a temporary storage area within the instrument and the most significant 4 digits of this frozen total are read back as '1F'. Subsequent reading of '2F' will yield the least-significant 4 digits of this frozen total thus ensuring that 'matching halves' of the flow total are sent.

NOTE: If '2F' is read before '1F' then the re-assembled total may be meaningless.

(ii) Writing to the Flow Total via the SSDL

The flow total is also written in two parts '1F' and '2F'. When writing to '1F' the data is placed in a temporary storage area and '2F' is 'write enabled'. Writing to '2F', completing the update, causes both parts of the flow total to be updated simultaneously.

NOTE: Attempts to write to '2F' before '1F' are rejected.

(iii) Writing to the Flow Total via the HHT, or VDU Terminal

As with the SSDL, the flow total must be written to in two parts. As a security measure (to prevent accidental and unrecoverable loss of a flow total), the procedure for writing via the HHT, or VDU programming terminal, is different to that for writing via the SSDL.

Two 'write buffer' parameters '1B' and '2B' are used and must be written in sequence, '1B' then '2B'. At this stage, these buffers are 'primed' to update the flow total. The operator may inspect the current flow total, in '1F' and '2F', and the intended new value, in '1B' and '2B', before completing the update. The operation is completed by setting the 'write strobe' bit in the 'ST' parameter. With '1B' and '2B' primed the instrument will respond, on detecting the write strobe, by moving '1B' and '2B' into the flow total and clearing the write strobe bit.

Interrupting this sequence by writing to any other parameter will cause the flow total update to be aborted.

NOTE: '1B' and '2B' are not accessible via the SSDL.

(iv) Other effects of writing to the Flow Total

On completing an update of the flow total, the fractional part is always cleared. The pulse totalisation accumulator (described in Section 3.5.3) is also cleared.

b) Flow Total Overflow

This condition is described as part of the discussion of the instrument diagnostics facilities; refer to Section 2.6.3 j).

3.5.3 Pulse Output Totaliser

The pulse output totaliser is not completely independent of the displayable total and there are three characteristics of their operation which are common to both modes of totalisation.

a) Totalisation time units are common (See Section 3.5.1 a)).

b) The low flow substitution and totalisation hold facilities apply to both modes of totalisation (See Section 3.5.1 b) and 3.5.1 c)).

c) The pulse totalisation accumulator is cleared when the displayable total accumulator is updated via the HHT, SSDL, or VDU Terminal.

The pulse output totalisation calculation is performed, for a given channel, if the ALMPLS option board is fitted, and if the board is enabled and the output is characterised for pulse totalisation by setting the appropriate bit in the 'CT' parameter (see Section 4.3.2 d)). The calculation is basically an integration but differs from displayable totaliser integration in the following ways:-

a) Before being added into the accumulator the calculated flow rate 'FL' is pre-divided by a scaling factor parameter 'FS'.

b) The contents of the accumulator are not accessible for inspection.

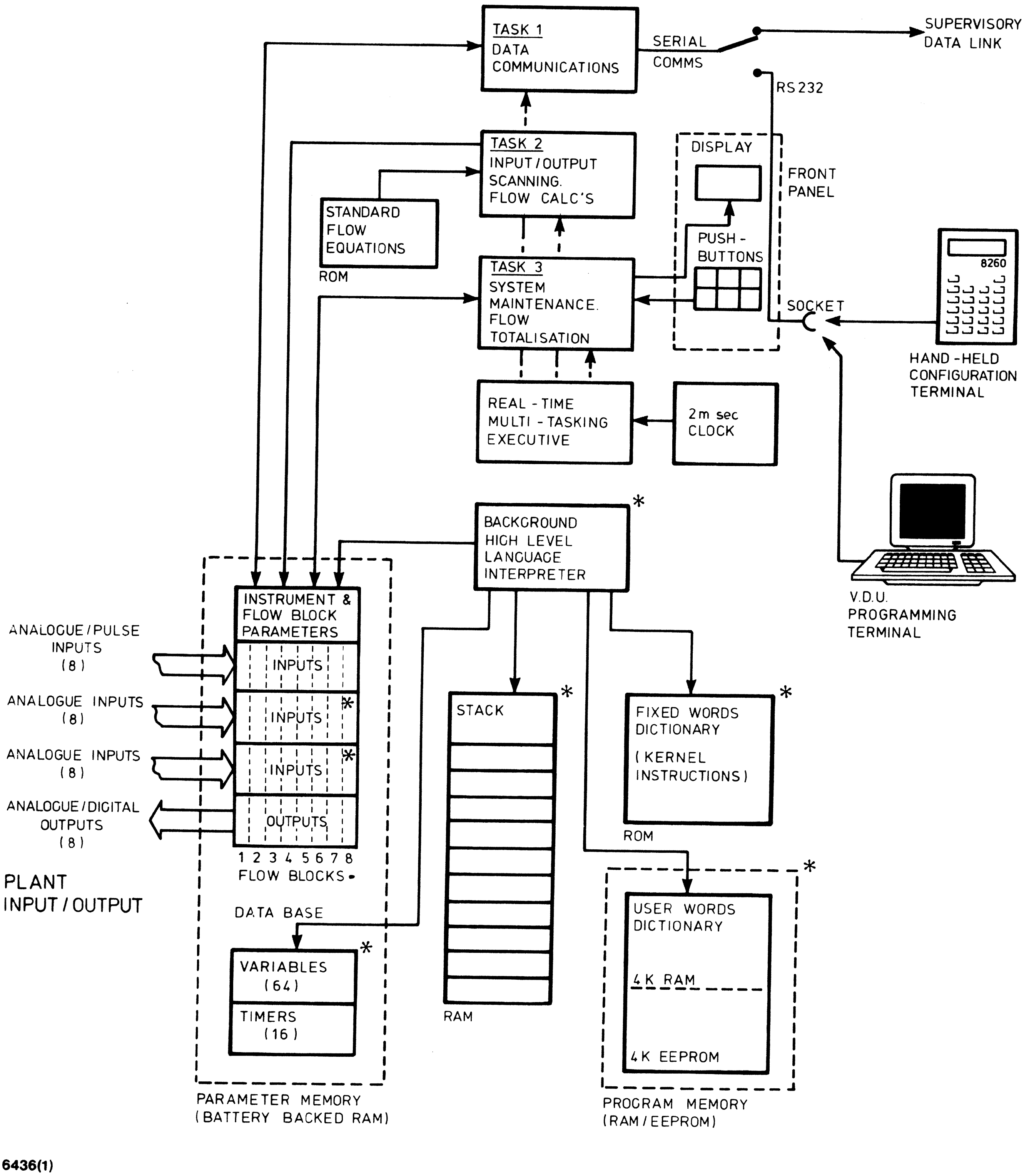
c) The accumulator is decremented as each output pulse is produced and so should never overflow.

When the value of the accumulator exceeds a preset level, a pulse is produced at the digital output and 'FL'/'FS' is subtracted from the accumulator. Thus 'FS', and 'FL' together determine the rate at which the accumulator fills and thus the output pulse rate.

NOTE: The maximum output pulse rate is 4.0Hz and the value of 'FS' should be chosen such that:-

$$\frac{HR}{TB} \times \frac{1}{FS} \leqslant 4 \text{ Hz}$$

where TB is the integration time base in seconds as selected in 'ST' parameter (see Section 4.2.5 a)).



* 6437 ONLY

FIG 3.2 6436 & 6437 SOFTWARE FUNCTIONAL OVERVIEW

3.6 Software Structure

A software functional overview of the 6436/7 is given in Fig 3.2. Much of the discussion in this section applies only to the 6437, especially the FORTH facilities. The differences between the two instruments are indicated by asterisks in the overview.

3.6.1 The Data Base

The heart of the instrument is the data base which holds the instrument and channel parameters, standard flow equations, and user flow equations written in FORTH. Parameters are organised into 'flow blocks'. Each 6437 flow block consists of three inputs and one output. A 6436 flow block has one input and one output only.

The data base is scanned continuously and updated with new values as these arise. All the flow and input values can be displayed on the front panel under pushbutton control. The instrument parameters are accessible via the Hand-held Terminal, or VDU terminal, plugged into the front panel RS232 socket. Alternatively, the rear panel RS422 supervisory data link may be used.

Also held in the data base are the current values of 64 variables and 16 timers. Variables are stored in 32-bit floating point format. Timer values are stored as 32-bit numbers with one bit corresponding to 2 milliseconds. This gives a range of ±4,294,960 sec., i.e. about 7 weeks.

3.6.2 Flow Calculation

Flow calculation is done using any one of the 32 (in the 6437) standard resident flow equations, or by a flow equation written by the user. User flow equations (foreground programs) are written in a high level interpretive language based on a version of FORTH. Program statements are called 'words' which loosely correspond to subroutines. A kernel set of the most common functions are resident in ROM in the Fixed Words Dictionary.

3.6.3 Programming

User memory is 8K RAM and 8K EEPROM. Programs are developed in RAM by using an RS232 'teletype' compatible device such as a VDU plugged into the front panel programming socket. A program developed in RAM can be 'fixed' into ROM from the programming device. The program is, however, always run from RAM. This allows programs to be loaded into RAM, edited, and then debugged before the original program is overwritten.

The front panel RS232 socket supports two terminal modes:-

1) Command Mode, which accesses the configuration parameters via 2-character mnemonics. In this mode, programs are enabled to run.

2) Programming Mode, which accesses the FORTH editor for entering and modifying programs. This mode is protected by a security number associated with a user name. In programming mode, all programs are halted.

3.6.4 The System Tasks

The basic software structure of the 6436/7 is shown in Fig. 3.2, and consists of the following main components:-

1) EXECUTIVE

At the centre of the 6436/7 software is a real-time multi-tasking executive which schedules the three system 'tasks' on an interrupt driven basis, derived from a 2ms real-time clock. As well as controlling this task-scheduling scheme, the executive is also responsible for multiplexing the front panel displays and incrementing the system timer.

2) TASK 1 : COMMUNICATIONS

The highest priority task in the system is the scheduling of the communications routines. The receive character-handling routine is scheduled whenever the UART generates an interrupt after receiving a character via the RS232 or RS422 ports. The transmit character-handling routine is scheduled when data has to be sent to RS232 (Hand-held Terminal, or VDU terminal) or RS422 ports, and the UART generates an interrupt after each character has been transmitted.

3) TASK 2 : INPUT/OUTPUT & CURRENT FLOW CALCULATION

The second highest priority task is scheduled by the executive every 62ms. The functions of the task are:-

a) A-to-D conversion for the current flow input channels.

b) Frequency input calculation, if the pulse input card is fitted and enabled.

c) Flow calculation for the current flow block, using input values calculated earlier. Either the selected standard flow equation or the user flow equation 'FLOWn' (a foreground program, stored in the user FORTH word dictionary, where 'n' is the channel number) may perform the calculation.

NOTE

A foreground Forth program must run in a maximum of 50ms, otherwise it will be de-scheduled from Task 2 automatically.

d) Updating the intermediate flow total (used in the totalisation calculation).

e) Outputting the current flow information via the analogue output or digital output channel.

4) TASK 3 : FLOW TOTALISATION & SYSTEM MAINTENANCE

The lowest priority task is scheduled by the executive every 496ms. The functions of this task are:-

a) Updating the current flow total using the intermediate flow total calculated by Task 2.

b) System maintenance routine accessing the instrument data base directly using the values obtained by Task 2, and providing the executive with the current front-panel display data.

c) Scanning the front-panel pushbuttons to detect operator changes.

d) Various other 'housekeeping' functions.

e) Servicing the Hand-held Terminal.

WORD	STACK	DESCRIPTION
GETTOT	(Cn,--,d1,d2)	Return the channel Cn Flow total as two values on the stack.
SETTOT	(d1,d2,Cn,--,)	Set the channel Cn Flow total.
TOTAL+	(n1,n2,N1,N2,--,d1,d2)	Add two double word numbers and leave the result as one double word.
TOTAL-	(n1,n2,N1,N2,--,d1,d2)	Subtract two double word numbers and leave the result as a double word.
GETCN	(--,n)	Return the current channel number.
SETCN	(n,--)	Set n as the current channel.
GETPAR	(Cn,Pn,--,d)	Return the data for the parameter Pn which is stored in channel Cn data base.
SETPAR	(d,Cn,Pn,--)	Update the Pn parameter which is stored in channel Cn data base.
GETAN	(Cn,Bn,--,d)	Return the data for channel Cn from board Bn.
SETAN	(d,Cn,Bn,--)	Set data for output channel Cn, board Bn.
DCTx	(Cn,--,d)	Calculate the stated (x) density correction term for channel Cn, and leave the result.
MOD9	(n,--,d)	Return the 4 least significant digits of any number. E.g. 19999,MOD9,9999
RUN	(--)	Search install and run the programs defined by FLOWn and BGRND, where 'n' is the channel number.
HALT	(--)	Stop all user programs.

Table 3.4 6437 FORTH Words

5) INTERPRETER

The interpreter is activated only when all the other three Tasks have been executed and de-scheduled; it can thus be considered as a 'background' activity.

The interpreter executes the user-defined program sequence (background program 'BGRND'), accessing input variables from the instrument data base, processing them as required, and updating the output variables with the results.

It also allows the user to write foreground programs (user flow equations) which are executed during Task 2. Foreground programs must start with the FORTH word FLOWn, where n is the channel number.

3.6.5 FORTH Words Specific to the 6437

The following list of FORTH words is specific to the 6437 Flow Computer software issue 1, release 1. Other FORTH words and information are given in the TCS publication 'Programmable Instruments Programming Manual'.

In the 'STACK' column, items are listed in the order they are placed on the stack, or appear on the stack after execution of the word. The FORTH word is shown on the stack list as '--'. Items to the right of the '--' symbol replace those to the left after execution.

Note the convention in the 6437, of placing channel number on the stack before board number or parameter number. This applies to all 6437 FORTH words involving channel number, including the non-specific words given in the Programming Manual. This convention differs for other (earlier) TCS instruments at time of issue.

NOTE

Full details of the 6437 FORTH facilities are given in the 6437 User Guide. For information on how to write FORTH programs for TCS instruments, consult the TCS publication 'Programmable Instruments Programming Manual'.

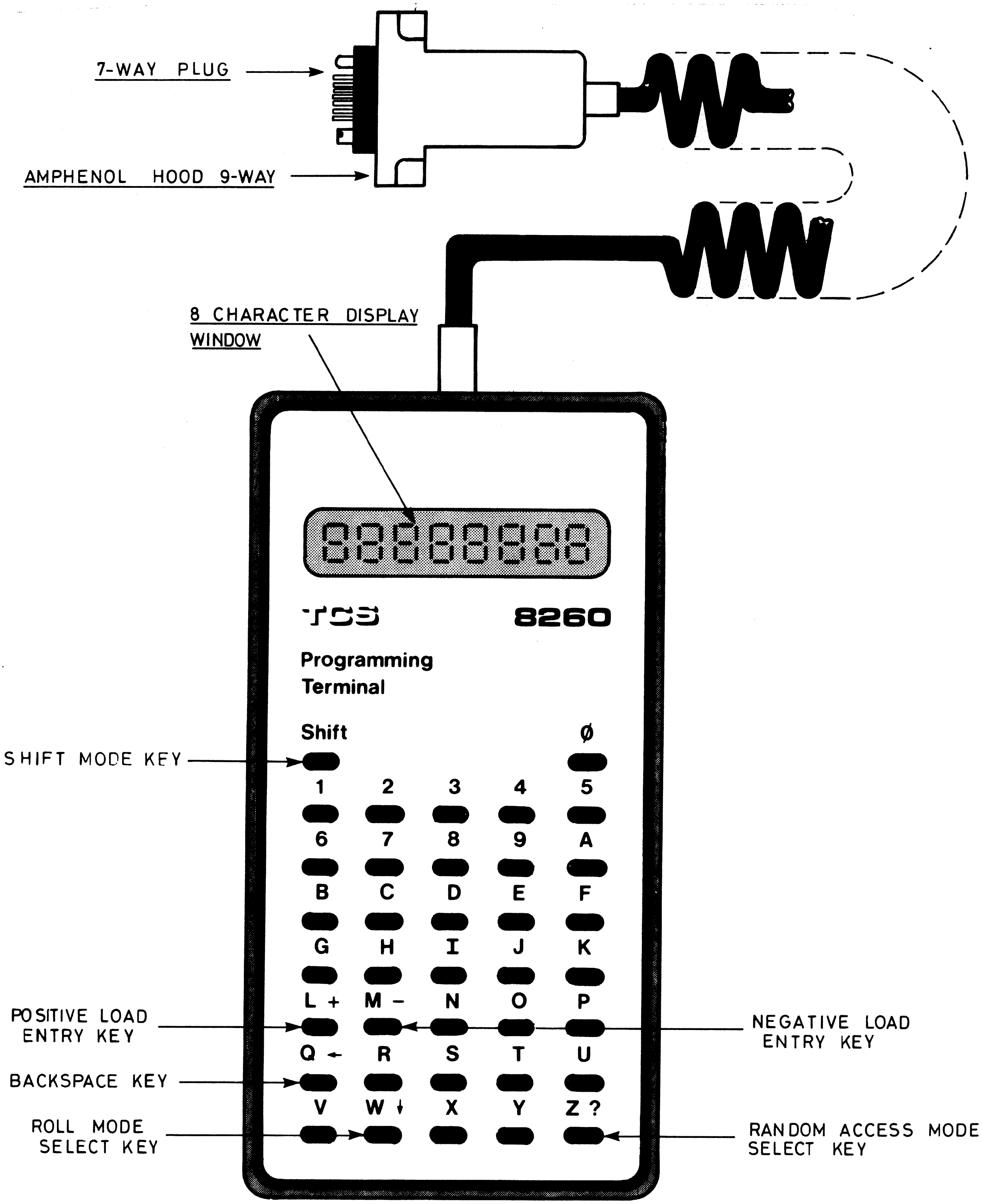


FIG 4.1) HAND-HELD TERMINAL KEYBOARD LAYOUT

Section 4 PROGRAMMING THE 6436/7 VIA THE HAND-HELD TERMINAL

4.1 Programming Terminal Characteristics

The 8260 Hand-held Programming Terminal (HHT) is a device the same size as a pocket calculator. It is provided with a 37-key positive tactile response keyboard and is capable of sending and receiving data in eight bit serial ASCII code.

The terminal has a single line display of eight characters using 16-segment 'starburst' LEDs which can clearly and legibly generate all 64 ASCII upper case alphanumerics and symbols. When it is being used to enter parameters into the 6436/7 only the first 7 character positions are used starting from the left-hand end of the display. These 7 characters include the decimal point position so that a typical message would have the following structure:-

AA34.56

The interface between the terminal and the 6436/7 is at standard RS232/V24 voltage levels using a transmission rate of 300 baud and 10 bit characters as defined in Section 1.5.9 A). Connection to the 6436/7 is via a 7-pin plug and socket arrangement, the socket being situated behind a small door just above the catch handle on the front panel of the instrument. This 7-pin connector is also used to provide power to the terminal from the internal +5V supply within the 6436/7 and it requires typically 350mA.

A plan view of the keyboard of the Hand-held Terminal is given in Fig 4.1.

FORMAT	RANGE	POLARITY	DECIMAL POINT POSITION
1	0000 to +/-9999	Bipolar (+/-)	Defined by Status Word
2	0000 to +9999	Positive (+)	Defined by Status Word
3	00.00 to +99.99	Positive (+)	Fixed
4	000.0 to +999.9	Positive (+)	Fixed
5	0000 to FFFF	4 Hexadecimal Digits	
6	00 to 99	2 Decimal Digits	
7	0 to 9	1 Decimal Digit	
8	AAAA to ZZZZ	4 ASCII Characters (Upper case)	
9	0.000 to +9.999	Positive (+)	Fixed
10	0000. to +9999.	Positive (+)	Fixed
11	.0000 to +.9999	Positive (+)	Fixed
12	0000. to +/-9999.	Bipolar (+/-)	Fixed
13	0.000 to +/-9.999	Bipolar (+/-)	Fixed
14	00.00 to +/-99.99	Bipolar (+/-)	Fixed
15	000.0 to +/-999.9	Bipolar (+/-)	Fixed
16	0000 to +/-9999	Bipolar (+/-)	Fixed

Table 4.1 List of Command Parameter Data Formats

4.2 Parameter Entry Procedures

4.2.1 Terminal Initialisation

When the 8260 Hand-held Terminal (HHT) is first plugged into the front-panel of the 6436/7, the CPU detects its presence via one of the pins of tHE 7-way connector. As soon as this occurs, the RS422 supervisory serial data link (SSDL) on the rear connector is disabled and after a delay of about 2 seconds, the terminal is initialised. The following message is transmitted to the display:-

```
?? CMD
```

This message is a prompt to the operator requesting that a 2 character Command Parameter is entered in the position of the two question marks. These parameters are divided into the following 2 types:-

a) Instrument Command Parameters, which are concerned with the overall functions and operation of the instrument.

b) Channel Command Parameters, which are concerned with the status and operating characteristics of each of the flow monitoring channels. There may be up to 8 active channels within the 6436/7 (determined by the 'S1' parameter, See Section 4.3.1 b)), and for each active channel there will be a set of channel parameters.

When setting up a 6436/7 instrument for the first time it is recommended that the Instrument Command parameters be entered first (See Section 4.3).

Table 4.1 shows a list of the command parameters data formats. For a detailed explanation of the use of the Hand-held Terminal, refer to Section 4 of the System 6000 communications handbook.

COMMAND MNEMONICS	COMMAND PARAMETER FUNCTION	UNITS	FORMAT	PARAMETER TYPE
II	Instrument Identity	-	5	Monitor Only
S1	Slot 1 board type and status indication with active channel selection 1-8.	-	5	Input/ Output Board Status
S2*	Slot 2 board type and status indication	-	5	
S3*	Slot 3 board type and status indication	-	5	
S4	Slot 4 board type and status indication	-	5	
CT	Channel Type selection, digital output option card used for common absolute alarms or pulse output totalisation signal	-	5	Channel Type
AC	Current HI and LO Alarm indication	-	5	Alarms
AH	Historic change of state indication of HI & LO Alms.	-	5	
AA	Alarm acknowledge indication of HI & LO Alms.	-	5	
SW	Switch bank S1 & S2 setting	-	5	Operating Mode
MD	Front panel and diagnostic status indications	-	5	

Table 4.2 List of Instrument Command Parameters and their Respective Mnemonics.

* These parameters apply to the 6437 only

4.3 Instrument Command Parameters

4.3.1 Instrument Command Parameter Functional Description

In this section, the instrument Command Parameters are summarised (in Table 4.2), and then discussed in order of appearance.

a) II - Instrument Identity

This parameter returns the instrument identity and issue number, i.e. 4361 for the 6436 issue 1. II is a read only parameter (See Section 4.3.2 a)).

b) S1 I/O Slot Status

The S1 command parameter indicates the status of the I/O daughter board fitted in slot 1 of the 6436/7 module. S1 is also used to select the number of active channels (1-8) in the instrument. In the 6437 only S1 is used to indicate errors in the FORTH program. (See Section 4.3.2 b)).

c) S2, S3 and S4 I/O Slot Status

These three command parameters, S2, S3, and S4 indicate the status of the I/O daughter boards fitted in the slots 2, 3 and 4 of 6436/7 module. These parameters are read only (See Section and 4.3.2 c)).

d) CT - Channel Type

This command determines for each channel, the functional interpretation of the digital output (provided an optional digital/analogue output board is fitted in Slot 4) as commoned absolute flow rate alarm or pulse totalisation output (See Section 4.3.2 d) and Table 4.3 and 4.4).

e) AC - Alarms Current

This status word shows the current alarm condition of each channel whether in high alarm, in low alarm or not in alarm. AC is a read only parameter. The function of each bit is shown in Section 4.3.2 e).

f) AH - Alarms Historical

For each channel AH records the occurrence of a change of alarm status into high or low alarm since the status bits for that channel were last cleared. Section 4.3.2 f) shows the parameter format.

NOTE: Appendix D shows a pictorial explanation of the behaviour of AH and AC in response to changing alarm conditions.

g) AA - Alarm Acknowledge

Each bit of AA corresponds to an alarm bit in AC. When a bit is set in AA, any alarm that occurs/has occurred is acknowledged, thus alarm led flashing is suppressed (See Section 4.3.2 g)).

h) SW - Internal Switches

This status word reflects the settings of the internal switches on Switch Banks 1 and 2 so that these may be monitored (via the HHT or SSDL), without removing the instrument from its rack slot or powered sleeve (See Section 4.3.2 h)).

i) MD - Instrument Mode Word

This status word displays bits controlled by the 'built-in' diagnostic routines, and also shows the current front panel push-button status. Table 2.3 shows the front-panel error indication produced by the diagnostic routines (See Section 4.3.2 i)).

Appropriate CT Bit	FP Parameter			Functions
	Bit 2	1	0	
0	X	1	X	Flow rate alarm output
0	0	0	X	Retransmitted flow output
0	1	0	X	User output (SETAN)
1	X	X	X	Retransmitted flow pulse output

Table 4.3 Analogue Output Board

Appropriate CT Bit	FP Parameter			Functions
	Bit 2	1	0	
0	X	X	X	Flow rate alarm output
1	X	X	X	Retransmitted flow pulse output

Table 4.4 Digital Output Board

4.3.2 Instrument Command Parameters Format Details

This section provides detailed layouts for those parameters described in Section 4.3.1 which display instrument status or select certain instrument functions.

a) II - Instrument Identity (Read Only)

Parameter format 5 (4 hexadecimal digits)

Product code												Issue No.			
Bit 15							Bit 8	Bit 7							Bit 0
Digit A				B				C				D			

DIGIT	BIT	FUNCTION
A,B & C	15-4	Product Code (6) 436 (or 7)
D	3-0	Issue Number 1

b) S1 - Slot 1 Status (Read/Write)

Parameter Format 5 (4 hexadecimal Digits)

Hardware Status				Active Channels				Board Identity							
Bit 15							Bit 8	Bit 7							Bit 0
Digit A				B				C				D			

DIGIT	BIT	FUNCTION	
A	14	Background Programme halted	0=OK 1=Halted
	13	Background Programme run time or sumcheck error	0=OK 1=Error
	12	Board hardware status	0=OK 1=Hardware error
B		Number of active channels: 1-8	
C, D		Board identity (see Table 4.5)	

c) <u>S2, S3 and S4 - Slot 2, 3 and 4 Status</u> (Read Only)

Parameter Format 5 (4 hexadecimal Digits)

Hardware Status								Board Identity							
Bit 15							Bit 8	Bit 7							Bit 0
Digit A				B				C				D			

DIGIT	BIT	FUNCTION
A	12	Board hardware status: 0=O.K. 1=Hardware error
B		0
C,D		Board Identity (see Table Below) for S2 if fitted this will be: 00 for S3 if fitted this will be: 00 for S4 if fitted this may be: 08 or: 18

BOARD IDENTITY CODE	BOARD TYPE
00	Analogue input
08	Analogue output
10	Digital input
11	Pulse input
18	Digital output
1F	Board not fitted

<u>Table 4.5</u> <u>Board Identities</u>

d) <u>CT - Channel Type</u> (Read/Write)

Parameter Format 5 (4 Hexadecimal Digits)

|← Alarm/Pulse Totalisation Select →|

<table>
<tr><td>Bit 15</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Bit 8</td><td>Bit 7</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Bit 0</td></tr>
<tr><td colspan="4">Digit A</td><td colspan="4">B</td><td colspan="4">C</td><td colspan="4">D</td></tr>
</table>

DIGIT	BIT	FUNCTION	
A ↓ B	15 ↓ 8	Channel 1 ↓ Channel 8	Commoned Alarms/ Pulse Totalisation Select: 0=Commoned Alarm 1=Pulse Totalisation

e) <u>AC - Current Alarms</u> (Read Only)

Parameter Format 5 (4 Hexadecimal Digits)

|← High Alarm →|← Low Alarm →|

<table>
<tr><td>Bit 15</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Bit 8</td><td>Bit 7</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Bit 0</td></tr>
<tr><td colspan="4">Digit A</td><td colspan="4">B</td><td colspan="4">C</td><td colspan="4">D</td></tr>
</table>

DIGIT	BIT	FUNCTION	
A ↓ B	15 ↓ 8	Channel 1 ↓ Channel 8	Current high alarm (absolute)
			0=Safe 1=alarm
C ↓ D	7 ↓ 0	Channel 1 ↓ Channel 8	Current low alarm (absolute)

NOTE: Each bit of AC is automatically set/reset as a channel enters/exits an alarm condition.

f) AH - Historic Alarms (Read/Write)

Parameter Format 5 (4 Hexadecimal Digits)

|← High Alarm →|← Low Alarm →|

Bit 15							Bit 8	Bit 7							Bit 0
Digit A				B				C				D			

DIGIT	BIT	FUNCTION	
A ↓ B	15 ↓ 8	Channel 1 ↓ Channel 8	Historic high alarm (absolute)
			0=Safe 1=alarm
C ↓ D	7 ↓ 0	Channel 1 ↓ Channel 8	Historic low alarm (absolute)

g) AA - Alarm Acknowledge (Read/Write)

Parameter Format 5 (4 Hexadecimal Digits)

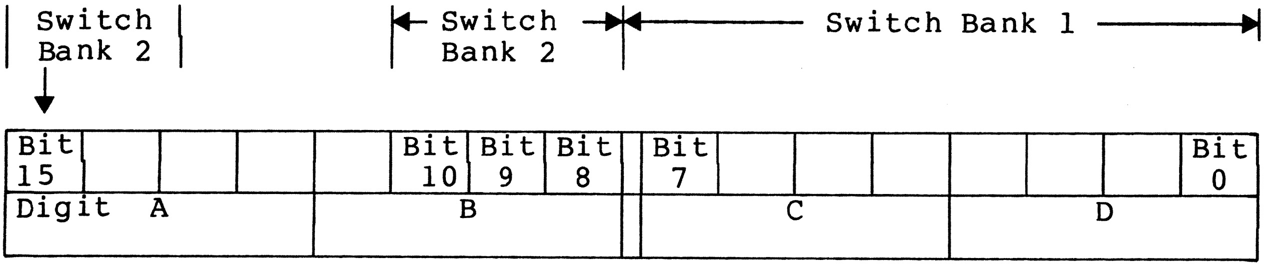
|← High Alarm →|← Low Alarm →|

Bit 15							Bit 8	Bit 7							Bit 0
Digit A				B				C				D			

DIGIT	BIT	FUNCTION	
A ↓ B	15 ↓ 8	Channel 1 ↓ Channel 8	Historic high alarm (absolute)
			0=Unacknowledged 1=Acknowledged
C ↓ D	7 ↓ 0	Channel 1 ↓ Channel 8	Historic low alarm (absolute)

h) SW - Internal Switch States (Read only)

Parameter Format 5 (4 Hexadecimal Digits), refer to Table 2.1 and Fig 2.1 for switch positions



DIGIT	BIT	SWITCH		FUNCTION
A	15	1	S2	UID Select 0=0-7, 1=8-F
B	10	2		Slot 2 Enable (CMP1 Option)
	9	3		Slot 3 Enable (CMP2 Option)
	8	4		Slot 4 Enable (ALMPLS/RFL Option)
C	7	1	S1	HHT Baud Rate (300 Baud)
	6	2		Baud Rate Selection
	5	3		(See Table 2.2)
	4	4		
D	3	5		Protocol Select: 0=ASCII Data Format 1=Binary Data Format
	2	6		4 Group
	1	7		2 Identifier
	0	8		1 (GID)

SWITCH BANK S2 SWITCH NO. 1	UID TRANSMITTED	CHANNEL ACCESSED	6436/7 NO.
OFF	0 ↓ 7	1 ↓ 8	1
ON	8 ↓ F	1 ↓ 8	2

Table 4.6 Relationship Between the transmitted UID and the Channel Accessed for two 6436/7 Instruments with the same Group Address

i) MD - Mode Word (Read/Write)

Parameter Format 5 (4 Hexadecimal Digits).

Diagnostic Status								Front Panel							
Bit 15							Bit 8	Bit 7							Bit 0
Digit A				B				C				D			

DIGIT	BIT	FUNCTION	
	15	Collected change of state alarm	Diagnostic Status
	14	Parameter change via HHT	
A	13	Common channel parameter sumcheck failure	
	12	Common hardware failure	
	11	Battery voltage low alarm	
	10	Common 1-5V input out of range alarm	
B	9	Power failure warning flag	
	8	Instrument parameter sumcheck failure	
	7	Hand held terminal present	Front Panel
	6	Front panel test bit	
C	5	Raise (▲)	
	4	Inspect (INS)	
	3	Channel (CHN)	
	2	Lower (▼)	
D	1	Alarm (ALM)	
	0	Total (TOT)	

COMMAND MNEMONICS	COMMAND PARAMETER FUNCTION	UNITS	FORMAT	PARAMETER TYPE
CN*	Channel Number	-	7	See Section 4.4
ST*	Channel Status	-	5	Status Words
FP*	Flow Processing	-	5	
1P*	Input 1 Signal Processing	-	5	
2P	Input 2 Signal Processing	-	5	
3P	Input 3 Signal Processing	-	5	
HR*,LR*	Calc.Flow High & Low Range	Eng	2	Flow Range
1H*,1L*	Input 1 High & Low Range	Eng	2	Input Channel Ranging
2H, 2L	Input 2 High & Low Range	Eng	1	
3H, 3L	Input 3 High & Low Range	Eng	1	
HI*	Input Frequency equivalent to 1H	Eng	2	Pulse Input Option only
LI*	Input Frequency equivalent to 1L	Eng	2	
HA*,LA*	Flow Absolute Alarm Levels	Eng	2	Alarm and Limit Settings
FC*	Low Flow Threshold	Eng	2	
DF*	Default Flow (Totalisation)	Eng	2	
1K*	1V Default (Flow Calc)	Eng	2	Flow Calculation Related Parameters
2K	2V Default (Flow Calc)	Eng	1	
3K	3V Default (Flow Calc)	Eng	1	
SG	Relative Density	-	9	
XO	Base Compressibility	-	11	
1D	Decimal Point Position TO, PO, TA, PA	-	5	
TO	Reference Temperature (ABS)	Eng	1	
PO	Reference Pressure (ABS)	Eng	1	
TA	Offset to Absolute Temperature	Eng Eng	1 1	
PA	Offset to Absolute Pressure	Eng	1	

Table 4.7a List of Channel Command Parameters and their Respective Mnemonics.

* See the note to Table 4.11.

COMMAND MNEMONICS	COMMAND PARAMETER FUNCTION	UNITS	FORMAT	PARAMETER TYPE
2D*	Decimal Point Position 1C, 2C, 3C, 4C	-	5	
1C*	Scaling Factor	-	1	
2C*	Scaling Factor	-	1	
3C	Density Correction Constant	-	1	
4C	Density Correction Constant	-	1	
3D	Decimal Point Position 5C, 6C, 7C, 8C	-	5	
5C	Density Correction Constant	-	1	
6C	Density Correction Constant	-	1	
7C	Density Correction Constant	-	1	
8C	Density Correction Constant	-	1	
FL*	Calculated Flow	Eng	2	Monitor Only
1V*	Input 1 Value	Eng	2	
2V	Input 2 Value	Eng	1	
3V	Input 3 Value	Eng	1	
FS*	Scaling Factor (Pulse Output)	-	4	Pulse Totalising Settings
FT*	Scaling Factor (Flow Total)	-	4	
1F*,2F*	Flow Total M.S.&L.S. Parts	Eng	10	Total Display
1B*,2B*	Flow Total Write Buffers	Eng	10	See Note 1
1T*,2T*	Channel Tag Words	ASCII	8	See Note 2
SN*	Store Channel Parameters	-	7	
RN*	Copy Channel Parameters	-	7	

Table 4.7b List of Channel Command Parameters and their Respective Mnemonics.

* See the note to Table 4.11.

NOTE 1: To update/clear the flow total using the HHT:-

a) Write the most significant part of the eight digit total into '1B'.

b) Write the least significant part of the eight digit total into '2B'.

c) Set the write strobe bit in the 'ST' status word: X4XX, where 'X' means re-write the original data.

NOTE 2: These parameters do not appear in the parameter list when scrolled via the HHT (W ↓ button). Instead they must be accessed individually by first using the '?? CMD' prompt (Z? button) once the required channel number has been selected.

4.4 CN - Channel Selection Parameter

The CN parameter allows an operator with a hand-held terminal to select which of the eight sets of Channel Parameters he wishes to inspect. The CN parameter is not accessible via the serial link as each channel has its own unit identifier and is accessed as a separate unit.

4.5 Channel Command Parameters

4.5.1 Channel Command Parameters Functional Descriptions

In this section the flow monitoring channel command parameters are summarised (in Table 4.7) and then discussed in order of appearance.

a) ST - Channel Status Words

The lower half (bits 0 - 7) of this status word indicates the status of the channel as reported by the diagnostic routines (See Section 2.6.3). The upper half of the status word serves five purposes:-

(i) Allows input pulses to be directed straight to the totaliser.

(ii) Selecting the Calculated flow rate time units used in the totalisation calculation (See Section 3.5.1 a)).

(iii) Indicates a FORTH flow equation error.

(iv) Controlling the process of updating the flow total via the Hand-held Terminal (see Table 4.7 note 1).

(v) Indicates a frequency/pulse input channel failure.

(vi) Allowing the user to halt totalisation, leaving the value of the flow total 'frozen'.

b) FP - Flow Processing selection Status Word

This status word is arranged as four hexadecimal digits and defines for a given channel:-

i) The decimal point position for displaying the Calculated flow rate.

ii) The type of transducer (flow equation) being used and therefore, in accordance with the transducer characteristics, the type of calculation to be performed, specifically whether or not to 'square root' the primary variable, '1V', and the density correction term, DCT.

iii) The required density correction term.

iv) The standard transducer type (flow equation) or transducer type in FORTH user word dictionary.

v) The selection of retransmitted flow, or retransmitted pulse output, or SETAN (FORTH).

c) 1P, 2P, 3P - Input 1, 2 or 3 Processing Selection Status Word

These status words are arranged as 4 hexadecimal digits and define for input 1, 2, or 3 of a given channel:-

i) The decimal point position of the input variable.

ii) the input variable conditioning routine (linearisation etc).

iii) The input variables filter time constant.

iv) a) For Analogue Inputs:-

The interpretation of the input variable signal range as 0-10V or 1-5V.

This last facility allows the 6436/7 to be used with 4-20mA signals provided an external burden resistor is used. (See System 6000 Installation Guide Section 6.2).

b) For Pulse Inputs:-

Decimal point position of frequency range parameters 'HI', 'LI'.

v) Nomination of flow rate output channel to be software patched to current input.

d) HR, LR - Calculated Flow Rate High and Low Range

These parameters define, in engineering units, the displayable span of the calculated flow rate. With the RFL option selected the value of 'HR' equivalent to a 10V output and the value of 'LR' is equivalent to a 0V output. The range of values is 0 to +9999 and 'HR' must be greater than 'LR' (a negative 'LR' or 'HR' would imply backward flow through the transducer).

e) 1H, 1L - Primary Variable High and Low Range

These parameters define, in engineering units, the span of the primary input variable '1V' (flow derived), and its default constant '1K'. The value entered in '1H' is equivalent to an input of 10V (or 5V if 1-5V range is selected in '1P' or the frequency selected by 'HI'). The value entered in '1L' is equivalent to an input of 0V (or 1V if 1-5V range is selected in '1P' or the frequency selected by 'LI'). The range of values is 0 to +9999 and '1H' must be greater than '1L'. (a negative '1L' or '1H' would imply a backward flow through the transducer).

f) <u>2H, 2L - Secondary Variable High and Low Range</u>

These parameters define, in engineering units, the span of the secondary input variable '2V' (Static Pressure/direct density), and its default constant '2K'. The value entered in '2H' is equivalent to an input of 10V (or 5V if 1-5V range is selected in '2P') and the value entered in '2L' is equivalent to an input of 0V (or 1V if 1-5V range is selected in '2P'). The range of values is 0 to ±9999, but '2H' must be more positive than '2L'.

g) <u>3H, 3L - Tertiary Variable High and Low Range</u>

These parameters define, in engineering units, the span of the tertiary input variable '3V' (Temperature) and its default constant '3K'. The value entered in '3H' is equivalent to an input of 10V (or 5V if 1-5V range is selected in '3P') and the value entered in '3L' is equivalent to an input of 0V (or 1V if 1-5V range is selected in '3P'. The range of values is 0 to ±9999 but '3H' must be greater than '3L'.

h) <u>HI, LI - Primary Variable Pulse Input High Low Range</u>

These parameters are used only for frequency inputs. HI defines the input frequency that corresponds to 1H LI defines the input frequency that corresponds to 1L (c.f. analogue inputs where 0V corresponds to 1L and 10V corresponds to 1H).

i) <u>HA, LA - High and Low Flow Rate Absolute Alarm Levels</u>

Independent high and low flow rate absolute alarm levels can be programmed using these parameters. If the calculated flow rate 'FL' exceeds 'HA' then the high alarm LED for the given channel will flash (going steady when acknowledged). If 'LA' exceeds 'FL' then the low alarm LED for the given channel will flash (going steady when acknowledged). If a digital output card is fitted (ALMPLS option) and the given channel digital output is selected as an alarm (See Section 4.3.1 d)) on the 'CT' parameter) then the alarm output will be active if either a current high or low alarm condition exists.

j) FC, DF - Low Flow Threshold and Default Flow

These parameters are used by the totalisation algorithm to perform a low flow substitution. If the calculated flow rate 'FL' drops below the value of 'FC' programmed by the operator then the value of 'DF', also programmed by the operator, is used in totalisation instead of 'FL'. This facility may be used to implements a low flow cut-off.

k) 1C, 2C - Scaling Factor

This is a scaling factor used in the flow rate calculation and may be any number in the range 0.0001 to 9999.

l) 1K, 2K, 3K - Secondary and Tertiary Input Default Constants

These parameters are default constants used instead of the '1V', '2V' and '3V' variables respectively in the flow rate calculation if:-

(i) the corresponding range is 1 to 5V and Out of Range Error occurred.

(ii) the corresponding input card is faulty (as detected by the diagnostic routines, See Section 2.6.3).

(iii) a constant is required in the calculation rather than a plant derived, analogue input variable. (Not in the case of 1K).

The parameters have the same range as the corresponding input variables e.g. '2K' ranged the same as '2V' (high and low range set in '2H' and '2L', decimal point position set in '2P').

m) XO - Compressibility Base

This parameter is used in some forms of the flow rate calculation and should be set to the compressibility factor of the monitored gas at the reference temperature and pressure.

n) SG - Specific Gravity (relative density)

This parameter is used in some forms of the flow rate calculation and should be set to the density of the monitored gas (expressed as a multiple of the density of air) at the reference temperature and pressure.

o) TO, PO - Reference Temperature and Reference Pressure

These parameters are used in some forms of the flow rate calculation where a volumetric flow rate at line temperature and pressure is represented by the corresponding flow rate that would occur at the reference temperature and pressure if the mass flow rate in both cases were the same.

p) FL - Calculated Flow Rate

This parameter indicates the instantaneous value of the calculated flow rate and allows a remote operator to monitor the flow rate via the SSDL.

q) 1V, 2V and 3V - Primary, Secondary and Tertiary Input Variables

These parameters indicate the current values of the primary secondary and tertiary input variables respectively and allow a remote operator to monitor the variables via the SSDL.

r) FS - Pulse Output Totalisation Scaling Factor

This parameter is used to pre-divide the calculated flow rate, 'FL', when it is used in the pulse output calculation (typically used for changing unit ranges etc.).

s) FT - Displayed Totalisation Scaling Factor

This parameter performs a similar function to that of FS but it is a pre-divider for the calculated flow rate as it is 'fed into' the displayable totaliser.

t) TA - Temperature Offset to Absolute Zero

Use of this parameter allows temperature to be displayed in normal engineering units though for the purpose of the flow rate calculation temperature must be in absolute units. TA would be 273.2 if temperature was being measured by the instrument in degrees Centigrade, and 459.7 if in Fahrenheit (See Section 3.3.1 B b)).

u) PA - Pressure Offset to Absolute Zero

This would be the local atmospheric pressure in engineering units so that gauge static pressure can be displayed though the flow rate calculation requires absolute pressure measurement (See Section 3.3.1 B b)).

v) 1F, 2F - Flow Total (Most and Least significant halves)

These parameters together indicate the current value of the displayable flow total and allow a remote operator to monitor the flow total via the SSDL. These parameters may be changed via the SSDL are read only via the HHT (See note 1 of Table 4.7).

w) 1B, 2B - HHT Flow Total Write Buffers

These parameters are only available via the HHT not the SSDL. They allow an operator to clear or preset the displayable flow total. Both halves of the flow total must be written using the buffers before the total is updated (See note 1 of Table 4.7).

x) 1T, 2T - Tag parts 1 and 2

The 8 character alpha-numeric display may be used to provide a 'channel identity' or 'Tag name' for each channel. This tag is displayed if none of the (TOT), (CHN), (ALM), or (INS), push-buttons are pressed. When any of the above mentioned buttons are pressed, the alpha-numeric display will show:-

' Flow n '

where n is the channel number.

Some of the keys of the HHT have specific functions e.g. Q is the backspace key (See System 6000 communications handbook). When entering '1T' or '2T', these functions are disabled so that all the alpha-numeric characters are available for the 'tag' parameters. This means that once the '1T' or '2T' parameters are started, they must be completed (or aborted by pulling out the HHT plug). For similar reasons as the above, the '1T' and '2T' parameters do not appear on the HHT when scrolling through the parameter list.

y) SN, RN - Store and Recall Channel Parameters

Each channel of the 6436 or 6437, when initially configured, stores its parameters in RAM. The built-in battery enables the parameters to survive for long periods whilst the instrument is switched off, but they are lost if the battery fails or is disconnected.

To avoid this risk, you can copy a channel's complete parameter set from RAM into an area of EEPROM, reserved for that channel. Here it is stored securely and independently of any power supply, for typically ten years. This is done using the SN command.

When you need to recall a parameter set from its EEPROM area back into RAM, you use the RN command. The parameters need not be copied back to their original channel; any one of the eight channels can be specified. This means that the SN and RN commands together can be used to move parameters from one channel to another.

Refer to the 6437 User Guide for details of using these commands.

4.5.2 Channel Command Parameters Format Details

a) ST - Channel Status (Read/Write)

Parameter Format 5 (4 hexadecimal digits)

← Flow Rate Time Units →

Bit 15							Bit 8	Bit 7							Bit 0
Digit A				B				C				D			

DIGIT	BIT	FUNCTION	
	15	Low frequency totalisation mode (1=enable)	
A	14-12	Flow rate time units select (totalisation)	0 =/second 1 =/minute 2 =/hour 3 =/day
	11	FORTH flow equation error	
	10	Flow total HHT write strobe bit	
B	9	Pulse input channnel fault	
	8	Totalisation hold bit	0=totalising 1=hold
	7	Total roll over warning flag	
	6	-	
C	5	Totalisation while in default (i.e. 'FL' 'LF')	
	4	-	
	3	Channel parameters sumcheck error bit	
	2	Input 1 out of range error bit	
D	1	Input 2 out of range error bit	
	0	Input 3 out of range error bit	

BINARY NUMBER				HEXADECIMAL EQUIVALENT
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9
1	0	1	0	A
1	0	1	1	B
1	1	0	0	C
1	1	0	1	D
1	1	1	0	E
1	1	1	1	F

Table 4.8 Binary Numbers and their Hexadecimal Equivalents

HEX. CHAR	PROCESSING ROUTINE FUNCTION	RANGE
0	No Processing	0 to 10V
1	Square Root Function:- $V_{out}=\sqrt{V_{in} x 10V}$	0 to 10V
2	Thermocouple type J (Iron-Constantan)	0 to 800 °C
3	Thermocouple type K (Chromel-Alumel)	0 to 1280 °C
4	Thermocouple type T (Copper-Constantan)	-240 to 400 °C
5	Thermocouple type S (Pt10%RH-Pt)	0 to 1750 °C
6	Thermocouple type R (Pt13%RH-Pt)	0 to 1750 °C
7	Thermocouple type E (Chromel-Constantan)	0 to 1000 °C
8	Thermocouple type B (Pt30%Rh-Pt6%Rh)	0 to 1800 °C
9	Platinum Resistance Thermometer (Pt100%)	-200 to 1000 °C
A	Reserved for User Specified Linearisation	As Required
B	Reserved for User Specified Linearisation	As Required
C	Reserved for User Specified Linearisation	As Required
D	Reserved for User Specified Linearisation	As Required
E	Reserved for User Specified Linearisation	As Required
F	Inversion Function:- Vout=10V-Vin	0 to 10V

Table 4.9 List of the Available Input Channel Processing Functions Selected by 1P, 2P and 3P Parameters Digit B

HEXADECIMAL CHARACTER	SELECTED INPUT FILTER TIME IN SECONDS
0	0
1	0.2
2	0.4
3	0.6
4	0.8
5	1.0
6	2.0
7	4.0
8	6.0
9	8.0
A	10.0
B	15.0
C	20.0
D	25.0
E	30.0
F	60.0

Table 4.10 List of Filter Time Constant Values Selected by 1P, 2P and 3P Parameters Digit C

b) FP - Flow Processing (Read/Write)

Parameter Format 5 (4 hexadecimal digits)

Decimal Point				Primary Device Type				Density Correction Select				Analogue Output Select			
Bit 15							Bit 8	Bit 7							Bit 0
Digit A				B				C				D			

DIGIT	BIT	FUNCTION	
A	15-12	Decimal point position select (see Table 4.13)	0-4
B	11-8	Transducer type select (see Table 4.11)	0-A
C	7 6	Density correction select (see Table 4.12)	
	5	3V/3K select in calculation	0=3K selected 1=3V selected
	4	2V/2K select in calculation	0=2K selected 1=2V selected
D	3	Unused	
	2	Analogue Board Output Select	
	1	(See below)	
	0	Transducer type (flow equation) in FORTH user word select	0= follows Digit B 1= Transducer type in FORTH selected

Appropriate CT Bit (See Section 4.3.2 d)	FP Parameter Bit		Output Type
	2	1	
0	X	1	Flow rate alarm
0	0	0	Retransmitted flow
0	1	0	FORTH SETAN
1	X	X	Retransmitted Flow Pulse

(X = Don't Care)

Table 4.10.1 Analogue Board Output Select (FP Bits 1,2)

Transducer Type Digit Entry	Calculation Form	Typical Transducer	Config* Transducer Type No.
0	$1C.2C.1V.DCT$	Turbine Meter	3
1	$1C.2C.1V.\sqrt{DCT}$	Gilflo Orifice Meter	4
2	$1C.2C.\sqrt{1V}.\sqrt{DCT}$	Orifice Meter	5
3	$1C.2C.\sqrt{1V}.DCT$	Extra	7
4	$1C.2C.1V.1/DCT$	TU1	8
5	$1C.2C.1V.1/\sqrt{DCT}$	GI2	9
6	$1C.2C.\sqrt{1V}.1/\sqrt{DCT}$	OR1	10
7	$1C.2C.\sqrt{1V}.1/DCT$	EX1	11
8	$1C.2C.1V$	Uncorrected Flow	1
9	(Not used)		-
A	$1C.2C.\sqrt{1V}$	Uncorrected Flow	2

* As used in the 6437 configuration program 'CONFIG' detailed in the 6437 User Guide.

Table 4.11 FP Parameter Transducer Type Selection

Note: When transducer type 0 to 7 is selected, all the parameters listed in Table 4.7 are enabled. When transducer type 8 or A is selected, only those parameters marked with an asterisk (*) in Table 4.7 are enabled.

Density Correction Type Bit :7:6:5:4:	Calculation Form
:0:0:x:x:	Selects DIRECT DENSITY DCT = 2X
:0:1:x:x:	Selects INFERRED GAS DENSITY $DCT = \frac{TO.(2X+PA)}{SG.PO.(3X+TA)} . \frac{XO}{ZF}$ (Set SG to 1 for turbine meter) Note: IF XO is zero THEN XO/ZF :=1 ELSE ZF is calculated ZF :=1+b.(2X+PA)+c.(2X+PA)**2 b :=[3C+(4C.3V)-(5C.3V**2)].1E-5 c :=[6C+(7C.3V)+(8C.3V**2)].1E-8
:1:0:x:x:	Selects SECOND ORDER APPROXIMATION DENSITY CALC. $DCT = 3C. \frac{1+5C.1E-2.(2X+PA-PO)+6C.1E-5.(2X+PA-PO)**2}{1+7C.1E-3.(3X+TA-TO)+8C.1E-7.(3X+TA-TO)**2}$
:1:1:x:x:	Selects ANALOGUE MANIPULATION CALC. DCT = term1 + term2 IF 2X < 3C THEN term1 = (2X+5C).6C ELSE term1 = 0 IF 2X ≥ 4C THEN term2 = (3X+7C).8C ELSE term2 = 0 Note: 2X, 3X represents either 2V or 2K, 3V or 3K dependent upon whether constants have been selected or not.

Table 4.12 Density Correction Select. Digit C

c) 1P, 2P and 3P - Input 1, 2 and 3 Processing (Read/Write)

Parameter Format 5 (4 hexadecimal digits)

Decimal Point				Input Conditioning				Input Filter				Input Select			
Bit 15							Bit 8	Bit 7							Bit 0
Digit A				B				C				D			

DIGIT	BIT	FUNCTION	
A	15-12	Decimal point position select (see Table 4.13)	0-4
B	11-8	Input conditioning select (see Table 4.9)	0-F
C	7-4	Input Filter time constant select (see Table 4.10) Not applicable to pulse input option.	0-F
D	3	Borrow output enable bit (see Table 4.14)	1=enable
	2-0	Input Range select	0=0-10V 1=1-5V

If 'PULSE' Option fitted (1P only)

2-0	Decimal point position select for parameter HI and LI (see Table 4.13)

1D, 2D, 3D, FP, 1P, 2P and 3P Parameter Digit A HI, LI Parameter Digit D	Decimal Point Position
0	9999 (no decimal point)
1	999.9
2	99.99
3	9.999
4	.9999

Table 4.13 Decimal Point Selection

HEX. CHAR.	8	9	A	B	C	D	E	F
Borrowed output from Channel No.	1	2	3	4	5	6	7	8

Table 4.14 Borrowed Output Channel Selection (FL) Digit D - 1P, 2P, 3P

Section 5 COMPUTER SUPERVISION OF 6436/7 FLOW COMPUTER

In common with all System 6000 instruments the 6436/7 Flow Computer is fitted with 2 ports for serial data communications. The first of these is the RS232 port available on the front-panel which is used for connection of the 8260 Hand-held terminal as described in Section 4.1. This port allows local operators to communicate on a one-to-one basis when entering the Command Parameters which are used to set-up the control loops within the 6436/7 for particular characteristics.

The second communications port is an RS422 serial interface available on the module rear connector pins 45 to 48 inclusive. The RS422 ports of a number of 6436/7 units may be bussed onto a supervisory data link connected to a remote Supervisory Computer or other intelligent device. This bus structure then allows the Supervisory Computer to monitor or update the Command Parameters of a whole network of 6436/7 units and other System 6000 instruments. As the means of implementing the Supervisory link are common to all System 6000 instruments, these are described in other TCS documents as follows:-

5.1 Serial Data Bus Hardware Installation

A full definition of the RS422 transmission standards are given in Section 7 of the System 6000 Installation Guide (part no: HA 076567) together with a discussion of:-

a) Interface connections.

b) Cable impedance and termination.

c) Interface signal polarity.

5.2 Serial Data Transmission

Section 2.3.2 a) briefly mentions the role of Switch bank S1 in setting up the RS422 baud rate and Group Identifier (GID). While Section 2.3.2 b) covers the use of S2 switch no. 1 to generate the necessary Unit Identifier (UID). A more complete description is given in Section 4 of the System 6000 Communications Handbook (part no: HA 076568) together with a discussion of:-

a) RS422 characteristics and technical specification.

b) Serial data transmission.

c) Binary Synchronous Communications Data Link Control.

d) Instrument Group and Unit addressing.

5.3 Communications Protocol

All data transfers between the 6436/7 and a Supervisory Computer via the RS422 data link are carried out using a communications protocol. TCS has chosen an ANSI standard protocol called BISYNC (Binary Synchronous) for System 6000 instruments and this is known by the abbreviation X3.28. The 6436/7 unit can operate this protocol in either the ASCII or Binary mode depending upon the setting of S1 no. 5 (see Section 2.3.2 a) (iii)). A full definition of these two protocol modes is given in the following sections:-

5.3.1 **ASCII Protocol**

A detailed discussion of the ASCII mode of the protocol will be found in Section 5 of the System 6000 Communications Handbook. The 6436/7 supports the ASCII protocol as follows:-

a) 2 Character Command Mnemonics

The parameters listed in Table 5.1 can all be accessed via their standard 2 ASCII character command mnemonics. Thus a typical message would contain the following sequence of ASCII characters:-

[GID][GID][UID][UID][C1][C2]

These characters have the following functions:-

(i) [GID][GID]

These data characters are the Group Address Identifier repeated twice for security. The Group Identifier is set up on switches 6, 7 and 8 of switch bank S1 as described in Section 2.3.2 a) and can vary from binary 0 to 7.

(ii) [UID][UID]

These characters are the Unit Address Identifier repeated twice for security. The Unit Identifier is set up on switch 1 of switch bank S2 and its value can vary from binary 0 to 7 or 8 to F. The eight addresses in each range correspond to the eight channels of the instrument.

(iii) [C1][C2]

These two alphanumeric characters specify the required command mnemonic from the parameter list of Table 5.1:-

i.e. II, S1, S2, S3 etc.

The following points should be noted concerning the 2 character command mnemonics.

(1) The CN, SN and RN parameters are not available via the ASCII protocol.

(2) The first parameter in the instrument set is II and the last parameter is MD.

(3) The first parameter in the channel set is ST and the last parameter is 2T.

(4) If the Scroll-mode facility (ACK) is used then the first parameter in each set will appear immediately after the last parameter is reached.

(5) The 6436 has a reduced parameter set from the 6437 as shown by (+) on Table 5.1.

(6) The parameters 1B and 2B are only available on the hand held terminal.

	0	1	2	3	4	5	6	7
0	(+) II	(+) S1	S2	S3	(+) S4	(+) CT	(+) AC	(+) AH
8	(+) AA	(+) SW	(+) MD	(+) II	(+) ST	(+) FP	(+) 1P	2P
16	3P	(+) HR	(+) LR	(+) 1H	(+) 1L	2H	2L	3H
24	3L	(+) HI	(+) LI	(+) HA	(+) LA	(+) FC	(+) DF	(+) 1K
32	2K	3K	SG	XQ	1D	TO	PO	TA
40	PA	(+) 2D	(+) 1C	(+) 2C	3C	4C	3D	5C
48	6C	7C	8C	(+) FL	(+) 1V	2V	3V	(+) FS
56	(+) FT	(+) 1F	(+) 2F	(*) 1B	(*) 2B	(+) 1T	(+) 2T	(+) ST

Table 5.1 List of 6436/7, Parameter Mnemonics [C1 C2] for ASCII Protocol and Hand Held Terminal

NOTES: (*) Those parameters marked (*) are only available on the HHT
(+) Only those parameters marked (+) are available with a 6436

	0	1	2	3	4	5	6	7
0	(+) II	(+) S1	S2	S3	(+) S4	(+) CT	(+) AC	(+) AH
8	TA	PA	(+) SW	(+) MD	(+) AA	(+) FP	(+) FP	(+) FP
16	(+) FP	(+) 1P	2P	3P	(+)(*) ST	(+)(*) HR	(+)(*) LR	(+)(*) HA
24	(+)(*) LA	(+)(*) FL	(+)(*) 1F	(+)(*) 2F	(+) 1H	(+) 1L	2H	2L
32	3H	3L	(+) 1V	2V	3V	(+) FC	(+) DF	(+) 1K
40	2K	3K	3K	SG	TO	PO	(+) FS	(+) FT
48	(+) T1	(+) T2	(+) T3	(+) T4	1D	(+) 2D	3D	XQ
56	(+) 1C	(+) 2C	3C	4C	5C	6C	7C	8C
64	(+) HI	(+) LI						

Table 5.2 List of 6436/7 Parameter Numbers [PNO]s, and their Respective Mnemonics for Binary Protocol

NOTES: (*) Only those parameters marked (*) are available with Enquiry Polling
(+) Only those parameters marked (+) are available with a 6436

5.3.2 Binary Protocol

A detailed discussion of the Binary mode of the protocol will be found in Section 6 of the System 6000 Communications Handbook. The differences between the implementation of the Binary protocol in the 6436/7 units are discussed in the following paragraphs.

a) Instrument Number [INO]

The Instrument Number [INO] consists of a 7 bit word where bits 0-3 represent the Unit Identifier [UID] value and bits 4-6 represents the Group Identifier value [GID]. Thus as the UID varies from 0 to 7 and the GID varies from 0 to 7, the INO varies from 0 to 127.

b) Parameter Number [PNO]

The Parameter Number [PNO] is a single 7 bit byte covering the range 0 - 65 and corresponds to the parameters given in Table 5.2 such that each value of [PNO] accesses one of the parameters in the list as shown.

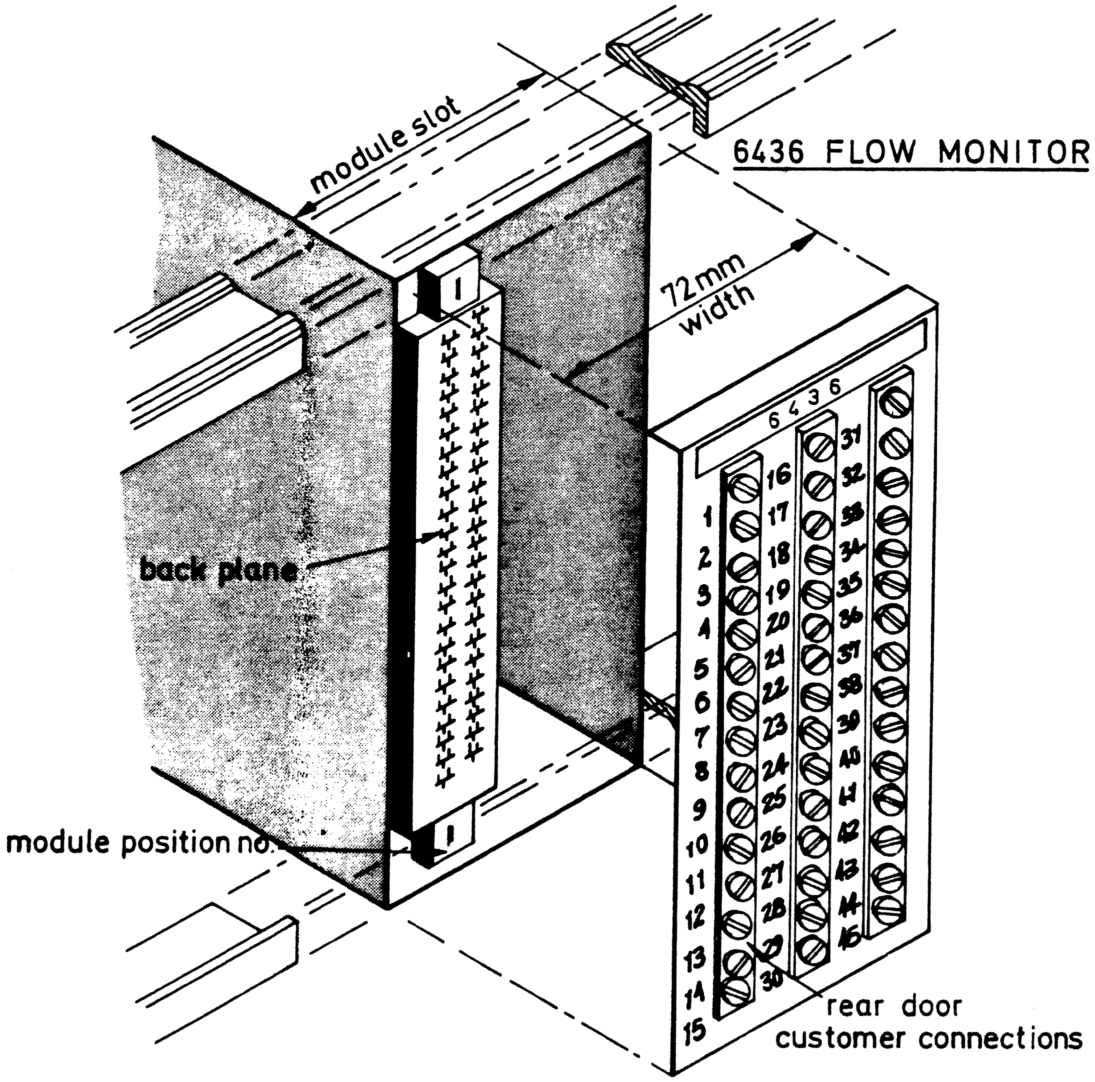
APPENDIX A

Pin No.	Designation	Function	
1			
2	OVR	OV REFERENCE	
3	OVP	OV POWER	
4			
5			
6			
7	+15V.OUT	+15V SUPPLY OUTPUT	
8	DC SUPP.IN	DC SUPPLY (20-30V) INPUT	
9	W.DOG.OUT(1)	WATCHDOG TIMER OUTPUT	
10	FL1/DP1.IN/PULSE-IN 1	0-10V FLOW DERIVED /DIFFERENTIAL PRESSURE INPUTS 0-15V PULSE INPUT/TURBINE	
11	FL2/DP2.IN/PULSE-IN 2		
12	FL3/DP3.IN/PULSE-IN 3		
13	FL4/DP4.IN/PULSE-IN 4		
14	FL5/DP5.IN/DIG-IN 5		
15	FL6/DP6.IN/DIG-IN 6		
16	FL7/DP7.IN/DIG-IN 7		
17	FL8/DP8.IN/DIG-IN 8		
18	PR1/DNS1.IN	0-10V STATIC PRESSURE /DIRECT DENSITY INPUTS (CMP1 OPTION)*	
19	PR2/DNS2.IN		
20	PR3/DNS3.IN		
21	PR4/DNS4.IN		
22	PR5/DNS5.IN		
23	PR6/DNS6.IN		
24	PR7/DNS7.IN		
25	PR8/DNS8.IN		
26	TMP1.IN	0-10V TEMPERATURE INPUTS (CMP2 OPTION)*	
27	TMP2.IN		
28	TMP3.IN		
29	TMP4.IN		
30	TMP5.IN		
31	TMP6.IN		
32	TMP7.IN		
33	TMP8.IN		
34	FL1/ALM1/PLS1.OUT	0-10V RE-TRANSMITTED FLOW RATE (RFL OPTION). 0-15V PULSE OUTPUT TOTALISATION /COMMONED ABSOLUTE ALARM OUTPUTS (ALMPLS OPTION)	
35	FL2/ALM2/PLS2.OUT		
36	FL3/ALM3/PLS3.OUT		
37	FL4/ALM4/PLS4.OUT		
38	FL5/ALM5/PLS5.OUT		
39	FL6/ALM6/PLS6.OUT		
40	FL7/ALM7/PLS7.OUT		
41	FL8/ALM8/PLS8.OUT		
42			
43			
44			
45	XMT.OUT(-)	TRANSMIT OUTPUTS	RS422 SUPERVISORY SERIAL DATA LINK
46	XMT.OUT(+)		
47	RCV.IN (-)	RECEIVE INPUTS	
48	RCV.IN (+)		

* 6437 only

loop identifier

rack & module no.



The B6436 termination assembly consists of a 48-pin back plane connector with a wire loom linking the module connections on the back plane to three rows of 15 customer terminals.

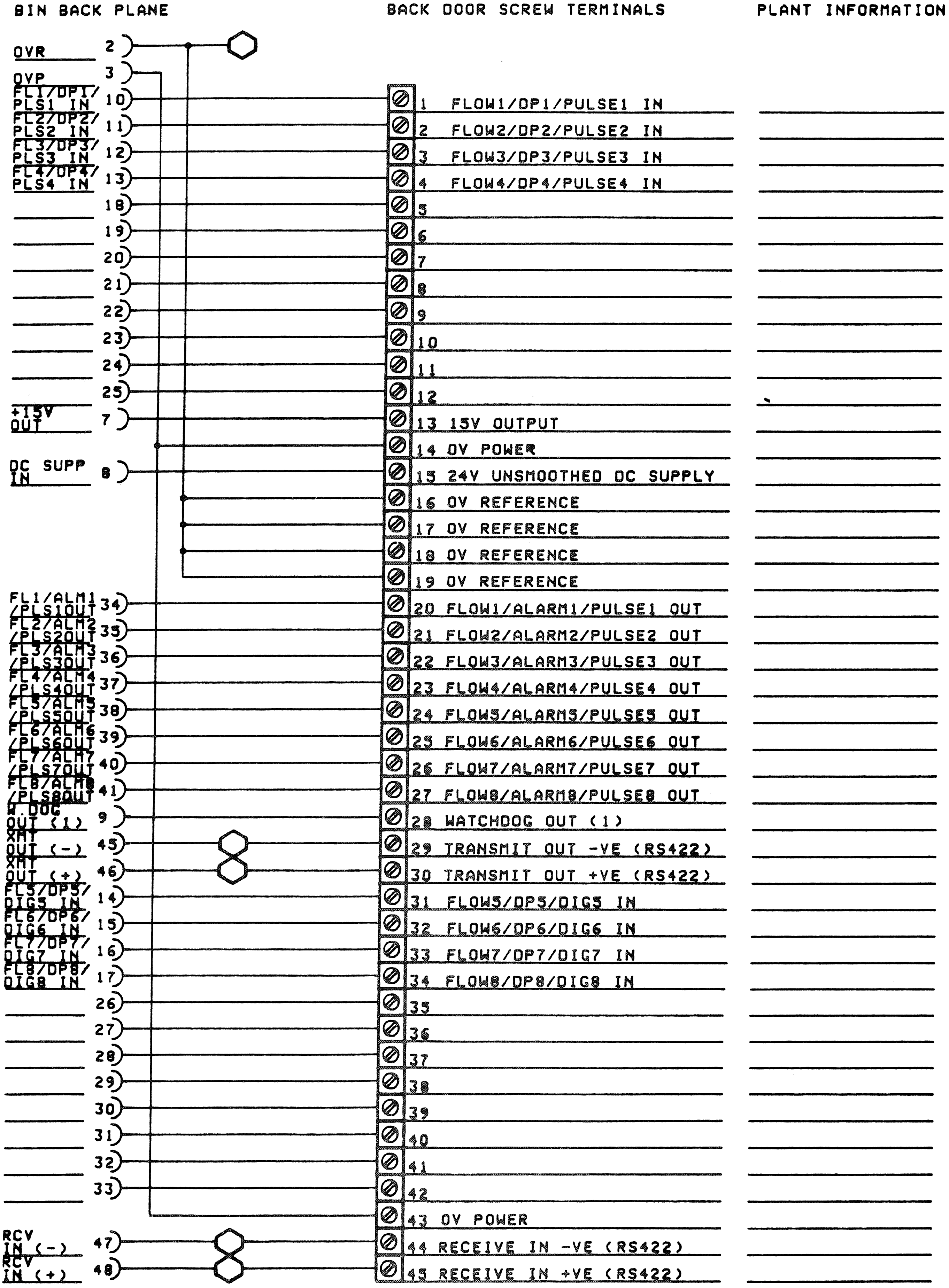
The assembly is used to mount 6436 Flow Monitors into 7600 bin units and can only be ordered as part of a 7600 bin system.

Detailed technical and mechanical specifications can be found in the following documents :-

7600 Sales Literature
6436/7 Product Specification
6436/7 Technical Manual

Iss 1; Aug 86 Part no: HA 079107 U007

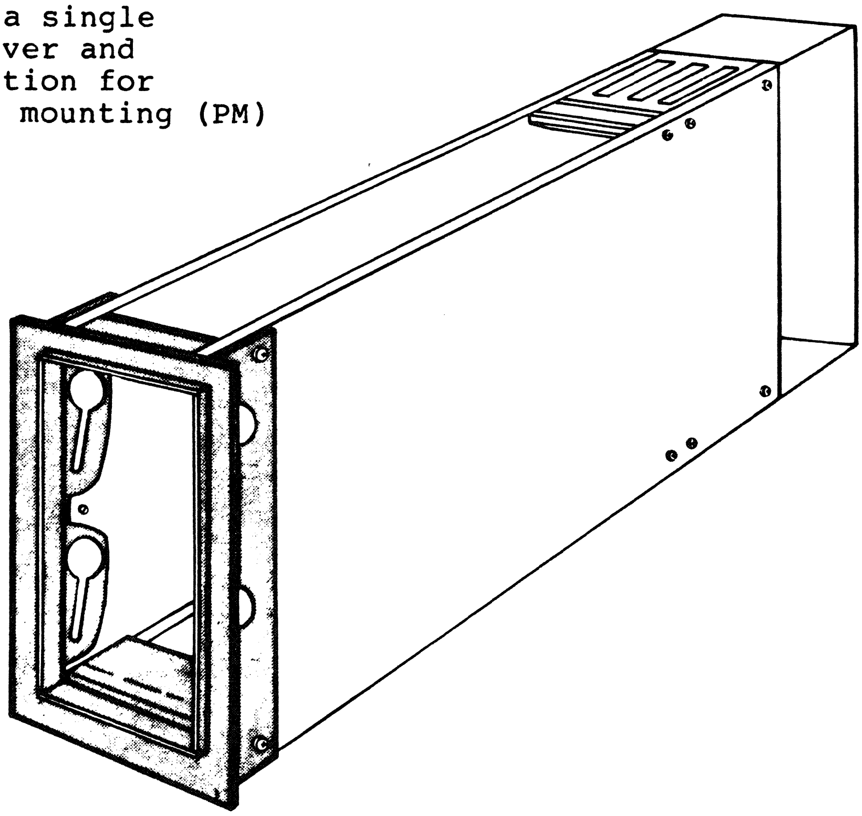
B64 36 BIN INTERCONNECTIONS



⬡ THESE LINES MAY BE BUSED TO OTHER MODULES IN THE BIN

SINGLE OR MULTI-WAY SLEEVE ASSEMBLY FOR MICROPROCESSOR BASED INSTRUMENTATION

NOTE
Drawing shows a single sleeve with cover and gland plate option for standard panel mounting (PM)

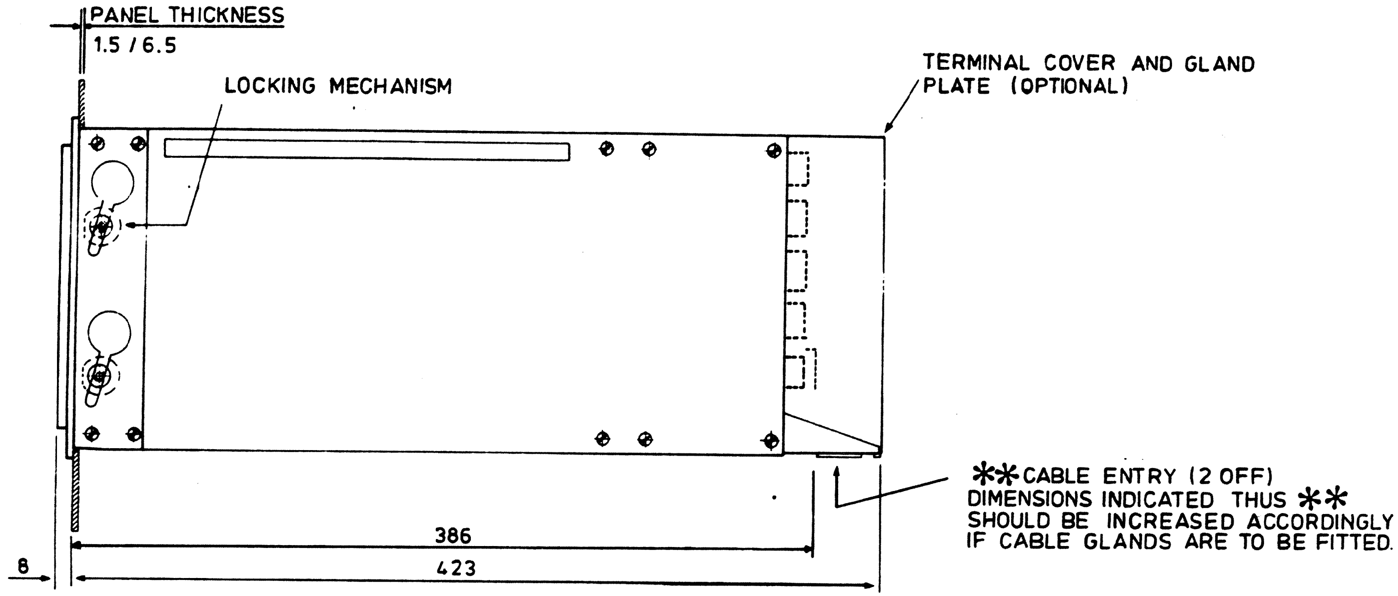


- * Single, 3-way or 6-way panel mounting versions
- * 6-way 19" rack mounting version
- * all module connections available via screw terminals
- * each module individually powered from 24V d.c. or mains

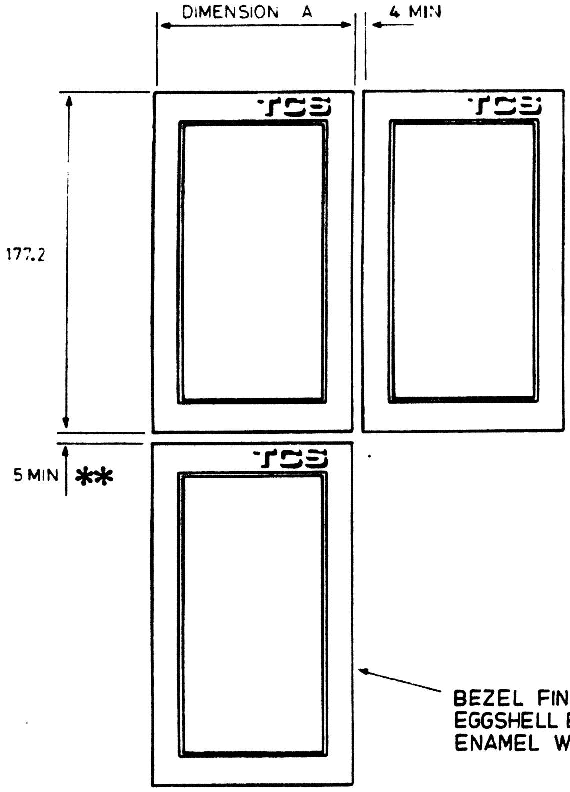
The 7900 assembly enables from 1 to 6 modules from the TCS System 6000 range of microprocessor based instruments to be panel or rack mounted in sleeves. Any combination of modules can be specified including Controllers, Signal Processors, and Flow Totalisers. Each instrument within the 7900 unit is individually powered via its own rear termination assembly, which also gives access to all the module connections.

TECHNICAL SPECIFICATION

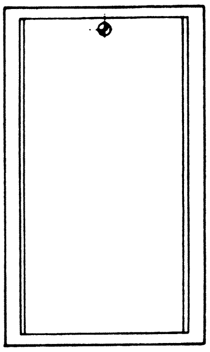
1) Installation Details for Panel Mounting Sleeves



SIDE VIEW



BEZEL FINISH :-
EGGSHELL BLACK STOVE
ENAMEL WITH SILVER TRIM



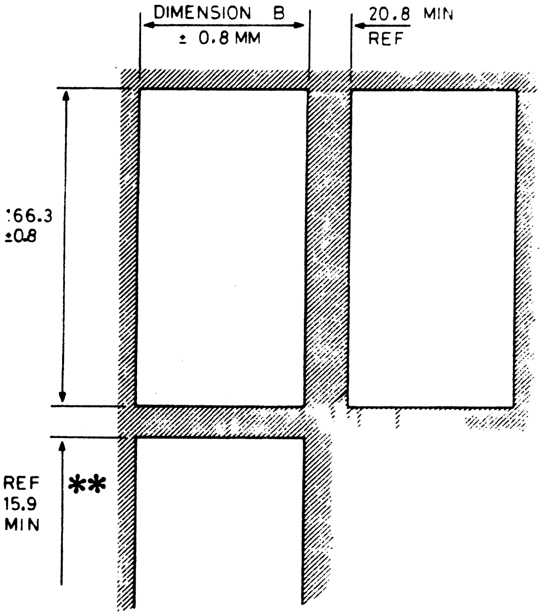
REAR VIEW

DIMENSION A	SLEEVE WIDTH
105	1-WAY
249	3-WAY
465	6-WAY

FRONT VIEW SHOWING OTHER POSSIBLE ADJACENT SLEEVES

2) Mounting Instructions

The dimensions of the various 7900 assemblies can be ascertained from the side and front view diagrams which also show the closest positioning of adjacent units. The diagram below gives the panel cut-out dimensions corresponding with the closest unit positioning.



DIMENSION B	SLEEVE WIDTH
88.2	1-WAY
232.2	3-WAY
448.2	6-WAY

PANEL CUT-OUT DETAILS

To position a 7900 assembly in a panel and subsequently mount a microprocessor based instrument within it, the following installation procedure is carried out:-

(i) Press an empty 7900 sleeve assembly firmly into the panel cut-out.

(ii) On the 1-way sleeves, insert the 2 locking mechanisms into the lower keyhole slots on either side and push them down as far as possible. On 3 and 6 way sleeves, fit locking mechanisms in all four positions.

(iii) Tighten the socket screw inside each locking mechanism in a clockwise direction using the 2.5 A/F Hex Key provided.

(iv) For the TPM option fit the locating spigot on the DIN clip into the slot on the side plates, with the face pressed against the rear of the panel then tighten the screw until the assembly is secure.

(v) Slide the instrument, with its own 72mm module sleeve firmly into the recess using the catch-handle to lock it into position.

(vi) The optional rear-terminal cover may be removed to allow wiring access for power-supply and plant connections which may be brought in via the 2 cable entry glands provided. Rear supporting is recommended especially on mains powered versions.

TECHNICAL SPECIFICATION

a) Length : 423mm with CGP option
: 386mm without CGP option

b) Width
(i) 1-Way PM or TPM : 105mm
(ii) 3-Way PM or TPM : 249mm
(iii) 6-Way PM or TPM : 465mm
(iv) 6-Way 19" RM : 482.6mm (19")

c) Height (all versions) : 177.2mm (7")

d) Panel cut-out dimensions
(i) 1-Way : 88.2 x 166.3 + 0.8mm
(ii) 3-Way : 232.2 x 166.3 + 0.8mm
(iii) 6-Way : 448.2 x 166.3 + 0.8mm

e) Panel thickness
(i) PM version : 1.5 to 6.5mm
(ii) TPM version : 6.5 to 24mm

f) Permissible mounting angle : Panel may slope from vertical by -45 to +90 degrees

g) Customer cable size : 0.5 to 1.5mm

h) Bezel finish : Eggshell black stove enamel with silver trim

i) Weight

	DC VERSION	MAINS VERSION
(i) 1-Way PM or TPM :	3.6Kg	4.3Kg
(ii) 3-Way PM or TPM :	8.4Kg	10.5Kg
(iii) 6-Way PM or TPM or RM :	15.6Kg	19.8Kg

DESCRIPTION	ORDER CODE
Single or Multi-way Sleeve Assembly	7900
<u>Sleeve Width</u>	
a) Single Sleeve	1-WAY PM
or b) 3-Way Sleeve Panel Mounting	3-WAY PM
or c) 6-Way Sleeve Panel Mounting	6-WAY PM
or d) 6-Way Sleeve Rack Mounting	6-WAY 19" RM
or e) 1-Way Sleeve Thick Panel Mounting	1-WAY TPM
or f) 3-Way Sleeve Thick Panel Mounting	3-WAY TPM
or g) 6-Way Sleeve Thick Panel Mounting	6-WAY TPM
<u>Supply Voltage</u>	
a) 24V DC	24V
or b) 110V AC	110V
or c) 240V AC	240V
<u>N.B.</u> Multi-Way assemblies all have the same supply voltage	
Rear door cover and gland plate option for the rear termination assemblies	CGP

DESCRIPTION	ORDER CODE
Rear Termination Assemblies	
Specify which instrument is to fit into each sleeve position starting from the left-hand end (front view). Select from the following:-	
a) 6350, 6351, 6352, 6353, 6355, 6356 - single loop Controllers	7350, 7351, 7352, 7353, 7355, 7356
or b) 6358 - 8-loop Controller	7358
or c) 6360, 6363, 6365, 6366 - Bargraph Controllers	7360, 7363, 7365, 7366
or d) 6432, 6433 - Signal Processors	7432, 7433
or e) 6434, 6435, 6436, 6437 - Flow Totalisers	7434, 7435, 7436, 7437
or f) 6255, 6445 - Communications units	7255, 7445
or g) 6850 - Setpoint Programmer	7850
or h) Blank slot	BLANK
Current Inputs	
For the following modules the option of 1-5V or 4-20mA is provided. (All channels to be the same)	
a) 7350, 7351, 7352, 7353, 7355, 7356 b) 7360, 7363, 7365, 7366 c) 7850	
1-5V (Standard)	--
4-20mA (Option)	BR
N.B. Every slot must be specified in order:- /slot 6 /slot 5 /....../slot 2 /slot 1 / where slot 1 is in the most right-hand position viewed from the front. These options form the second line of the Ordering Code.	

ORDER CODE EXAMPLES

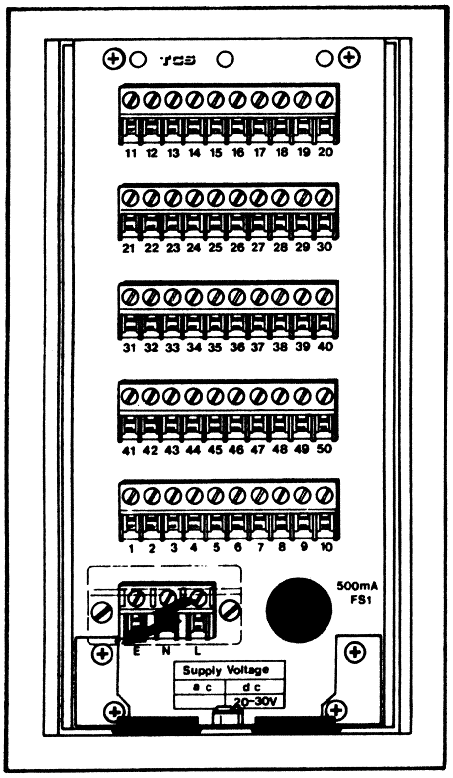
a) A 6350 Process Controller in a single sleeve with 4-20mA current input on all three channels:-
7900/1-WAY PM/240V/CGP/7350/BR

b) A 3-way panel mounting assembly with two Controllers and a Programmer:-
7900/3-WAY PM/240V/CGP/7350/7350/BR/7850

c) A 6-way 19" rack mounting assembly:-
7900/6-WAY 19" RM/240V/7350/7350/7350/7350/BR/7432/7850/BR

d) A 1-way thick-panel mounting sleeve:-
7900/1-WAY TPM/24V/CGP/7432

6436 FLOW COMPUTER REAR TERMINATION ASSEMBLY



* Panel Mounting
* Modular Construction
* All Module Connections Available Via Screw Terminals
* 24V DC and Mains Powered
* Input/Output terminals ergonomically arranged in blocks of 8

REAR VIEW WITH TERMINAL COVERS REMOVED
DRAWING SHOWS 1WAY/MAINS POWERED VERSION

The 7436 Rear Termination assembly enables 6436 Flow Computers to be fitted into 7900 single or multi-way sleeves. Each 7436 assembly allows an associated 6436 module to function as a stand-alone instrument and enables it to be fitted into conventional panel cut-outs.

The Block Diagram shows that the 7436 contains a mains transformer and bridge rectifier assembly. A 0.5A screw-in type fuse is provided and 110V or 240V AC operation is selected internally. The mains input terminals have a separate 3-way connector block (51-53), while a further terminal (2) may be used for a 24V DC input or back-up supply, if required.

The input/output connections are arranged in 2 rows of 10 terminals for Flow/Differential Pressure inputs, Channels 1-8 (11-18), and Re-transmitted Flow/Totalisation Pulse/Absolute Alarm outputs (41-48). Each row also has a 0V ref. terminal (19 and 49), and a 0V power terminal (20 and 50), to facilitate plant wiring.

The inter-connections between the 7436 screw terminals and the 6436 module pins are given in the cross-reference table which lists all those connections not shown in the Block Diagram.

SLEEVE TERMINAL NUMBER	MODULE PIN NUMBER	FUNCTION	
1	3	0V.POW	POWER SUPPLIES
2	8	DC.SUPP.IN	
3	7	+15V.OUT	
4	5		
5	43		
6	9	W.DOG.OUT(1)	
7	45	XMT.OUT(-)	RS422 SERIAL BUS
8	46	XMT.OUT(+)	
9	47	RCV.IN(-)	
10	48	RCV.IN(+)	
11	10	FL1/DP1.IN/PULSE-IN(1)	FLOW/ DIFFERENTIAL PRESSURE/ TURBINE INPUTS
12	11	FL2/DP2.IN/PULSE-IN(2)	
13	12	FL3/DP3.IN/PULSE-IN(3)	
14	13	FL4/DP4.IN/PULSE-IN(4)	
15	14	FL5/DP5.IN/-	
16	15	FL6/DP5.IN/-	
17	16	FL7/DP5.IN/-	
18	17	FL8/DP5.IN/-	
19	2	0V.REF	
20	3	0V.POW	
21	18		
22	19		
23	20		
24	21		
25	22		
26	23		
27	24		
28	25		
29	2		
30	3		
31	26		
32	27		
33	28		
34	29		
35	30		
36	31		
37	32		
38	33		
39	2		
40	3		
41	34	FL1/ALM1/PLS1.OUT	RE-TRANSMITTED FLOW/ TOTALISATION/ ABSOLUTE ALARMS OUTPUTS (OPTION)
42	35	FL2/ALM2/PLS2.OUT	
43	36	FL3/ALM3/PLS3.OUT	
44	37	FL4/ALM4/PLS4.OUT	
45	38	FL5/ALM5/PLS5.OUT	
46	39	FL6/ALM6/PLS6.OUT	
47	40	FL7/ALM7/PLS7.OUT	
48	41	FL8/ALM8/PLS8.OUT	
49	2	0V.REF	
50	3	0V.POW	
51		EARTH	A.C. MAINS
52		NEUTRAL	
53		LINE	

TECHNICAL SPECIFICATION

(A) Electrical

The 6436 Flow Computer Module which is plugged into the 7436 sleeve, contains 8 independent Flow Totalisation channels. The electrical specification for each channel is as follows:-

a) Analogue Inputs

Number of inputs : 1 direct, non-isolated input

Input functions : Input 1 = Flow derived signal

b) Analogue Outputs

Number of outputs : 1 direct non-isolated output (optional)

Output function : Output 1 = Calculated flow rate (optional).

c) Pulse Inputs

Number of inputs : 1 direct non-isolated input to positive edge triggered counter 4 channels only

Input functions : Input 1 = Flow derived signal

Input frequency range : 0.0001Hz to 10kHz

Input voltage levels : 5V to 15V = Logic One
0V = Logic Zero

d) Digital Outputs

Number of outputs : 1 optional non-isolated output + watchdog.

Output function : Output 1 = common absolute alarms /pulse totalisation.

Output signal levels : Logic zero = 0V.

(B) Power Supplies

a) Supply Inputs

Mains Version	: 110V AC at 220mA rms 240V AC at 100mA rms
24V DC Version	: 20-30V DC at 650mA
Back-up Supply Input	: 20-30V DC on mains versions only

b) Supply Outputs : 15V DC ± 0.5V at 100mA max

c) Fuse Rating : Separate 0.5A screw-in type fuse provided with mains versions only

FL1/DP1 /PULSE 1	FL2/DP2 /PULSE 2	FL3/DP3 /PULSE 3	FL4/DP4 /PULSE 4	FL5/ DP 5/-	FL6/ DP 6/-	FL 7/ DP 7/-	FL8/ DP 8/-	0V REF	0V POW
11	12	13	14	15	16	17	18	19	20

FLOW/ DIFFERENTIAL PRESSURE INPUTS

								0V REF	0V POW
21	22	23	24	25	26	27	28	29	30

PRESSURE/ DENSITY INPUTS

								0V REF	0V POW
31	32	33	34	35	36	37	38	39	40

TEMPERATURE INPUTS

FL 1/ALM 1 /PLS 1	FL 2/ALM 2 /PLS 2	FL 3/ALM 3 /PLS 3	FL 4/ALM 4 /PLS 4	FL 5/ALM 5 /PLS 5	FL 6/ALM 6 /PLS 6	FL 7/ALM 7 /PLS 7	FL 8/ALM 8 /PLS 8	0V REF	0V POW
41	42	43	44	45	46	47	48	49	50

RE-TRANSMITTED FLOW /PULSE/ TOTALISATION /ABSOLUTE ALARMS OUTPUT

0V POW	+24V DC	+15V OUT			W.DOG OUT (1)	XMT OUT (-)	XMT OUT (+)	RCV IN (-)	RCV IN (+)
1	2	3	4	5	6	7	8	9	10

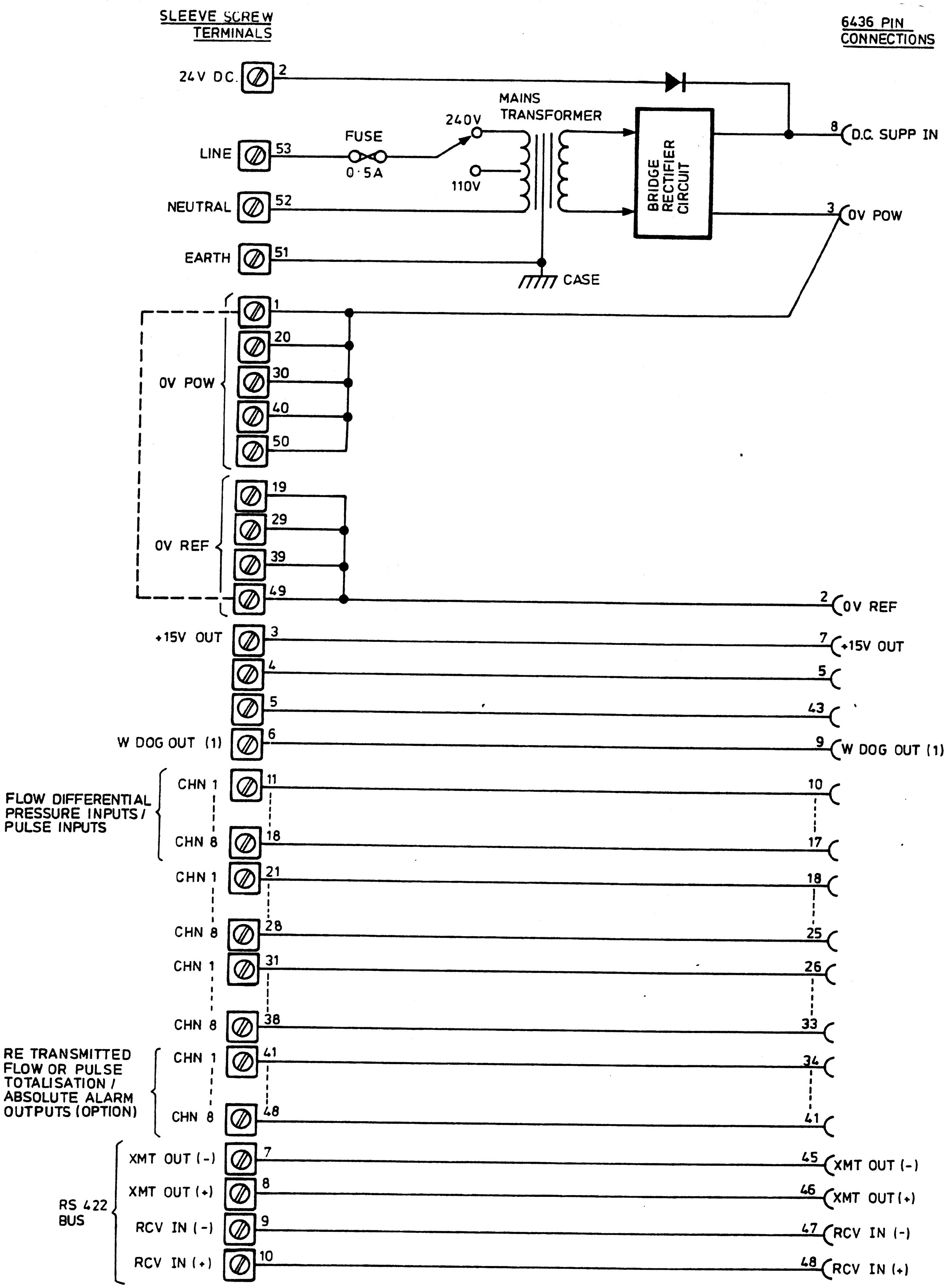
POWER SUPPLIES

COMMS

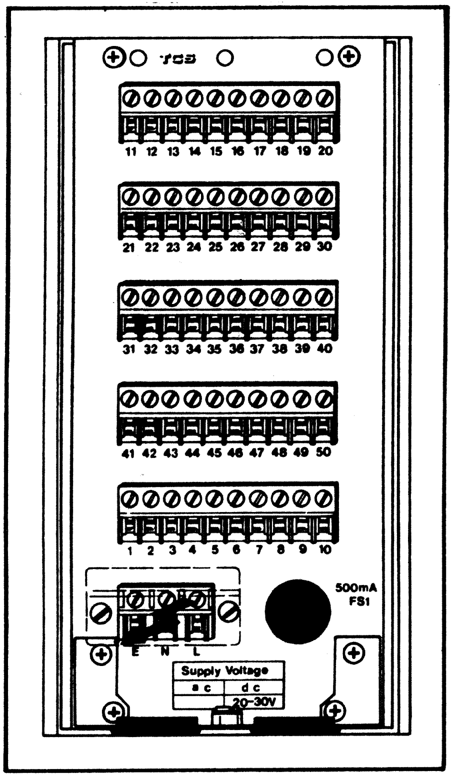
MAINS CONNECTIONS		
E	N	L
51	52	53

FLOW
MONITOR
7436

SLEEVE REAR TERMINAL FUNCTIONS


SLEEVE SCREW TERMINALS
6436 PIN CONNECTIONS
24V DC.
2
MAINS TRANSFORMER
240V
110V
FUSE
0·5A
LINE
53
NEUTRAL
52
EARTH
51
CASE
BRIDGE RECTIFIER CIRCUIT
8
D.C. SUPP IN
3
0V POW
0V POW
1
20
30
40
50
0V REF
19
29
39
49
2
0V REF
+15V OUT
3
7
+15V OUT
4
5
5
43
W DOG OUT (1)
6
9
W DOG OUT (1)
FLOW DIFFERENTIAL PRESSURE INPUTS / PULSE INPUTS
CHN 1
11
10
CHN 8
18
17
CHN 1
21
18
CHN 8
28
25
CHN 1
31
26
CHN 8
38
33
RE TRANSMITTED FLOW OR PULSE TOTALISATION / ABSOLUTE ALARM OUTPUTS (OPTION)
CHN 1
41
34
CHN 8
48
41
RS 422 BUS
XMT OUT (-)
7
45
XMT OUT (-)
XMT OUT (+)
8
46
XMT OUT (+)
RCV IN (-)
9
47
RCV IN (-)
RCV IN (+)
10
48
RCV IN (+)

6437 FLOW COMPUTER REAR TERMINATION ASSEMBLY



* Panel Mounting
* Modular Construction
* All Module Connections Available Via Screw Terminals
* 24V DC and Mains Powered
* Input/Output terminals ergonomically arranged in blocks of 8

REAR VIEW WITH TERMINAL COVERS REMOVED
DRAWING SHOWS 1WAY/MAINS POWERED VERSION

The 7437 Rear Termination assembly enables 6437 Flow Computers to be fitted into 7900 single or multi-way sleeves. Each 7437 assembly allows an associated 6437 module to function as a stand-alone instrument and enables it to be fitted into conventional panel cut-outs.

The Block Diagram shows that the 7437 contains a mains transformer and bridge rectifier assembly. A 0.5A screw-in type fuse is provided and 110V or 240V AC operation is selected internally. The mains input terminals have a separate 3-way connector block (51-53), while a further terminal (2) may be used for a 24V DC input or back-up supply, if required.

The input/output connections are arranged in 4 rows of 10 terminals for Flow/Differential Pressure inputs, Channels 1-8 (11-18), Pressure/Density inputs (21-28), Temperature inputs (31-38) and Re-transmitted Flow/Totalisation Pulse/Absolute Alarm outputs (41-48). Each row also has a 0V ref. terminal (19,29,39,49), and a 0V power terminal (20,30,40,50), to facilitate plant wiring.

The inter-connections between the 7437 screw terminals and the 6437 module pins are given in the cross-reference table which lists all those connections not shown in the Block Diagram.

SLEEVE TERMINAL NUMBER	MODULE PIN NUMBER	FUNCTION	
1	3	0V.POW	POWER SUPPLIES
2	8	DC.SUPP.IN	
3	7	+15V.OUT	
4	5		
5	43		
6	9	W.DOG.OUT(1)	
7	45	XMT.OUT(-)	RS422 SERIAL BUS
8	46	XMT.OUT(+)	
9	47	RCV.IN(-)	
10	48	RCV.IN(+)	
11	10	FL1/DP1.IN/PULSE-IN(1)	FLOW/ DIFFERENTIAL PRESSURE/ TURBINE INPUTS
12	11	FL2/DP2.IN/PULSE-IN(2)	
13	12	FL3/DP3.IN/PULSE-IN(3)	
14	13	FL4/DP4.IN/PULSE-IN(4)	
15	14	FL5/DP5.IN/DIG-IN(5)	
16	15	FL6/DP5.IN/DIG-IN(6)	
17	16	FL7/DP5.IN/DIG-IN(7)	
18	17	FL8/DP5.IN/DIG-IN(8)	
19	2	0V.REF	
20	3	0V.POW	
21	18	PR1/DNS1.IN	PRESSURE/ DENSITY INPUTS (OPTION)
22	19	PR2/DNS2.IN	
23	20	PR3/DNS3.IN	
24	21	PR4/DNS4.IN	
25	22	PR5/DNS5.IN	
26	23	PR6/DNS6.IN	
27	24	PR7/DNS7.IN	
28	25	PR8/DNS8.IN	
29	2	0V.REF	
30	3	0V.POW	
31	26	TMP1.IN	TEMPERATURE INPUTS (OPTION)
32	27	TMP2.IN	
33	28	TMP3.IN	
34	29	TMP4.IN	
35	30	TMP5.IN	
36	31	TMP6.IN	
37	32	TMP7.IN	
38	33	TMP8.IN	
39	2	0V.REF	
40	3	0V.POW	
41	34	FL1/ALM1/PLS1.OUT	RE-TRANSMITTED FLOW/ TOTALISATION/ ABSOLUTE ALARMS OUTPUTS (OPTION)
42	35	FL2/ALM2/PLS2.OUT	
43	36	FL3/ALM3/PLS3.OUT	
44	37	FL4/ALM4/PLS4.OUT	
45	38	FL5/ALM5/PLS5.OUT	
46	39	FL6/ALM6/PLS6.OUT	
47	40	FL7/ALM7/PLS7.OUT	
48	41	FL8/ALM8/PLS8.OUT	
49	2	0V.REF	
50	3	0V.POW	
51		EARTH	A.C. MAINS
52		NEUTRAL	
53		LINE	

TECHNICAL SPECIFICATION

(A) Electrical

The 6437 Flow Computer Module which is plugged into the 7437 sleeve, contains 8 independent Flow Totalisation channels. The electrical specification for each channel is as follows:-

a) Analogue Inputs

Number of inputs : 1 direct, non-isolated input + 2 optional inputs.

Input functions : Input 1 = Flow derived signal.
: Input 2 = Static pressure/direct density (optional).
: Input 3 = Temperature (optional).

Input signal levels : 0-10V or 1-5V selected by software.

b) Analogue Outputs

Number of outputs : 1 direct non-isolated output (optional).

Output function : Output 1 = Calculated flow rate (optional).

c) Pulse Inputs

Number of inputs : 1 direct, non-isolated input to positive edge triggered counter 4 channels only

Input functions : Input 1 = Flow derived signal.

Input frequency range : 0.0001Hz to 10kHz

Input voltage levels : 5V to 15V = Logic One
0V = Logic Zero

d) Digital Inputs

Number of inputs	: 1 non-latched, non-isolated input 4 channels only
Input functions	:
Input voltage levels	: 15V = logic one 0V = logic zero
Input impedance	: 100kohm pull-down to 0V (gives 150uA for logic one)

e) Digital Outputs

Number of outputs	: 1 optional non-isolated output + watchdog.
Output function	: Output 1 = common absolute alarms /pulse totalisation.
Output signal levels	: Logic zero = 0V.

(B) Power Supplies

a) Supply Inputs

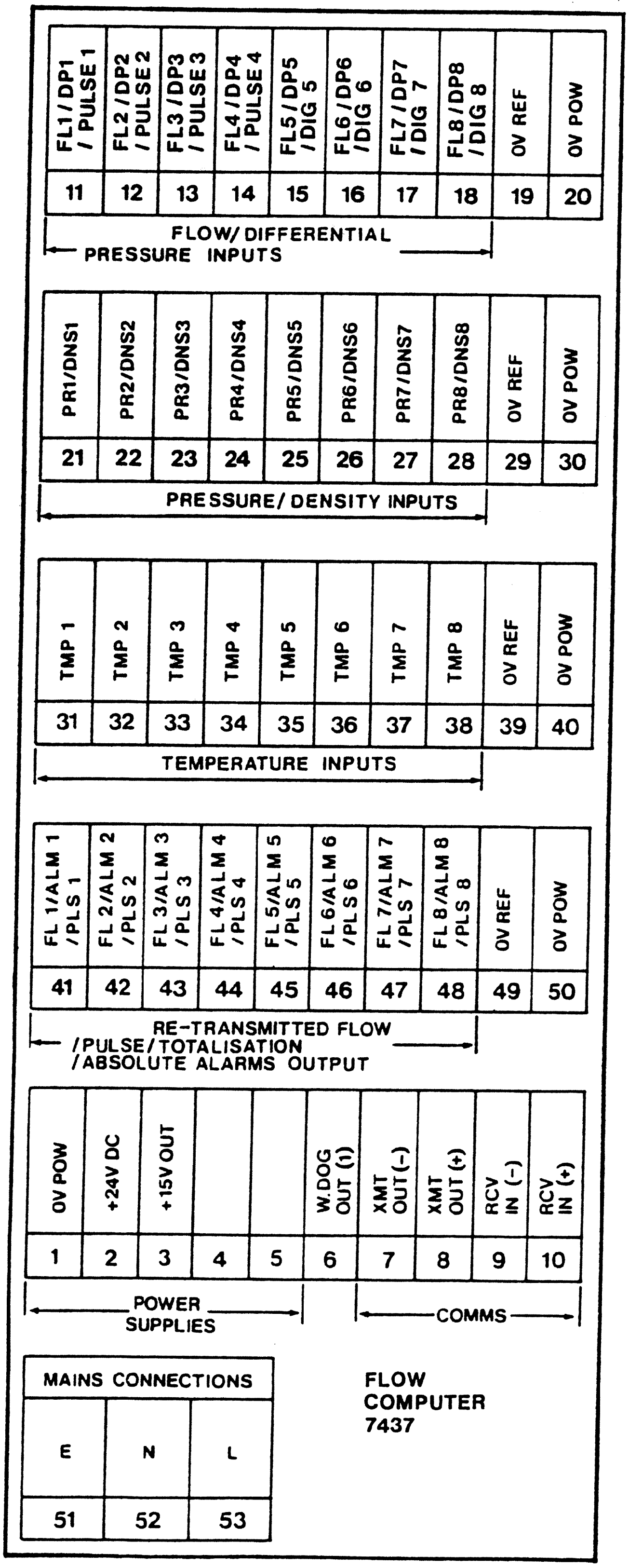
Mains Version : 110V AC at 220mA rms
240V AC at 100mA rms

24V DC Version : 20-30V DC at 650mA

Back-up Supply Input : 20-30V DC on mains versions only

b) Supply Outputs : 15V DC + 0.5V at 100mA max

c) Fuse Rating : Separate 0.5A screw-in type fuse provided with mains versions only



FL1 / DP1 / PULSE 1	FL2 / DP2 / PULSE 2	FL3 / DP3 / PULSE 3	FL4 / DP4 / PULSE 4	FL5 / DP5 / DIG 5	FL6 / DP6 / DIG 6	FL7 / DP7 / DIG 7	FL8 / DP8 / DIG 8	OV REF	OV POW
11	12	13	14	15	16	17	18	19	20

FLOW/ DIFFERENTIAL PRESSURE INPUTS

PR1/DNS1	PR2/DNS2	PR3/DNS3	PR4/DNS4	PR5/DNS5	PR6/DNS6	PR7/DNS7	PR8/DNS8	OV REF	OV POW
21	22	23	24	25	26	27	28	29	30

PRESSURE/ DENSITY INPUTS

TMP 1	TMP 2	TMP 3	TMP 4	TMP 5	TMP 6	TMP 7	TMP 8	OV REF	OV POW
31	32	33	34	35	36	37	38	39	40

TEMPERATURE INPUTS

FL 1/ALM 1 /PLS 1	FL 2/ALM 2 /PLS 2	FL 3/ALM 3 /PLS 3	FL 4/ALM 4 /PLS 4	FL 5/ALM 5 /PLS 5	FL 6/ALM 6 /PLS 6	FL 7/ALM 7 /PLS 7	FL 8/ALM 8 /PLS 8	OV REF	OV POW
41	42	43	44	45	46	47	48	49	50

RE-TRANSMITTED FLOW /PULSE/TOTALISATION /ABSOLUTE ALARMS OUTPUT

OV POW	+24V DC	+15V OUT			W.DOG OUT (1)	XMT OUT (-)	XMT OUT (+)	RCV IN (-)	RCV IN (+)
1	2	3	4	5	6	7	8	9	10

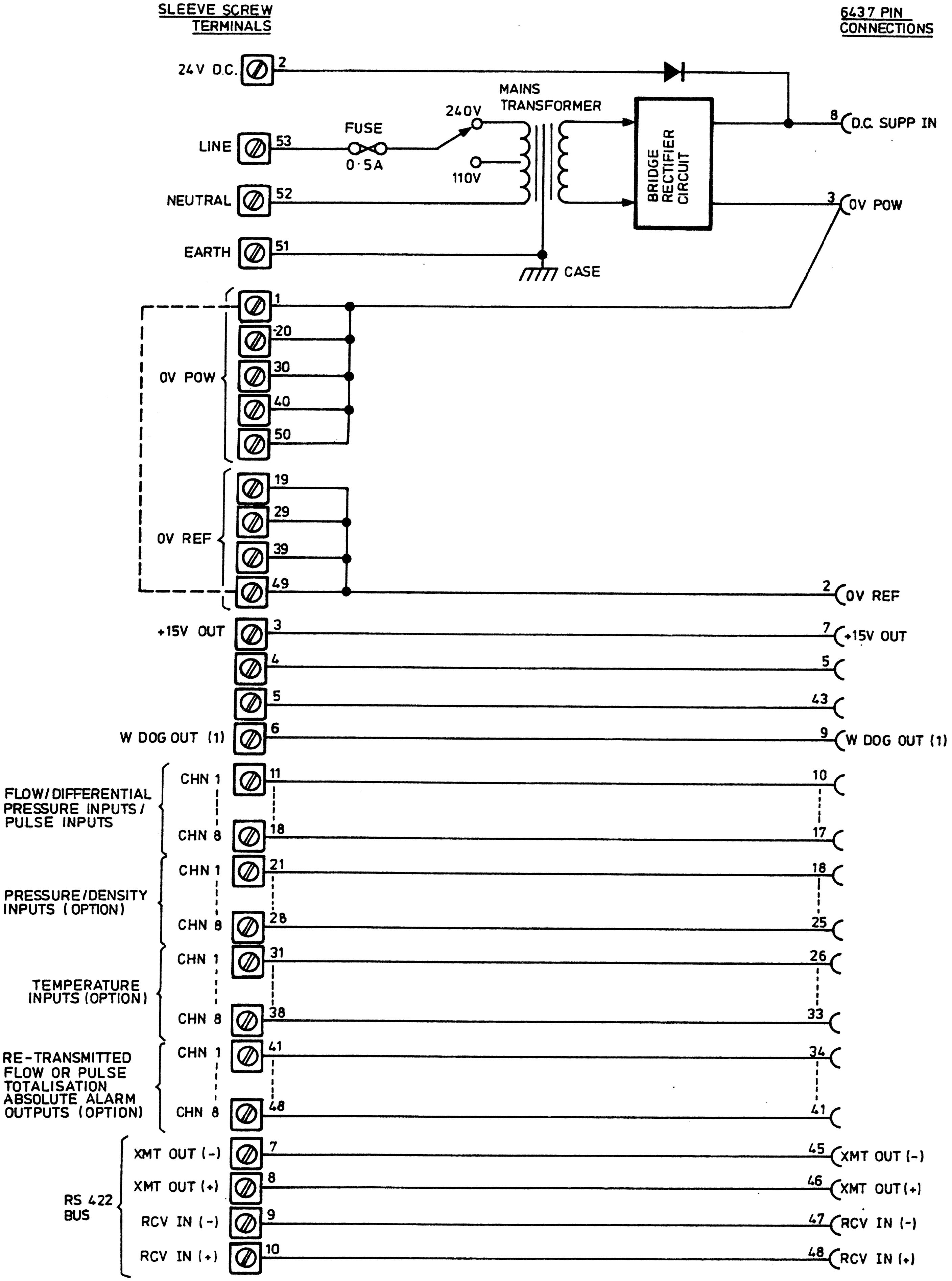
POWER SUPPLIES

COMMS

MAINS CONNECTIONS		
E	N	L
51	52	53

FLOW COMPUTER 7437

SLEEVE REAR TERMINAL FUNCTIONS


SLEEVE SCREW TERMINALS
6437 PIN CONNECTIONS
24V D.C.
2
MAINS TRANSFORMER
240V
FUSE
LINE
53
0·5A
110V
BRIDGE RECTIFIER CIRCUIT
8
D.C. SUPP IN
NEUTRAL
52
3
0V POW
EARTH
51
CASE
1
20
0V POW
30
40
50
19
29
0V REF
39
49
2
0V REF
+15V OUT
3
7
+15V OUT
4
5
5
43
W DOG OUT (1)
6
9
W DOG OUT (1)
FLOW/DIFFERENTIAL PRESSURE INPUTS/ PULSE INPUTS
CHN 1
11
10
CHN 8
18
17
PRESSURE/DENSITY INPUTS (OPTION)
CHN 1
21
18
CHN 8
28
25
TEMPERATURE INPUTS (OPTION)
CHN 1
31
26
CHN 8
38
33
RE-TRANSMITTED FLOW OR PULSE TOTALISATION ABSOLUTE ALARM OUTPUTS (OPTION)
CHN 1
41
34
CHN 8
48
41
RS 422 BUS
XMT OUT (-)
7
45
XMT OUT (-)
XMT OUT (+)
8
46
XMT OUT (+)
RCV IN (-)
9
47
RCV IN (-)
RCV IN (+)
10
48
RCV IN (+)

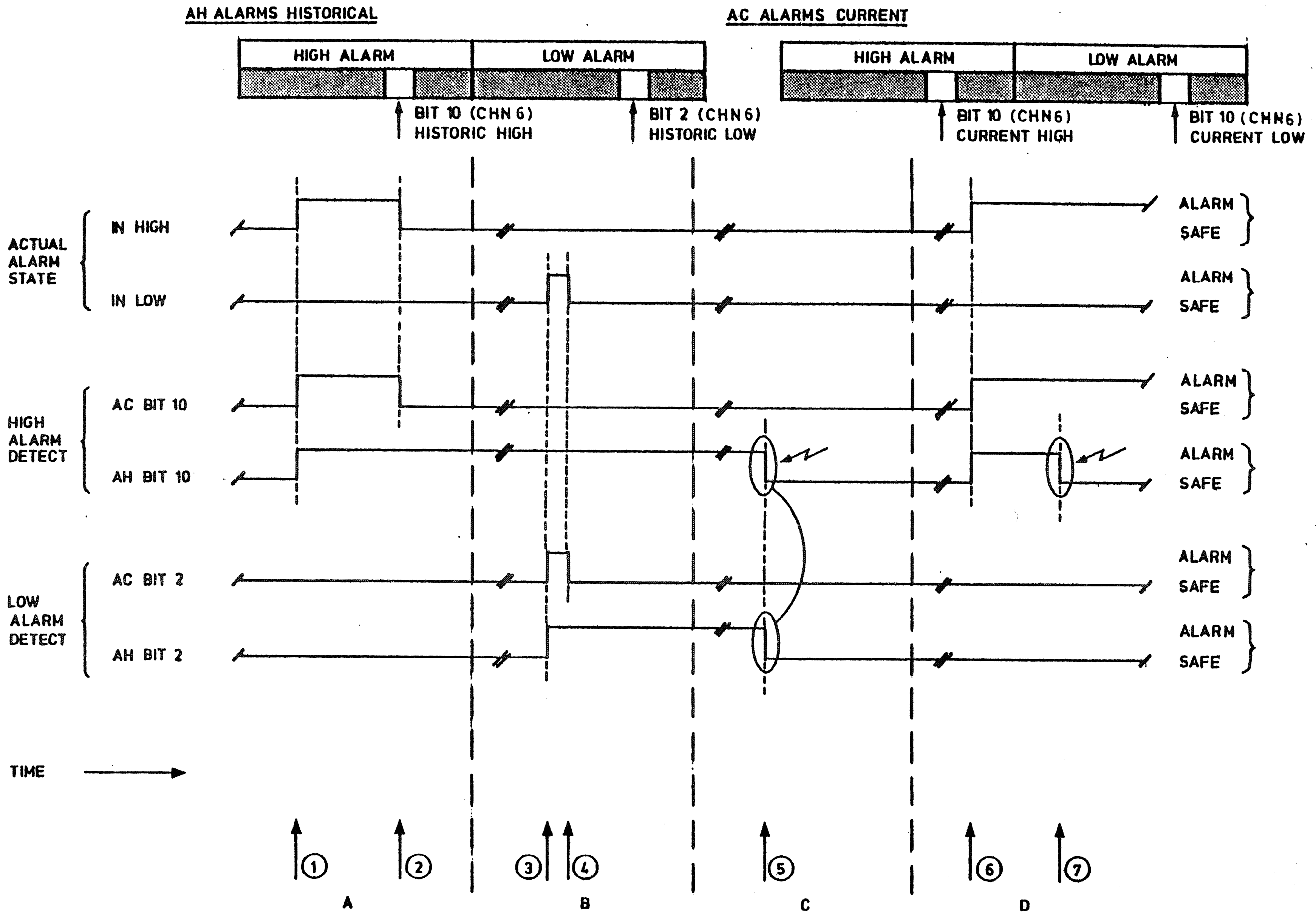


Fig. D.1 Relationship Between Flow Computer Current and Historic Alarms (AC and AH)

APPENDIX D Relationship Between 6436/7 Current and Historic Alarms (AC and AH)

A) Entry and Exit of High Alarm Conditions

(i) High alarm condition entered, AC indicates a current high alarm. AH records the occurence of an entry into high alarm.

(ii) High alarm condition disappears, AC indicates no current alarm, AH maintains a record that the alarm has occurred.

B) Fleeting Low Alarm Conditions

(i) AC indicates a low alarm for the duration of the alarm. AH records the occurrence of an entry into the low alarm state.

C) AH Cleared via the HHT or SSDL (no current alarms)

(i) Bits 2 and 10 of AH are set to zero via the HHT or SSDL, clearing the record of any previous entries into an alarm state.

D) AH Cleared via the HHT or SSDL (current high alarm)

(i) High alarm condition entered, AC indicates a current high alarm. AH records the occurence of an entry into the high alarm state.

(ii) Bit 10 of AH set to zero via HHT or SSDL, clearing the record of entry into an alarm state. The high alarm state still exists so AC still indicates a high alarm.

APPENDIX E

For the purpose of explanation the term 'fluid' is taken to include liquids and gases.

E.1 Orifice Plate Metering

E.1.1 Mass Flow Rate

The formula for calculating the mass flow rate, through an orifice meter, as specified in the International Standards document ISO 5167 is:-

$$Qm = a.E.\frac{Pi}{4}.d^2.\sqrt{2.r.Dp} \qquad Kg/s \qquad (1.1)$$

Where

Qm is the mass flow rate (in Kg/s).
a is the flow coefficient (dimensionless).
E is the expansibility factor (dimensionless).
Pi is the mathematical constant.
d is the diameter of the orifice at operating conditions (in metres).
r is the density of the metered substance at the up-stream pressure tapping (in Kg/m^3).
Dp is the differential pressure (in Pascal).

E.1.2 Volumetric Flow Rate

The volumetric flow rate, Qv, is related to the mass flow rate by:-

$$Qv = \frac{Qm}{r} \qquad m^3/s \qquad (1.2)$$

At a given temperature, TO, and pressure, PO, the density is ro and the volumetric flow rate is Qvo or Qo for short. Where Qo is related to the mass flow rate by:-

$$Qo = \frac{Qm}{r} \qquad m^3/s \qquad (1.2a)$$

E.1.3 Gas Density, Compressibility Factors

Definitions

The volumetric behaviour of a real gas departs from the ideal gas law because of molecular interactions and the finite size of the molecules. These departures are usually characterised by the Compressibility Factor, Z. It is defined as:-

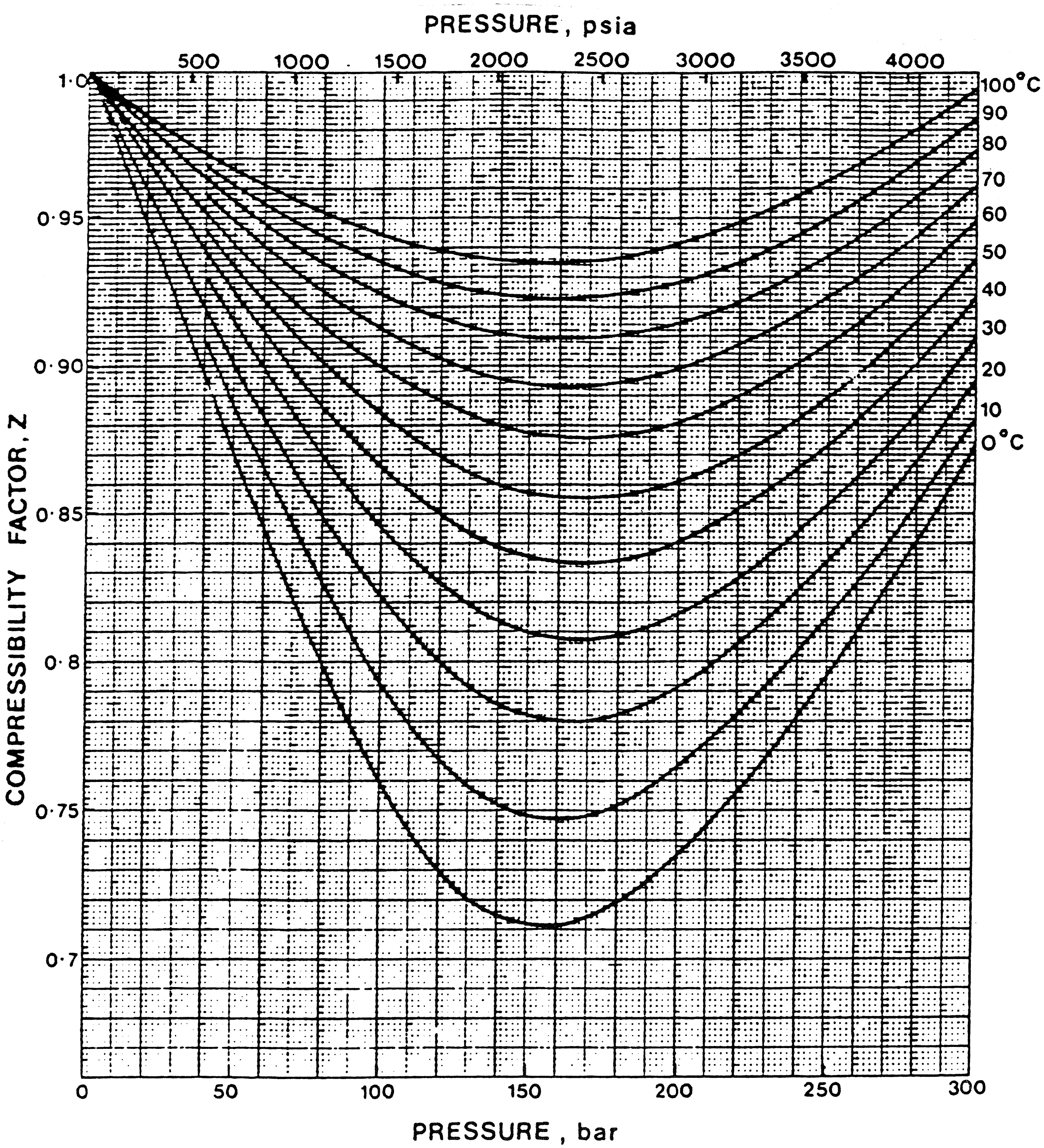


Fig E.1 COMPRESSIBILITY FACTORS OF MEAN BACTON GAS

$$Z = \frac{PV}{nRT} = \frac{PM}{nrRT} \qquad (1.3)$$

Where P = absolute pressure
T = absolute temperature
R = universal gas constant
n = number of gas moles
M = molecular weight
V = volume
r = density: mass per unit volume

The compressibility factor of an ideal gas is equal to 1.0 at all temperatures and pressures. The compressibility factor of a real gas approaches the limiting value of 1.0 as the pressure tends to zero, but at higher pressures it is not generally equal to 1.0: it is a function of pressure and temperature having the general form shown in Fig. E.1.

Other factors are sometimes used in gas metering: the Gas Deviation Co-efficient, K, is defined as:-

$$K = \frac{Z}{ZO} \qquad (1.4)$$

where ZO is the compressibility factor of the gas at standard conditions, which in the British Gas Industry (SI units) are defined as 1013.25m bar, 15°C, and dry. (These standard conditions differ from those given in the definition of K in BS 1042).

Simple Equations for the Calculation of Compressibility Factors

In the region of most interest (0°C to 40°C, up to 70 bar) the compressibility factor of 'Mean Bacton Gas' may be expressed as a simple function of pressure and temperature.

$$Z = 1 + bP + cP^2 \qquad (1.5)$$

where $b = (-264.3 + 3.5t - 0.03t^2)10^{-5}$

$c = (120 + 1.2t + 0.093t^2)10^{-8}$

P is the absolute pressure in bar, t is the temperature in °C. This equation is accurate to within 0.3%. It must not be used for pressures higher than 70 bar or for temperatures outside the range 0°C to 40°C.

E.1.4 Finding the Density

The density of the flowing gas, r, may be measured directly with an on-stream density meter. such devices are usually calibrated with pure Nitrogen or Methane. For a gas the density may be alternatively determined. Consider that the gas behaves as a theoretical perfect gas, then:-

$$PV = nRT \quad \text{(perfect gas law)}$$

For a real gas this becomes:-

$$PV = ZnRT \tag{1.6}$$

where Z is the compressibility factor at T and P.

Given that:-

$$n = \frac{m}{M} \tag{1.7}$$

and:-

$$r = \frac{m}{V} \tag{1.8}$$

where:-

m = Mass of the Gas
M = Molar weight of the Gas
r = Gas density

It can be shown that:-

$$r = \frac{M.P}{R.T}\cdot\frac{1}{Z} \quad \text{Kg/m}^3 \tag{1.9}$$

The density of a real gas at a reference temperature, TO, and reference pressure, PO, is ro where:-

$$ro = \frac{M}{R}\cdot\frac{PO}{TO}\cdot\frac{1}{ZO} \quad \text{Kg/m}^3 \tag{1.10}$$

We can obtain the following expression by dividing equation (1.9) by (1.10):-

$$r = ro.\ \frac{P}{T}\cdot\frac{TO}{PO}\cdot\frac{ZO}{Z} \quad \text{Kg/m}^3 \tag{1.11}$$

It is usual to express the density of a gas at reference conditions, ro, in terms the ratio of its density to that of air at the same conditions and this density ratio, represented as G, is called the relative density of the gas:-

Note: Specific gravity will always have the same value as relative density.

$$G = \frac{ro(gas)}{ro(air)} \qquad (1.12)$$

and using this in (1.11) gives:-

$$r = \frac{P}{T}.\frac{TO}{PO}.\frac{ZO}{Z}.G.ro(air) \qquad Kg/m^3 \qquad (1.13)$$

E.1.5 Referenced volumetric flow rate

In a typical metering installation the operating temperature and pressure will almost certainly be changing with time and this means that the fluid density will be varying. Under these circumstances, totalisation of volumetric flow rate can give only an approximate indication of the amount of fluid that has flowed through the line. Volumetric measurements are often more convenient (even a requirement) in some applications and the solution to this problem is to calculate (and totalise) a referenced volumetric flow rate. The referenced volumetric flow rate, Qvo or Qo for short, is the volumetric flow rate, with constant fluid density, ro, that corresponds to the actual mass flow rate Qm.

$$Qo = \frac{Qm}{ro} \qquad m^3/s \qquad (1.14)$$

Combining this with (1.1), Qo can be expressed as:-

$$Qo = \frac{1}{ro}.a.E.\frac{Pi}{4}.d^2.\sqrt{2.r.Dp} \qquad m^3/s \qquad (1.15)$$

Combining this with the expression for gas density, (1.13), gives:-

$$Qo = a.E.\frac{Pi}{4}.d^2\sqrt{2.Dp}\,.\sqrt{\frac{P.TO}{PO.T}.\frac{ZO}{Z}.\frac{1}{G.ro(air)}} \qquad m^3/s \qquad (1.16)$$

Equations (1.1), and (1.16) can be used in conjunction with any coherent system of units. For the SI units to be used in the British Gas Industry, the variables appearing in the equations will almost certainly be expressed as follows:-

Qm in Kg/hour	(Kg/s in ISO 5167)
Qo in m^3/hour	(m^3/sec in ISO 5167)
d in mm	(metres in ISO 5167)
Dp in mbar	(pascal in ISO 5167)
r in Kg/m^3	
P in Bar (absolute)	(pascal in ISO 5167)
T in K (°C + 273.2)	(°C in ISO 5167)

The reference conditions are metric standard conditions:-

PO = 1.01325 bar

TO = 288.2K (15 °C)

ro(air)= 1.2255 Kg/m^3 (dry air, 0.03% C02)

With the variables expressed in the preceding units, and base conditions as specified, equation (1.1) and can be re-written:-

$$Qm = a.E.\frac{pi}{4}.d^2.3,6.10^{-2}.\sqrt{2}.\sqrt{Dp.r} \qquad \text{Kg/hr} \qquad (1.17)$$

Temperature will usually be measured in degrees centigrade rather than in Kelvin, while pressure measurements will usually be gauge pressure (i.e. relative to atmospheric pressure) rather than absolute.

Temperature in Kelvin = 273.2 + Temperature in Centigrade

Pressure Absolute = Local atmospheric pressure + gauge pressure measurement

Equation 1.16 can be re-written as :-

$$Qo = a.E.\frac{Pi}{4}.d^2.3,6.10^{-5}.\sqrt{\frac{2}{ro(air)}}.\sqrt{Dp.\frac{(P+PA)}{PO}.\frac{TO}{(T+TA)}.\frac{1}{G}.\frac{XO}{ZF}} \qquad m^3/hr \quad (1.18)$$

where:-

TA is the temperature offset to absolute zero from measurement scale zero.
PA is the pressure offset to absolute zero from gauge pressure zero.
TA = 273.2 °K
PA = local atmospheric pressure (bar)
XO = compressibility factor at reference conditions
ZF = compressibility factor at T and P

E.2 Turbine Metering

Turbine Meter is the name given to a type of rotating flowmeter. It consists of a propeller, running on bearings, mounted within a pipe (of slightly greater diameter than the propeller) so that the propeller spins freely. The Turbine meter has the characteristic that the angular velocity of the propeller blades (spinning under pressure from the flowing fluid) is proportional to the volumetric flow rate of the metered fluid:-

$$v \propto Qv \qquad (2.1)$$

The propeller velocity is sensed using a pickup coil mounted in the pipe wall. Passage of each blade past the coil produces an electrical pulse. The pulse rate is proportional to the propeller velocity and therefore also to the volumetric flow rate:-

$$f \propto Qv \qquad (2.2)$$

$$f = k.Qv \qquad (2.3)$$

where:-

f is the pulse rate (Hz).
k is a constant of proportionality, known as the meter 'K-factor'.

As in the case of the Orifice meter, described earlier, the mass flow rate is related to the volumetric flow rate by:-

$$Qv = \frac{Qm}{r} \qquad m^3/s$$

The referenced volumetric flow rate Qo is related to the mass flow rate by:-

$$Qo = \frac{Qm}{ro} \qquad m^3/s$$

So combining these two equations:-

$$Qo = \frac{r}{ro}.Qv \qquad m^3/s \qquad (2.4)$$

In the case of a gas, using equation 1.11:-

$$Qo = \frac{P}{T}\cdot\frac{TO}{PO}\cdot\frac{ZO}{Z}\cdot Qv \qquad m^3/s \qquad (2.5)$$

which can be re-written as:-

$$Qo = \frac{(P+PA)}{(T+TA)}\cdot\frac{TO}{PO}\cdot\frac{ZO}{Z}\cdot Qv \qquad m^3/s \qquad (2.6)$$

E.3 Reference Conditions

There are a number of accepted sets of reference conditions some of which are shown here:-

Standard Temperature and Pressure (Metric Standard Conditions) : m^3(st)

Temperature = 15°C (288.15K)
Pressure = 1 atmosphere (1.01325 bar or 101,325 Pa)

Normal Temperature and Pressure : ft^3(NTP).m^3(NTP)

Temperature = 0°C (273.15K)
Pressure = 1 atmosphere (1.01325 bar or 101,325 Pa)

Imperial Standard Conditions : ft^3(ISC)

Temperature = 60°F (288.705K)
Pressure = 30in Hg (1.01374 bar or 101,374 Pa)

'International' Cubic Foot : ft^3(Int)

Temperature = 60°F (288.705K)
Pressure = 30in Hg (1.01592 bar or 101,592 Pa)

APPENDIX F

F.1 Introduction

The standard method of compensation for temperature and pressure on all types of flowmeter to date has been to use the perfect gas laws for gases and steam and a linear curve fit for liquids.

These corrections are only valid for small changes around the base conditions.

The method proposed in this note is to use the same correction method for all fluids - liquids, gases and steam, using 5 fixed values. All mass flow compensations consist of correcting for variations of the fluid density with temperature and pressure.

$$\text{Density Correction (DCT)} = \frac{\text{Actual Density}}{\text{Base Density}}$$

It is this Density Correction (DCT) which is used in the formula:-

$$DCT = \frac{1 + a_1(P - P_B) + a_2(P - P_B)^2}{1 + b_1(T - T_B) + b_2(T - T_B)^2}$$

For a given fluid and conditions, the values of a_1, a_2, b_1 and b_2 are calculated.

F.2 Basis of Method

F.2.1 Liquids

With the exception of water in the range 0 to 4°C, all liquid densities decrease with increasing temperature.

$$\text{Actual Density} = \text{Base Density} \times f\left(\frac{1}{T}\right)$$

$$\therefore\ DCT = f\left(\frac{1}{T}\right) = \frac{1}{1 + b_1(T - T_B) + b_2(T - T_B)^2}$$

where b_1, b_2 are constants for a given liquid, base temperature and temperature range.

F.2.2 Gases and Steam

The well known perfect gas law forms the basis for the correction:-

$$\text{Actual Density} = \text{Base Density} \times \frac{P}{P_B} \times \frac{T_B}{T}$$

where P and T are in absolute units.

To obtain the true density, the compressibility term must be applied:-

$$\text{DCT} = \frac{\text{Actual Density}}{\text{Base Density}} = \frac{P}{P_B} \times \frac{TB}{T} \times \frac{Z_B}{Z}$$

where $Z = f\left(\frac{P}{P_C}, \frac{T}{T_C}\right)$

This then requires a lot more effort but can be allowed for to some extent if the pressure and temperatures had second order terms.

Generally, density of gases and steam increase with pressure rise and decrease with temperature rise.

$$\therefore \text{DCT} = \frac{1 + a_1 (P - P_B) + a_2 (P - P_B)^2}{1 + b_1 (T - T_B) + b_2 (T - T_B)^2}$$

a_1, a_2 - fluid constants for given base condition and pressure range
b_1, b_2 - fluid constants for given base condition and temperature range

P = Actual pressure Bar
P_B = Base pressure Bar
} use same reference either gauge or absolute.

T = Actual temperature °C

T_B = Base temperature °C

F.3 Calculation of Constants

F.3.1 Liquids

For liquids, 3 temperature values and the corresponding 3 density values are required.

Temp.	Density	DBase/Density	Δ	Δ^2
Tmin	DTmin	Dbase/DTmin	$\Delta_1 = 1 - \text{Dbase/DTmin}$	
Tbase	Dbase	1		$\Delta_2 - \Delta_1$
Tmax	DTmax	Dbase/DTmax	$\Delta_2 = \text{Dbase/DTmax}^{-1}$	
			SUM $= \Delta_1 + \Delta_2$	

It is important that Tbase - Tmin = Tmax - Tbase = ΔT is the same on both sides of Tbase.

Our estimate assumes

$$\frac{\text{Dbase}}{\text{Density}} = \frac{1}{\text{DCT}} = 1 + b_1(T - T_B) + b_2(T - T_B)^2$$

Temperature	Dbase/Density	Δ	Δ^2
Tmin	$1 - b_1\Delta T + b_2\Delta T^2$		
$-\Delta T$		$b_1\Delta T - b_2\Delta T^2$	
Tbase	1		$2b_2\Delta T^2$
$+\Delta T$		$b_1\Delta T + b_2\Delta T^2$	
Tmax	$1 + b_1\Delta T + b_2\Delta T^2$		
		SUM $= 2b_1\Delta T$	

$$2b_1\Delta T = \Delta_1 = \Delta_2$$

$$2b_2\Delta T^2 = \Delta_2 - \Delta_1$$

$$b_1 = \frac{\Delta_1 + \Delta_2}{2\Delta T}$$

$$b_2 = \frac{\Delta_2 - \Delta_1}{2\Delta T^2}$$

F.3.2 Gases and Steam

For gases and steam 5 values of density are required.

1. Dbase at T = Tbase, P = Pbase
2. DTmin at T = Tmin , P = Pbase
3. DTmax at T = Tmax , P = Pbase
4. DPmin at P = Pmin , T = Tbase
5. DPmax at P = Pmax , T = Tbase

The method of calculation is as before with liquids for temperature variations.

$$DC = \frac{1 + a_1(P - P_B) + a_2(P - P_B)^2}{1 + b_1(T - T_B) + b_2(T - T_B)^2}$$

a) Temperature Compensations

With $P = P_B$ the top line reduces to liquid case:-

$$DCT = \frac{1}{1 + b_1(T - T_B) + b_2(T - T_B)^2}$$

$$\therefore \quad \frac{1}{DCT} = 1 + b_1(T - T_B) + b_2(T - T_B)^2$$

Calculate the following:-

Temp.	Density	DBase/Density	Δ	Δ^2
Tmin	DTmin	Dbase/DTmin		
$-\Delta T$			Δ_1 = 1 - Dbase/DTmin	
Tbase	Dbase	1		$\Delta_2 - \Delta_1$
$+\Delta T$				
Tmax	DTmax	Dbase/DTmax	Δ_2 = Dbase/DTmax - 1	
			SUM = $\Delta_1 + \Delta_2$	

From the results:-

$$2b_1\Delta T = SUM = \frac{\Delta_1 + \Delta_2}{\Delta T}$$

$$\therefore\ b_1 = \frac{\Delta_1 + \Delta_2}{2\Delta T}$$

b) Pressure Correction

With $T = T_B$ the bottom line reduces to unity.

$$\therefore\ DCT = 1 + a_1(P - P_B) + a_2(P - P_B)^2$$

Pres.	Density	DBase/Density	Δ	Δ^2
Pmin	DPmin	DPmin/Dbase		
$-\Delta P$			Δ_1 = 1 - DPmin/Dbase	
Pbase	Dbase	1		$\Delta_2 - \Delta_1$
$+\Delta P$			Δ_2 = DPmax/Dbase - 1	
Pmax	DPmax	DPmax/Dbase		
			SUM = $\Delta_1 + \Delta_2$	

Rewriting in the proposed form of:-

$$1 + a_1(P - P_B) + a_2(P - P_B)^2$$

Pressure	Density/Dbase	Δ	Δ^2
Pmin	$1 - a_1\Delta P + a_2\Delta P^2$		
$-\Delta P$		$a_1\Delta P - a_2\Delta P^2$	
Pbase	1		$2a_2\Delta P^2$
$+\Delta P$		$a_1\Delta P + a_2\Delta P^2$	
Pmax	$1 + a_1\Delta P + a_2\Delta P^2$		
		SUM = $2a_1\Delta P$	

$$\therefore\ 2a_1\Delta P = \Delta_1 + \Delta_2$$

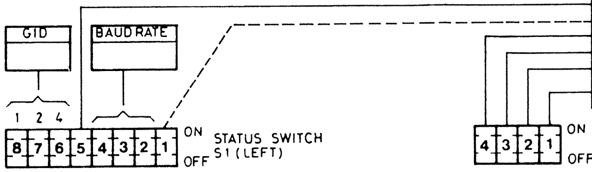
$$a_1 = \frac{\Delta_1 + \Delta_2}{2\Delta P}$$

$$2a_2\Delta P^2 = \Delta_2 - \Delta_1$$

$$a_2 = \frac{\Delta_2 - \Delta_1}{2\Delta P^2}$$

SERIAL COMMS

* DELETE AS APPLICABLE



MODE SELECTION

FUNCTION	OFF *	ON *
PROTOCOL MODE	ASCII	BINARY
TERMINAL BAUD RATE	300	SW SEL
SLOT 4 ENABLE (RFL/ALMPS)	DISABLE	ENABLE
SLOT 3 ENABLE (CMP 2)	DISABLE	ENABLE
SLOT 2 ENABLE (CMP 1)	DISABLE	ENABLE
U.I D SELECT	RANGE 0–7	RANGE 8–F

BOARD FUNCTION

BOARD CODE/TYPE		00 ANALOGUE I/P 11 PULSE I/P. *	00 ANALOGUE I/P * 1F BOARD NOT FITTED	00 ANALOGUE I/P * 1F BOARD NOT FITTED	08 ANALOGUE O/P 18 DIGITAL O/P * 1F BOARD NOT FITTED
CHANNEL	CHAN ACTIVE	SLOT 1 (FLOW/DIFF PRESS PULSE INPUTS)	SLOT 2 (PRESS/DENSITY INPUTS)	SLOT 3 (TEMPERATURE INPUTS)	SLOT 4 (RETR FLOW/ PULSE OP/ALM OP)
1					
2					
3					
4					
5					
6					
7					
8					

INSTRUMENT PARAMETERS

PARAMETER TYPE	PARAMETER FUNCTION	MNEMONIC	VALUE (4 CHARS)	UNITS
INPUT / OUTPUT BOARD STATUS	SLOT 1 BOARD TYPE & STATUS ACTIVE CHAN SEL	S1	- - - -	▨
	SLOT 2 BOARD TYPE & STATUS	S2	0 0 - -	▨
	SLOT 3 BOARD TYPE & STATUS	S3	0 0 - -	▨
	SLOT 4 BOARD TYPE & STATUS	S4	0 0 - -	▨
CHANNEL TYPE	CHANNEL TYPE: ALARM/PULSE O/P SELECTION	CT	- - - -	▨
ALARMS	CURRENT HI & LO ALARM STATUS	AC	▨	▨
	HISTORIC HI & LO ALARM STATUS	AH	▨	▨
	ALARM ACKNOWLEDGE	AA		▨
MONITOR ONLY	SWITCH BANK S1 – S2 SETTINGS	SW	▨	▨
	6437 OPERATING STATUS	MD	▨	▨

▨ = READ ONLY OR READ/WRITE

ISS	DATE	COMPILED	INSTRUMENT IDENTITY II	6437/1	FUNCTION
			SERIAL NO.		
		CHECKED	PROGRAM FILE REF		

TURNBULL CONTROL SYSTEMS LTD

6437 FLOW COMPUTER
SET-UP DATA SHEET

6437 CHANNEL PARAMETERS

PARAMETER TYPE	CHANNEL COMMAND PARAMETER FUNCTION	COMMAND MNEMONIC	CHANNEL 1 VALUE	CHANNEL 1 UNITS	CHANNEL 2 VALUE	CHANNEL 2 UNITS	CHANNEL 3 VALUE	CHANNEL 3 UNITS	CHANNEL 4 VALUE	CHANNEL 4 UNITS	CHANNEL 5 VALUE	CHANNEL 5 UNITS	CHANNEL 6 VALUE	CHANNEL 6 UNITS	CHANNEL 7 VALUE	CHANNEL 7 UNITS	CHANNEL 8 VALUE	CHANNEL 8 UNITS
STATUS WORDS	CHANNEL STATUS,FLOWRATE TIME UNITS SEL	ST		▨		▨		▨		▨		▨		▨		▨		▨
	FLOW PROCESSING	FP		▨		▨		▨		▨		▨		▨		▨		▨
	INPUT 1 SIGNAL PROCESSING	1P		▨		▨		▨		▨		▨		▨		▨		▨
	INPUT 2 SIGNAL PROCESSING	2P		▨		▨		▨		▨		▨		▨		▨		▨
	INPUT 3 SIGNAL PROCESSING	3P		▨		▨		▨		▨		▨		▨		▨		▨
CHANNEL RANGING	CALCULATED FLOW HIGH RANGE	HR																
	CALCULATED FLOW LOW RANGE	LR																
	INPUT 1 HIGH RANGE	1H																
	INPUT 1 LOW RANGE	1L																
	INPUT 2 HIGH RANGE	2H																
	INPUT 2 LOW RANGE	2L																
	INPUT 3 HIGH RANGE	3H																
	INPUT 3 LOW RANGE	3L																
●	FREQUENCY EQUIVALENT TO IH	HI		Hz		Hz		Hz		Hz		Hz		Hz		Hz		Hz
●	FREQUENCY EQUIVALENT TO IL	LI																
ALARM AND LIMIT SETTINGS	FLOW RATE HIGH ALARM	HA		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR
	FLOW RATE LOW ALARM	LA																
	LOW FLOW CUT OFF	**CF**		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR
	DEFAULT FLOW (TOTALISATION)	DF																
FLOW PARAMETERS	1V DEFAULT (FLOW CALCULATION)	1K		AS 1H,1L		AS 1H,1L		AS 1H,1L		AS 1H,1L		AS 1H,1L		AS 1H,1L		AS 1H,1L		AS 1H,1L
	2V DEFAULT (FLOW CALCULATION)	2K		AS 2H,2L		AS 2H,2L		AS 2H,2L		AS 2H,2L		AS 2H,2L		AS 2H,2L		AS 2H,2L		AS 2H,2L
	3V DEFAULT (FLOW CALCULATION)	3K		AS 3H,3L		AS 3H,3L		AS 3H,3L		AS 3H,3L		AS 3H,3L		AS 3H,3L		AS 3H,3L		AS 3H,3L
	RELATIVE DENSITY	SG		▨		▨		▨		▨		▨		▨		▨		▨
	BASE COMPRESSIBILITY	XO																
	DECIMAL POINT POSITION (TO, PO, TA, PA)	1D		▨		▨		▨		▨		▨		▨		▨		▨
	REFERENCE TEMPERATURE (ABS)	TO																
	REFERENCE PRESSURE (ABS)	PO																
	OFFSET TO ABSOLUTE TEMPERATURE	TA																
	OFFSET TO ABSOLUTE PRESSURE	PA																
	DECIMAL POINT POSITION (1C, 2C, 3C, 4C)	2D		▨		▨		▨		▨		▨		▨		▨		▨
	SCALING FACTOR	1C																
	SCALING FACTOR	2C																
	DENSITY CORRECTION CONSTANT	3C																
	DENSITY CORRECTION CONSTANT	4C																
	DECIMAL POINT POSITION (5C, 6C, 7C, 8C)	3D		▨		▨		▨		▨		▨		▨		▨		▨
	DENSITY CORRECTION CONSTANT	5C																
	DENSITY CORRECTION CONSTANT	6C																
	DENSITY CORRECTION CONSTANT	7C																
	DENSITY CORRECTION CONSTANT	8C																
PULSE TOTALISING SETTINGS	PULSE OUTPUT SCALING FACTOR	FS		▨		▨		▨		▨		▨		▨		▨		▨
	FLOW TOTAL SCALING FACTOR	FT																
CHANNEL NAME	CHANNEL TAG WORD CHAR 1 - 4	1T		ASCII		ASCII		ASCII		ASCII		ASCII		ASCII		ASCII		ASCII
	CHANNEL TAG WORD CHAR 5 - 8	2T																
	STORE CHANNEL PARAMETERS	SN		1		2		3		4		5		6		7		8
	COPY CHANNEL PARAMETERS	RN																
		PRIMARY DEVICE TYPE																
		CHANNEL FUNCTION																

● PULSE INPUT CARD DEPENDENT ONLY

PARAMETER TYPE	CHANNEL COMMAND PARAMETER FUNCTION	COMMAND MNEMONIC	CHANNEL 1		CHANNEL 2		CHANNEL 3		CHANNEL 4		CHANNEL 5		CHANNEL 6		CHANNEL 7		CHANNEL 8	
			VALUE	UNITS	VALUE	UNITS	VALUE	UNITS	VALUE	UNITS	VALUE	UNITS	VALUE	UNITS	VALUE	UNITS	VALUE	UNITS
STATUS WORDS	CHANNEL STATUS, FLOWRATE TIME UNITS SEL	ST		▨		▨		▨		▨		▨		▨		▨		▨
	FLOW PROCESSING	FP		▨		▨		▨		▨		▨		▨		▨		▨
	INPUT 1 SIGNAL PROCESSING	1P		▨		▨		▨		▨		▨		▨		▨		▨
CHANNEL RANGING	CALCULATED FLOW HIGH RANGE	HR																
	CALCULATED FLOW LOW RANGE	LR																
	INPUT 1 HIGH RANGE	1H																
	INPUT 1 LOW RANGE	1L																
ALARM AND LIMIT SETTINGS	● FREQUENCY EQUIVALENT TO 1H	HI		Hz		Hz		Hz		Hz		Hz		Hz		Hz		Hz
	● FREQUENCY EQUIVALENT TO 1L	LI																
	FLOW RATE HIGH ALARM	HA		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR
	FLOW RATE LOW ALARM	LA																
	LOW FLOW CUT OFF	**CF**		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR		AS HR,LR
	DEFAULT FLOW (TOTALISATION)	DF																
	1V DEFAULT (FLOW CALCULATION)	1K		AS 1H,1L		AS 1H,1L		AS 1H,1L		AS 1H,1L		AS 1H,1L		AS 1H,1L		AS 1H,1L		AS 1H,1L
FLOW PARAMETERS	DECIMAL POINT POSITION (1C,2C)	2D		▨		▨		▨		▨		▨		▨		▨		▨
	SCALING FACTOR	1C																
	SCALING FACTOR	2C																
PULSE TOTALISING SETTINGS	PULSE OUTPUT SCALING FACTOR	FS		▨		▨		▨		▨		▨		▨		▨		▨
	FLOW TOTAL SCALING FACTOR	FT																
CHANNEL NAME	CHANNEL TAG WORD CHAR 1-4	1T		ASCII		ASCII		ASCII		ASCII		ASCII		ASCII		ASCII		ASCII
	CHANNEL TAG WORD CHAR 5-8	2T																
	STORE CHANNEL PARAMETERS	SN		1		2		3		4		5		6		7		8
	COPY CHANNEL PARAMETERS	RN																
		PRIMARY DEVICE TYPE																
		CHANNEL FUNCTION																

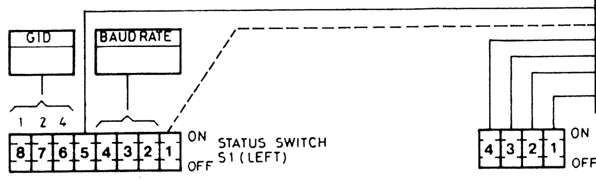
● PULSE INPUT CARD DEPENDENT ONLY

6436CHANNEL PARAMETERS

TCS

SERIAL COMMS

* DELETE AS APPLICABLE



MODE SELECTION

FUNCTION	OFF *	ON *
PROTOCOL MODE	ASCII	BINARY
SLOT 2 ENABLE (CMP 1)	DISABLE	ENABLE
U.I.D. SELECT	RANGE 0-7	RANGE 8-F

BOARD FUNCTION

BOARD CODE/TYPE		00 ANALOGUE I/P 11 PULSE I/P *			08 ANALOGUE O/P 18 DIGITAL O/P * 1F BOARD NOT FITTED
CHANNEL	CHAN ACTIVE	SLOT 1 (FLOW/DIFF PRESS PULSE INPUTS)			SLOT 4 (RETR FLOW/ PULSE OP/ALM OP)
1					
2					
3					
4					
5					
6					
7					
8					

INSTRUMENT PARAMETERS

PARAMETER TYPE	PARAMETER FUNCTION	MNEMONIC	VALUE (4 CHARS)	UNITS
INPUT / OUTPUT BOARD STATUS	SLOT 1 BOARD TYPE & STATUS ACTIVE CHAN SEL	S1	- - - -	▨
				▨
				▨
	SLOT 4 BOARD TYPE & STATUS	S4	0 0 - -	▨
CHANNEL TYPE	CHANNEL TYPE: ALARM/PULSE O/P SELECTION	CT	- . . -	▨
ALARMS	CURRENT HI & LO ALARM STATUS	AC	▨	▨
	HISTORIC HI & LO ALARM STATUS	AH	▨	▨
	ALARM ACKNOWLEDGE	AA		▨
MONITOR ONLY	SWITCH BANK S1—S2 SETTINGS	SW	▨	▨
	6436 OPERATING STATUS	MD	▨	▨

▨ = READ ONLY OR READ/WRITE

ISS	DATE	COMPILED	INSTRUMENT IDENTITY II 6436/1	FUNCTION
			SERIAL NO.	
		CHECKED	PROGRAM FILE REF	

TCS TURNBULL CONTROL SYSTEMS LTD

6436 FLOW MONITOR

SET-UP DATA SHEET

APPENDIX H.1 6436 Parameter Tables - Revision History

Software part No. RD 079017 issue 1, release 1

Table 4.2 lists the 2 character Instrument command parameters of the 6436 Flow Monitor used when accessing data via the 8260 Hand-held Terminal or the ASCII mode of the RS 422 serial link protocol (see Section 5 of the System 6000 Communications Handbook). The similarly accessed Channel command parameters are given in Tables 4.7a and 4.7b.

Table 5.2 gives the corresponding Parameter Numbers used with the Binary mode of the protocol (see Section 6 of the System 6000 Communications Handbook). Table 5.1 gives the corresponding Parameter Numbers for the ASCII protocol and the 8260 Hand-held Terminal when accessed in the same way.

The table below shows the modification history of the 6436 software with respect to changes in these parameter tables:-

SOFTWARE		DATE	MEMORY BOARD	PROMS		REMARKS
ISS.	REL			TYPE	NO	
1	1	01/09/86	Mk 6 (007)	27128	2	Initial release

APPENDIX H.2 6437 Parameter Tables - Revision History

Software part No. RD 079129 issue 1, release 1

Table 4.2 lists the 2 character Instrument command parameters of the 6437 Flow Computer used when accessing data via the 8260 Hand-held Terminal or the ASCII mode of the RS 422 serial link protocol (see Section 5 of the System 6000 Communications Handbook). The similarly accessed Channel command parameters are given in Tables 4.7a and 4.7b.

Table 5.2 gives the corresponding Parameter Numbers used with the Binary mode of the protocol (see Section 6 of the System 6000 Communications Handbook). Table 5.1 gives the corresponding Parameter Numbers for the ASCII protocol and the 8260 Hand-held Terminal when accessed in the same way.

The table below shows the modification history of the 6437 software with respect to changes in these parameter tables:-

SOFTWARE		DATE	MEMORY BOARD	PROMS		REMARKS
ISS.	REL			TYPE	NO	
1	1	01/09/86	Mk 6 (014)	27256 27128	1 1	Initial release

MANUAL		DATE	PAGE	AMENDMENT
ISS.	REV			
A		Oct 86		Initial release in Xerox form
1	A	Nov 86		Initial release in standard TCS technical manual format

ISS.	DATE	ISS.	DATE
1	18/11/86		

TECHNICAL MANUAL AMENDMENT RECORD SHEET

DRAWN : DMB
CHECKED : RWM.
APPROVED :

MANUAL TITLE : Eight Channel Flow Monitor and Flow Computer

PRODUCT CODE: 6436/37

TURNBULL CONTROL
SYSTEMS LTD.

DRAWING NO.
ZZ 076904C

SHT 1
OF 1 SHTS