COMMISSION OF THE EUROPEAN COMMUNITIES

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C A M A C

A modular instrumentation system for data handling

Revised description and specification

EUR 4100 EN, FR
3rd edition

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Joint Nuclear Research Centre

Esone Committee

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1. INTRODUCTION

Instrumentation for measurement and control purposes is often provided by modular units each of which performs an independent function. Equipment of varying degrees of complexity can be created by a combination of these relatively simple units.

The increasing demand for data processing has generated a need for a modular system that communicates efficiently and in a standardised manner with a digital controller or computer. At the same time the use of integrated circuit elements has reduced the volume required for individual units, and increased reliability makes it possible to envisage more complex assemblies.

Representatives of European nuclear laboratories, under the auspices of the ESONE Committee (Appendix 3), have therefore collaborated in the specification of a new modular system which incorporates a data highway as a basic feature and exploits the use of integrated circuits.

The system, known as CAMAC, is not restricted to nuclear instrumentation but is applicable to all forms of data processing that make use of a digital controller or computer.

The specification of the CAMAC system was first published in EUR 4100e (1969). Subsequent experience has shown the need for further standardisation in certain respects. This revised document EUR 4100e (1972) therefore includes a number of new requirements and recommendations. These have been specified in such a way that equipment conforming to this revised document can generally be used in association with older equipment, although under such conditions it may not be possible to derive the full benefit from new features.

2. INTERPRETATION OF THIS DOCUMENT

This document is the reference text describing and specifying the CAMAC system. Authorised translations are available in French, German and Italian.

Statements that specify mandatory aspects of the system are written in bold type, as here, and are usually accompanied by the word 'must'.

Statements that specify new mandatory aspects of the system, not included in the previous issue of this document, are written in bold type and indicated by vertical lines, as here.

The word 'should' indicates a recommended or preferred practice which is to be followed unless there are sound reasons to the contrary.

New recommendations and other significant changes are indicated by vertical lines, as here.

The word 'may' indicates a permitted practice, leaving freedom of choice to the designer.

In order to claim compatibility with the CAMAC Specification any equipment or system must comply with the mandatory requirements of either EUR 4100e (1969) or this revised specification. New designs must conform fully to this revised specification.

3. BASIC FEATURES OF THE CAMAC SYSTEM

This specification is intended to serve as a basis for a range of modular instrumentation capable of linking transducers and other devices with digital controllers or computers. It consists of mechanical standards and signal standards that are sufficient to ensure compatibility between units from different sources of design and production.

The basic features of CAMAC are summarised as follows:

(a) It is a modular system, with functional units which can be combined to form equipment assemblies.
(b) The functional units are constructed as 'plug-in units' and are mounted in a standard 'crate'.
(c) The mechanical structure is designed to exploit the high component packing density possible with integrated circuit packages and similar devices.
(d) Each plug-in unit makes direct connection to a standard 'Dataway'. This highway forms part of the crate and conveys digital data, control signals and power. The standards of the Dataway are independent of the type of plug-in unit or computer used.
(e) The system has been designed so that an assembly consisting of a crate and plug-in units can be connected to an on-line digital computer. However, the use of a computer is entirely optional and no part of this specification depends upon its presence in the system.
(f) External connections to plug-in units may conform to the digital or analogue signal standards of associated transducers, computers etc., or to the recommended standards given in this specification (for digital signals) and EUR 5100e (for analogue signals).
(g) Assemblies of up to seven CAMAC crates may be interconnected by the CAMAC Branch Highway specified in EUR 4600e.
(h) No licence or other permission is needed in order to use this specification.

4. MECHANICAL CHARACTERISTICS

CAMAC is a modular system. Equipment assemblies are formed by mounting appropriate *plug-in units* in a standard chassis or *crate*. Each plug-in unit occupies one or more mounting *stations* in the crate. At each station there is an 86-way connector socket giving access to the CAMAC *Dataway*, a data highway which forms part of the crate. The Dataway consists mainly of bus-lines for data, control and power.

Drawings for the manufacture of CAMAC compatible crates and plug-in units can be derived from the definitive dimensions given in Figures 1–3 for crates, Figure 4 for plug-in units, and Figure 5 for Dataway connector plugs and sockets.

Recommended dimensions for ventilated crates, NIM adaptors, and printed wiring cards for plug-in units are given in the non-mandatory Figures 6–8, respectively.

All dimensions in these Figures are in millimetres unless indicated otherwise.

4.1 The Crate

The crate mounts in a 19-inch rack and has up to 25 stations for plug-in units on a pitch of 17·2mm. Each station has upper and lower guides for the runners of a plug-in unit, an 86-way Dataway connector socket, and a tapped hole for the fixing screw of a plug-in unit. Modules conforming to the USAEC NIM specification (see Appendix 2) can be mounted in the crate on their basic pitch of 34·4mm (see Section 4.3).

Unless indicated otherwise, all crates must conform to Figures 1–3 and those parts of Figure 5 defining the connector socket.

Sections 4.1.1. and 4.1.2 are comments on these Figures.

4.1.1 Dimensions

Figure 1 shows the front view of a basic 25-station crate which occupies the minimum height of 5U (U = 44·45mm). Crates may have less than 25 stations, which, as indicated by Note 3 on Figure 1, need not be positioned symmetrically.

The lower cross-member has holes tapped ISO.M4 pitch 0·7 for the fixing screws of CAMAC plug-in units, and intermediate holes tapped UNC 6-32 for the lower fixing screws of NIM units. The upper cross-member may also have holes for the fixing screws of NIM units. The positions of these holes for CAMAC and NIM units, relative to the left-hand edge of the front aperture, are given in Figure 1 by the formulae for dimensions 'z' and 'w', respectively.

The positions of the centres of the guides, also relative to the left-hand edge of the aperture, are given by the formula for dimension 'x' in Figure 1. Detail A shows the entry into a guide. The dimensions of the 'lead-in' are not specified.

Detail B gives dimensions provisionally specified for 19-inch rack-mounting equipment by the International Electrotechnical Commission in their document IEC 45 (Central Office) 24.

Figure 2 is a plan view of the lower guides in the crate. In order to remove any heat generated in the plug-in units it is necessary to provide adequate ventilation through the bottom and top of the crate. The unobstructed area between adjacent guides, both at the top and bottom of the crate, is not permitted to be less than 15cm^2 and should preferably be distributed over the full depth of the crate from the front cross-members to the Dataway assembly. If crates such as that shown in Figure 1 (with height 5U) are mounted above or below other equipment (including other similar crates) it may be necessary to use intermediate deflectors, etc., to ensure adequate ventilation. Alternatively, the crate may be extended to include additional ventilation features, as described in Section 4.1.3.

Figure 3 is a sectioned side view on the offset line d-d in Figure 1, passing through the centre of an upper guide and a ventilating space between lower guides. The front faces of the upper and lower cross-members constitute the vertical datum of the crate. This datum is set back from the front face of the crate by a distance 'e', typically between 3 and 4mm, so that the front panels of plug-in units do not project beyond the front of the crate. The backs of the crate-mounting flanges are typically, but not necessarily, aligned with the datum.

The front ends of the upper and lower guides may be set back from the vertical datum. The guides extend sufficiently far towards the rear of the crate to ensure that the connector plug of a plug-in unit is guided into the entry of the connector socket.

The minimum overall depth of the crate provides mechanical protection for the Dataway assembly. The side panels are shorter than the frontal height of the crate (see dimensions 'a' in Figures 1, 3 and 6) to permit the use of typical runners for supporting the crate in the rack. This reduction in height extends at least to within 25mm of the rear face of the rack-mounting flanges of the crate.

The running-surface of the lower guide constitutes the crate horizontal datum. The Dataway assembly is not permitted to extend upwards more than 135mm from this horizontal datum, so that there is unrestricted access to the upper part of the rear of plug-in units.

The positions of the connector sockets are defined with respect to the three datum lines of the crate. The centre lines of the sockets are defined with respect to the left-hand edge of the front aperture by dimension 'y' in Figure 1. The vertical datum of the sockets is shown relative to the vertical datum of the crate in Figures 2 and 3, and the horizontal datum of the sockets relative to the horizontal datum of the crate in Figure 3.

4.1.2 Dataway Connector Sockets

The Dataway connector sockets have two rows of 43 contacts on a pitch of 0·1 inch (2·54mm). Mandatory and recommended dimensions of the sockets are given in Figure 5, together with additional 'commonly used' dimensions upon which the designs of many existing crates and Dataway assemblies have been based.

The vertical datum of the connector sockets is the nominal position of the leading edge of the connector plug of a plug-in unit fully inserted into the crate. The position of the vertical datum is defined in Figure 5.5 with respect to other functional features of the socket. In some commonly used sockets the plane of the mounting face coincides with the vertical datum of the connector socket, but this is not necessarily so.

The maximum forward projection of the connector socket in front of the vertical datum is shown in Figure 5.5. The shapes of the straight or curved chamfers that guide the connector plug into the socket are shown in Figures 5.6, 5.7 and 5.8. Within the minimum width shown for each chamfer the angle between any tangent to the chamfer and the line of entry of the connector plug does not exceed 60°.

If the front aperture of the crate extends to the inner surface of the right-hand side panel (as in Figures 1 and 2) the adjacent connector socket cannot exceed the recommended width of 12mm. Elsewhere, sockets up to the maximum width of 17·2mm can be used.

The dimensions of the contacts of the connector socket are shown in Figure 5.4. The position of each edge is defined by a dimension (d, D) relative to the horizontal datum of the socket, and is completely independent of the positions of all other edges on both rows of contacts.

Alternatively, a connector socket with point contacts may be used, in which case the distance between each point contact and the horizontal datum of the connector socket is $(2{\cdot}56 + 2{\cdot}54k) \pm 0{\cdot}13$.

4.1.3 Optional Features of the Crate

The height of the crate may be extended by an integral number of U units (U = 44·45mm), as in Figure 6, in order to provide an entry for cool air, which then flows up between the guides, and an exit for any warm air that may be rising from equipment below.

A crate may have fewer than 25 stations. The width of the front aperture is $17{\cdot}2s^{+0{\cdot}3}_{-0{\cdot}0}$mm for s stations, and formulae given in Figure 1 are used for locating the guides, connector socket, etc. at each station.

Power supply units may be mounted at the rear of a CAMAC crate. The overall depth of a crate with rear-mounted power supplies may be limited by the depth of the rack. A recommended maximum depth of 525mm is shown in Figure 3. A power supply unit is not allowed to extend upwards above the maximum height of the Dataway assembly. It should not obstruct the entry or exit of the ventilating air flows in a crate such as that shown in Figure 6. The width of a rear-mounted power supply is limited to 447mm.

4.2 Plug-in Units

Basically a plug-in unit consists of a front panel with fixing screw, top and bottom runners that slide in the guides of the crate, and an 86-way Dataway connector plug. The connector plug is typically an integral part of a printed-wiring card, but may be a separate male connector mounted at the rear of the plug-in unit. A plug-in unit may occupy more than one station and, if so, may have more than one set of runners and more than one connector plug.

Unless indicated otherwise, all plug-in units must conform to Figure 4 and those parts of Figure 5 defining the connector plug.

The following sections are comments on these Figures.

4.2.1 Dimensions

The horizontal datum of a plug-in unit is the edge of the lower runner. The vertical datum is the rear face of the front panel. The upper and lower parts of the rear face should be in contact with the cross-members of the crate when the plug-in unit is fully inserted. Figure 4 therefore requires that the upper and lower 11mm of the rear face of the front panel are free from projections, other than the fixing screws.

Figure 4 shows the dimensions of single-width and double-width plug-in units and gives general formulae for the front-panel widths of units.

It is recommended that the fixing screw should also provide a jacking action to assist in overcoming the insertion and withdrawal forces of the connector socket. The fixing screw of a single-width plug-in unit is located on the centre line of the front panel. If a multiple-width unit has only one fixing screw, and this has a jacking action, the screw should be positioned to give the most effective pull and thrust against the insertion and withdrawal forces of the Dataway connector or connectors (hence it should be at the same station as a single connector or approximately symmetrical with respect to two or more connectors).

Above the maximum height of the Dataway assembly there can be projections at the rear of the plug-in unit, extending more than 290mm from the vertical datum. Below this height, in order to provide clearance for the connector socket, only the connector plug is allowed to extend beyond 290mm.

There should be adequate ventilation through the bottom and top of each plug-in unit to remove any heat generated within the unit.

4.2.2 Dataway Connector Plug

The dimensions of the connector plug are shown in Figures 5.1, 5.2 and 5.3.

The full 86 contacts are always present and extend to the extreme edge of the plug, without a chamfer, in order to avoid the risk of damage to the contact plating of connector sockets by exposed abrasives in the substrate of the connector plug.

Chamfers are provided at the top and bottom of the connector socket and are therefore not needed at the top and bottom corners of the connector plug where the maximum permitted chamfer is 1 x 1mm. For at least 13mm from the edge of the plug the contacts are straight and plated.

The dimensions of the contacts of the connector plug are shown in Figure 5.3. The position of each edge is defined by a dimension (h, H) relative to the horizontal datum and is completely independent of the position of all other edges on both sides of the plug. The lowest contact on each side of the plug may be extended to the horizontal datum in order to reduce the impedance of the 0V line.

4.2.3 Insertion of the Plug-in Unit into the Crate

In the initial stages of insertion the plug-in unit is supported by the lower guide in the crate. The upper runner, although within the guide, has some vertical clearance. When the plug-in unit is fully inserted the connector plug is located by the connector socket and the front panel is supported by the securing screw. The top and bottom runners are then within the guides and approximately parallel to them, but both have some vertical clearance. The transition between these two states is described in detail below.

The dimensions of the guides and runners (Figures 1 and 4) ensure that the plug-in unit moves freely and is guided so that the leading edge of the connector plug enters the chamfers of the connector socket. The lower corner of the leading edge of the plug comes into contact with the chamfer at the bottom of the connector socket. Further insertion of the plug-in unit lifts the connector plug until its lower edge rests on the horizontal datum face of the connector socket. Even a connector plug with the maximum permitted 1 x 1mm chamfer will have been lifted into correct alignment before any electrical contact occurs between the connector plug and socket. The position of maximum insertion without electrical contact, even with a maximum thickness plug, is defined in Figure 5.5 with respect to the vertical datum of the connector socket.

Before this point has been reached it will have been possible to engage the fixing screw in the corresponding tapped hole in the lower cross-member of the crate. This can be facilitated by having a tapered end to the screw, so that the front panel is lifted into the correct alignment. The fixing screw has a jacking action which can be used to draw the plug-in unit further into the crate.

Further insertion of the plug-in unit brings the contacts of the plug and socket into engagement, and the insertion force of the connector is encountered. The recommended maximum insertion and withdrawal forces are 80 Newtons for each connector plug. Forces in excess of this can cause difficulty in inserting and withdrawing the plug-in unit and can also result in damage to front panels, etc.

Figure 5.5 defines, with respect to the vertical datum of the connector socket, the line beyond which there is reliable contact between corresponding contacts on the plug and socket, even with a plug of minimum thickness.

Finally, when the plug-in unit is fully inserted in the crate, the leading edge of the connector plug is nominally at the vertical datum of the connector socket and the lower datum face of the front panel of the plug-in unit is in contact with the lower cross-member of the crate. However, the forces due to the connector socket and jacking screw are not in line and tend to lift the connector plug off the horizontal datum of the socket, in which case there may be clearance between the upper datum face of the front panel and the upper cross member. Figure 5.5 ensures that there is adequate clearance beyond the extreme position of the connector plug, by defining a minimum distance between the vertical datum of the socket and any internal obstruction.

4.2.4 Printed-Wiring Card

Figure 8 gives recommended dimensions for a printed-wiring card suitable for use with typical (but not necessarily all) commercially available frameworks for plug-in units conforming to this specification.

4.2.5 Other Connectors

Connectors or other components such as switches may be mounted on the front panel, or at the rear of the plug-in unit above the maximum height limit of the Dataway assembly.

For coaxial connectors the LEMO 00C50 (50Ω impedance) connector or an equivalent type is strongly recommended.

There may, however, be special circumstances requiring the use of other connectors in order to suit a specific external equipment with which the plug-in unit is closely associated.

4.3 Adaptor for NIM Units

Plug-in units conforming to the USAEC NIM Specification (see Appendix 2) can be inserted into the guides of a CAMAC crate. In order to supply power to a NIM unit, which is shorter than a CAMAC plug-in unit, an adaptor is required between the Dataway connector socket and the connector on the NIM unit. The essential dimensions of such an adaptor are given in Figure 7.

4.4 The Dataway

Communication between plug-in units takes place through the Dataway. This passive multi-wire highway is incorporated in the crate and links the Dataway connector sockets at all stations. The Dataway consists of signal lines and power lines, as shown in Table I.

The extreme right-hand station, as viewed from the front of the crate, has the special rôle of *control station*. The data lines in the Dataway are accessible at the remaining *normal stations*, but not at the control station.

Most signal lines are *bus-lines* linking corresponding contacts of the Dataway connector sockets at all normal stations and, in some cases, the control station. There are also *individual lines*, each linking one contact at a normal station to one contact at the control station. At each station there are contacts for unspecified uses. Two of these contacts are linked across all normal stations to form *free bus-lines*. The remainder are available as *patch contacts*, but do not have specified Dataway wiring. The Dataway construction may extend these patch contacts, and others associated with the individual lines and certain bus-lines, to more readily accessible *patch points* to which patch connections can be attached.

The power lines link corresponding contacts of the Dataway connector sockets at all stations. The power return line (0V) links two contacts in parallel at all stations.

TABLE I STANDARD DATAWAY USAGE

TITLE	DESIGNATION	CONTACTS	USE AT A MODULE
Command			
Station Number	N	1	Selects the module (Individual line from control station).
Sub-Address	A1, 2, 4, 8	4	Selects a section of the module.
Function	F1, 2, 4, 8, 16	5	Defines the function to be performed in the module.
Timing			
Strobe 1	S1	1	Controls first phase of operation (Dataway signals must not change).
Strobe 2	S2	1	Controls second phase (Dataway signals may change).
Data			
Write	W1–W24	24	Bring information to the module.
Read	R1–R24	24	Take information from the module.
Status			
Look-at-Me	L	1	Indicates request for service (Individual line to control station).
Busy	B	1	Indicates that a Dataway operation is in progress.
Response	Q	1	Indicates status of feature selected by command.
Command Accepted	X	1	Indicates that module is able to perform action required by the command.
Common Controls			*Operate on all features connected to them, no command required.*
Initialise	Z	1	Sets module to a defined state. (Accompanied by S2 and B).
Inhibit	I	1	Disables features for duration of signal.
Clear	C	1	Clears registers. (Accompanied by S2 and B).
Non-Standard Connections			
Free bus-lines	P1, P2	2	For unspecified uses.
Patch contacts	P3–P5	3	For unspecified interconnections. No Dataway Lines.
Mandatory Power Lines			*The crate is wired for mandatory and additional lines.*
+24V d.c.	+24	1	
+6V d.c.	+6	1	
-6V d.c.	-6	1	
-24V d.c.	-24	1	
0V	0	2	Power return.
Additional Power Lines			*Lines are reserved for the following power supplies*
+200V d.c.	+200	1	Low current for indicators etc.
+12V d.c.	+12	1	
-12V d.c.	-12	1	
117V a.c. (Live)	ACL	1	
117V a.c. (Neutral)	ACN	1	
Clean Earth	E	1	Reference for circuits requiring clean earth.
Reserved	Y1, Y2	2	Reserved for future allocation.
TOTAL		86	

TABLE II CONTACT ALLOCATION AT A NORMAL STATION

(Viewed from front of crate)

Bus-line	Free Bus-line	P1	B	Busy	Bus-line
Bus-line	Free Bus-line	P2	F16	Function	Bus-line
Individual patch contact		P3	F8	Function	Bus-line
Individual patch contact		P4	F4	Function	Bus-line
Individual patch contact		P5	F2	Function	Bus-line
Bus-line	Command Accepted	X	F1	Function	Bus-line
Bus-line	Inhibit	I	A8	Sub-address	Bus-line
Bus-line	Clear	C	A4	Sub-address	Bus-line
Individual line	Station Number	N	A2	Sub-address	Bus-line
Individual line	Look-at-Me	L	A1	Sub-address	Bus-line
Bus-line	Strobe 1	S1	Z	Initialise	Bus-line
Bus-line	Strobe 2	S2	Q	Response	Bus-line
24 Write Bus-lines W1 = least significant bit W24 = most significant bit		W24	W23		
		W22	W21		
		W20	W19		
		W18	W17		
		W16	W15		
		W14	W13		
		W12	W11		
		W10	W9		
		W8	W7		
		W6	W5		
		W4	W3		
		W2	W1		
24 Read Bus-lines R1 = least significant bit R24 = most significant bit		R24	R23		
		R22	R21		
		R20	R19		
		R18	R17		
		R16	R15		
		R14	R13		
		R12	R11		
		R10	R9		
		R8	R7		
		R6	R5		
		R4	R3		
		R2	R1		
Power Bus-lines	-12V d.c.	-12	-24	-24V d.c.	Power Bus-lines
	+200V d.c.	+200	-6	-6V d.c.	
	117V a.c. Live	ACL	ACN	117V a.c. Neutral	
	Reserved	Y1	E	Clean Earth	
	+12V d.c.	+12	+24	+24V d.c.	
	Reserved	Y2	+6	+6V d.c.	
	0V (Power Return)	0	0	0V (Power Return)	

The assignment of contacts at the Dataway connector and their connections to bus-lines, individual lines and patch contacts must be as shown in Table II for normal stations and Table III for the control station. The control station must be to the right of all normal stations.

TABLE III CONTACT ALLOCATION AT THE CONTROL STATION

(Viewed from front of crate)

Individual patch contact		P1	B	Busy	Bus-line	
Individual patch contact		P2	F16	Function	Bus-line	
Individual patch contact		P3	F8	Function	Bus-line	
Individual patch contact		P4	F4	Function	Bus-line	
Individual patch contact		P5	F2	Function	Bus-line	
Bus-line	Command Accepted	X	F1	Function	Bus-line	
Bus-line	Inhibit	I	A8	Sub-address	Bus-line	
Bus-line	Clear	C	A4	Sub-address	Bus-line	
Individual patch contact		P6	A2	Sub-address	Bus-line	
Individual patch contact		P7	A1	Sub-address	Bus-line	
Bus-line	Strobe 1	S1	Z	Initialise	Bus-line	
Bus-line	Strobe 2	S2	Q	Response	Bus-line	
		L24	N24			
		L23	N23			
		L22	N22			
		L21	N21			
		L20	N20			
		L19	N19			
		L18	N18			
		L17	N17			
		L16	N16			
		L15	N15			
		L14	N14			
24 individual Look-at-Me lines		L13	N13	*24 individual Station Number lines*		
L1 from Station 1, etc.		L12	N12	N1 to Station 1, etc.		
		L11	N11			
		L10	N10			
		L9	N9			
		L8	N8			
		L7	N7			
		L6	N6			
		L5	N5			
		L4	N4			
		L3	N3			
		L2	N2			
		L1	N1			
	-12V d.c.	-12	-24	-24V d.c.		
	+200V d.c.	+200	-6	-6V d.c.		
Power	117V a.c. Live	ACL	ACN	117V a.c. Neutral		Power
Bus-lines	Reserved	Y1	E	Clean Earth		Bus-lines
	+12V d.c.	+12	+24	+24V d.c.		
	Reserved	Y2	+6	+6V d.c.		
	0V (Power Return)	0	0	0V (Power Return)		

The method of construction of the Dataway must be consistent with the signal standards for signal lines (see Section 7) and with the maximum current loads specified for the power lines (see Section 8).

Apart from this, the construction of the Dataway is not specified. Appropriate techniques include printed wiring on flexible or rigid substrates (with and without ground planes), and soldered or wrapped wiring. Particular attention should be given to the cross-coupling between signal lines, and to their capacitance to ground. Relatively high voltages are encountered on three power lines (+200V d.c., 117V a.c. live, and 117V a.c. neutral).

5. USE OF THE DATAWAY LINES

Each line of the Dataway must be used in accordance with the mandatory requirements detailed in the following sections and summarised in Table I.

A typical Dataway operation involves at least two plug-in units, one of which acts as a *controller* and the other as a controlled *module.* In this document the terms 'controller' and 'module' have the following specific meanings. 'Controller' refers to a unit occupying the control station and at least one normal station. 'Module' refers to a unit occupying one or more normal stations. Both receive signals from some Dataway lines and generate signals on others in accordance with the definitions given in Appendix 1. (In practice there can be special cases of units that combine some properties of a controller with some properties of a module).

There are two types of Dataway operations. During *command operations* the controller generates a command consisting of signals on individual *Station Number* lines to specify one or more modules, on the *Sub-address* bus-lines to specify a sub-section of the module, and on the *Function* bus-lines to specify the operation to be performed. During *unaddressed operations* there is no command, but the controller generates one of the *common control signals* on the *Initialise* or *Clear* bus-lines, and this operates on all modules connected to the bus-line. During command operations and unaddressed operations the controller generates a signal on the *Busy* bus-line. The Busy signal is available at all stations to indicate that a Dataway operation is in progress. Two timing signals, *Strobes S1 and S2,* are generated in sequence on separate bus-lines during command operations. Only Strobe S2 is mandatory during unaddressed operations, but S1 may also be generated.

During a Dataway command operation there may be a *read* data transfer from a module to the controller, or a *write* data transfer from the controller to a module, or neither.

In response to a read command the addressed module establishes Read data signals which are available to the controller from the time of Strobe S1 onwards. In response to a write command the addressed module accepts Write data signals from the controller at the time of Strobe S1.

The addressed module indicates by a signal on the *Command Accepted* bus-line whether it is able to perform the action required by the command. It may also transmit one bit of status information on the *Response* bus-line. The controller accepts the Command Accepted and Response signals at the time of Strobe S1.

Any module may generate a signal on its individual *Look-at-Me* line to indicate that it requires attention.

Three *common control* signals are available at all stations, without requiring addressing by a command, in order to *Initialise* all units (typically after switch-on), to *Clear* data registers, or to *Inhibit* features such as data taking.

The use of each Dataway line is defined in the following sections. The relationship between signals in order to generate specific commands is defined in Section 6, and the electrical signal standards, including timing, are defined in Section 7.

The sequence of events during command operations is described in Section 7.1.3.1 and shown in Figure 9. The sequence during unaddressed operations is described in Section 7.1.3.2 and shown in Figure 10.

5.1 Commands

The state of the signals on the individual Station Number lines (specifying a module or modules), the four Sub-address lines (specifying a sub-section of the module) and the five Function lines (specifying the type of operation) constitute a command.

The command signals are maintained for the full duration of the Dataway operation. They are accompanied by a signal on the Busy bus-line, which indicates to all units that a Dataway operation is in progress.

Plug-in units must not rely on the state of signals on the Sub-address and Function lines when no command operation is in progress.

5.1.1 Station Number (N)

Each normal station is addressed by a signal on an individual Station Number line (N_i) which comes from a separate contact at the control station (see Tables II and III). The stations are numbered in decimal from the left-hand end as viewed from the front, beginning with Station 1 (addressed by N1).

There is no restriction on the number of stations that can be addressed simultaneously.

5.1.2 Sub-address (A8, A4, A2, A1)

Different sections of a module are addressed by signals on the four A bus-lines. These signals are decoded in the module to select one of up to sixteen sub-addresses, numbered in decimal from A(0) to A(15).

The sub-address may be used to select, for example, a register within the module, or a feature that is to control the Response signal (Q), or a section of the module that is to be operated on by functions such as Enable, Disable, and Execute. The use made of the sub-address within a module is discussed in relation to the function codes in Section 6.

Each sub-address code used in a module must be fully decoded in the module. Full decoding means that all 4 Dataway Sub-address signals are used in the decoding process.

The sub-address codes are designated A(0), A(1), A(2), A(3) etc. to distinguish them from the individual Sub-address lines A1, A2, A4 and A8. For example, the Sub-address signals A1 = 1, A2 = 1, A4 = 0 and A8 = 0 represent the code A(3).

TABLE IV THE FUNCTION CODES

CODE F( )	FUNCTION	USE OF R AND W LINES	FUNCTION SIGNALS F16	F8	F4	F2	F1	CODE F( )
0	Read Group 1 Register	Functions using the R lines	0	0	0	0	0	0
1	Read Group 2 Register		0	0	0	0	1	1
2	Read and Clear Group 1 Register		0	0	0	1	0	2
3	Read Complement of Group 1 Register		0	0	0	1	1	3
4	Non-standard		0	0	1	0	0	4
5	Reserved		0	0	1	0	1	5
6	Non-standard		0	0	1	1	0	6
7	Reserved		0	0	1	1	1	7
8	Test Look-at-Me	Functions not using the R or W lines	0	1	0	0	0	8
9	Clear Group 1 Register		0	1	0	0	1	9
10	Clear Look-at-Me		0	1	0	1	0	10
11	Clear Group 2 Register		0	1	0	1	1	11
12	Non-standard		0	1	1	0	0	12
13	Reserved		0	1	1	0	1	13
14	Non-standard		0	1	1	1	0	14
15	Reserved		0	1	1	1	1	15
16	Overwrite Group 1 Register	Functions using the W lines	1	0	0	0	0	16
17	Overwrite Group 2 Register		1	0	0	0	1	17
18	Selective Set Group 1 Register		1	0	0	1	0	18
19	Selective Set Group 2 Register		1	0	0	1	1	19
20	Non-standard		1	0	1	0	0	20
21	Selective Clear Group 1 Register		1	0	1	0	1	21
22	Non-standard		1	0	1	1	0	22
23	Selective Clear Group 2 Register		1	0	1	1	1	23
24	Disable	Functions not using the R or W lines	1	1	0	0	0	24
25	Execute		1	1	0	0	1	25
26	Enable		1	1	0	1	0	26
27	Test Status		1	1	0	1	1	27
28	Non-standard		1	1	1	0	0	28
29	Reserved		1	1	1	0	1	29
30	Non-standard		1	1	1	1	0	30
31	Reserved		1	1	1	1	1	31

5.1.3 Function (F16, F8, F4, F2, F1)

The function to be performed at the specified sub-address in the selected module or modules is defined by the signals on the five F bus-lines. These signals are decoded in the module to select one of up to 32 functions, numbered in decimal from F(0) to F(31). The definitions of the 32 function codes are summarised in Table IV and are detailed in Section 6 in relation to the command structure.

In some systems the controller partially decodes the Function signals in order to determine whether a data transfer is required to a module (writing) or from a module (reading). Multiple station addressing allows operations with the same function code to be performed simultaneously in more than one module. These features depend on some standardisation in the assignment of function codes.

The function codes are sub-divided into three groups, involving read operations, write operations, and operations with no transfer of data. The *standard* function codes have defined actions in modules and controllers. There are also *reserved* codes, for any future additions to the standard codes, and *non-standard* codes whose use is neither defined in detail nor co-ordinated by the ESONE Committee.

Each function code used in a module must be fully decoded in the module. Full decoding means that all 5 Dataway Function signals are used in the decoding process.

The function codes are designated F(0), F(1), F(2), F(3) etc. to distinguish them from the individual function lines F1, F2 etc. For example, the Function signals F1 = 1, F2 = 0, F4 = 0, F8 = 1 and F16 = 1 represent the code F(25).

5.2 Strobe Signals (S1 and S2)

During each command operation the controller generates two Strobe signals S1 and S2 in sequence on separate bus-lines. In response to these timing signals plug-in units initiate various actions appropriate to the command that is present on the Dataway.

Both Strobe signals must be generated during each command operation.

Plug-in units must not take irreversible action based on the command or data signals until the time of S1. Actions concerned with the acceptance of data and status information from the R, W, Q and X lines must be initiated at the time of S1 (with the possible exception given below). Other actions may also be timed by S1, but must not change the state of signals on the R and W lines.

Any actions that can change the state of Dataway Read or Write signals must be initiated by the second strobe S2. For example, S2 must be used if it is required to clear a register whose output is connected to the Dataway.

Modules normally accept write data in response to S1, because the data signals are permitted to change at the time of S2. However, modules may accept write data in response to S2 under special circumstances, but this is not recommended.

During unaddressed Dataway operations the controller generates Strobe S2 to indicate when modules accept the common control signal. Strobe S1 may also be generated, but this is not mandatory and modules cannot rely on it.

Strobe S2 must be generated during each unaddressed operation.

5.3 Data

All information carried by the Read and Write lines is conveniently described as *data*, although it may be information concerned with status or control features in modules. Information that is transferred to or from a control register in a module is thus regarded as data.

Up to 24 bits may be transferred in parallel between the controller and the selected module. Independent lines are provided for the read and write directions of transfer.

If the bits of a data word have different numerical significance, line R_n should be used for a higher-order bit than R_{n-1}, and W_n for a higher-order bit than W_{n-1}.

It is recommended that controllers have 24-bit capability. For particular applications assemblies are permitted in which the controller has a word length less than 24 bits and the modules have an equal or smaller word length.

Plug-in units must not rely on the state of signals on the Read and Write bus-lines when no command operation is in progress.

5.3.1 Write Lines (W1—W24)

The controller generates data signals on the W bus-lines during each write operation. The W signals must reach a steady state before S1 and must be maintained until the end of the operation, unless modified by S2. Strobe S1 must be used by the modules to strobe the data unless there are very strong technical reasons for choosing S2 (see Section 5.2).

The W lines serve a few data sources (typically only one controller) and many data receivers.

5.3.2 Read Lines (R1—R24)

Data signals are set up on the R bus-lines by the module during a read operation. The R signals must reach a steady state before S1 and must be maintained for the full duration of the Dataway operation, unless the state of the data source is changed by S2. The controller must initiate action concerned with the acceptance of data from the R lines at the time of the Strobe S1 and must not take irreversible action before this.

The R lines serve a few data receivers (typically only one controller) and many data sources.

5.4 Status Information

Status information is conveyed by signals on the Look-at-Me (L), Busy (B), Response (Q) and Command Accepted (X) lines.

5.4.1 Look-at-Me (L)

The Look-at-Me lines, like the N lines, are individual connections from each normal station to separate contacts at the control station (L1 from station 1, etc.)

Any module may generate a signal on its individual line (L_i) to indicate that it requires attention. Modules that occupy more than one station may indicate different demands by signals on the appropriate L lines.

The L signal generated by a module may represent demands for attention originating from more than one Look-at-Me source (*LAM source*) in the module. A LAM structure by which various demands can be selected and grouped to form the L signal is shown in Figure 11 and described below. All modules that generate L have the mandatory features shown in Figure 11 and may incorporate additional features for more complex demand handling.

Individual bits of the *LAM status register* are set by the corresponding LAM sources, and are cleared by appropriate commands and by the initialise signal. The outputs *(LAM status)* may be examined collectively by reading the state of all outputs (Read Group 2 at A(12)), or individually by the command Test Status with the appropriate sub-address A(i). Each LAM status should be individually enabled and disabled (for example by a *LAM mask*) to form the corresponding *LAM request*. The LAM requests are examined collectively by reading the state of all LAM requests (Read Group 2 at A(14)), or individually by the command Test LAM with the appropriate sub-address A(i). The internal Look-at-Me signal *(L signal)*, derived from the OR-combination of the LAM requests, is tested by the command Test LAM, with sub-address A(k) distinguishing this from tests of individual LAM requests. Finally, the output of this signal as the *Dataway L signal* is inhibited while the module is addressed by N, possibly in conjunction with certain F and A codes or groups of codes. (See Section 5.4.1.3).

5.4.1.1 Look-at-Me: Clear, Disable and Test

Provision must be made for resetting each bit of the LAM status register individually, either by a Clear Look-at-Me operation F(10) (see Section 6.2.3), or by a Selective Clear Group 2 operation F(23) (see Sections 5.4.1.2 & 6.3.6). All LAM status bits must be reset collectively by the Initialise signal (see Section 5.5.1).

If the LAM request calls for some specific action (for example, reading the contents of a data register) then the corresponding bit of the LAM status register should also be cleared when the appropriate Dataway operation is performed.

A module that has generated L = 1 must not clear the LAM status register until it receives an appropriate command or the Initialise signal.

Each module that generates L should have a means of enabling and disabling the LAM requests. This may be done by loading and clearing a mask register, or by Enable and Disable commands.

All LAM requests that can be disabled by commands must also be disabled by the Initialise signal (Z).

A module that generates L must have a means of testing the L signal by a Test Look-at-Me operation (Function code F(8), with a sub-address distinguishing this from tests of individual LAM requests). If there are several LAM sources the corresponding LAM requests must also be capable of being examined either by Test Look-at-Me operations associated with appropriate sub-addresses or by reading a LAM request pattern in a read operation.

5.4.1.2 Look-at-Me: Commands for Access

Modules may contain registers for LAM information. These registers are not mandatory but if included they should be accessed as Group 2 registers at the following sub-addresses:

LAM Status Register	A(12)
LAM Mask Register	A(13)
LAM Request Register	A(14)

Corresponding bit-positions should be associated with the same LAM source.

The state of each data-bit read from the LAM status or LAM request register is the same as the state of the Q response that would be obtained by a Test Status or Test Look-at-Me operation.

The data word read from A(12) should have LAM status information in the low-order bits and may also contain other status information. Each bit of the data word loaded into A(13) should be in the '1' state to enable the corresponding LAM request, and in the '0' state to disable it.

The operations used to access LAM information may be divided into two classes. One class consists of Read F(1), Write F(17), Clear F(11), Selective Set F(19) & Selective Clear F(23) addressed to the Group 2 LAM registers described above. This class is preferred for operations on modules with many LAM sources. The other class consists of Clear LAM F(10), Enable F(26), Disable F(24), Test Status F(27) and Test LAM F(8) addressed to specific demands. This class is preferred for modules with few LAM sources. In the one class a LAM source, LAM (i), is associated with bit position (i) in data words, and in the other class with sub-address A(i). For ease of programming it is recommended that all the operations related to a particular LAM source should belong to only one class.

5.4.1.3 Look-at-Me: Gating

When a module that is generating $L_i = 1$ receives a command that will cause it to cease doing so, it must inhibit the L signal or the appropriate LAM request. The inhibit condition must be effective before Strobe S1 and must be maintained until the end of the Dataway operation.

This requirement may be met very simply by inhibiting the L signal output when a module is addressed by any command ($L_i = 0$ when $N_i = 1$). Unaddressed modules can thus initiate $L_i = 1$ at any time, but addressed modules cannot do so until the end of the current Dataway operation.

The requirements may be met more precisely by inhibiting only those LAM status signals that are cancelled by the current command. The ability to initiate $L_i = 1$ during a Dataway operation is thus extended to all LAM requests that are not being cancelled. This requires the recognition of $N_i = 1$ with the specific functions and sub-addresses, and the generation of appropriate inhibit conditions.

The requirement may be interpreted in ways intermediate between these extremes. For example, the ability to initiate $L_i = 1$ can be extended to all LAM requests during most Dataway operations if the L signal output is inhibited when the module is addressed by $N_i = 1$ together with appropriate, easily identifiable groups of functions and sub-addresses.

The mandatory statement above replaces the previous requirement in EUR 4100e (1969) that all modules gate off their L signal output during every operation ($L_i = 0$ when $B = 1$). It allows L signals to be initiated at any time, maintained continuously, and removed in advance of Strobes S1 and S2. This counteracts delays elsewhere in systems and leads to improved performance in handling demands for attention.

Units conforming to this specification and to the earlier specification can generally be used together in systems where the improved performance is not required.

5.4.2 Busy (B)

The Busy signal is used to interlock various aspects of a system that can compete for the use of the Dataway. The signal $B = 1$ indicates to all units that a Dataway operation is in progress.

The Busy signal $B = 1$ must be generated during each Dataway command operation (when N signals are also generated) and during unaddressed operations (when Z or C are generated).

5.4.3 Response (Q)

During every command operation the addressed module may generate a signal on the Q bus-line to indicate the status of any selected feature of the module.

The controller must initiate action concerned with the acceptance of the status information from the Q line at the time of Strobe S1 and must not take irreversible action before this.

In read and write operations (see Sections 6.1 and 6.3) addressed modules must establish the signal $Q = 0$ or $Q = 1$ before Strobe S1 and must maintain it until at least Strobe S2.

In Test Look-at-Me operations (see Section 6.2.1) addressed modules may initiate the Q signal at any time during a Dataway operation if the status of the appropriate LAM request changes. If Q = 1 has been initiated it will remain static until the end of the operation since this command is not allowed to reset LAM status.

In all operations other than read, write, and Test Look-at-Me the Q signal is permitted to change at any time. There is a risk that status information will be missed if Q = 1 is initiated between Strobes S1 and S2 during an operation in which the module resets the status condition at the time of Strobe S2.

In any operation the Q signal conveys only one bit of information, which should be clearly defined for each sub-address and function code used by the module.

Examples of the use of the Q signal during read and write operations are given in Sections 5.4.3.1, 5.4.3.2 and 5.4.3.3, which define three methods of transferring blocks of data. These three methods are summarised in the following table. However, the status information transmitted by the addressed module during read and write operations is not restricted to these examples.

RESPONSE	Q MODE		
	Address Scan	Repeat	Stop
Q = 1	Register present	Register ready	Within block
Q = 0	Register absent	Register not ready	End of block

5.4.3.1 Use of Q for Block Transfers: Address Scan Mode

If a module contains registers that are intended to be accessed sequentially in Address Scan mode they must be located at consecutive sub-addresses starting at A(0). During read and write operations the module must generate Q = 1 at all sub-addresses at which these registers are present and Q = 0 at the first unoccupied sub-address, if any. A module with n such registers must therefore generate Q = 1 at A(0) to A(n–1). If n <16 the module must generate Q = 0 at A(n).

The Address Scan mode of block transfer is used for data transfers to or from an array of modules that do not necessarily occupy consecutive stations or all sub-addresses. The state of Q during each operation is used by the controller to determine the station number and sub-address for the next operation. When Q = 1, the sub-address is incremented, with carry-over into the station number. When Q = 0, the sub-address is set to A(0) and the station number is incremented. This allows unoccupied stations within an array.

The block transfer may be terminated by the controller on reaching a specified word count (recommended) or address.

5.4.3.2 Use of Q for Block Transfers: Repeat Mode

If a module contains a register that is intended to be accessed in Repeat mode it must generate Q = 1 during a read or write operation if the register is ready to participate in a data transfer. It must generate Q = 0 during a read or write operation if the register is not ready to participate in a data transfer.

The Repeat mode of block transfer is used when data transfers to or from one register have to be related to the state of readiness of the register or of associated external equipment. The response Q = 0 indicates that the same operation should be repeated until the register becomes ready (Q = 1). The operation may be repeated continuously if the module samples the state of readiness in a way that tolerates the B and N signals being maintained continuously. There is a risk that a system will lock up if an operation is repeated indefinitely while waiting for Q = 1.

5.4.3.3 Use of Q for Block Transfers: Stop Mode

If a module contains a register that is intended to be accessed in Stop mode it must generate Q = 1 during each read or write operation while the block of data is being transferred and must generate Q = 0 during any further operations after the end-of-block condition has been encountered.

The Stop mode of block transfer is used when data transfers to or from one register have to be terminated by an end-of-block indication from the module. A block of data transfers accompanied by Q = 1 is followed by at least one further operation accompanied by Q = 0 to indicate end-of-block.

5.4.4 Command Accepted (X)

Whenever a module is addressed during a command operation it must generate X = 1 on the Command Accepted bus-line if it recognises the command as one that it is equipped to perform, either within the module or in association with external equipment. The signal on the X line must reach a steady state before S1 and must be maintained until S2. Controllers that accept the X signal must do so at the time of S1.

The signal X = 0 should indicate a serious malfunction, for example a module that is not present, not powered, lacks external connections or is not equipped to perform the required action. The action taken by the controller in response to X = 0 may, for example, be to call for intervention by the operator or operating system.

Modules designed according to EUR 4100e (1969), in which the X line was reserved for future allocation, can be adapted for use in systems that depend on X = 1 by generating $X = N_i$.

5.5 Common Controls (Z, C, I)

During unaddressed Dataway operations either Initialise (Z) or Clear (C) is generated by the controller and received by each unit connected to the appropriate bus-line.

The common control signal Inhibit (I) is not associated with Dataway operations. It may be generated at any time and is received by each unit connected to the I bus-line.

The Initialise (Z) and Clear (C) signals must be accompanied by Busy (B) and Strobe S2 signals, in a timing sequence as described in Section 7.1.3.2 and shown in Figure 10. The sequence is permitted to include Strobe S1, but units must not rely on the generation of S1 with Z or C.

5.5.1 Initialise (Z)

The Initialise signal is intended to be used during system start-up.

Initialise must have absolute priority over other signals. In response to Z = 1 all data and control registers must be set to a defined initial state, all LAM status registers must be reset and, if possible, all LAM requests must be disabled.

Units that generate Z must also initiate a sequence including Busy, Strobe S2 and Inhibit (see Section 5.5.2).

Units that accept Z must gate it with Strobe S2 as a protection against spurious signals on the Z line.

5.5.2 Inhibit (I)

The signal I = 1 must inhibit any feature to which it is connected in a module.

The designer is free to choose which activities (for example, data taking) within a module are inhibited by this signal. The signal may be gated or routed within the module, for example as a result of a previous command or by patch wiring.

When any unit generates the Initialise signal Z = 1 it must also generate I = 1. The Inhibit signal accompanying Z must be established by time t_1 (see Figure 10) and must be maintained for at least the duration of the Z signal. All units that generate I and can maintain I = 1 must respond to Z.S2 by generating and maintaining I = 1 until specifically reset.

5.5.3 Clear (C)

The signal C = 1 must clear all registers and bistables to which it is connected.

Units that generate C must also initiate a sequence including Busy and Strobe S2.

Units that accept C must gate it with Strobe S2 as a protection against spurious signals on the C line.

The designer is free to choose which registers and bistables are cleared in response to C.S2. The signal may be gated or routed within the module, for example as a result of a previous command or by patch wiring.

5.6 Non-standard Connections (P1–P7)

Five contacts (P1–P5) on the Dataway connector at each normal station, and seven contacts (P1–P7) at the control station, are available for unspecified uses.

5.6.1 Free Bus-lines (P1, P2)

The contacts P1 and P2 at all normal stations must be linked by two Free bus-lines.

Each plug-in unit is permitted to generate signals on either or both of these lines, or to accept signals from them. Within the plug-in unit there must be means by which any access to these lines can be disconnected or disabled.

Signals on the Free bus-lines must either conform to Section 7.1.4 and Table VII (with distributed pull-ups and freedom to vary the number of inputs and outputs) or to Section 7.1.2 and Table VI (with one pull-up on each line, not necessarily in the controller, and with current standards as for Read or Write lines).

No standard uses are defined for the Free bus-lines. Conflicts between various uses can be resolved by making appropriate disconnections within units (for example by wired or plug-in links).

In EUR 4100e (1969) the contacts P1 and P2 at normal stations were defined as individual patch points. Some older units may have used these contacts in ways inconsistent with the bussed connections required by this revised specification.

5.6.2 Patch Contacts (P3–P7)

Contacts P3–P5 at each normal station and P1–P7 at the control station are not wired to Dataway lines. They are available for patch connections to other of these contacts, to optional patch points on certain Dataway lines, to the 0V line, or to external equipment.

Patch connections must not be essential for the operation of the main features of general-purpose units.

The signals on patch connections must conform to Section 7.1.4 and Tables V and VII.

The patch contacts on the Dataway connector socket may either be directly accessible for making patch connections or may be wired to separate patch points. An earthed patch point, or access to the 0V line, should be provided at each station. Patch connections may also be made to the I, C, N, and L lines at each station, but the permitted loadings on these lines (See Table VI) restrict the number of such additional connections.

5.7 Power Lines

The Dataway must include lines for all the mandatory, additional and reserved power supplies shown in Table I.

Two Reserved power lines (Y1, Y2) must not be used until they have been fully defined by the ESONE Committee, for example to meet the needs of any new circuit technology for which the existing supply voltages are unsuitable.

Details of the voltage tolerances and permitted loadings of the power lines are given in Section 8.

6. DATAWAY COMMANDS

A command consists of signals on the Station Number lines, the Sub-address lines and the Function lines. During each command operation the crate controller generates the appropriate command, accompanied by the Busy signal (B = 1) and by the two Strobes S1 and S2. Data may be transferred on the Read or Write lines in response to the command. Modules generate the Command Accepted signal (X = 1) when they recognise the command (see Section 5.4.4). Modules may also transfer one bit of status information on the Response line (see Section 5.4.3).

The following sections define the mandatory actions by modules and controllers in response to each command, including mandatory transfers of data and status information via the Dataway. The term 'register' is used here, and in the summary of the Function codes in Table IV, to indicate an addressable data source or receiver, without necessarily implying that it has a data storage property.

During a Dataway command operation modules and controllers must perform the actions specified for the particular command. They may also perform additional internal actions, but these must not involve transferring to or from the Dataway any data or status information other than that specified for the command. Additional internal actions must not convert one standard command into another standard command.

The function codes F(0) to F(3), F(9), F(11), F(16) to F(19), F(21) & F(23) allow the registers in a module to be divided into two distinct sets, known as Group 1 and Group 2, so that it is possible to operate on two sets of 16 registers. Within each group the appropriate register is selected by the sub-address. Information concerning status or system organisation, or requiring restricted access, should be held in Group 2 registers (for example see Section 5.4.1.2).

If a module allows a descriptor (module characteristic) to be read, the command used should be Read Group 2 Register, F(1).A(15).

6.1 Read Commands: Function Codes F(0) to F(7)

Read commands are identified by the combination F16 = 0 and F8 = 0 in the function code. All read commands involve the transfer of data and status information from a module to the controller via the Read, Q and X lines (see mandatory statements in Sections 5.3.2, 5.4.3 and 5.4.4).

Recommendations for the use of the Q signal in read operations are given in Section 5.4.3.

6.1.1 Read Group 1 Register, Code F(0)

This command transfers to the controller the contents of a register in the first group in the module. The contents of the register are not changed.

The required register within the group is selected by the sub-address.

6.1.2 Read Group 2 Register, Code F(1)

This command transfers to the controller the contents of a register in the second group in the module. The contents of the register are not changed.

The required register within the group is selected by the sub-address.

6.1.3 Read and Clear Group 1 Register, Code F(2)

This command transfers to the controller the contents of a register in the first group in the module. The contents of the register are cleared at time S2.

The required register within the group is selected by the sub-address.

6.1.4 Read Complement of Group 1 Register, Code F(3)

This command transfers to the controller the 'ones' complement of the contents of a register in the first group in the module. The contents of the register are not changed.

The required register within the group is selected by the sub-address.

The command is provided mainly as a means of error detection. A read transfer with F(0) or F(2) can be checked by preceding it with a transfer from the same register with F(3). The two data words received by the controller should be complementary. A write transfer with F(16) can be checked by following it with a read transfer from the module with F(3). The data words sent and received by the controller should be complementary.

6.1.5 Other Read Commands, Codes F(4) to F(7)

These commands transfer the contents of a register in the module to the controller. Codes F(4) and F(6) are available as non-standard functions. Codes F(5) and F(7) are reserved for extensions of the standard functions.

6.2 Control Commands: Function Codes F(8) to F(15)

This first group of control commands is identified by F8 = 1 and F16 = 0 in the function code. Information is not transferred on either the R or W lines. However, status information may be conveyed on the Q line in response to any of these commands. The signal on the Q line is permitted to change at any time. It is strobed into the controller at time S1 and may, except in operations with code F(8), be reset by strobe S2. There is a risk that information can be lost due to Q signals appearing between S1 and S2.

6.2.1 Test Look-at-Me, Code F(8)

This command transfers to the controller a signal on the Response line Q, representing the state of the L signal or a LAM request in the module (see Sections 5.4.1 and 5.4.1.1). The response must be Q = 0 if the feature is in the '0' state or is prevented, by masking or gating, from contributing to a '1' state L signal. The LAM status must not be reset by this command.

The feature to be tested (the L signal or a particular LAM request) is selected by the sub-address.

6.2.2 Clear Group 1 Register, Code F(9)

This command clears the contents of a register in the first group in the module.

The required register within the group is selected by the sub-address.

6.2.3 Clear Look-at-Me, Code F(10)

This command resets a LAM status in the module (see Section 5.4.1).

The required LAM status is selected by the sub-address. The Q signal may indicate the status of any selected feature in the module.

6.2.4 Clear Group 2 Register, Code F(11)

This command clears the contents of a register in the second group in the module.

The required register within the group is selected by the sub-address.

6.2.5 Other Control Commands, Codes F(12) to F(15)

These commands do not transfer data on the R or W bus-lines. Codes F(12) and F(14) are available for use as non-standard functions. Codes F(13) and F(15) are reserved for extensions to the standard functions.

6.3 Write Commands: Function Codes F(16) to F(23)

Write commands are identified by the combination F16 = 1 and F8 = 0 in the function code. All write commands involve the transfer of data from the controller to a module via the Write bus-lines, and status information from a module to the Controller via the Q and X lines (see mandatory statements in Sections 5.3.1, 5.4.3 and 5.4.4).

Recommendations for the use of the Q signal in write operations are given in Section 5.4.3.

6.3.1 Overwrite Group 1 Register, Code F(16)

This command forces each bit of a register in the first group in the module to the same state as the corresponding data bit transmitted by the controller.

The required register within the group is selected by the sub-address.

The effect of this command is to write data bit W_i into bit M_i of the Group 1 register. Thus:

$$M_i := W_i$$

6.3.2 Overwrite Group 2 Register, Code F(17)

This command forces each bit of a register in the second group in the module to the same state as the corresponding data bit transmitted by the controller.

The required register within the group is selected by the sub-address.

The effect of this command is to write data bit W_i into bit M_i of the Group 2 register. Thus:

$$M_i := W_i$$

6.3.3 Selective Set Group 1 Register, Code F(18)

This command operates on selected bit positions of a register in the first group in the module. The bit positions are selected by '1' bits in a data word transmitted by the controller, and their contents are set to the '1' state. The contents of unselected bit positions are unchanged.

The required register within the group is selected by the sub-address.

The effect of this command is to form the inclusive OR function of the data bit W_i and the bit M_i in the Group 1 register. Thus:

$$M_i := W_i + M_i$$

This can also be regarded as overwriting the '1' bits from the data word. It is therefore a special case of the selective overwrite operation previously defined in EUR 4100e (1969) for F(18).

6.3.4 Selective Set Group 2 Register, Code F(19)

This command operates on selected bit positions of a register in the second group in the module. The bit positions are selected by '1' bits in a data word transmitted by the controller, and their contents are set to the '1' state. The contents of unselected bit positions are unchanged.

The required register within the group is selected by the sub-address.

The effect of this command is to form the inclusive OR function of the data bit W_i and the bit M_i in the Group 2 register. Thus:

$$M_i := W_i + M_i$$

This can also be regarded as overwriting the '1' bits from the data word. It is therefore a special case of the selective overwrite operation previously defined in EUR 4100e (1969) for F(19).

6.3.5 Selective Clear Group 1 Register, Code F(21)

This command operates on selected bit positions of a register in the first group in the module. The bit positions are selected by '1' bits in a data word transmitted by the controller, and their contents are cleared to the '0' state. The contents of unselected bit positions are unchanged.

The required register within the group is selected by the sub-address.

The effect of this command is to form the function of the data bit W_i and the bit M_i in the Group 1 register:

$$M_i := \overline{W_i} \cdot M_i$$

In EUR 4100e (1969) this function code was reserved for extensions to the standard write functions.

6.3.6 Selective Clear Group 2 Register, Code F(23)

This command operates on selected bit positions of a register in the second group in the module. The bit positions are selected by '1' bits in a data word transmitted by the controller, and their contents are cleared to the '0' state. The contents of unselected bit positions are unchanged.

The required register within the group is selected by the sub-address.

The effect of this command is to form the function of the data bit W_i and the bit M_i in the Group 2 register:

$$M_i := \overline{W_i} \cdot M_i$$

In EUR 4100e (1969) this function code was reserved for extensions to the standard write functions.

6.3.7 Other Write Commands, Codes F(20) and F(22)

These codes are available for use as non-standard functions that operate on some or all bits of a register in the module in accordance with the data transmitted by the controller.

6.4 Control Commands: Function Codes F(24) to F(31)

This second group of control commands is identified by F8 = 1 and F16 = 1 in the function code. Information is not transferred on either the R or W bus-lines. However, status information may be conveyed on the Q line in response to any of these commands. The signal on the Q line is permitted to change at any time. It is strobed into the controller at time S1 and may, except in operations with code F(27), be reset by strobe S2. There is a risk that information can be lost due to Q signals appearing between S1 and S2.

6.4.1 Disable, Code F(24)

This command disables a feature of the module or masks off a signal. The action is initiated by Strobe S1 or S2.

The feature that is disabled, for example a LAM request or data input, is selected by the sub-address.

The Disable command is preferably used to disable a feature that is enabled by another command, such as Enable F(26).
(Compare with Execute, Section 6.4.2, which does not form a pair with Enable.)

6.4.2 Execute, Code F(25)

This command initiates or terminates an action when Enable or Disable is not appropriate. The initiation or termination occurs at the time of Strobe S1 or S2. The Execute command must not be used to set a feature of the module that requires a Disable command F(24) to reset it, nor to reset a feature that requires an Enable command F(26) to set it.

The action that is to be executed, or the feature of the module to which it is to be applied, is selected by the sub-address.

Execute may be used, for example, to initiate the generation of a pulse. The operation Increment Pre-selected Registers, which was defined for F(25) in EUR 4100e (1969), is one of the possible uses of the Execute command.

6.4.3 Enable, Code F(26)

This command activates or enables a feature of the module or unmasks a signal. The action is initiated by Strobe S1 or S2.

The feature that is to be enabled, for example a LAM request or data input, is selected by the sub-address.

The Enable command is preferably used to enable a feature that is disabled by another command, such as Disable F(24).
(Compare with Execute, Section 6.4.2, which does not form a pair with Disable.)

6.4.4 Test Status, Code F(27)

This command produces on the Q line a response corresponding to the status of a feature of the module. The feature, which is selected by the sub-address, may be a LAM status but must not be a LAM request or L signal (use Test Look-at-Me, Section 6.2.1). The feature must not be reset by the Test Status command.

6.4.5 Other Control Commands, Codes F(28) to F(31)

These commands do not transfer information on the R or W bus-lines. Codes F(28) and F(30) are available for use as non-standard functions. Codes F(29) and F(31) are reserved for extensions to the standard functions.

6.5 External Representation of the Command

A command is represented on the Dataway by the 5-bit function code, the 4-bit sub-address code, and signals on the appropriate N lines. The specification does not define the form in which the command should be transmitted externally (e.g. between a computer and a crate). It will generally be convenient to use the same function and sub-address codes. An external 5-bit code for N could be more convenient than the 24-bit form used internally. For example the binary code 00001 could correspond to Station Number 1 and therefore generate a signal on line N1. The other station numbers would then correspond to the binary codes in sequence.

Fewer than 32 codes are needed for addressing individual stations. Spare codes are therefore available, for example, to select multi-addressing modes. For example, one code may address all modules simultaneously, and another may allow the N lines to be controlled by a 'Station Number Register'. Other codes may be used to address registers, etc., within the controller. (See EUR 4600e for examples of spare station number codes used in this way in Crate Controller Type A.)

7. SIGNAL STANDARDS

The standards specified in this section apply to signals into and out of plug-in units through:

(a) The Dataway (including timing standards for the main signals associated with Dataway operations).

(b) Non-standard connections (P1 P7) via the Dataway connector.

(c) Other connectors on the front panel or at the rear of the unit above the Dataway (with separate standards for terminated and unterminated digital signals and for analogue signals).

The signal standards do not restrict the freedom of designers to use other signals or conventions within units.

7.1 Digital Signals on the Dataway

The potentials for the binary digital signals on the Dataway lines have been defined to correspond with those for compatible current sinking logic devices (e.g. the TTL and DTL series). The signal convention has, however, been chosen to be negative logic. The high state (more positive potential) corresponds to logic '0' and the low state (near ground potential) corresponds to logic '1'. Intrinsic OR outputs are thus available from standard product ranges.

It is an essential feature of the Dataway that many units may have signal outputs connected to the Read, Command Accepted and Response lines. Outputs onto these lines therefore require intrinsic OR gates. The same principle is extended to other lines (command, Write, etc.) in order to allow more than one controller-like unit in a crate.

Signal outputs from all plug-in units onto all Dataway lines must be delivered through intrinsic OR gates. Each line must be provided with an individual pull-up current source to restore the line to the '0' state in the absence of an applied '1' signal.

The rise and fall times at signal outputs to Dataway lines must not be less than 10ns, in order that cross-coupling of signals on the Dataway is not excessive.

7.1.1 Voltage Standards for Dataway Signals

All Dataway signals must conform to the voltage levels shown in Table V.

TABLE V VOLTAGE LEVELS OF DATAWAY SIGNALS

	'0' STATE	'1' STATE
Accepted at input	+2·0V to +5·5V	0 to +0·8V
Generated at output	+3·5V to +5·5V	0 to +0·5V

7.1.2 Current Standards for Dataway Signals

All Dataway signals must conform to the standards for input and output currents shown in Table VI.

Pull-up current sources for all standard Dataway bus-lines are located in the controller (occupying the control station and at least one other station) so as to ensure that there is one and only one current source per line. The pull-up current sources for the N lines are located in the unit generating the signals and for the L lines in a unit receiving the signals so that the individual lines may be joined or grouped within these units if desired.

The Strobe signals S1 and S2, which time all actions in modules, have larger pull-up currents than other signals in order to give improved transition times and immunity against cross-coupling from other Dataway lines.

7.1.3 Timing of Dataway Signals

The sequence of events during a Dataway command operation is shown in Figure 9 by means of simplified signal waveforms. Section 7.1.3.1 is an explanation of Figure 9.

The sequence of events during a Dataway unaddressed operation is shown in Figure 10, and an explanation is given in Section 7.1.3.2.

In both Figures the shaded areas indicate the permitted variation in the timing of each signal. The vertical edge of each shaded area corresponds to an ideal signal without delay. The sloping edge corresponds to a signal that reaches the appropriate threshold (0·8V or 2·0V) after the maximum permitted delay.

The performance of all plug-in units and Dataway assemblies must be consistent with the timing requirements shown in Figures 9 and 10.

TABLE VI STANDARDS FOR SIGNAL CURRENTS THROUGH DATAWAY CONNECTORS AND FOR PULL-UP CURRENT SOURCES

Where appropriate, the current passing through the Dataway connector of a plug-in unit is defined as a function of the width of the unit ('s' stations). Values are given, as examples, for typical controllers (s = 2, Control Station and one Normal Station) and other units (s = 1).

NOTE 1: Although only the controller and one module are connected directly to each N and L line, additional units may be connected via patch points or auxiliary connectors.

<table>
<tr><th>DESIGNATION OF DATAWAY SIGNAL LINE</th><th>N</th><th>L</th><th>Q, R, X</th><th>W, A, F,
B, Z, C, I</th><th>S1, S2</th></tr>
<tr><td rowspan="2">Line in '1' state at +0·5V
Minimum current sinking capability (current drawn from line) of each unit generating the signal.</td><td rowspan="2">6·4mA</td><td colspan="2" rowspan="2">16mA</td><td colspan="2">Controllers
1·6 (25–s)mA
36·8mA typical</td></tr>
<tr><td>Other Units
9·6+1·6(25–s)mA
48·0mA typical</td><td>58+1·6(25–s)mA
96·4mA typical</td></tr>
<tr><td rowspan="2">Line in '1' state at +0·5V
Maximum current fed into line by each unit receiving the signal.</td><td rowspan="2">3·2mA each unit,
6·4mA total
(Note 1).</td><td colspan="2">Unit with pull-up current source: 11·2mA</td><td colspan="2" rowspan="2">1·6s mA</td></tr>
<tr><td colspan="2">Units without pull-up current source 1·6mA each:
4·8mA total (Note 1)</td></tr>
<tr><td>Line in '0' state at +3·5V
Minimum pull-up capability (current fed into line) of the unit with pull-up current source.</td><td colspan="4">100(25–s)µA
2·3mA typical for controllers
2·4mA typical for other units</td><td>9·9mA</td></tr>
<tr><td>Line in '0' state at +3·5V
Maximum current drawn from line by each unit without pull-up current source.</td><td>200µA</td><td colspan="4">100s µA</td></tr>
<tr><td>Location of pull-up current source</td><td>Unit generating the signal.</td><td>One unit receiving the signal.</td><td colspan="3">Controller</td></tr>
<tr><td>Pull-up current Ip, from positive potential
Line in '1' state at +0·5V</td><td colspan="4">6mA ≤ Ip ≤ 9·6mA</td><td>38mA ≤ Ip ≤ 58mA</td></tr>
<tr><td>Pull-up current Ip, from positive potential
Line in '0' state at +3·5V</td><td colspan="4">2·5mA ≤ Ip</td><td>10mA ≤ Ip</td></tr>
</table>

7.1.3.1 Timing of Dataway Command Operations

The sequence of events during a command operation is shown in Figure 9.

During the operation command and data signals may take up either the '1' state or the '0' state. For convenience Figure 9 shows only signals that take up the '1' state, but similar timing requirements apply to those that take up the '0' state.

The Busy signal and the various command signals need not occur in exact synchronism, provided each is individually within the shaded areas of the diagram. Similar variation is permitted between the signals on the various data and status lines.

The W, R, Q and X signals are shown as being maintained until the end of the operation, but a broken line indicates the earliest time at which they are permitted to change as a result of actions initiated by Strobe S2. During some operations the Q signal may change at any time.

The L signal is shown for the particular case of a module that inhibits its L signal output in response to a command that does not clear the LAM source (see Section 5.4.1.3). The signal $L_i = 1$ is therefore removed but reappears at the end of the operation.

Time-markers $t_0 - t_{12}$ in Figure 9 indicate key points at which signal transitions are initiated or reach one of the threshold levels (0·8V or 2·0V).

At t_0 the transition of the Busy signal to the '1' state is initiated. Command signals on the N, A and F lines also take up the '1' or '0' states as appropriate to the command.

At t_1 the Busy signal has reached the 0·8V threshold and all the command signals have reached the appropriate thresholds.

During the period $t_1 - t_2$ the addressed module responds to the command, and by t_2 the appropriate X, Q and data signals are initiated. By t_3 at the latest these signals have all reached the appropriate thresholds. Any L signals that are inhibited during the operation have reached the 2·0V threshold by t_3.

The transition of the S1 signal to the '1' state is initiated at t_3 and has reached the 0·8V threshold by t_4.

At t_5 the transition of the S1 signal to the '0' state is initiated and reaches the 2·0V threshold by t_6.

The transition of the S2 signal to the '1' state is initiated at t_6 and has reached the 0·8V threshold by t_7. Modules may respond to S2 by changing the state of the R, Q, and X signals.

The transition of the S2 signal to the '0' state is initiated at t_8 and has reached the 2·0V threshold by t_9, which is the end of the Dataway operation.

At t_9 the transition of the B signal to the '0' state is initiated and the command signals may also change from their established states.

At t_{10} the B signal and command signals have reached the 2·0V threshold. During the period $t_{10}-t_{11}$ the module responds to the removal of the command. By t_{11} the transitions of the W, R, Q and X signals to the '0' state are initiated, and the inhibit is removed from the L signal. By t_{12} the L signal has reached the 0·8V threshold and all other signals have reached the 2·0V threshold.

Controllers must initiate the transitions of the command and strobe signals at intervals not less than the minimum times shown in Figure 9. Modules must respond to the command within the time (t_1-t_2) and to the strobes in the times (t_4-t_5) and (t_7-t_8). The electrical characteristics of the Dataway and connections from it into plug-in units must allow transitions between the two threshold levels to take place within the times (t_0-t_1), (t_2-t_3) etc.

The next Dataway operation must not start before t_9.

In the extreme case when the next operation starts at t_9, the time-markers t_0, t_1, t_2 of the new operation coincide with t_9, t_{10}, t_{11} of the previous operation. The command and data signals of one operation may thus be removed while those of the next operation are being established. The Busy signal may be maintained continuously during a sequence of consecutive Dataway operations. Under suitable conditions any command or data signals which have the same state during successive operations may also be maintained. In the extreme case of successive operations with the same command and data there could be a complete absence of signal transitions between t_0 and t_3.

7.1.3.2 Timing of Unaddressed Operations

The sequence of events during an unaddressed Clear or Initialise operation is shown in Figure 10.

At t_0 the transition of the Busy signal to the '1' state is initiated. In a Clear operation the transition of the C signal is also initiated at this time. In an Initialise operation the transitions of the Z and I signals are initiated.

By t_1 the B signal and, as appropriate, either Z and I or C have reached the 0·8V threshold.

The interval t_1-t_6 allows integration of the Z or C signals within the module if required.

At t_6 the transition of the S2 signal to the '1' state is initiated. The S2 signal is established and removed as described previously. (The S1 signal may be generated with timing relative to t_6 as shown in Figure 9.)

The S2 signal reaches the 2·0V threshold by t_9. The transitions of the B signal and C or Z to the '0' state are initiated at t_9 and reach the 2·0V threshold by t_{10}. The Inhibit signal may be removed at t_9 or, if possible, it is maintained in the '1' state as indicated by the broken line.

7.1.4 Digital Signals on Non-Standard Connections

Signals on the Free bus-lines (contacts P1 and P2 at normal stations) must be generated from intrinsic OR outputs and conform to the voltage standards of Table V. They must conform to the current standards of either Table VII or Table VI, for Read or Write lines as appropriate (see also Section 5.6.1).

Signals on patch connections using contacts P3–P5 at normal stations or P1–P7 at the control station must be generated from intrinsic OR outputs and must conform to the voltage standards of Table V and the current standards of Table VII. Disconnected inputs must take up the '0' state.

In Table VII each input and output has an individual pull-up current source to compensate for leakage current in the '0' state. This allows flexibility in the number of inputs and outputs that can be patched together.

TABLE VII CURRENT STANDARDS FOR PATCH CONTACTS

STATE OF LINE	CURRENT TO AND FROM PATCH CONNECTIONS	
	Outputs	Inputs
'1' State at +0·5V	Units must be capable of drawing more than 15mA from connection when generating '1'. Unit must not feed more than 300μA into connection when generating '0'.	Unit must not feed more than 2mA into connection.
'0' State at +3·5V	Pull-up capability (current fed into connection):	100μA minimum 300μA maximum

7.2 Other Digital Signals

The standards defined below should normally be used for all terminated and unterminated digital signals via connectors on the front panel and at the back of plug-in units above the Dataway. There may, however, be special circumstances requiring the use of other signals, for example to suit a specific equipment with which the plug-in unit is closely associated.

7.2.1 Unterminated Signals

Unterminated signals should conform to the standard set out in Table VIII, unless there are special reasons for using other standards.

Individual outputs must be able to withstand, without damage, a short-circuit to ground. Outputs through multiway connectors need not withstand a short-circuit on all pins simultaneously.

Disconnected inputs must take up the '0' state.

TABLE VIII UNTERMINATED SIGNALS

*OUTPUTS	V_{out}	Logic '1'	Unit must generate 0V to +0·5V
		Logic '0'	Unit must generate +2·4V to +5·5V
	I_{out}	Logic '1' at +0·5V	Unit must draw >16mA from connection
		Logic '0' at +2·4V	Unit must feed >6mA into connection
INPUTS	V_{in}	Logic '1'	Unit must accept 0V to +0·8V
		Logic '0'	Unit must accept +2·0V to +5·5V
	I_{in}	Logic '1' at +0·5V	Unit must feed <2·0mA into connection
		Logic '0' at +2·4V	Unit must feed current into connection or draw <100μA from connection

* *Not necessarily intrinsic OR*

7.2.2 Terminated Signals

The characteristic impedance for terminated signals is 50Ω. Signals terminated in 50Ω should conform to the standard set out in Table IX, unless there are special reasons for using other standards.

Negative signs indicate currents flowing into an output circuit.

TABLE IX TERMINATED SIGNALS

	LOGIC '0'	LOGIC '1'
Outputs must deliver into 50Ω	-2 to +2mA *Preferred* *-1 to +1mA*	-14 to -18mA
Inputs must accept	-4 to +20mA	-12 to -36mA

7.3 Analogue Signals

Recommended standards for amplitude analogue signals are defined in Euratom Report EUR 5100e (see Appendix 2).

8. POWER LINE STANDARDS

The Dataway includes bus-lines for mandatory, additional and reserved power supplies.

Designers of plug-in units may assume that the mandatory lines (+24V, +6V, -6V, -24V, and 0V power return) are powered in every installation.

The additional bus-lines are provided for special requirements, for example compatibility with the USAEC NIM System. There are heavy current lines for +12V and -12V d.c., and low-current lines for +200V d.c. (intended primarily for neon-indicators), 117V a.c. (ACL and ACN), and for an independent and isolated 'Clean Earth' return (E). These lines are not necessarily powered unless specifically required for use.

The voltages available to plug-in units at the contacts of each Dataway connector must be within the tolerances specified in Table X. Individual plug-in units, and assemblies of plug-in units within a crate, must not exceed the current loadings specified in Table X.

The Dataway power lines, and any wiring from them to the point at which power supplies enter the crate, must be capable of carrying the maximum current loadings permitted in the crate. The resistance between any point on the Dataway 0V power return bus-line and the point at which power supplies enter the crate must not exceed 2mΩ.

TABLE X POWER LINE STANDARDS

NOMINAL VOLTAGE ON POWER LINE IN CRATE	VOLTAGE TOLERANCE AT DATAWAY CONNECTORS	MAXIMUM CURRENT LOADS		NOTES
		In the Plug-in (per unit width) See Notes (1) and (3)	In the Crate See Note (2)	
Mandatory				1. The current carried by each contact of the Dataway connector must not exceed 3A.
+24V d.c.	±1·0%	1A	6A	2. The total power dissipation in a crate without forced ventilation must not exceed 200W.
+6V d.c.	±2·5%	2A	25A	3. The power dissipation in each station must not exceed 8W in general or 25W under special circumstances.
-6V d.c.	±2·5%	2A	25A	
-24V d.c.	±1·0%	1A	6A	
0V				
Additional (as required)				
+200V d.c.	+60V, -20V		0·1A	
+12V d.c.	±1·0%			Provisionally as specified in A.E.C. TID-20893 (Latest Revision)
-12V d.c.	±1·0%			Provisionally as specified in A.E.C. TID-20893 (Latest Revision)
117V a.c.			0·5A	Frequency 47–63Hz, to be obtained from an isolating transformer.

The voltage tolerances specified in Table X do not define the performance of a suitable power supply unit directly. They take into account factors within the crate, for example voltage drops due to the internal wiring of the crate and to the Dataway bus-line under worst-case distributions of current loading.

The maximum current loads for a plug-in unit will often be restricted by power dissipation (see Notes 2 and 3 in Table X), or by the current-carrying capacity of the Dataway connector (Note 1) and the Dataway power lines. In a crate without forced ventilation the total power dissipation is restricted to 200W, corresponding to 8W per station. Under special circumstances this may be increased to 25W per station, for example by using forced ventilation or by taking care that the total dissipation is less than 200W.

9. GENERAL ENVIRONMENTAL CONDITIONS

The system is intended for use in environments typically associated with laboratory instrumentation. The ambient temperature range has been provisionally defined as 10°C to 45°C.

Appendix 1

DEFINITIONS OF MODULE AND CONTROLLER

In this specification the terms 'module' and 'controller' refer to plug-in units whose use, if any, of each Dataway line is consistent with the following table. A controller occupies the control station and at least one normal station. A module occupies one or more normal stations. A plug-in unit may combine some features of a module with some of a controller.

LINE	USE BY A MODULE	USE BY A CONTROLLER
A	Receives	Generates
B	Receives	Generates
C	Receives	Generates
F	Receives	Generates
L	Generates	Receives
N	Receives	Generates
Q	Generates	Receives
R	Generates	Receives
S	Receives	Generates
W	Receives	Generates
X	Generates	Receives
Z	Receives	Generates

Appendix 2

RELATED SPECIFICATIONS

CAMAC: A Modular Instrumentation System for Data Handling. Description and Specification.
Euratom Report EUR 4100e, Luxembourg, March 1969.
(Superseded by this revised specification. Authorised translations in French, German and Italian)*

CAMAC: Organisation of Multicrate Systems. Specification of the Branch Highway and CAMAC Crate Controller Type A.
Report EUR 4600e, Commission of the European Communities, Luxembourg, April 1972.*

CAMAC: A Modular Instrumentation System for Data Handling. Specification of Amplitude Analogue Signals.
Report EUR 5100e
(To be published in 1972)*

Standard Nuclear Instrument Modules.
United States Atomic Energy Commission, TID-20893 (Revision 3, December 1969).
(From U.S. Government Printing Office, Washington D.C. 20402.)

* From sales offices listed on the rear cover of this report.

Appendix 3

THE ESONE COMMITTEE

The Committee comprises representatives from laboratories, institutes and organisations that have an interest in the compatibility of electronic equipment.

The Committee has a permanent Secretariat. When the Committee is not in session its business is handled by an Executive Group consisting of the secretary and one representative from each of C.E.R.N., Euratom, C.E.A. France, U.K. Nuclear Laboratories, Deutsche Studiengruppe für Nuklear Electronik, and C.N.E.N. Italy. These representatives are nominated by their respective organisations. The Chairman of the Executive Group is also the Chairman of the Esone Committee and is chosen annually from the nominated representatives.

A list of member laboratories is given in this Appendix. Further information about current membership and nominated representatives on the Committee and Executive Group can be obtained from the Secretary*.

This document is issued with the approval of the Executive Group. Any questions relating to the interpretation of this document should be submitted to the Secretary. Any points that cannot be cleared by him will be referred to the Executive Group for resolution.

Users of this document who wish to be informed of any future revisions should inform the Secretary.

* Address of the Secretary:	Dr. W. Becker, C.C.R. Euratom, 1-21020 Ispra, Italy, (VA).
Telephone:	Italy (39), Varese (332), 780131 Extension 245
Telex Number:	38042

Membership of the ESONE Committee

International	European Organization for Nuclear Research (CERN)	Geneva, Switzerland
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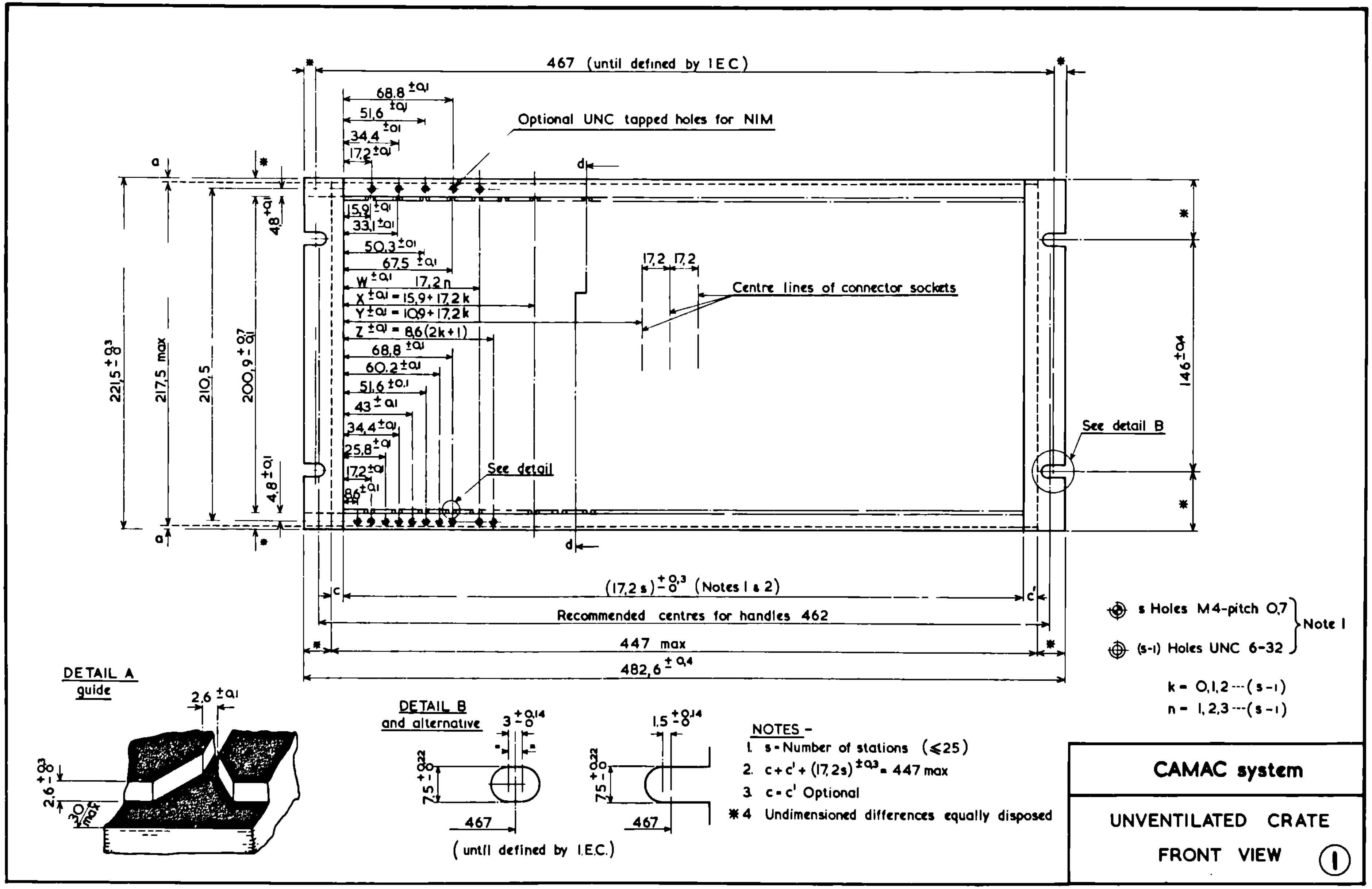

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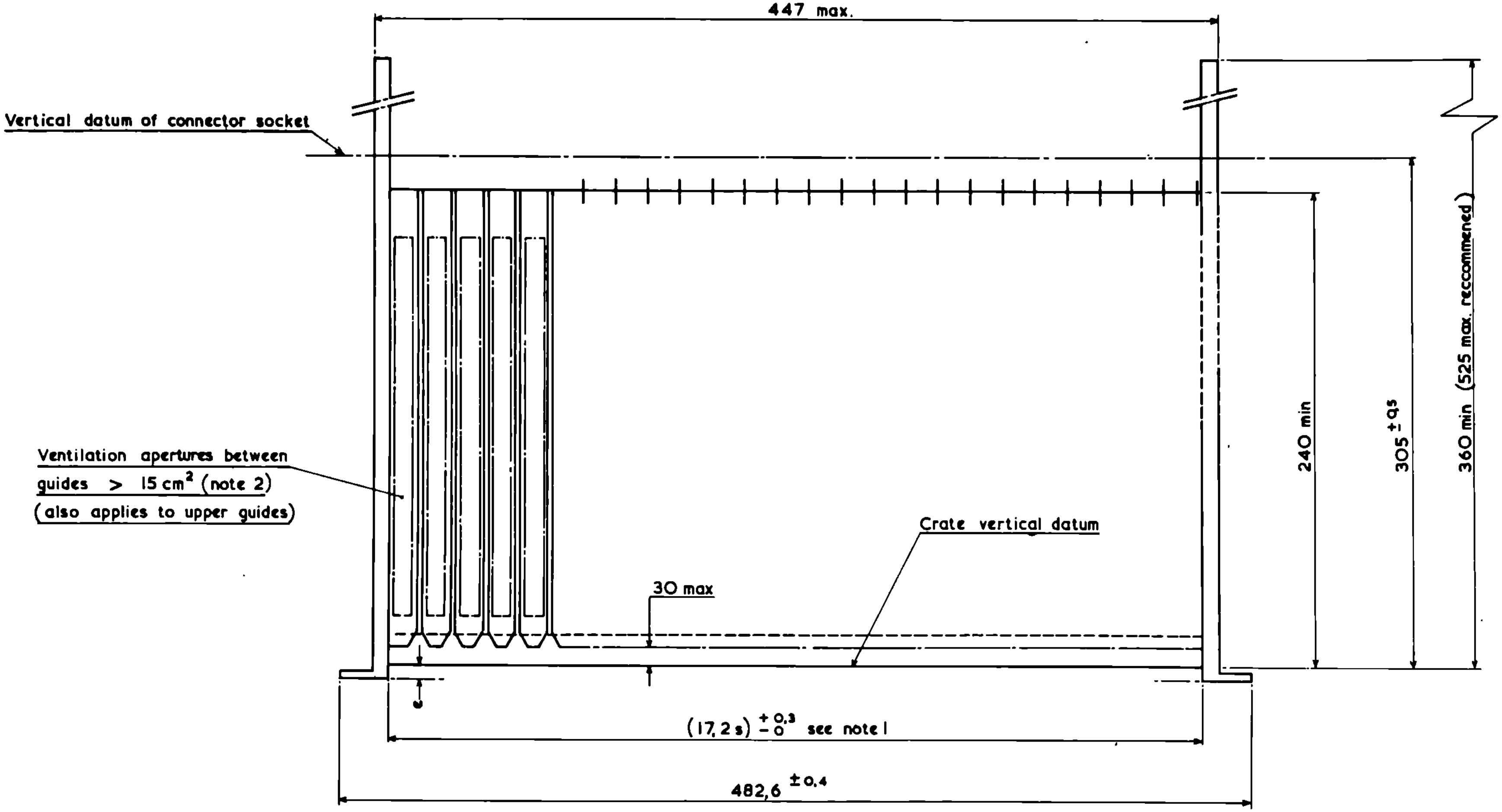


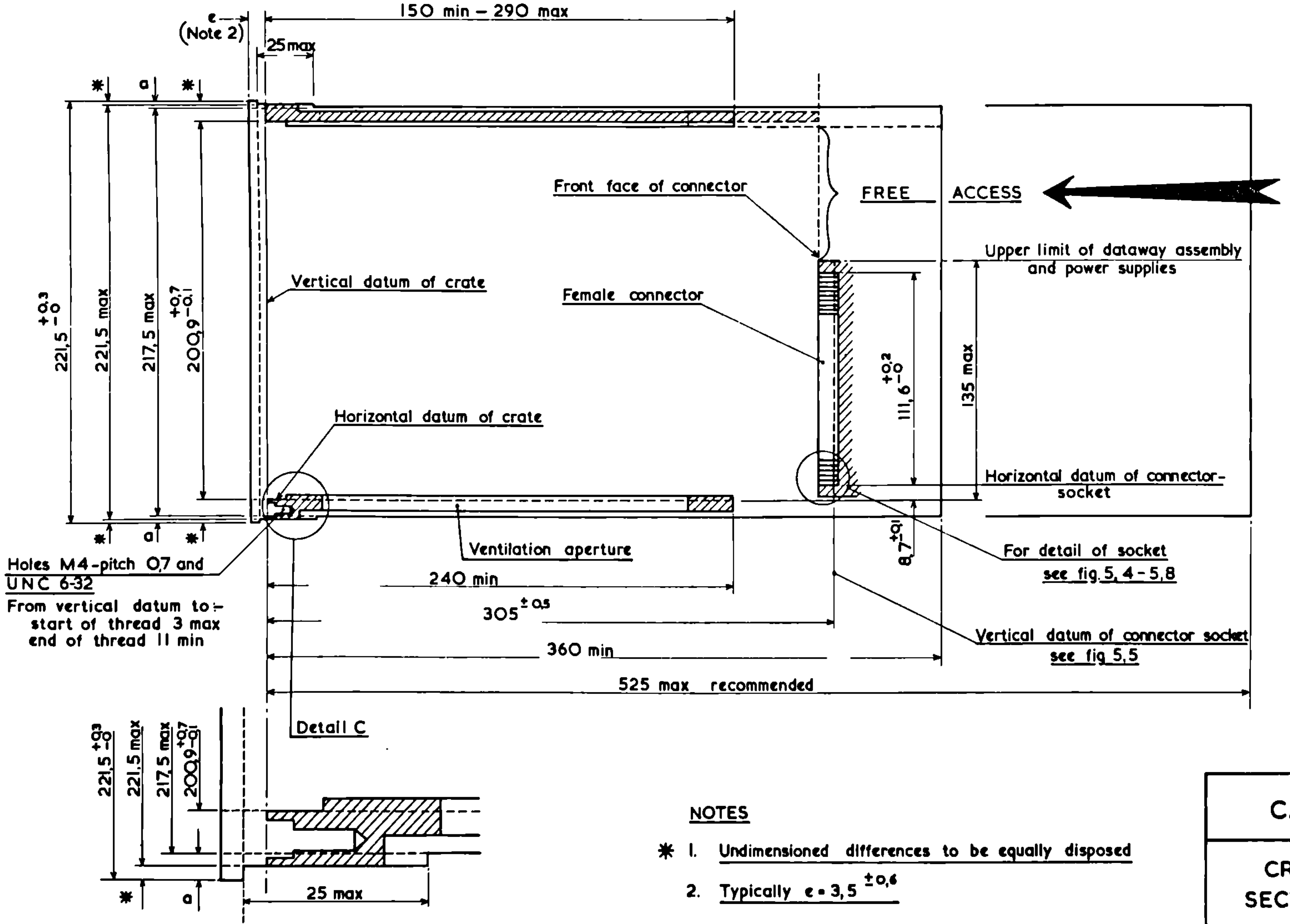
NOTES

1. s = No of stations for plug-in units
2. Ventilation apertures between guides to be as long as possible
3. Typically $e = 3{,}5^{\pm 0{,}6}$

CAMAC system

PLAN VIEW OF LOWER GUIDES IN CRATE.

②



NOTES

✱ 1. Undimensioned differences to be equally disposed

2. Typically $e = 3,5^{\pm 0,6}$

CAMAC system

CRATE SIDE VIEW SECTION d-d (FIG. 1) ③

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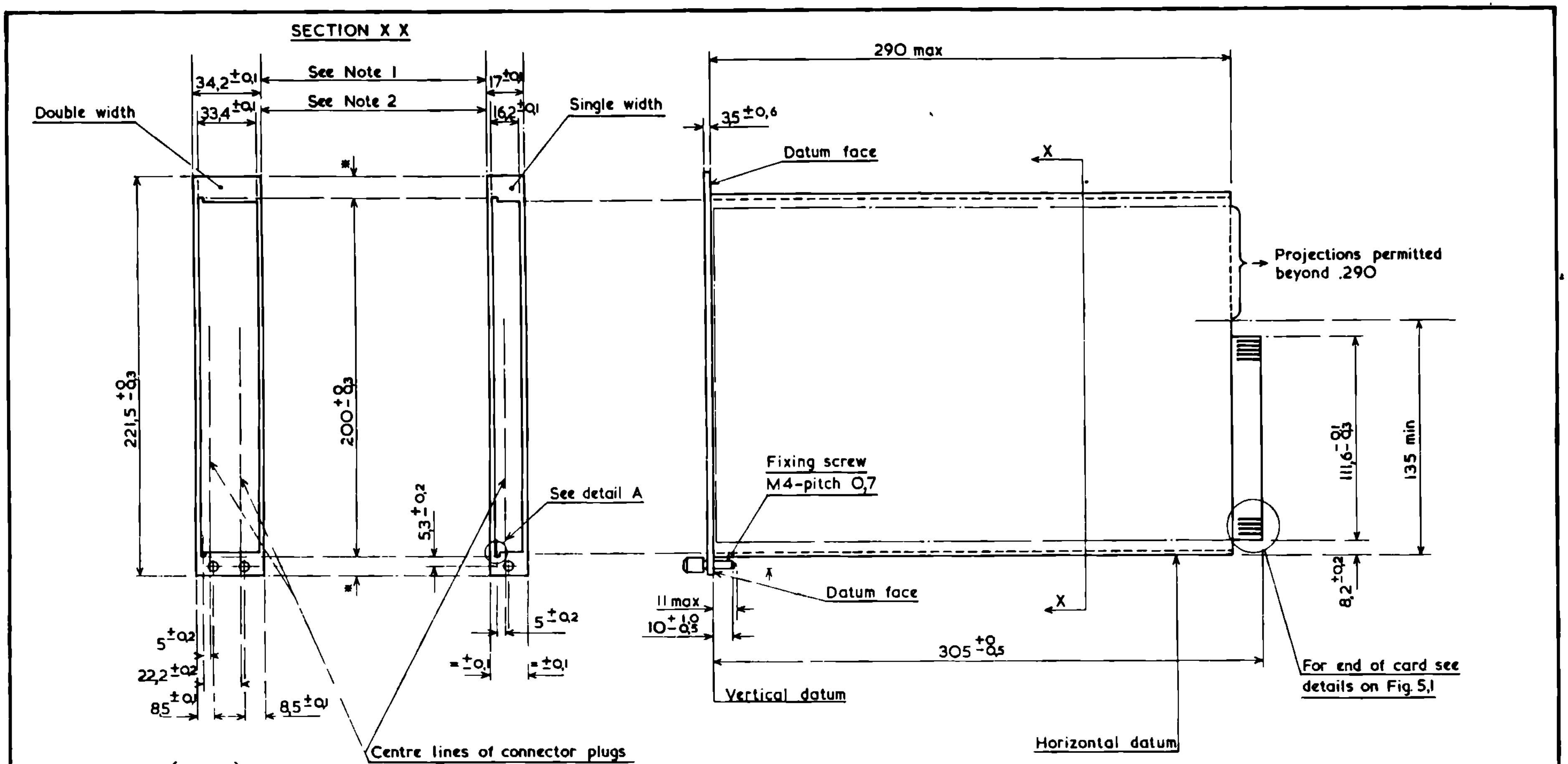
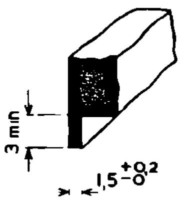


DETAIL A (Runner)



NOTES

1. Width of front panels of units occupying 's' stations
   (17,2s − 0,2) for s = 1,2 or 3
   (17,2s − 0,4) for s = 4, etc.
2. Recommended width of rear panel = 0,8 less than width of front panel
3. ✱ Undimensioned differences to be equally disposed
4. Datum faces above and below runners clear of projections except for fixing screw

CAMAC system

PLUG-IN UNIT
SIDE AND REAR VIEWS

4

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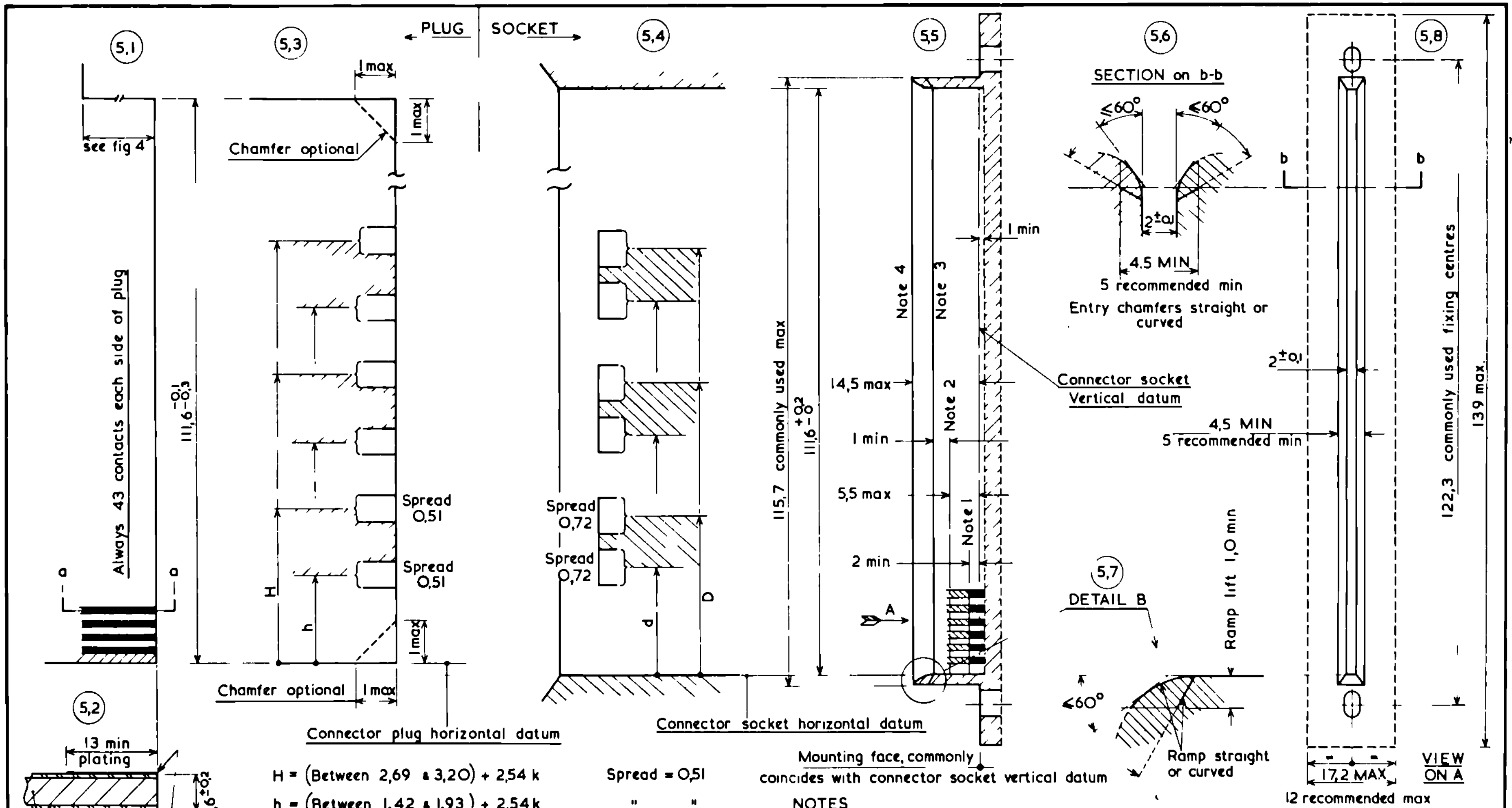


H = (Between 2,69 & 3,20) + 2,54 k — Spread = 0,51

h = (Between 1,42 & 1,93) + 2,54 k — " "

d = (Between 1,71 & 2,43) + 2,54 k — Spread = 0,72

D = (Between 2,69 & 3,41) + 2,54 k — " "

The position of any contact edge within the spread of its positional limits is entirely independent of the position of any other contact edge on either side of the plug &/or socket

k = 0, 1, 2 --- 42

NOTES

1. Plugs inserted to this line must have established all contacts
2. Plugs inserted to this line must not have established any contacts
3. Horizontal datum face of connector socket must extend to this line
4. Front face of connector must not extend beyond this line

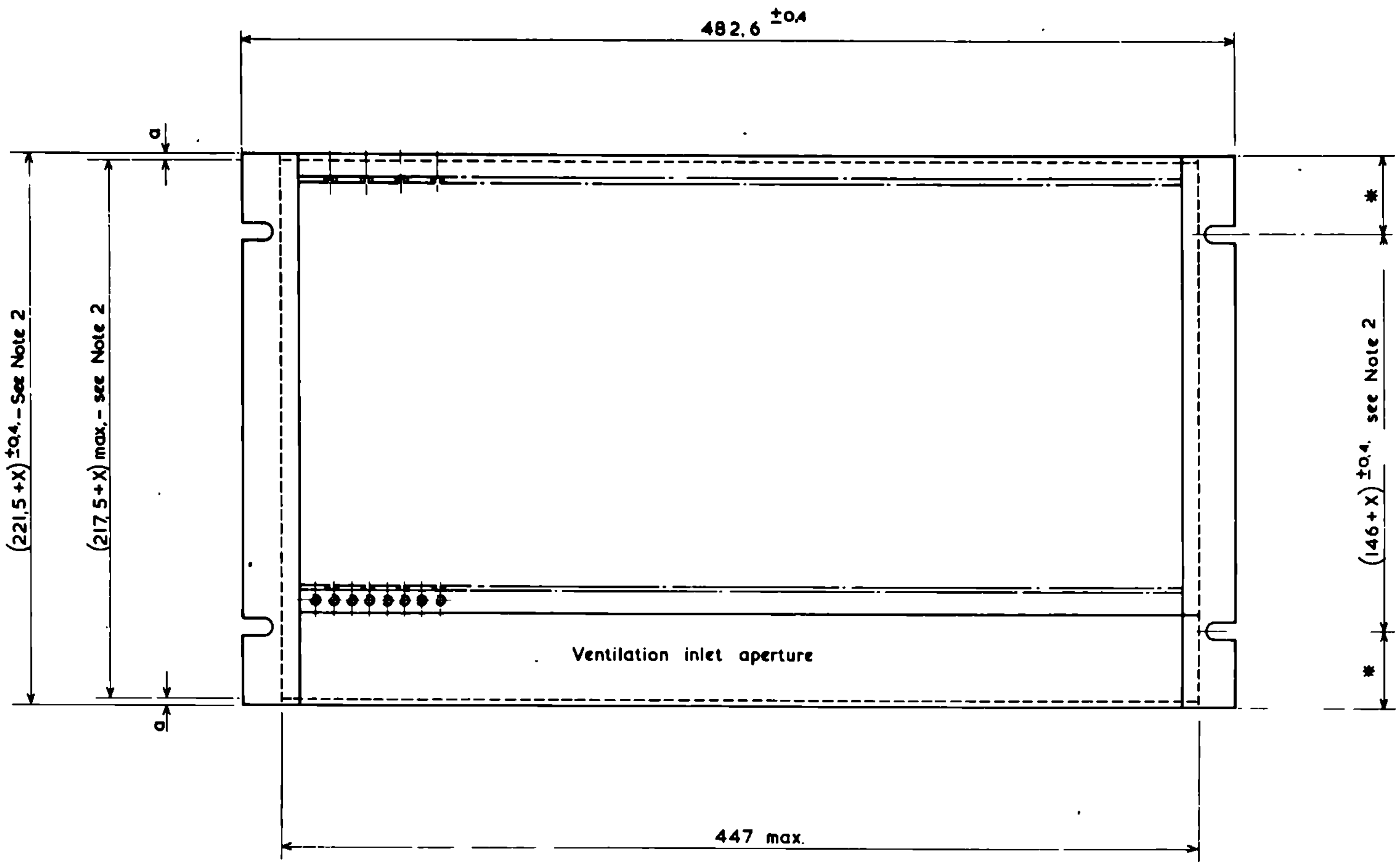
CAMAC system

DATAWAY CONNECTOR

5,1 - 5,3 Connector plug

5,4 - 5,8 Connector socket

5



NOTES

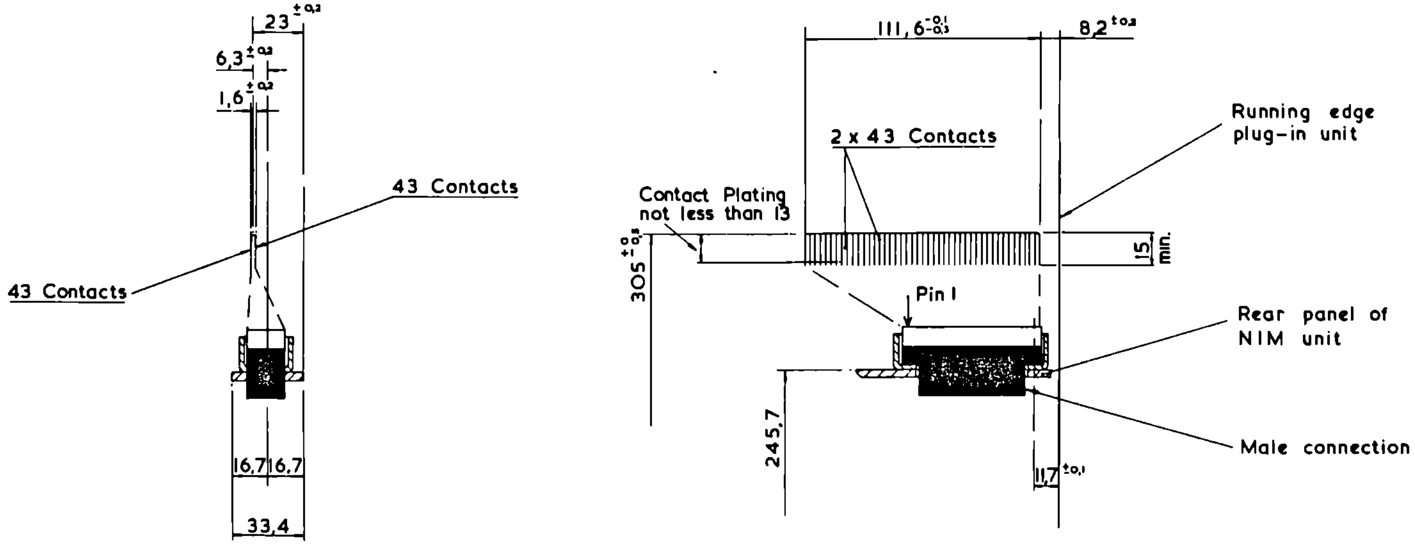
1. For all details not shown see Fig. 1
2. X = 44,45 L, where L = 1,2,3, etc.

* 3. Undimensioned differences to be equally disposed.

CAMAC system

VENTILATED CRATE
FRONT VIEW

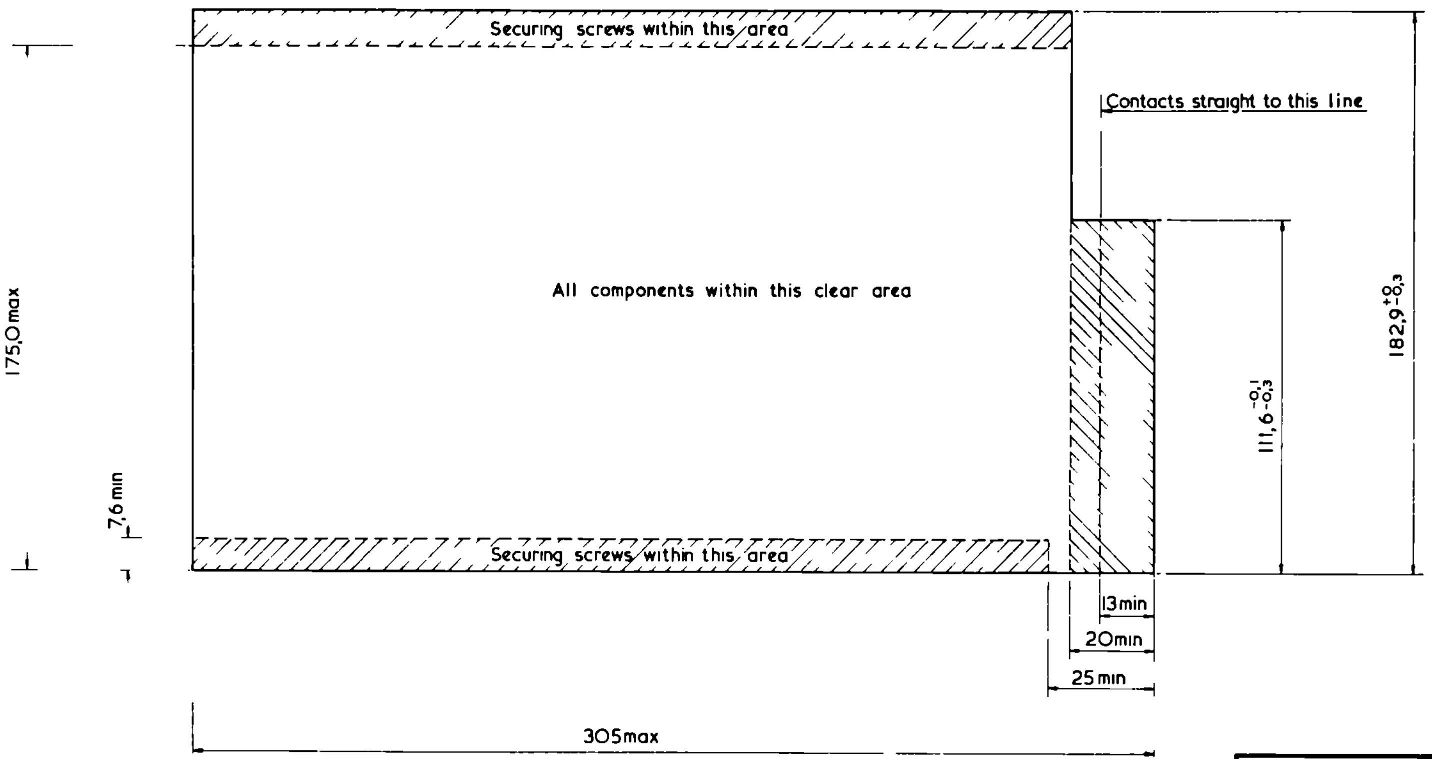
(6)



NOTE For Contact details, see Fig. 5.

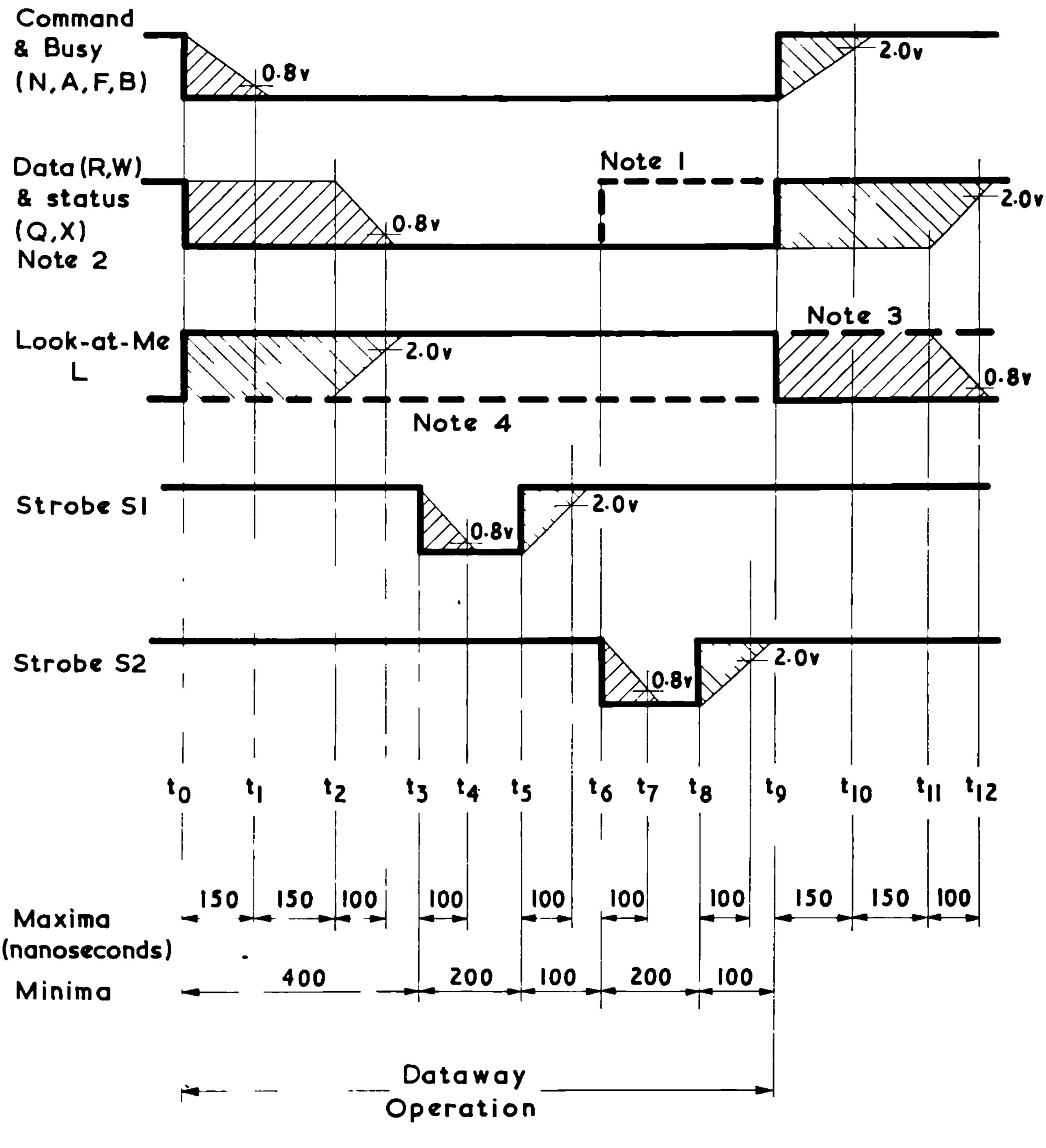
CAMAC system

ADAPTOR FOR NIM UNITS 7



CAMAC system

TYPICAL PRINTED WIRING CARD (8)



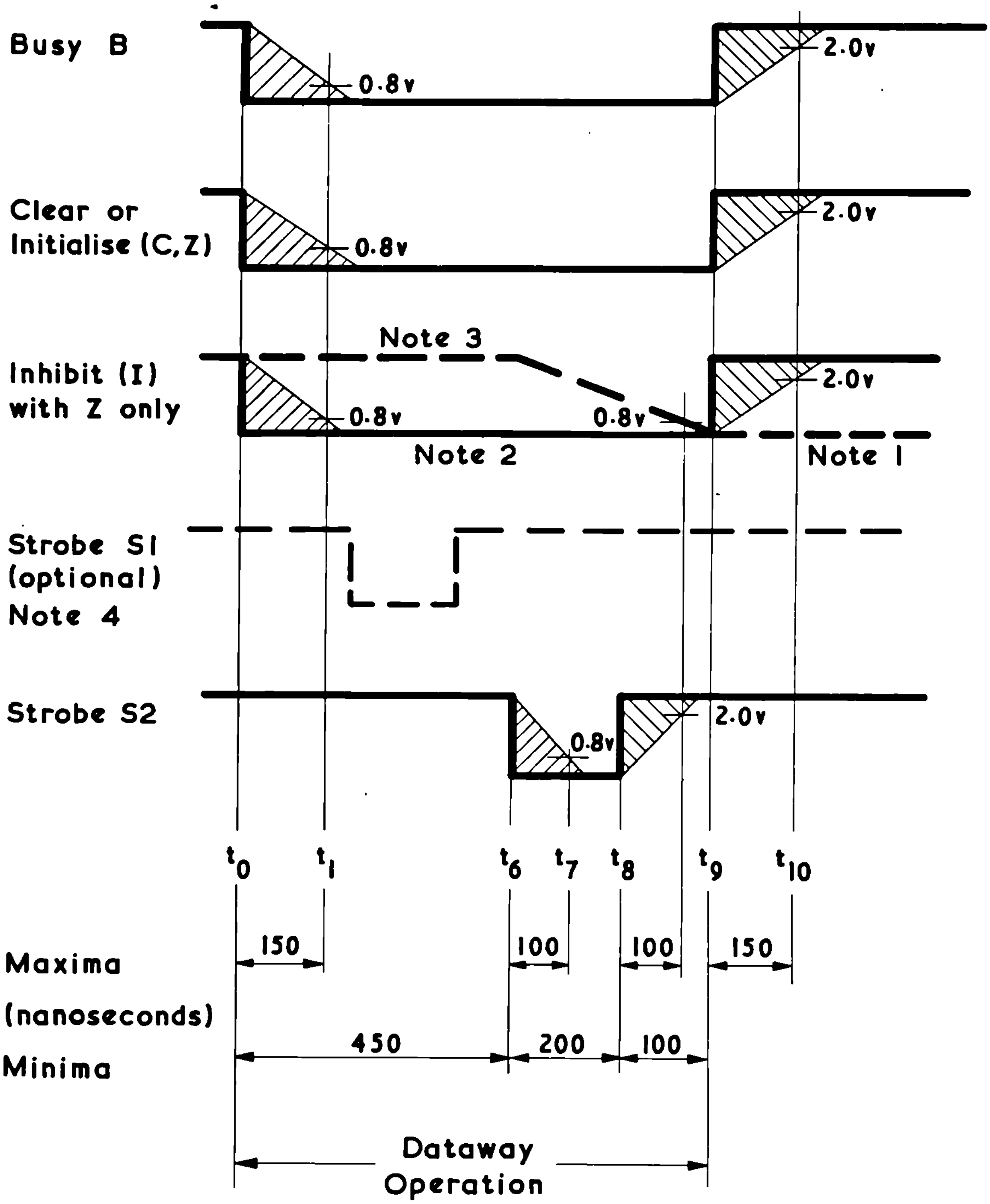
Note 1: Data & status may change in response to S2.

Note 2: During some operations Q may change at any time.

Note 3: LAM status may be reset during operation.

Note 4: L signal may be maintained during operation.

FIG. 9. TIMING OF A DATAWAY COMMAND OPERATION.



Note 1 : I preferably maintained .
Note 2 : I accompanying Z.
Note 3 : I generated in response to Z.S2
Note 4 : Other times as in Fig. 9.

FIG. 10. TIMING OF A DATAWAY UNADDRESSED OPERATION.

OPERATION	ON LAM i — VIA DATA BIT i	ON LAM i — VIA A(i)	ON ALL LAM
Clear all LAM status			* Initialise Clear Gp2 F(11). A(12)
*Clear LAM status i	Sel.Clear Gp2 F(23) .A(12)	Clear LAM F(10)	Clear LAM F(10) A(k)
Set LAM status i	Sel.Set Gp2 F(19) .A(12)	Execute F(25)	
Examine LAM status i	Read Gp2 F(1) .A(12)	Test Status F(27)	
Disable all LAM requests			* Initialise Clear Gp2 F(11) .A(13)
Disable LAM request i	Sel.Clear Gp2 F(23) .A(13)	Disable F(24)	
Enable LAM request i	Sel.Set Gp2 F(19) .A(13)	Enable F(26)	
Examine LAM mask bit i	Read Gp2 F(1) .A(13)		
Disable all LAM requests			* Initialise Disable F(24) .A(k)
Enable all LAM requests			Enable F(26) .A(k)
*Examine LAM request i	Read Gp2 F(1) .A(14)	Test LAM F(8)	
*Examine L signal			Test LAM F(8) .A(k)
* Mandatory See Section 5.4.1.1	Preferred for modules with many LAM	Preferred for few LAM	Choose A(k) to distinguish from A(i)

STRUCTURE

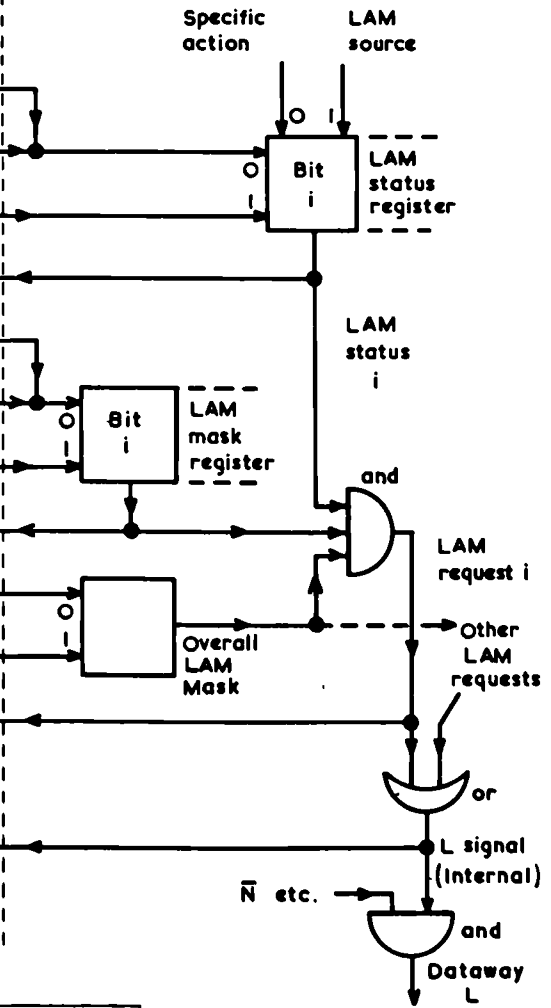


FIG. 11. SOME LAM STRUCTURE OPTIONS.

Index

The principal references are given first. Any subsidiary references follow, after a semi-colon (;).

TABLE IV THE FUNCTION CODES

CODE F( )	FUNCTION	USE OF R AND W LINES	FUNCTION SIGNALS F16	F8	F4	F2	F1	CODE F( )
0	Read Group 1 Register		0	0	0	0	0	0
1	Read Group 2 Register	Functions using the R lines	0	0	0	0	1	1
2	Read and Clear Group 1 Register		0	0	0	1	0	2
3	Read Complement of Group 1 Register		0	0	0	1	1	3
4	Non-standard		0	0	1	0	0	4
5	Reserved		0	0	1	0	1	5
6	Non-standard		0	0	1	1	0	6
7	Reserved		0	0	1	1	1	7
8	Test Look-at-Me		0	1	0	0	0	8
9	Clear Group 1 Register	Functions not using the R or W lines	0	1	0	0	1	9
10	Clear Look-at-Me		0	1	0	1	0	10
11	Clear Group 2 Register		0	1	0	1	1	11
12	Non-standard		0	1	1	0	0	12
13	Reserved		0	1	1	0	1	13
14	Non-standard		0	1	1	1	0	14
15	Reserved		0	1	1	1	1	15
16	Overwrite Group 1 Register		1	0	0	0	0	16
17	Overwrite Group 2 Register	Functions using the W lines	1	0	0	0	1	17
18	Selective Set Group 1 Register		1	0	0	1	0	18
19	Selective Set Group 2 Register		1	0	0	1	1	19
20	Non-standard		1	0	1	0	0	20
21	Selective Clear Group 1 Register		1	0	1	0	1	21
22	Non-standard		1	0	1	1	0	22
23	Selective Clear Group 2 Register		1	0	1	1	1	23
24	Disable		1	1	0	0	0	24
25	Execute	Functions not using the R or W lines	1	1	0	0	1	25
26	Enable		1	1	0	1	0	26
27	Test Status		1	1	0	1	1	27
28	Non-standard		1	1	1	0	0	28
29	Reserved		1	1	1	0	1	29
30	Non-standard		1	1	1	1	0	30
31	Reserved		1	1	1	1	1	31

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