NBS TECHNICAL NOTE 790

MIDAS
Modular Interactive Data Acquisition System— Description and Specification

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MIDAS Modular Interactive Data Acquisition System— Description and Specification

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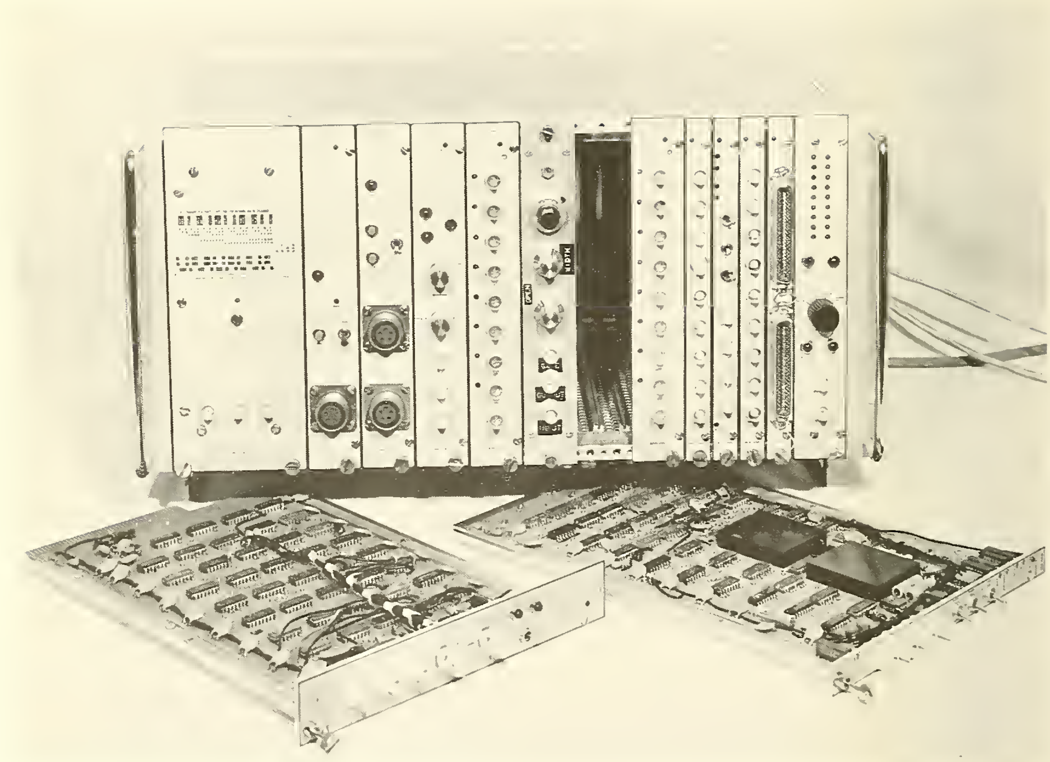

Figure 1. MIDAS System consisting of a crate, power supply and a number of single- and double-width modules. The system controller occupies the rightmost slot position.

MIDAS
Modular Interactive Data Acquisition System
Description and Specification

*Charles H. Popenoe and Mack S. Campbell**

The task of interfacing experiments to computers and data-logging systems should be made as painless as possible for the scientist. With this intent, MIDAS, a user-oriented, modular digital interface system based on CAMAC hardware and USASCII-bus data communication has been developed. MIDAS modules enable the experimenter to set up, program, modify and operate automated or computer-controlled experiments independently of the experts. Salient features of the concept are described and operating configurations discussed both with and without computer control. System interface requirements are specified in sufficient detail to enable one skilled in the art to design and construct modules operable within a MIDAS system.

Key words: Computer-controlled experiment; computer interfacing; data acquisition system; digital interface; instrumentation; laboratory automation; MIDAS; programmable controller.

1. Introduction

Historically, laboratory automation has followed two patterns -- either a hard-wired dedicated system has been designed to accomplish a specific function efficiently, or a digital computer has been interfaced to laboratory instruments and then laboriously programmed in assembly language to perform somewhat more flexibly one or a number of jobs. The first approach unquestionably leads to an efficient but very inflexible system which performs the specified task well. However, requirements in research laboratories continually change, which sometimes leads to scrapping very expensive systems that will no longer satisfy current needs. The computer approach on the other hand, is a marvelous one for a well-financed, well-staffed establishment with the necessary expertise in minicomputer programming and digital interfacing techniques. Lacking this expertise, the experimenter is forced to either divert time from his research functions to gain education in these fields or alternatively, to employ the services of experts who will supply him with the system that he thinks he wants at the time of

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specification. The latter leads to a situation where the experimenter does not really understand the system and is therefore not capable of making small changes without again bringing in the experts. Neither of these approaches supplies the user with what he really needs -- a ready-to-run universal interface to computers and instruments from any manufacturer which he may plug together quickly himself as easily as he might plug probes and plug-ins into his familiar oscilloscope; and which he may then program, run, modify and reprogram on the spot until his experiment is running to his complete satisfaction.

The decreasing cost and size of integrated circuit logic has recently made possible data acquisition and control systems which may operate independently of a computer, yet have many of the attributes of computer-based systems. These relatively new "programmable" systems are generally modular in concept and programmable by "software" techniques, employing easily changed program storage such as paper tape, magnetic tape or punched cards. Such systems must necessarily sacrifice some of the extreme flexibility and high speed attainable with a machine-language programmed computer in exchange for simplicity of operation and ease of programming. This exchange is effected by increasing the complexity of hardware logic to assume functions once accomplished by sophisticated computer programming. Hardware costs have, however, been shown to be small or insignificant when compared to the labor involved in "bringing-up" a complex system. We can well afford to spend a few extra dollars on logic hardware if by doing so we may save a few minutes of an inexperienced user's time in programming or using the resulting system.

We have developed a new system with the acronym MIDAS, which we believe will alleviate many of the present experiment-automation difficulties. MIDAS is a user-oriented, modular, programmable digital interface system based on CAMAC hardware and on USASCII-bus communication between modules. It has been designed with the idea of making the task of interfacing instruments, experiments, computers and data-recording devices as painless as possible for the scientist-user.

The MIDAS concept is based on two strong beliefs. The first is that a good universal automation system should have enough capability to handle perhaps 80% of experimental situations without reliance upon a computer. Computers should properly be reserved for functions that computers do best -- high-speed computation and decision-making. To use a computer for data acquisition and sequential control is "over-kill". When these computer attributes are required, however, the same system which has been running stand-alone must be able to be quickly plugged into and indeed be controlled completely by a computer, whether it be a local minicomputer or a remotely accessed time-shared facility. It is important that the systems be upgradable in a rational manner through a series of easy transitions ranging from the simplest stand-alone data recording system up through a full parallel multi-instrument complex operating at computer speeds.

The second strong belief underpinning MIDAS philosophy is that somebody must be able to configure and modify conveniently both hardware and software of every automation system. It is most efficient that this person be the experimenter himself (noting the exception of very large systems) provided that he can do so conveniently without having to learn disciplines such as assembly language computer programming or digital electronics, which are most probably unrelated to his specialty.

We do not wish to imply that MIDAS can or should be applied to all situations -- it provides no advantage to very large, very small or very fast experiments. MIDAS was designed to apply to situations requiring moderate capabilities, where less than state-of-the-art performance is acceptable, but where cost, setup time and versatility are of great importance.

In short, MIDAS is meant to be a convenient do-it-yourself automation tool for the experimental scientist. In this respect MIDAS follows in the tradition established by the creators of OMNITAB* -- that perhaps the best way to help a large number of people with a large need is to make it very easy for them to help themselves.

1.1 Purpose of this Document

This report is intended to accomplish three purposes. First of all, it serves to provide an intorduction to the overall philosophy and functional characteristics of the MIDAS concept. By reading only Sections 1 through 4, an interested person may learn enough about the salient features of MIDAS and how MIDAS is applied to determine whether or not the MIDAS approach would be preferable to some other digital interface standard, such as CAMAC, in the light of his particular requirements and capabilities. Second, this report serves to document and specify the architecture, organization and electrical and mechanical standards of the MIDAS system, thus placing these standards and design concepts in the public domain. We have intentionally attempted to avoid unnecessary overspecification which would tend to lock the design of MIDAS components to a particular detail design or logic family. Third, the report is intended to provide sufficient detailed information to allow anyone skilled in the techniques of digital logic design to design and construct modules and controllers which will operate in MIDAS systems together with components designed by others. The information necessary to ensure this compatibility is found in the latter half of the document -- Sections 5 through 9 including the Tables and Appendix.

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*NBS Handbook 101, "OMNITAB, A Computer Program for Statistical and Numerical Analysis", J. Hilsenrath, G. G. Ziegler, C. G. Messina, P. J. Walsh and R. J. Herbold.

2. Basic Features and Terminology* of the MIDAS System

(a) MIDAS is a user-oriented digital interface system for laboratory data acquisition and experiment control, based on a building-block or "modular" construction. It is composed of a number of unit functional "modules" which may be plugged into "slots" in a standard "crate" which provides power and interconnections between modules to create more powerful and complex equipment assemblies. Each module is in itself a complete independent functional unit, and when plugged into the crate is able to communicate bidirectionally with other modules plugged into the same crate or other interconnected crates. A crate, and a number of such intercommunicating modules together with a "program source" for issuing "commands" to the modules and possibly a "recording device" for recording data and results form a complete "system".

(b) MIDAS is physically and mechanically based on CAMAC hardware and dimensions [1][1]. MIDAS and CAMAC hardware and crates are physically interchangeable but are not necessarily electrically compatible, due to differences in operating philosophy.

(c) Individual modules make connection to a standard CAMAC "dataway" through 86-way connectors mounted at the rear of the crate. The dataway provides common bussing of digital data, commands, control signals and power to the modules.

(d) MIDAS is a "programmable" system. A module will become "active" or perform a function in response to a command present on the dataway. A logical sequence of commands forms a "program". All commands and data are transferred between modules in standard 7-bit parallel USASCII code format [2]. A module may issue commands to or receive data from any other module, or any device external to the system which communicates in USASCII code.

(e) The rightmost two slots in the crate are unique and are occupied by the "System Controller". The System

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*In the interest of clarity, MIDAS terminology is enclosed in quotation marks when first introduced.

[1]Figures in brackets indicate the literature references at the end of this paper.

Controller performs in-crate housekeeping functions; decoding system commands and slot "addresses", activating slot positions and generating timing and control signals. In addition, the System Controller serves as an interface between MIDAS modules and external recording devices and program sources, performing serial-parallel and parallel-serial conversions where necessary.

(f) MIDAS is intended to be used extensively without requirement for an external computer as a "stand-alone" data acquisition and control system. In its simplest configuration, a low-cost teletypewriter ("TTY") serves as both program source and recording device. The TTY keyboard and paper tape reader are used to issue commands to the system, while data is recorded permanently on the teleprinter and paper tape punch. Hence, the Basic System Controller interfaces directly with a 20 ma current-loop TTY operating serially in the full-duplex mode. Similarly, it will interface directly to a CRT terminal, or when computer control is desired, will interface to minicomputers and telephone couplers (time-shared computers) which are TTY-compatible.

(g) There is no inherent limitation to the operating speed of the MIDAS system other than the limitation imposed by backplane transmission characteristics. The modules will operate at the speed of the program source, which may range from 10 characters (commands) per second for the slowest serial teletypewriters up to data rates approaching one megahertz for bit-parallel commands issued by a minicomputer. Recorded data must naturally be transferred at the operating rate of the recording device. It is the function of the System Controller to synchronize transfer of data and commands between the MIDAS modules and an external program source or recording device.

(h) MIDAS is not intended to compete with or supplant CAMAC; rather, it was developed to fill a void existing between NIM and CAMAC not serviced by either concept. MIDAS is for digital data acquisition and control situations of moderate complexity, where cost, flexibility and ease of programming are paramount, and where computer control is only an option. It is intended to be used as a general-purpose laboratory instrument to perform many and varied tasks during its lifetime.

3. Operating Configurations and Upgradability

Although MIDAS has been optimized for self-contained "stand-alone" applications where computer control is not required, the system may be upgraded through a series of easy transitions to more complex closed-loop operation under control of a local or remote computer. In most cases the transition involves only plugging in an appropriate cable, and at most, a different module. Several examples of possible operating configuration follow:

3.1 Stand-alone System - Teletypewriter Control

The simplest MIDAS configuration consists of only a crate with necessary modules connected through a Basic System Controller to an unmodified teletypewriter through the standard serial data current-loop connection, with the teletypewriter wired for 20 ma full-duplex operation (fig. 2). This mode of operation employs the teletypewriter keyboard, paper tape reader and answer-back drum for programming the system, and the teletypewriter printer and tape punch are used for recording the data in a format controlled by the program. Operating rate of the system is, of course, limited and determined by the rate of the teletypewriter, generally 10-30 characters (commands) per second. This rate is sufficient for a surprising number of experimental situations, especially those involving appreciable settling times such as are encountered in photometry or calorimetry, or involving very precise measurements which normally require a period of the order of one second to digitize the analog signal.

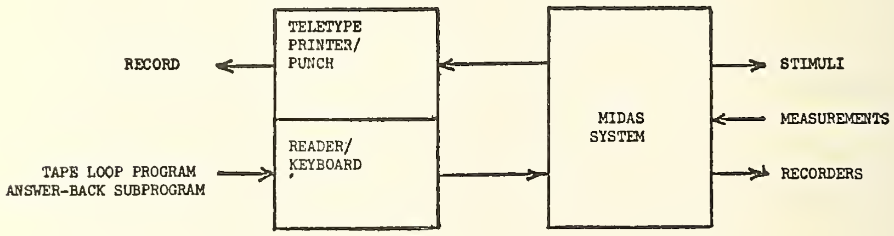


Figure 2. Simplest Stand-alone MIDAS System

The program command sequence is punched into paper tape from the keyboard with the teletypewriter in the LOCAL mode. The program tape is then loaded into the tape reader and, if the program is repetitive, may be formed into a continuous loop. Control may be transferred from the main program in the tape reader to a subprogram coded into the answer-back drum, or the program may halt and request input from the keyboard, but it is a requirement of this simplest configuration that the program must be sequential.

3.2 Stand-alone System - Programming Module Control with Teletypewriter Output

The second level of sophistication reached by a stand-alone system eliminates the teletypewriter tape reader and answer-back drum as the program source, employing instead a special "Programming Module" to store the program and issue commands to the system (fig. 3). The teletypewriter is now used solely for entering manual commands and recording the output data during an experiment. This greatly eases wear on electro-mechanical components of the teletypewriter and frees the system from the limitation of running at teletypewriter speeds, except when output is required. The Programming Module is loaded by entering a command sequence from the teletypewriter keyboard or reader. This program is stored in a small memory and may be run by transferring control to the Programming Module by keyboard or tape command. The program stored in the memory of the Programming Module need not be entirely sequential, but may consist of a main program and a number of subprograms which may be accessed by a "jump" command. Some closed-loop operation may be incorporated into the program, such as conditional jumps to subroutines dependent on the state of input lines from the experiment. This form of operation simulates closely a computer-controlled system except for the lack of computational capability.

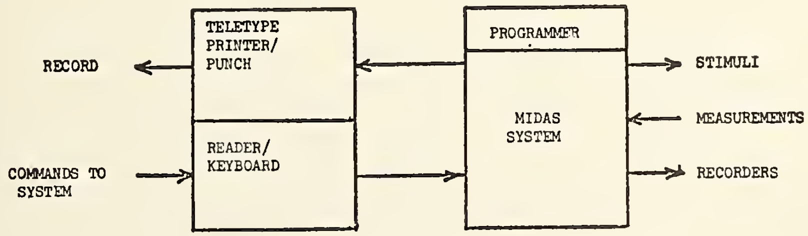


Figure 3. Stand-alone MIDAS System controlled by Programmer or Computer Module.

More sophisticated Programming Modules may be designed to further narrow the distinction between stand-alone and computer-controlled MIDAS configurations. There is no reason why Programming Modules should not have decimal computation capability with conditional jumps dependent on arithmetical or logical comparisons. A MIDAS system operating at this level approximates a special-purpose computer, with the program potential limited only by the imagination of the module designer and experiment programmer. The major disadvantage of this configuration is that programming of computational code is bound to be somewhat onerous due to limitations imposed by the simplicity of such a "computing module" when compared to a true computer. Since all computation must be "microprogrammed" in machine code, it would presumably be limited to simple tasks such as summing, averaging, scaling or arithmetical comparisons.

3.3 Computer-Controlled System - Remote Time-Shared Computer

When the decision has been made to go to computer control, it may be obtained via the nearest telephone. Figure 4 illustrates schematically this form of operation. Notice that the MIDAS system is interposed between the telephone coupler and the remote terminal, and once again, the operating speed of the system is determined by the teletypewriter (or other) terminal.

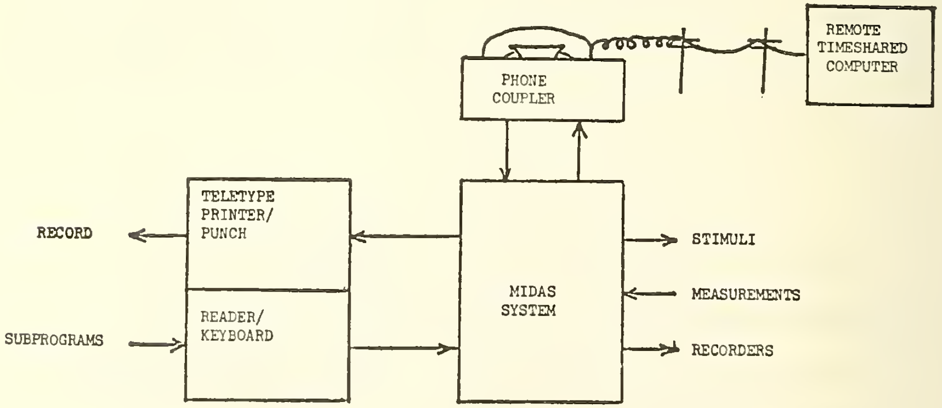


Figure 4. MIDAS System Controlled by Remote Time-shared Computer

There are a number of major advantages inherent in this configuration. First, the extra investment required is quite small when computer control is only occasionally required -- the system is operated as a stand-alone (sec. 3.1) configuration the majority of the time. Second, this configuration is quite portable and may be used in turn to control several experiments either stand-alone or under computer supervision. Sharing the system would be more difficult if the computer and associated peripherals would have to be moved along with the MIDAS hardware. Third, it allows great programming simplicity, since it is now possible to program both commands to MIDAS and sophisticated computations in an easy-to-use, higher-level language such as BASIC or interactive FORTRAN. These languages are universally available and are already familiar to a large segment of the research community. Fourth, the experimenter may also take advantage of all of the benefits of a large computer -- program storage, large data file storage, editing facilities, adequate user core, and possibly high-speed input/output peripherals.

The disadvantages encountered in using a remote time-shared computer for control are minimal; continuous operation over long periods can run up sizeable computer bills, and one is, of course, limited to the operating speed of the terminal and timesharing system, although some systems can operate at several different data transmission rates. There is an additional uncertainty inherent in the response time of a timesharing system -- when heavily loaded, the computer may take several seconds to respond to output from MIDAS. If operating speed is critical, this configuration may seem intolerably slow under peak load conditions.

3.4 Minicomputer Controlled System - Serial Communication at Normal Data Rate

The MIDAS equipment may be plugged in directly into the teletypewriter port of a minicomputer with no additional interfacing, as minicomputers almost invariably have provision for teletypewriter input/output on a 20 ma current loop interface. Once again the MIDAS system is simply placed in between the computer and the teletypewriter, as shown schematically in figure 5. The operating speed is determined by the teletypewriter speed, generally 10 characters per second. However, the system may now be operated fully closed-loop and programmed in a higher-level language such as BASIC. BASIC is available on a number of minicomputers and will run short programs with only 4 K words of core memory. The advantages offered by operating in this configuration include rapid and interactive program generation, debugging and modification, with provision for considerable amounts of computation. A MIDAS system operating through the TTY port functions as a universal interface from any minicomputer to almost any instrument, facilitating expansion or modification of the system or program to suit the changing requirements of the experimenter.

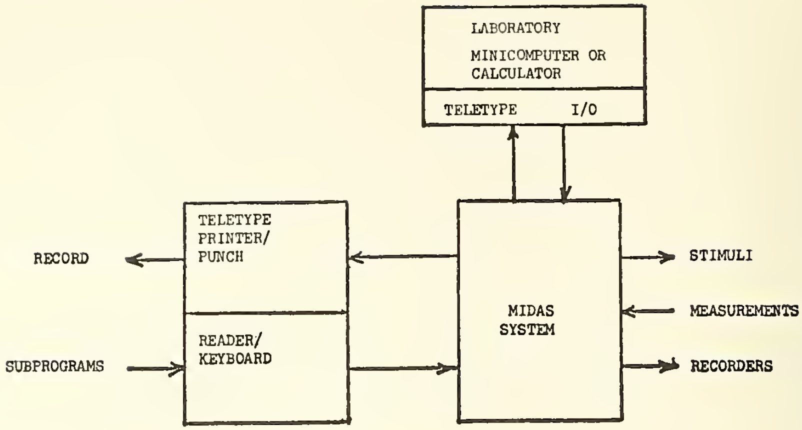


Figure 5. MIDAS System Controlled by Local Minicomputer.

3.5 Minicomputer Controlled System - Serial Communication at High Data Rate

If higher operating speeds are required, the MIDAS system may be plugged into a second teletypewriter interface with the teletypewriter plugged into the customary TTY interface (fig. 6). The clock rate of the second interface may be adjusted to run at any desired rate up to at least 9600 baud. Data and commands are still transmitted by serial start-stop codes, but in this configuration operation proceeds at nearly 100 times normal teletypewriter speeds. The teletypewriter is used to communicate with the computer program, which may again be written in BASIC or equivalent. It is necessary to modify the BASIC system program slightly to provide for additional commands which address the second teletypewriter interface as an additional peripheral device of the computer having an independent device number. In this way, communication with the teletypewriter may occur at teletypewriter rate while MIDAS may communicate with the same BASIC program at a much higher rate. After reduction of the data brought in through MIDAS, the results may be printed on the teleprinter at low speeds.

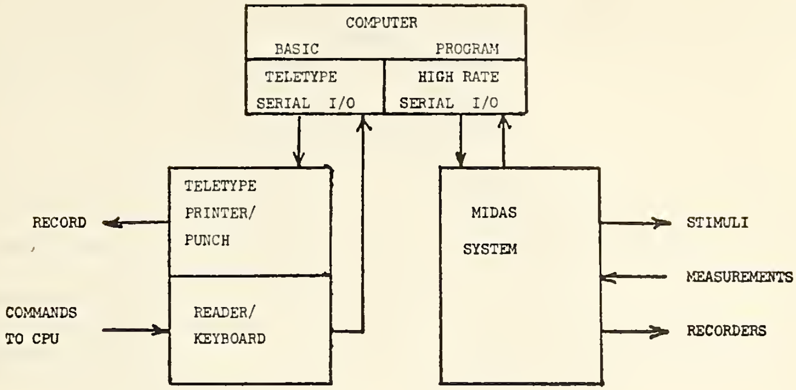


Figure 6. MIDAS System Operated Serially through High-Speed Interface.

3.6 Minicomputer Controlled System - Parallel Communication

The ultimate speed of operation may be realized by employing parallel data and command transfer between the computer and the MIDAS system. The Basic System Controller is designed primarily for serial communication; therefore a Parallel System Controller is required to interface with the minicomputers parallel I/O bus. This controller may be considerably less complex than the Basic System Controller due to the reduced need for timing and serial-to-parallel conversion functions. A system operating in this configuration is shown in figure 7 which enables MIDAS to be operated at computer speeds. The penalty paid for parallel operation lies in the increased difficulty in programming the system, as parallel data transfer must be programmed in machine or assembly language. It is possible with BASIC interpreters offered by several minicomputer manufacturers to write machine-language subprograms that may be called from a BASIC main program to transmit commands to MIDAS or to input data into the computer through the MIDAS system. Using this technique, complex calculations could still be performed entirely in BASIC, but commands to MIDAS would take the form of CALL subroutines using the USASCII command as the calling parameter.

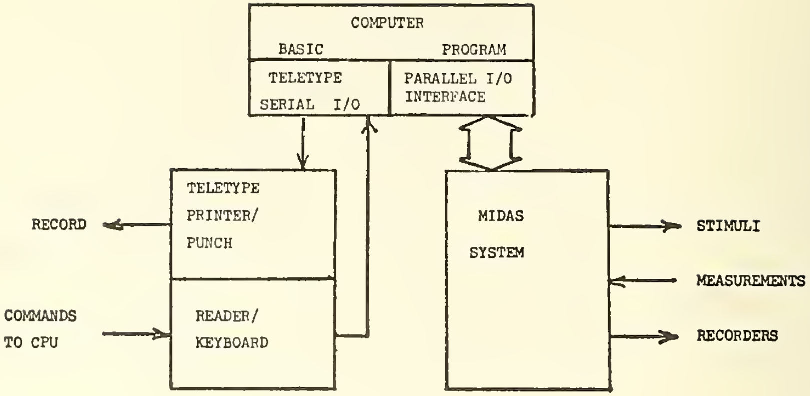


Figure 7. MIDAS System Operated from Parallel Computer I/O Interface.

One possible implementation of this configuration would employ a single universal Parallel System Controller and a number of separate interface cards designed to interface to specific computers. The alternative is to have an individual Parallel System Controller designed to interface directly by cable and plug to the I/O bus of each desired specific minicomputer family.

4. Mechanical Characteristics

The mechanical characteristics and dimensions of the modules and crate are entirely according to CAMAC specifications [1]. Excerpts from this document containing descriptions and details of the CAMAC mechanical specification are reproduced here in the Appendix; therefore the discussion of this section will be concise. MIDAS modules are constructed in CAMAC "plug-in unit" hardware -- there is no physical difference between these units and indeed, MIDAS modules could be operated in a CAMAC system with the proper programming. In addition, MIDAS systems may be operated in standard CAMAC crates. Standard CAMAC crates, however, have provision for 25 slots or "stations", somewhat more than may be addressed by a MIDAS system, which is limited to 16 slots. It is economically expeditious to construct special crates for MIDAS to CAMAC specifications, but with 16 instead of 25 slots, effecting some savings in cost. The crate pictured in figure 1 has 16 slots, eight of which are single-width, and 8 of which are double-width. The remaining slot position (No. 25), has a special connector to which a plug-in Power Supply makes connection when plugged into the crate. This particular power supply has quintuple-width dimensions, and when inserted into position, renders 2 double-width slots inaccessible. These slots may be recovered if necessary by mounting the unit outboard of the crate and making connections by cable.

5. Dataway and Bus Assignments

The dataway consists of a number of conductors interconnecting the modules with each other and with the control module. Each slot position is terminated with an 86-pin etched-circuit type connector [1] which mates to the etched-circuit extension at the rear of each module. The connectors are supported and interconnected by means of the "backplane", which may be either of etched circuit construction or wire-wrap construction, or a combination of the two. The backplane consists of the dataway, connectors and optional patch pins. All digital communication occurs along "bus-lines" connecting corresponding pins together at all slot positions along the dataway.

Two slot positions at the extreme right-hand side of the crate are reserved for the use of the System Controller. The rightmost slot is unique, having connections to all individual slot positions, but not having access to the data bus-lines. The second slot position from the right is normal in all respects but as with CAMAC, is reserved for the use of the controller. The remaining 14 slot positions are available for use by any module.

Additional bus-lines bring power to all slot positions, and provide power-return and "clean ground" bussing throughout the crate. There are five uncommitted contacts at each slot position. Two of these are "free bus-lines" and are connected across all normal slot positions. The remaining three are "patch-points" and may be employed arbitrarily to establish nonstandard interconnections at the user's option.

So far, the backplane and dataway layout have followed the CAMAC specification exactly. The use of the various bus-lines and MIDAS signal assignments do not necessarily follow the CAMAC usage; however, for comparison, CAMAC pin assignments may be found in the Appendix and reference 1. MIDAS pin assignments are detailed in table 1 for "normal" module slots, and in table 2 for the Controller position. It is seen that although many of the functions are identical, differences in operating philosophy preclude a one-to-one correspondence between the two systems.

6. System Controller

While the individual modules provide interfacing between external instruments or devices to be monitored and controlled and the MIDAS system, the System Controller provides the interface between programming and recording devices and the system, and is necessary for directing communication between modules. It may indeed be considered to be the nerve center of the system, being the only module having access to all lines and busses on the backplane. The architecture of the MIDAS system may best be understood by reference to figure 8, in which the general functions of the System Controller are schematically outlined. Specific minimum functional requirements of the System Controller are described below.

6.1 Dataway Terminations

All dataway busses are "wired-or" logic driven by open collector drivers in the modules. The System Controller must terminate all busses with approximately 3 k ohms to +5 V.

6.2 System Initialization and Reset

The System Controller is responsible for generating a bus signal upon initial application of power to the system. This initialization may also optionally be generated by system command or manual switch closure.

6.3 Slot Addresses

Slot addresses are decoded by the controller corresponding to the system commands A through O. These are used to activate the proper line to the addressed module, enabling it to respond to succeeding commands on the Command bus. System Commands to accomplish simultaneous addressing of two or more modules must be decoded and interpreted by the controller.

6.4 Code Conversion

All commands placed onto the command bus and data received from the data bus are in 7-bit parallel ASCII code. The controller must perform any conversions necessary to interface with external programming and recording devices which use other codes. Similarly, serial-to-parallel and parallel-to-serial conversions are performed in the controller when required to interface with serial input/output devices.

6.5 Strobes

The controller must generate strobes for each command directed to modules. These strobes are to be generated only when the logic lines have settled sufficiently to produce a valid command character and correct parity is established.

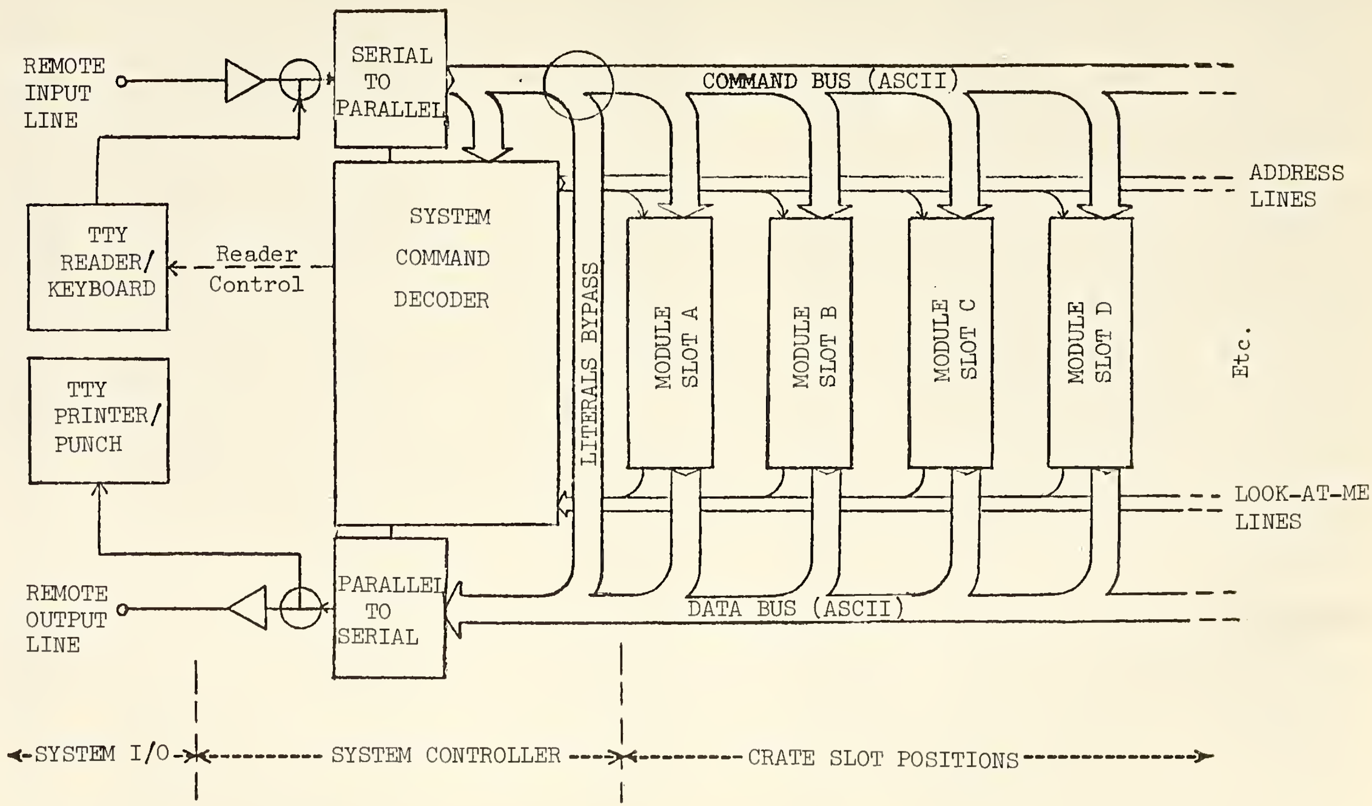


Figure 8. MIDAS System -- Functional Block Diagram

6.6 Synchronization

The controller must synchronize all data and command transfer between system modules and programming/recording devices. Transfer must be in full-duplex mode since there is no general limitation on simultaneous transmission and reception by the modules. A signal is generated by the controller to inform any module wishing to transmit data that the controller is busy and cannot receive. This signal may be used to synchronize the transfer of strings of characters from the modules. When a module has finished its transmission of a string of data, it generates another signal to inform the controller of this condition.

If it is required that the programming device be temporarily halted to allow completion of a module operation before resumption of the program command sequence, the controller must recognize system commands to enable the "waiting" function, and must respond to a completion signal from the module to restart the programming device.

The controller must clear the command bus and relinquish control over the system when a signal from an alternate programming device is present. It will, however, continue to transmit data to the recording device as dictated by the data strobe.

6.7 Inhibit

An additional responsibility of the controller is to generate an "inhibit" bus signal which inhibits sequencing of the programming device and halts all in-progress operations in the modules. A front panel connector must be available to allow a signal to be brought in from the outside world to inhibit system operation.

7. Command Structure

7.1 USASCII-7 Command Set

There are 256 possible code combinations formable using all eight bits of the USASCII-8 code, X3.4-1967 [2]. Unfortunately, the complete USASCII-8 code set is able to be utilized on only a very few types of equipment. Additionally, there are obvious advantages to using the eighth bit of an 8-bit code to provide a capability to check parity. Such practical considerations lead to the limitation of the valid code combinations for MIDAS to the lower-order 7 bits, the widely-used USASCII-7 code, consisting of 128 possible characters. The only character which is inherently unusable as a MIDAS command character is the rubout character "DEL" (octal 177), since it must be blocked from the system to allow correction of program tapes and to provide a code signifying "no-operation".

Of the USASCII-7 code, 32 characters (octal 000 through 037) represent control functions and are therefore non-printing. The lower-case font (octal 140-176) is unusable on many devices including less-expensive teletypewriters. These characters are all potentially usable as commands to MIDAS equipment, and as such are not excluded from the possible command set. It is strongly recommended, however, that only the printing characters (octal 40 through 137) be used as program commands, since programs composed of this set may be listed on the teletypewriter for program verification and debugging.

7.2 System Commands

Of the printing character set, 32 characters are reserved for MIDAS system commands and are interpreted by the System Controller. The reserved set includes the punctuation marks from octal 40 through 57 and the characters octal 100 through 117. The latter group includes the alphabetical letters A through O which designate the slot addresses. The use of the remaining system commands is arbitrary and is left to the discretion of the controller designer. The reserved System Commands and their octal representations are listed below:

Octal	Character	Octal	Character
40	Space	100	@
41	!	101	A
42	"	102	B
43	#	103	C
44	$	104	D
45	%	105	E
46	&	106	F
47	'	107	G
50	(	110	H
51	)	111	I
52	*	112	J
53	+	113	K
54	,	114	L
55	-	115	M
56	.	116	N
57	/	117	O

7.3 Module Commands

The remaining 96 characters not reserved above are usable by module designers as commands to modules, subject to the previous recommendation that only printing characters be selected when possible.

8. System Signals and Timing

8.1 Dataway System Lines

A number of dataway lines are reserved for system-required functions. The application, requirements and timing of these signals are discussed in the following sections. In all cases the dataway busses use "wired-or" logic; therefore all bus signals present on the dataway are negative-true (3.5-5 volts = logical "0"; 0-.5 volts = logical "1").

(a) CMMD (COMMAND MODE) is generated by the System Controller and indicates to all modules that the system is in the "COMMAND" mode -- that all character codes present on the Command bus are to be interpreted as commands. The CMMD signal additionally indicates that the Data bus is not being used by the controller and is therefore free to be used by the modules.

(b) CONTB (CONTROLLER BUSY) is generated by the System Controller at any time when the Controller is unable to respond to a data strobe (DATAS) generated by a module. It is present during the time required for the controller to transmit a character to, say, the teleprinter. The trailing edge of CONTB indicates that the controller is ready to accept a new data character from a module.

(c) ALT CONT (ALTERNATE CONTROLLER) is generated by a module desiring to take over system control. It disables the normal System Controller, and prevents it from responding to MODD signals. Upon receipt of this signal, the System Controller clears the Command bus and relinquishes control to the module generating the signal, after which the alternate controlling module may place characters on the Command bus.

(d) IDSC (INHIBIT DATASTROBE TO CONTROLLER) is generated by a module when communicating data between modules. IDSC prevents the System Controller from responding to DATAS. Thus, a module would generate this signal whenever it wished to place data on the Data bus which was not intended for an action by the System Controller such as output of that character on the teleprinter.

(e) DATAS (DATA STROBE) is generated by a module when data on the Data bus is valid and may be transferred. Lines of the Data bus must be stable for at least 100 ns prior to the leading edge of DATAS. Pulse width may vary with system operating rate but must not be shorter than 1 μs nor longer than strobe S2.

(f) MODB (MODULE BUSY) is generated by a module in response to addressing that module with ADDR, to indicate that the addressed module is still busy performing an operation initiated by a previous command and is therefore incapable of receiving new commands.

(g) MODD (MODULE DONE) is a pulse generated by a module upon completion of a module operation. It may be used to restart system operations following a pause initiated by a WAIT command. The pulse width must lie between 1 and 10 μs, and the leading edge of MODD must be delayed at least 1 μs after the leading edge of strobe S1.

(h) MODEOT (MODULE END-OF-TRANSMISSION) is generated by a module having the capability of transmitting a variable-length string of data characters in response to a single command. After all characters in the data string have been transmitted, the module activates the MODEOT bus to notify the controller that the transmission is complete. The controller uses this information to synchronize and interlock communications with the programming device, recording devices, and/or remote lines.

(i) INH (INHIBIT) may be generated by modules, System Controller or devices external to the system. It is normally used to provide a fail-safe interlock capability in standalone systems, and interrupts all activity if a limit in the external experiment has been exceeded. The INH line going low causes action to both System Controller and modules. The System Controller must be inhibited from placing further commands on the Command bus, and the programming device interrupted. All modules having an operation in process as a result of previous commands must cease activity until the condition causing actuation of the INH line has been corrected.

(j) S1 (STROBE 1) indicates that data on the Command bus is valid and may be transferred. Lines comprising the Command bus must be stable for at least 100 ns prior to the leading edge of S1. The width of S1 may vary with operating rate but must not be shorter than 1 μs.

(k) S2 (STROBE 2) is identical to S1 except for timing. S2 immediately follows S1, having its leading edge coincident with the trailing edge of S1. The command bus lines must remain stable for a minimum of 100 ns following the trailing edge of S2. This strobe may be "turned around" by a module to strobe data onto the Data bus.

(*l*) ADDR (SLOT ADDRESS) is generated by the System Controller only. There is one ADDR line from the System Controller to each slot position. The ADDR signal is used to activate a module in the addressed slot position. There is no limitation to the number of slots which may be addressed simultaneously. The MODB line will go low in response to ADDR if an operation is in process in the addressed module. Modules have no access to ADDR lines other than their own, and most therefore go through the System Controller to address another module.

(m) LAM (LOOK-AT-ME) lines are counterparts to the ADDR lines but transfer signals in the opposite direction -- from modules to the System Controller. There is a LAM line from each slot position leading only to the controller slot position. A signal generated by a module placed on this line notifies the controller that the module requires attention. The LAM lines may thus be used as an interrupt network, giving capability to a MIDAS system run by an intelligent program source to jump to an interrupt routine to service the module requesting attention.

(n) INIT (INITIALIZE) will be present at system startup or system reset and must set all control registers and bistable elements to a defined state. It is generated by the System Controller.

(o) C1 - C18 (COMMAND BUS) consists of eighteen lines used to transfer commands from the System Controller to the modules. The least significant seven bits (C1-C7) are normally used as the MIDAS USACII-7 Command bus. The total number may be used during parallel command operations when used with a minicomputer.

(p) D1 - D18 (DATA BUS) consists of another eighteen lines reserved for transfer of data words from the modules. Again only lines D1-D7 are used for transferring USASCII-7 data characters. The full complement may be used for parallel data transfer to a minicomputer.

(q) 60 HZ (60 HERTZ CLOCK) is an ac line frequency 5-volt square wave generated by the System Controller and available on this bus-line for use by the modules for timing purposes.

(r) EARTH (ANALOG RETURN) is an isolated "clean" ground bus intended to be used by analog circuitry as the return line. This bus must be kept free from digital switching transients. It may be left isolated or tied to digital ground or earth ground at one point as required.

8.2 General Signal Standards

a. Voltage Levels of Dataway Signals

All dataway signals must conform to the following:

	"0" State	"1" State
Accepted at input	+2.0 to +5.5 v	0 to +0.8 v
Generated at output	+3.5 to +5.5 v	0 to +0.5 v

b. Rise and Fall Times

Rise and fall times of dataway signals shall not be faster than 40 ns to keep cross-coupling among dataway lines to a reasonable level.

c. Loading

(1) Address Lines (ADDR)

Maximum signal requirement:

0.4 ma at "0" state

-16 ma at "1" state.

(2) All Other Dataway Lines

Maximum signal requirement:

40 μa at "0" state

1.6 ma at "1" state.

d. Drive Capability

Dataway drivers shall be open-collector type capable of sinking at least 25 ma at 0.4 v maximum.

9. Power Supplies

Module designers may assume that three power supplies are available in a MIDAS crate. These are a +6 Vdc supply capable of supplying 10 or more amperes of well-regulated and filtered power for digital logic circuitry, and a positive and negative 12 Vdc supply for analog circuitry. The additional mandatory CAMAC supplies (-6 Vdc and ±24 Vdc) may be supplied if required for the particular installation or if it is planned to operate both CAMAC and MIDAS modules in the same crate, but are not specified or required for MIDAS systems.

It is optional whether the power supplies are mounted at the rear of the crate or constructed in modular plug-in form and inserted from the front of the crate as is done in the system shown in figure 1.

The minimum power supply specifications are outlined below:

	Logic Supply	Analog Supplies
Voltage:	+6 Vdc ±1%	±12 Vdc ±1%
Current Output:	10 amp @45°C	1 amp each @45°C
Input:	105-120 Vac, 60 Hz	105-120 Vac, 60 Hz
Regulation:	0.25% line and load	0.25% line and load
Ripple:	less than 10 mv p-p	less than 10 mv p-p
Overvoltage:	6.5 V crowbar	

10. References

[1] "CAMAC: A Modular Instrumentation System for Data Handling; Revised Description and Specification", USAEC TID-25875, (July 1972).

[2] Little, John L., "Some Evolving Conventions and Standards for Character Information Coded in Six, Seven, and Eight Bits", Nat. Bur. Stand. (U.S.) Tech. Note 478, (May 1969).

TABLE I

MIDAS CONNECTOR PIN ASSIGNMENTS -
NORMAL SLOT VIEWED FROM FRONT OF CRATE
ALL DATAWAY SIGNALS ARE NEGATIVE-TRUE

	MIDAS DESIGNATION	CAMAC DESIGNATION	PIN NO.	PIN NO.	CAMAC DESIGNATION	MIDAS DESIGNATION	
PATCH BUS	P1*	P1	44	43	B		
	P2*	P2	45	42	F16		
PATCH POINTS	P3	P3	46	41	F8		
	P4	P4	47	40	F4		
	P5	P5	48	39	F2		
		X	49	38	F1		
	INH*	I	50	37	A8		
		C	51	36	A4		
	ADDR	N	52	35	A2		
	LAM	L	53	34	A1		
STROBES	S1*	S1	54	33	Z	INIT*	
	S2*	S2	55	32	Q	MODB*	
	CONTB*	W24	56	31	W23	IDSC*	
	ALT CONT*	W22	57	30	W21		
	CMMD*	W20	58	29	W19		
COMMAND BUS	C18*	W18	59	28	W17	C17*	COMMAND BUS
	C16*	W16	60	27	W15	C15*	
	C14*	W14	61	26	W13	C13*	
	C12*	W12	62	25	W11	C11*	
	C10*	W10	63	24	W9	C9*	
	C8*	W8	64	23	W7	C7*	
	C6*	W6	65	22	W5	C5*	
	C4*	W4	66	21	W3	C3*	
	C2*	W2	67	20	W1	C1*	
	MODD*	R24	68	19	R23	DATAS*	
		R22	69	18	R21	MODEOT*	
		R20	70	17	R19		
DATA BUS	D18*	R18	71	16	R17	D17*	DATA BUS
	D16*	R16	72	15	R15	D15*	
	D14*	R14	73	14	R13	D13*	
	D12*	R12	74	13	R11	D11*	
	D10*	R10	75	12	R9	D9*	
	D8*	R8	76	11	R7	D7*	
	D6*	R6	77	10	R5	D5*	
	D4*	R4	78	9	R3	D3*	
	D2*	R2	79	8	R1	D1*	
POWER BUS	-12V*	-12	80	7	-24		POWER BUS
		+200	81	6	-6		
		ACL	82	5	ACN		
	60HZ*	Y1	83	4	E	EARTH*	
	+12V*	+12	84	3	+24		
		Y2	85	2	+6	+6V*	
	GND*	0	86	1	0	GND*	

*BUS-LINE SIGNALS

TABLE II

MIDAS CONNECTOR PIN ASSIGNMENTS -
CONTROLLER SLOT VIEWED FROM FRONT OF CRATE
ALL DATAWAY SIGNALS ARE NEGATIVE-TRUE

	MIDAS DESIGNATION	CAMAC DESIGNATION	PIN NO.	PIN NO.	CAMAC DESIGNATION	MIDAS DESIGNATION	
PATCH POINT	P1	P1	44	43	B		
	P2	P2	45	42	F16		
	P3	P3	46	41	F8		
	P4	P4	47	40	F4		
	P5	P5	48	39	F2		
		X	49	38	F1		
	INH*	I	50	37	A8		
		C	51	36	A4		
PATCH POINTS	P6	P6	52	35	A2		
	P7	P7	53	34	A1		
	S1*	S1	54	33	Z	INIT*	
	S2*	S2	55	32	Q	MODB*	
		L24	56	31	N24		
		L23	57	30	N23		
		L22	58	29	N22		
		L21	59	28	N21		
		L20	60	27	N20		
		L19	61	26	N19		
		L18	62	25	N18		
		L17	63	24	N17		
		L16	64	23	N16		
		L15	65	22	N15		
LOOK-AT-ME LINES (LAM)	O	L14	66	21	N14	O	SLOT ADDRESS LINES (ADDR)
	N	L13	67	20	N13	N	
	M	L12	68	19	N12	M	
	L	L11	69	18	N11	L	
	K	L10	70	17	N10	K	
	J	L9	71	16	N9	J	
	I	L8	72	15	N8	I	
	H	L7	73	14	N7	H	
	G	L6	74	13	N6	G	
	F	L5	75	12	N5	F	
	E	L4	76	11	N4	E	
	D	L3	77	10	N3	D	
	C	L2	78	9	N2	C	
	B	L1	79	8	N1	B	
POWER BUS	-12V*	-12	80	7	-24		POWER BUS
		+200	81	6	-6		
		ACL	82	5	ACN		
	60HZ*	Y1	83	4	E	EARTH*	
	+12V*	+12	84	3	+24		
		Y2	85	2	+6	+6V*	
	GND*	0	86	1	0	GND*	

*BUS-LINE SIGNALS

APPENDIX excerpted from **TID-25875**

To be used in conjunction with TID-25877

INSTRUMENTATION CATEGORY UC-37

CAMAC

A MODULAR INSTRUMENTATION SYSTEM *for* DATA HANDLING

Revised Description and Specification

Endorsed by

AEC NIM Committee

(AEC Committee on Nuclear Instrument Modules)

ABSTRACT

CAMAC is a digital data handling system in widespread use with on-line digital processors and computers. The system is based on a digital highway for data and control. Mechanical and signal standards are specified to ensure physical and operational compatibility between units from different sources. Except for pages i-vi, 46A and 46B, this report is identical to EURATOM Report EUR 4100e dated 1972. AEC Report TID-25877 constitutes a supplement to and is to be used in conjunction with this report. This revised specification introduces several new features but is consistent with the previous version (EUR 4100e, 1969).

The CAMAC system was specified by European laboratories through the ESONE Committee and has been endorsed by the U.S. AEC NIM Committee.

KEY WORDS

CAMAC
COMPUTER INTERFACING
CONTROL SYSTEMS
INSTRUMENTATION
INSTRUMENTATION STANDARDS
NUCLEAR INSTRUMENTATION
STANDARDS

REFERENCE AEC REPORTS

TID-25876 Branch Highway
TID-25877 Supplement

Edited for the NIM COMMITTEE
by Louis Costrell, NIM Committee Chairman
National Bureau of Standards

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 (2·56 + 2·54k) ±0·13.

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 1.

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
		W24	W23		
		W22	W21		
		W20	W19		
		W1B	W17		
24 Write Bus-lines		W16	W15		
		W14	W13		
W1 = least significant bit		W12	W11		
W24 = most significant bit		W10	W9		
		WB	W7		
		W6	W5		
		W4	W3		
		W2	W1		
		R24	R23		
		R22	R21		
		R20	R19		
		R1B	R17		
24 Read Bus-lines		R16	R15		
		R14	R13		
R1 = least significant bit		R12	R11		
R24 = most significant bit		R10	R9		
		RB	R7		
		R6	R5		
		R4	R3		
		R2	R1		
	-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)	

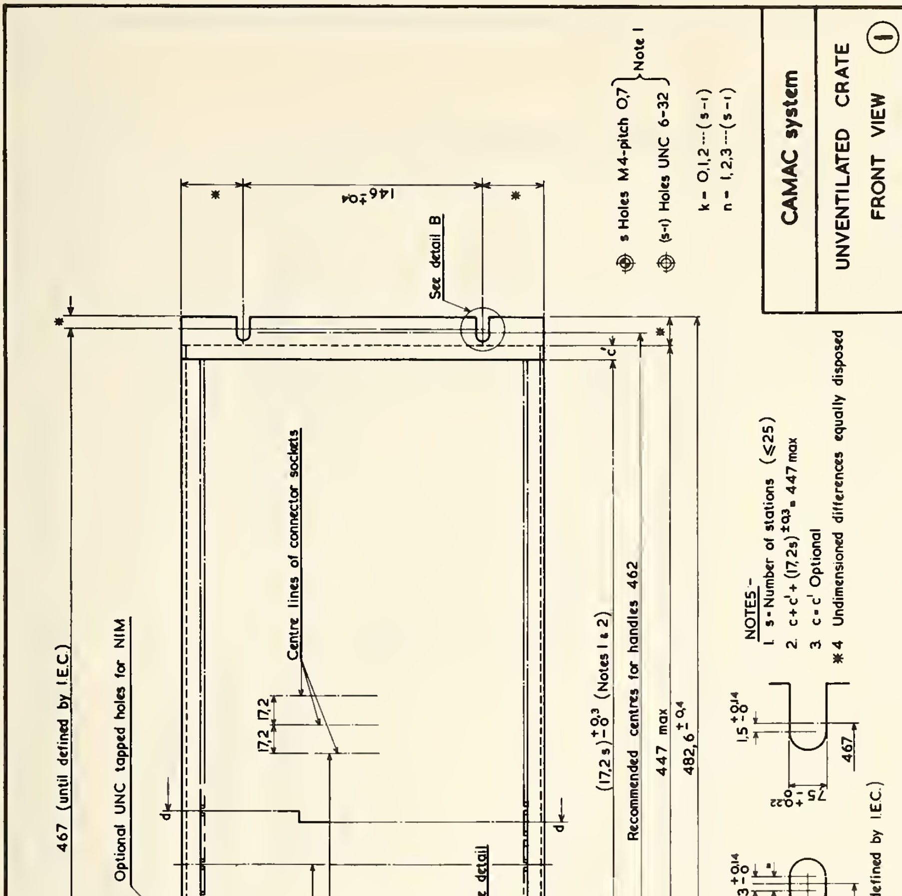
> The assignment of contacts at the Dataway connector and their connections to bus-lines, individual lines and patch contacts must be as shown in Table II for normal stations and Table III for the control station. The control station must be to the right of all normal stations.

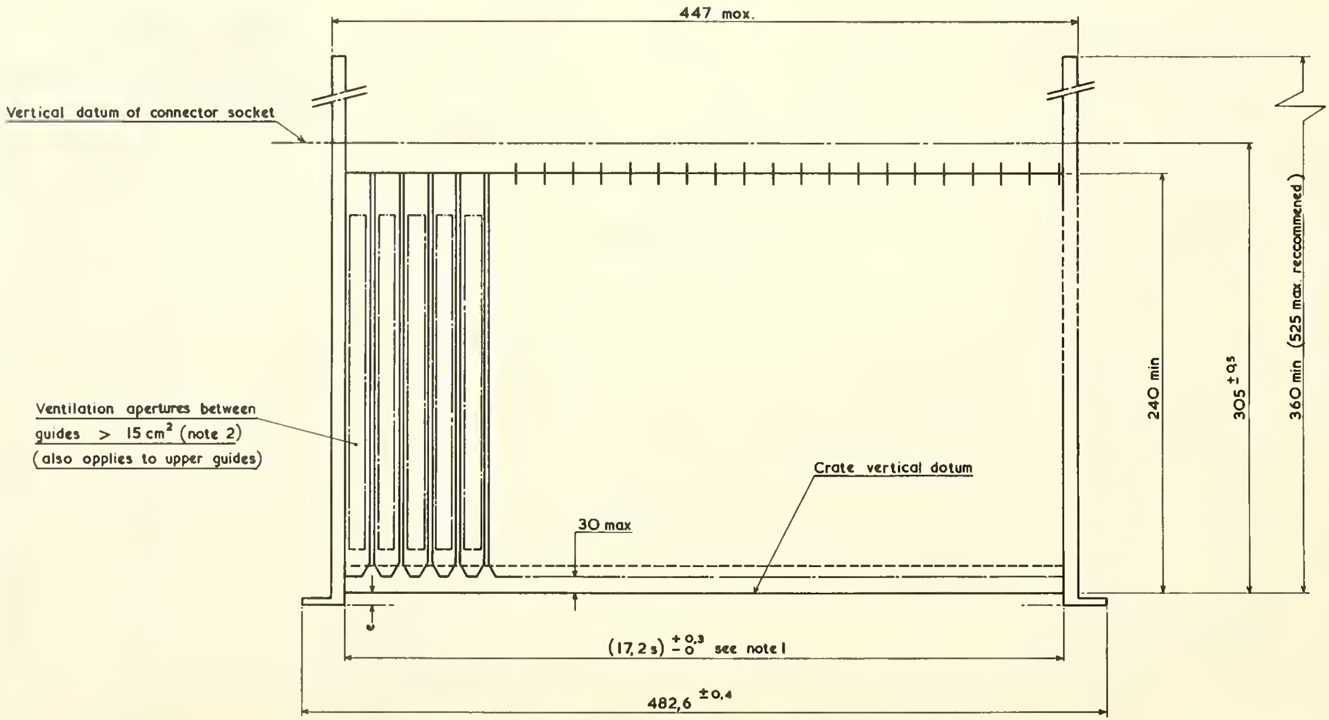
TABLE III CONTACT ALLOCATION AT THE CONTROL STATION

(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	AB	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		
		L1B	N1B		
		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		
		LB	NB		
		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).


CAMAC system
UNVENTILATED CRATE
FRONT VIEW
1
EUR 4100e ISSUE A MAY 1972
467 (until defined by I.E.C.)
Optional UNC tapped holes for NIM
Centre lines of connector sockets
See detail B
See detail
(17,2 s) +0,3 −0 (Notes 1 & 2)
Recommended centres for handles 462
447 max
482,6 +0,4
146 +0,4
s Holes M4-pitch 0,7
(s−1) Holes UNC 6-32
Note 1
k = 0,1,2 --- (s−1)
n = 1,2,3 --- (s−1)
NOTES:-
1 s = Number of stations (≤25)
2 c+c' + (17,2s) ±0,3 = 447 max
3 c = c' Optional
✱4 Undimensioned differences equally disposed
DETAIL B and alternative
(until defined by I.E.C.)
DETAIL A guide
221,5 +0,3
217,5 max
210,5
200,9 +0,7
4,8 +0,1
68,8 ±0,1
51,6 ±0,1
34,4 ±0,1
17,2 ±0,1
15,9 ±0,1
33,1 ±0,1
50,3 ±0,1
67,5 ±0,1
W ±0,1 17,2 n
X ±0,1 = 15,9 + 17,2 k
Y ±0,1 = 10,9 + 17,2 k
Z ±0,1 = 8,6 (2k+1)
68,8
60,2 ±0,1
51,6 ±0,1
43 ±0,1
34,4 ±0,1
25,8 ±0,1
17,2 ±0,1
8,6 ±0,1
17,2 17,2
2,6 ±0,1



NOTES

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

CAMAC system

PLAN VIEW OF LOWER GUIDES IN CRATE.

(2)

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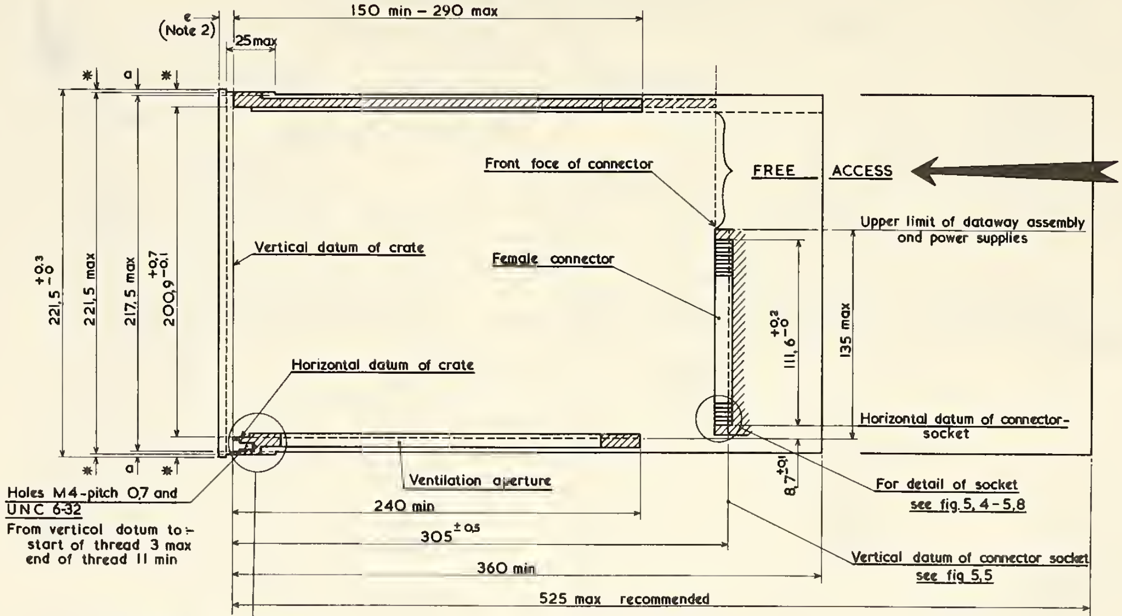

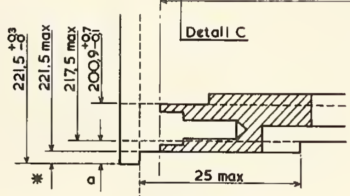

NOTES

✱ 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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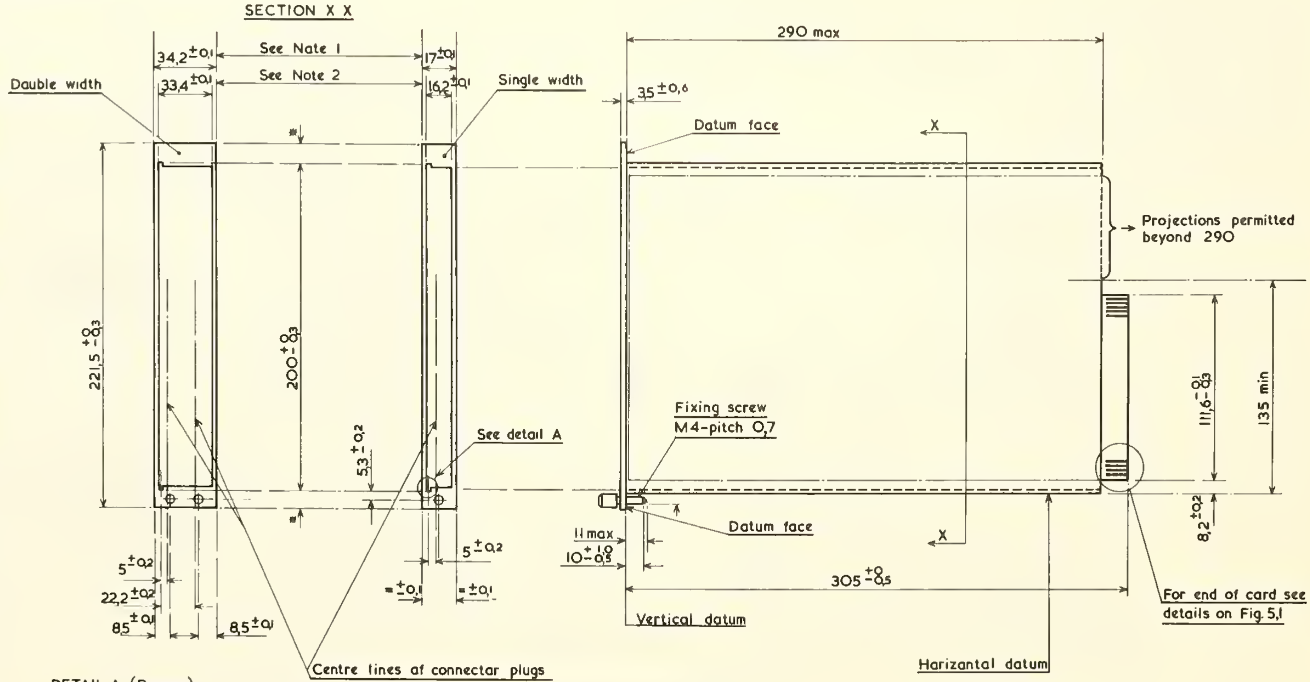
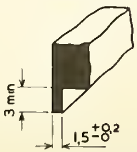


DETAIL A (Runner)



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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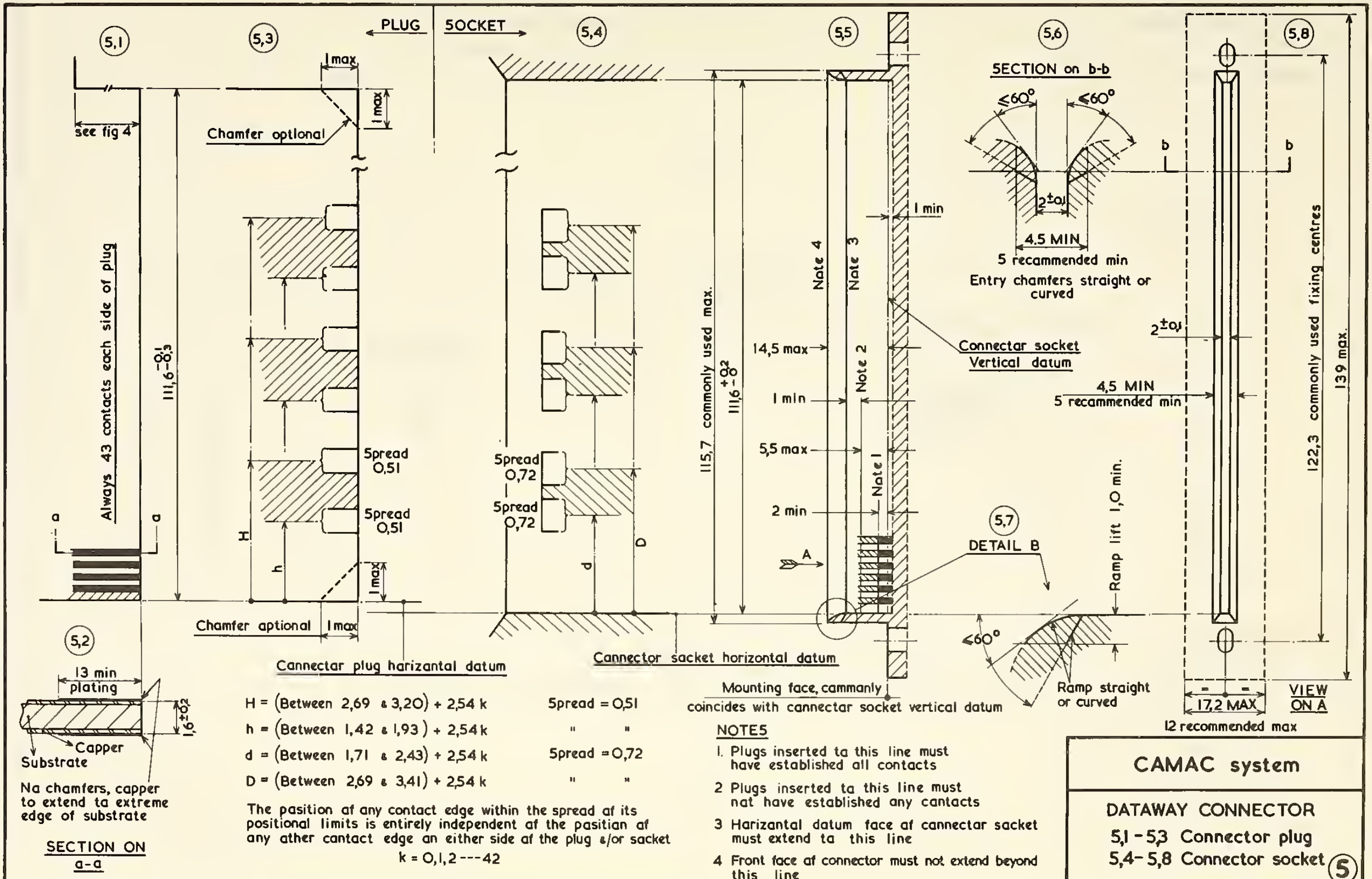

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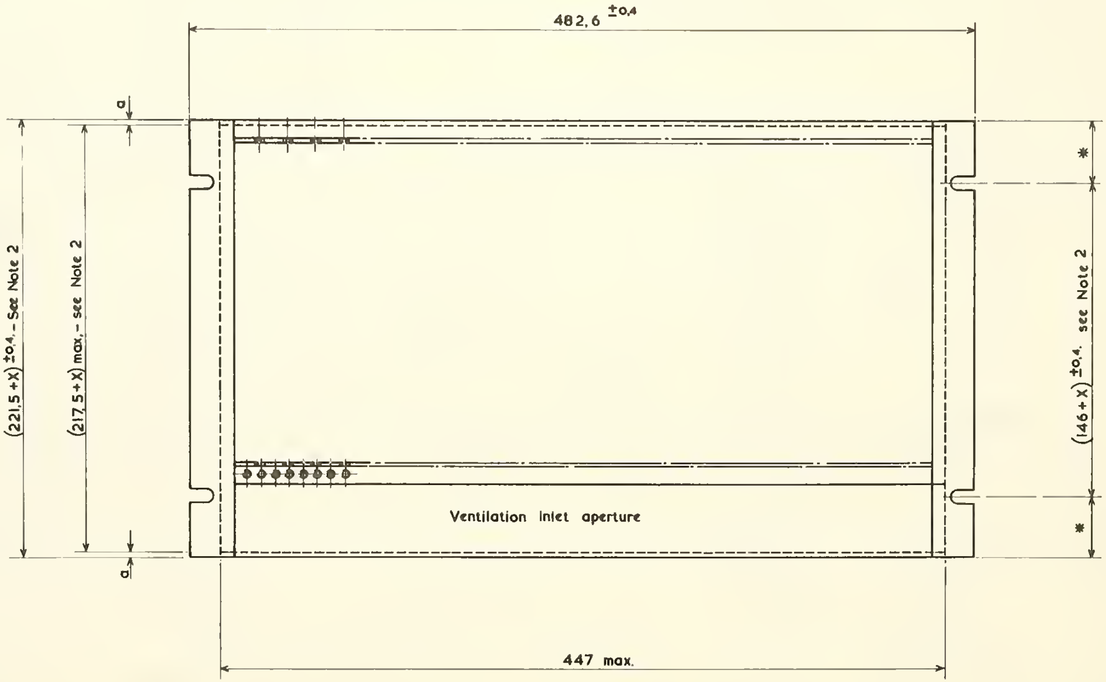

NOTES

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)

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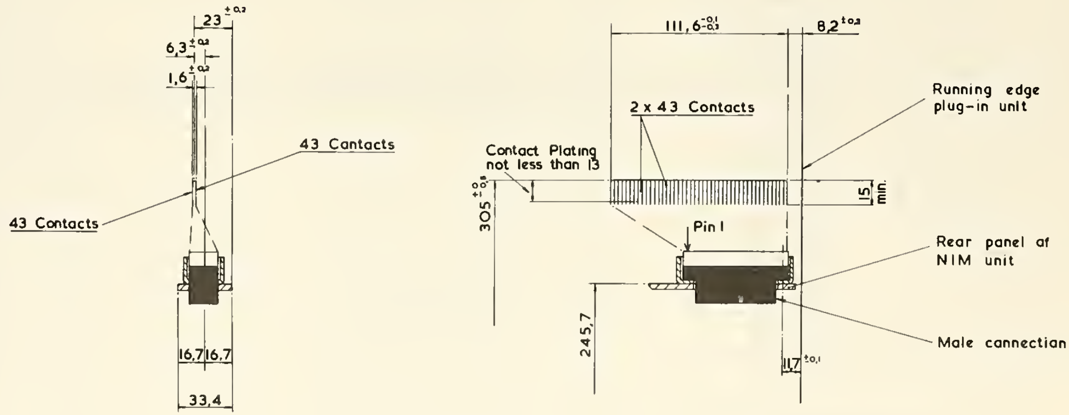

NOTE For Contact details, see Fig. 5.

CAMAC system

ADAPTOR
FOR NIM UNITS (7)

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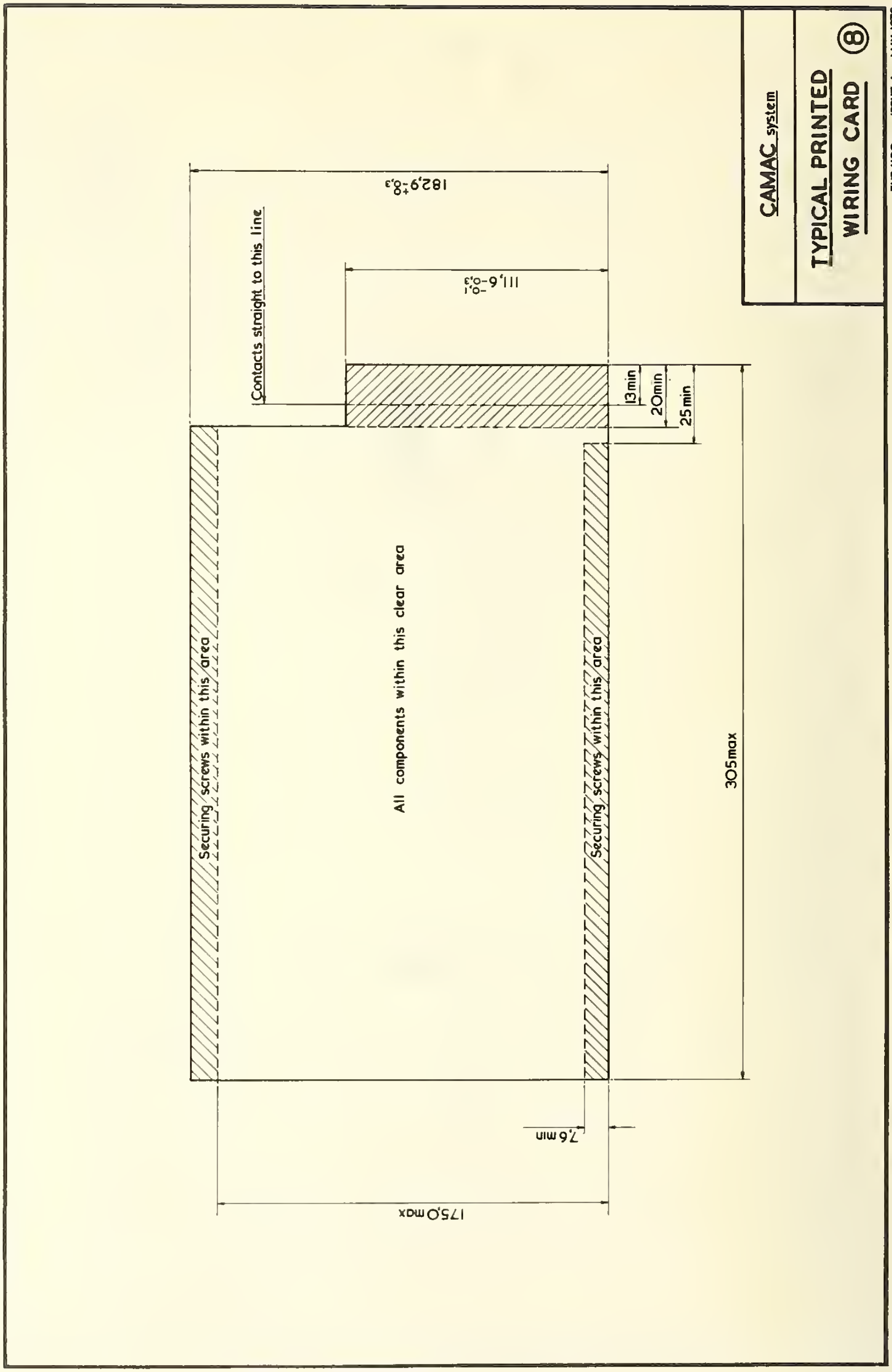

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15. SUPPLEMENTARY NOTES

16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)

The task of interfacing experiments to computers and data-logging systems should be made as painless as possible for the scientist. With this intent, MIDAS, a user-oriented, modular digital interface system based on CAMAC hardware and USASCII-bus data communication has been developed. MIDAS modules enable the experimenter to set up, program, modify and operate automated or computer-controlled experiments independently of the experts. Salient features of the concept are described and operating configurations discussed both with and without computer control. System interface requirements are specified in sufficient detail to enable one skilled in the art to design and construct modules operable within a MIDAS system.

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