RENATRAN BASIC FUNCTIONAL UNITS

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1 - Summary

A review is given of the present state of basic functional units developed in France with the assistance of manufacturers to meet the needs of French AEC laboratories. These Renatran plug-in units are in accordance with the Esone standard. Plug-in units main characteristics and examples of classical experimental settings obtained in assembling various types of plug-in units are mentioned.

In the same way, a transcription system towards printers, punching tape devices or computers has been studied and a brief description of it is given. The authors indicate their choice concerning the basic functions adopted in this case.

2 - Introduction

The advent of the semiconductors, and the reductions in bulk and power consumption that resulted from their use in electronic circuitry, have accelerated the development of "modular" systems in nuclear instrumentation and substantially generalized their use.

Adoption of this concept in instrumentation technology offers important advantages, a fact already demonstrated with tube-type circuitry between 1950 and 1960[1]. These advantages have acquired still greater significance with the transistor, which has added improved reliability to their list, and are of value both to those who use the instrumentation and those who design and produce it.[2]

3 - Advantages and disavantages of a modular system

3.1. This type of unit assembly offers the following advantages over the more conventional purpose-built assembly :

3.1.1. Flexibility in use, in that the operational rôle of an assembly can be changed to that required for another rôle by substitution or addition of other basic units.

3.1.2. An assembly, rendered non-operational by a faulty unit, can rapidly be brought back into operation on substitution of the faulty unit by one of a similar type

3.1.3. An expansion of the facilities available from one assembly can be rapidly obtained, by redevolopment or the additional development of a small number of units (often one), so that assemblies can be available when required.

3.1.4. Advantage can be taken of advances in electronic components and techniques, as these occur, by partial redevelopment of basic units.

3.1.5. Standardization of the electrical aspects of the system enables specialist circuit design effort to concentrate on those units which demand specialist techniques and in this way contributes to more thorough design and therefore increased reliability.

3.1.6. Mechanical standardization reduces the development time taken to arrive at a fully engineered unit from a bread-board design stage. It is also an important factor in reducing production time and time spent in fault repairs.

3.1.7. The specification of a single function unit is simpler than for a multi-functional unit and thereby offers better control over production and reduction of inspection and testing time.

3.1.8. The feature of compatibility, which must exist between units, requires that high electronic standards must be maintained throughout all design and development work, which in itself contributes to increase reliability.

3.2. The disadvantages of a unit system stem mainly from the fact that an assembly of units can be built up only by using cable assemblies. This, for the user, offers the possibility of incorrect interconnexion. It also sets a limit to the type of signals which can be transmitted between assemblies ; however, this limitation is seldom encountered. In addition, the capital cost of a unit assembly may be greater than that of a purpose-built assembly ; although the ease of replacement of units, their high reliability and their low repair cost can, in the long run, more than offset the greater capital cost.

4 - The Renatran Standard

Renatran is the name of a set of rules which standardize mechanical dimensions, supply voltages and stabilities, input and output signals, impedances and connectors, etc.., with the aim of achieving interchangeability and compatibility between instruments of various origins (manufacturers), within a system bearing the same name.

The general standards adopted in framing these rules were the Esone standards, developed by a Euratom working group formed in 1960, and with the participation of Great Britain (Harwell) and Austria (Vienne - Siebersdorf).

The Esone standards were first published in 1964 (Publication EUR 1831e - 1964, "Esone System of Nuclear Electronics"), and, as stated, form the basics of our Renatran rules, which include a number of supplementary recommendations concerning the choice and quality of surface finishes for mechanical parts, choice and quality of electrical components, and the documentation accompanying equipment.

4.1. Scope of Esone Standards.

Document EUR 1831e stipulates that"the system covers the field of nuclear electronics, that is at present both d.c. and pulse techniques, the latter up to the microsecond range (the time definition of the pulses being of the order of 0.1 microsecond)".

However, the field of application was extended to include "fast" electronics at the latest meeting of the Esone committee, which adopted electrical standards similar to those of the NIM system. This should at least promote electrical compatibility with U.S. equipment, in particular, and moreover conforms to the latest standards published by the AEC Committee on Nuclear Instrument Modules.

This decision would seem to indicate a desire on the part of the Esone Committee to further the eventual expansion of international agreement in this field.

The main Esone standards are as follow :

The height of the bin may be larger than 4U, of course in steps of U (U = 44,45mm). The overall external width of the bin must not exceed 443 mm. The bin is designed for having up to 8 plug-in units.

The height of the front panel for plug-in unit is 4U. The modules from which other dimensions for the width of the plug-in units are taken is 54,8 mm. Double unit, triple unit and quadruple unit can be used. The locking of the plug-in unit to the bin is done from the front side. A standard connector (16 or 24 contacts) is mounted in the rear part of plug-in unit, this connector assures the locking to the bin.

Coaxial connectors for general purposes are of the 50 Ohms BNC type.

In the range of ambient temperature between + 10°C and + 45°C minimum, all instruments must work within nominal characteristics. They also must be designed in order that they can be used in the range of ambient temperature between 0°C and + 55°C. Outside of the previous range of temperature (+ 10°C to + 45°C), reduced performances can be accepted and shall be specified by the manufacturer.

Analog signals are signals the amplitude of which is significant. The linear range of amplitudes at the output of the analog system must extend up to 10V ; for bipolar pulses from - 10V to + 10V. In every case the signivicant part for pulses is from 0 to - 10V.

Digital signals are divided into two categories :

Binary pulse signals are signals where just the occurence of the signal is significant ; polarity of signals is negative and amplitude ranges from - 3V to - 12V.

Binary signals are signals with two states called conventionally "1" and "0".

The range of the "1" is from - 3V to - 12V
The range of the "0" is from + 1V to + 12V

For both pulse and binary signals the threshold of input circuits must be in the range between - 1,7V and - 2,3V. The upper limit of the peak value of noise and parasitic signals must be in any case 0,7V (independently of polarity). During the last meeting of the Esone Committee held at Grenoble (France) in May 1966, the following recommandations concerning fast electronic equipments, were adopted :

a) Matching impedance : 50 Ohms
b) Standard connector : BNC type 50 Ohms
c) Fast pulse levels :
output logical "0" : 0 ± 100mV
(or 0 ± 2mA)

output logical "1" : - 700mV ± 100mV
(or - 14mA ± 2mA)

Input thresholds can be anywhere in the band from -200mV (-4mA) to -500mV (-10mA). This allows for the tolerance of the output signal plus 15% reflection or 15% attenuation.

Regarding supply voltages Esone text recommends that they must always be designed in order to work on a 220V r.m.s, 50Hz line. The defined regulated voltages degree of regulation and minimum available currents for plug-in units in one bin are :

Regulated voltage (volts) (referred to ground)	Degree of regulation better than	Available currents
Semi-regulated -24	± 5%	1 Amp
+ 24	± 0,5%	0,5 Amp
+ 12	± 1%	1 Amp
+ 6	± 1%	1 Amp
- 6	± 1%	1 Amp
- 12	± 1%	1 Amp
- 24	± 0,5%	0,5Amp

4.2. State of Renatran Development

A very extensive range of transistorized basic function units (or modules) has been created with the participation of private enterprise in both the design and production phases.

At the moment, more than 10.000 modules are operative in our laboratories, and failure statistics (MTBF, etc..) confirm the excellent reliability of this equipment.

The current range of Renatran instrumentation adequately resolves most of the instrumentation problems encountered within the C.E.A.

4.2.1. Modules for nuclear measurements

Main characteristics of these modules are indicated in Appendix I. Figures 1 and 2 show an amplifier (MAP) and a scaler module (M6DPI). Fig. 3 corresponds to the Renatran bin.

4.2.2. Examples of typical assemblies

Block-diagrams (Fig.4, 7, 9, 11) and corresponding photographs (Fig.5, 6, 8, 10) illustrate the flexibility in use of Renatran modules.

Figure 10 corresponds to a normal assembly to obtain a classic α or γ spectrometer. Special circuits (3) surrounded with dotted line, in the block-diagram which is given in Fig.11, may be added to the normal measuring system. They comprise a fast amplification line, a level comparator and logical output circuits. Their effect is to increase, in case of difficult experimentations in which pulse pile-up problems arise, the resolution by a factor of about three.

Figure 12 is a schematic of an earlier typical counting instrumentation assembly with automatic data printing or punching. The assembly includes such modules as THT supplies, amplifiers, discriminators and counting scalers and in this case, automatic printing facilities are mounted in a chassis.

Thirty such systems have been produced but experience has show that the chassis-mounted data output facility lacks flexibility it is therefore with the aim of achieving greater flexibility that we have introduced modules in nuclear data handling as well. This new system is discribed in the following (paragraph5)

4.2.3. Pulse generator system modules

In this field also, functional modules are developed in Renatran standard (Fig.13) Combinations of units can be rapidly arranged into an operational assembly and thus constitute a pulse generator. A wide range of characteristics can be obtained only replacing or adding plug-in units. Main characteristics of them are given in Appendix II. As an example of the possibility offered with the use of these units Figure 14 shows the block-diagram concerning a generator used for testing fast counting systems (scalers, registers etc..).

Main characteristics of this generator are:

- output signals : two bursts of pulses (lenght 5ns) with adjustable duration from 0 to 250ns and with delay between burst adjustable from 50ns to 4ms.
- Burst recurrency : adjustable from 100s to 10MHz.
- Pulse frequency in each burst : adjustable from 10MHz to 100MHz.

This generator is built by adding two "fast generators units" and a "fast mixer unit".

It is composed with :
- one "Pilot" unit type "PF20" delevering the burst recurrency from 100 Hz to 10MHz.

- two "pulse shaper and delay" units type FIR30 delivering burst duration and delay
- two "fast generators" units delivering the 5ns pulses with a frequency adjustable from 10MHz to 100MHz.
- one "fast mixer" unit (rise time less than 2ns).

Figure 15 is a diagram of the different output signals.

Figure 16 shows the double bursts generator.

5 - Renatran data units

5.1. Purpose and general design

Though Renatran units facilitate the assembly of automatic counting systems to suit variable requirements, the capabilities of such systems are largely determined by their on-line data handling facilities. These facilities consist essentially of electronics linking the counting scalers and the output units, which are usually arithmetical processing and printing/punching.

The job of the interposed Renatran unit, therefore, consists of :

a) programming the order in which data are transferred to output facilities ;

b) rendering the form in which the data are transmitted compatible with the inputs of the receiving units ;

c) programming the control of the counting assembly or associated equipment (sample changers, for example).

5.2. General characteristics

5.2.1. Flexibility

The modular design employed affords a high degree of flexibility and full compatibility with both the data generating and output equipment.

Specially designed for the transfer to printers of the outputs from Renatran counting scalers (6 character parallel words, 4 bits BCD per character), the system can also handle data stored in multichannel analyser memories (serial words of 7 characters, 4 bits BCD per character), decimal selector (manually selected parameters) or transmitted from a printer keyboard or punched tape reader.

Further, the system can also generate data, such as reference or identification number for printing with the measurement of other experimental data facilities.

The system's input code is usually BCD, but adjustment is possible for any other alphanumerical code. The number of data which can be admitted at the system's input is about 200.

A wide range of output units can be connected to the system, to operate simultaneously (Fig.17). At present these are : numerical and alphanumerical tape or tabulating printers (Addox, IBM-B, FRIEDEN Flexowriter, TELETYPE, etc. ; tape or card punchers (TALLY, IBM), and small office computers.

Development is scheduled to permit connection of incremental magnetic tape recorders and digital data transmitters.

The data can also be displayed by a central NIXIE tube display unit.

5.2.2. Matrix programming of sequences

is used to vary data selection sequences within a wide range, as also the order of output control sequences (data tabulation, for example, or arithmetical processing sequences).

5.2.3. Reliability of operation

Synchronization by a triggered generator ensures the high degree of reliability necessary in automatic counting systems operating frequently in "industrial" conditions, that is to say, in the immediate proximity of electromechanical machines and other sources of interference.

5.3. General organization

5.3.1. Data concentration and selection (Fig.18a, 18b)

5.3.1.1. Data register

Each scaler or parameter selector or multichannel analyser register, etc.. represents, for the input of the system, a data register for transcription by a printing facility.

This content of a register is represented by a value (word) of a maximum of 7 characters. Each character is expressed by 4 bits, in 1-2-4-8 code. The "position" of the character generally represents its decimal position. Each word therefore consists of 28 bits.

5.3.1.2. Data register selection

An adress is attributed to each data register. This adress is defined in an adress decoder.

Feeding out of the word contained in the register to the output printer is subordinated to reception by the decoder of the corresponding adress.

The adress appears as an octal coded number on two sets of 8 wires.

5.3.1.3. Character selection

Selection of a register is followed by appearance on the general data input line of the digital values of the 28 corresponding bits.

Gates are allocated to each bit per character and each set of gates is triggered sequentially by a character selection sub-program to pass the 1-2-4-8 value of the character in BCD, on 4 common conductors. These signals are transcoded and excite the magnets of the output printing or punching facilities.

Note : The system can in fact transfer data sequentially according to two different register organizations :

- parallel registers, which upon addressed orders feed out all bits in parallel ;
- serial registers, feeding out the seven 4-bit characters in sequence under the control of the programmer.

5.3.2. Interconnections (Fig. 19).

The system is organized around a network of common (bus) connections :

- 16 address lines (octal code : 1-2-4-10-20-40-100-200 and their complement);
- 8 "data character" lines (ISO code : 1-2-4-8 decimal characters and 4 control bits ;
- 7 character sequencing lines (10^6 to 10^0);
- register testing line (e.g. for register status testing) ;
- 8 sync. lines, namely :
  - 4"clock" lines timing all functions ;
  - 1 "sequence break" line (program synchronization) ;
  - 1 "cycle break" line (character selection and clock generator synchronization) ;
  - 1 special line for printer control ;
  - 1 "interrupt" line (granting priority to external program).

The basic function units are thus interconnected by these lines to form the main functions comprising the system.

5.3.3. Programming

5.3.3.1. Purpose :

As the data appear, in the data registers, in the form of decimal number to be transferred in series to the printers/punchers the system includes a sequencing programmer whose main functions are :

- sequential reading of the registers and definition of operation (printing mode, zero-setting, testing, etc..) ;
- programming of order transmission to output facilities (line space, tabulation, CR, etc..) ;
- addition of the digits indicating data origin ;
- programming of order transmission to associated facilities, such as sample changers, counting instrumentation etc.) ;
- definition of character selection sequence orders by sub-program.

5.3.3.2. Composition

The programmer consists essentially of:

a) a 2^8 binary counter and his associated decoding matrix to analyze sequentially the program memory contents.

b) a wired program matrix employing diodes and including :

- 1 address (8 bits) ;
- 1 instruction (4 bits).

This matrix therefore defines the sequential order of all operations ;

c) an address register and an instruction register for temporary active storage of the content of the analyzed matrix line ;

d) an instruction decoder (15 bits) ;

e) a serial character selection sub-program. As the printing outputs are usually fed characters in series, the sub-program permits analysis of parallel data registers ;

f) a "clock" generator, automatically triggered by the "cycle break" signal at the maximum rate of the slowest output printer, and which synchronizes all logic operations.

The repertoire of instructions includes :

- read scaler content ;
- reset individual scaler ;
- general reset, all scalers ;
- read and reset scaler ;
- read address register ;
- test : this initiates a test cycle and eventually modifies the program sequence according to the status of certain units.
- program jump. This transfers the 8 bits from the address register to the 2^8 binary counter to form a program loop. The operation may be subordinated to the result of a test permitting initiation of sub-sequences under predetermined conditions only;
- "mechanical function" demand.

Program insertion is direct and easy. The programmer briefly described affords a high degree of flexibility.

5.3.4. Data transcoding and output magnet control

At the character selection output, data

appears on the character-per-character basis and in ISO code (1-2-4-8 A, B, C, D), on 8 "data" lines.

However, output facilities, and in particular printers and punchers, require inputs in decimal code or in other than ISO code. Decoding or transcoding is therefore necessary before transmission of the signals to the power amplifiers controlling the printer/punch magnets.

Although the control modes of these facilities are generally similar, they differ sufficiently to preclude the design of a universal control unit. Further, several outputs may be controlled simultaneously. There must therefore be a specific control unit for each type of output.

Each such unit usually includes :

- a BCD-to-decimal decoder, or transcoder translating into the code accepted by the machine ;
- power circuits for magnet excitation ;
- magnet control pulse sampling circuits ;
- a sync. circuit inhibiting the character selection sub-program until each machine operation has been completed ;
- a circuit defining the transcription of non significant zeroes (zero printing or space).

Note : - There is a system synchronizing circuit for each output. The system is thus synchronized with the slowest output if several are simultaneously connected.

- The punched tape reader or keyboard signal reader also has a sync. circuit like that of the printer control unit.

5.3.5. Centralized display

The system includes NIXIE tube display of input unit data contents as selected by the program or manually.

5.4. Physical constitution

5.4.1. Data concentrator chassis CC8E-10 and CE8E-10

Parallel data is concentrated via diode-gate circuits situated either in the counting scalers (plug-in unit type) or in the wiring connecting the scalers to the concentrator chassis (rack mounted scalers).

The data from 8 inputs are concentrated by the primary chassis CC8E-10, which includes 8 data address decoders. This is a 5U3 chassis equipped with its own power supply and capable of accommodating 8 1/8 Renatran plug-in units.

The above can be associated with a secondary concentrator chassis, also having 8 inputs. This is a 3U3 unit, with 8 address decoders and which may be equipped with a 1/8 interface plug-in unit containing special circuits as determined by the application. It may also be associated with a further secondary concentrator chassis.

5.4.2. Basic function plug-in units.

5.4.2.1. Parallel/series-sequential converter and series-sequential data concentrator

(1/8) (MCPS)

5.4.2.2. Programming plug-in units

The programming function is contained in two plug-in units :

a) programming plug-in unit (MPM-1/8)

This includes the clock generator, 2^8 binary counter, instruction and address registers, and the character selection sub-program;

b) program matrix plug-in unit (MP-1/8)

This is a wired program unit employing diodes of two 32 x 12 matrix boards. Extension from 64 to 256 program steps is by associating four such plug-in units. Programs are adapted by changing the position of diodes on the matrix, though greater flexibility can be obtained by using matrixes of the plug-in diode type, where cost is not a major consideration.

Note : Further program plug-in unit are being developed for punched tape and card programming.

5.4.2.3. Transcoder and printer control plug-in unit.

There are several such units :

a) decimal machine control (MCMD-1/8). This unit is used for connection of Addo-X and IBM-B machines ;
b) binary code control (MCMC-1/8). This unit is used for connection of machines such as the IBM 735 , Flexowriter, TELETYPE, SAGEM teleprinter, etc..
c) transcoding plug-in unit (MTR-1/8). This unit translates the numerical or alphanumerical ISO code into any 8-bit code;
d) punch control plug-in unit (for TALLY or Olympia).

5.4.2.4. Accessory plug-in units.

These include :

a) Printer keyboard signal reader. This unit permits insertion on punched tape of digits selected at the keyboard of a printer, or from a punched tape reader ;

b) a "4-memory" interface plug-in unit, used to adapt program sequences as determined by the testing of 4 storage flip-flops ;
c) other control plug-in unit as required for special applications.

5.4.2.5. Accessory chassis
These include :

a) multichannel analyzer interface
b) central display.

5.4.3. Technology : DTL integrated circuits.

6 - Conclusion

Like all systems of its type, Renatran system has certain disadvantages. But these are more than adequately compensated, in our opinion, by its advantages. Four years experience in the designing, manufacturing, and use of more than 10.000 basic function units of various types has been conclusive in demonstrating the efficiency and performances of this technology.

No system can be allowed to remain static. Renatran does not escape this rule, and its development continues as new techniques appear. As already mentioned, Renatran is derived from the Esone standards. The Esone standards Committee has now undertaken study of the technological changes to follow the appearance of integrated circuits, and as rendered necessary by the increasing importance of interface problems in data processing and automatic control.

We hope that this will also lead to international standardization on a wider geographical basis.

7 - Acknowledgments

The authors wish to take this occasion to thank Mr. KEIRLE and Mr. DUPUY[4] for their excellent work in the designing of generator modules, and Mr. J.LECOMTE[5] for the important part he played in the general designing of Renatran units.

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Appendix 1

1 - Stabilized power supply

Chassis C7AL - C6BAL
Plug-in units M2BAL - M4BAL

Common specifications

Output voltage :
24 volts semi regulated (max output 1A)
± 24 volts regulated (max output 0,7A)
± 12 volts regulated (max output 1,2A)
± 6 volts regulated (max output 1,5A)

Stability :
versus ± 10% mains voltage change within + 10 and +45°C and versus load changes from 10 to 100% better than

± 1% for 6V and 12V regulated
± 0,5% for 24V regulated
± 1V for 24V semi regulated

Drift in 8 hours :
Less than ≤ 2.10^{-4} for regulated voltage

Temperature coefficient :
≤ 2.10^{-4}/°C between +10 and +45°C.

Ripple :
≤ 3mV peak to peak

2 - Height voltage supply

Plug-in units :

MHT-10 - MHT-30 : ± 300V ± 3000V max output 1mA
MHT-20 - MHT-21 : ± 300V ± 5000V max output 0,2A
MPSC-10 - MPSC-40 : 0 ± 1000V max output 50μA.

Common specifications

Stability :
better than ± 5‰ versus ± 10% mains voltage change within +10 and +45°C and versus load changes from 10 to 100%.

Drift in 8 hours : less than 1‰

Temperature coefficient :
≤ 10^{-4}/°C between +10 and +45°C.

Ripple :
≤ 20mV peak to peak

3 - Analog plug-in units

Common specifications :

Input impedance : 100Ω or 1000Ω
Output impedance : ≤ 50Ω
Rise and fall time : ≤ 200ns for output amplitude max (± 10V)
Differential non linearity : inclused between ±0,5% and ± 1% max.
Output pulse amplitude : ± 10V.

3.1. Proportionnal pulses amplifiers

Plug-in units	Polarity	input-output polarity inverter	Pulse shaping	Gain (max)
MAP-11 and MAP-30	Bipolar	Yes	RC-CR networks 10^{-7} at 10^{-5}s	60dB
MAP-31	Bipolar	Yes	Delay line 1μs	60dB
MAP-40	Bipolar	Yes	Multimode RC-CR networks and delay-time	60dB

Plug-in units	Polarity	Gain	output pulse stretcher	Gating signals levels
MPL-10	input-(neg) output-(neg)	1	No	Closed 0 to -1V Open - 3V to - 12V
MPL-11	input-(pos) output-(pos)	1	No	Open ± 7V
MPL-20	Bipolar	1	No	Open ± 3V to ± 12V
MPA-40	input (neg) output (neg)	1	Yes width - 6μs	Open - 3V to - 12V

3.3. Spectrum stabilizer - Analog delay - Pulse shaping

Plug-in unit	Spectrum stabilizer	Analog delay	Pulse shaping
MSS-10	Between 5cps and 3.10^{-4}cps input and output polarity ± 10V		
MRV-10		Between 0, 1μs and 2μs in steps of 0,1 μs input polarity ± 10V - stability ± 50ns	
MMF-10			Input and output polarity ±10V pulse shaping by delay-line (1μs) rise time ≤0,2 μs

3.4. Biased amplifiers

Plug-in units	Polarity	Gain	Output amplitude (max)	Output pulse stretcher
MAS-40	input neg. output neg.	2-4-8-16	- 10V	No
MASA-10	input neg. output neg.	1-2-4 8-16	+ 10V or - 10V	Yes width 2μs

3.5. Summing - Inverter

Plug-in unit - MIA-40

Input circuit :
Impedance : ≥ 30kΩ
Pulse amplitude : ± 10V
Polarity : pos or neg.

Output circuit :
Pulse amplitude ± 10V
Rise time : ≤ 2.10^{-7}s
Number channels : 2
Differential non linearity : ≤ ± 1%
Gain per channel : 1/2
Stability : better than 2.10^{-4}/°C between +10 and +45°C.

3.6. Precision pulse generator

Plug-in unit - MTQ-40

Output circuit :
Polarity : pos or neg.
Impedance ≤ 50 Ω
Scale : 0 - 10 MeV (0 - 10V)
Differential non linearity : better than ± 1%
Rise time : ≤ 10ns
Temperature coefficient : ≤ 10^{-4}/°C between +10 and + 45°C.

3.7. Amplitude selectors

Common specifications

Input circuit :
Impédance : 100Ω or 1000Ω
Time constant : ⩾500 μs

Output circuit :
Impedance : ⩽50Ω
Pulse amplitude : - 5V to - 7V
Discriminator sensitivity : < 5mV
Gating circuit signal levels : closed 0 to -1V, open - 3V to - 12V
Linearity : ± 1% absolute deviation
Temperature coefficient : ⩽3mV/°C between +10 and + 45°C
Drift in 8 hours : ⩽10mV
Test circuit : 50cs.

Plug-in units	Pulse height discriminator threshold range	Resolving time	Input pulse duration
MDI-11	Between ±20mV and ± 10V	1μs	0,1μs at 100μs
MDID-30	Between -200mV and - 10V	50ns	100ns at 1000 ns
MECP-10	Between - 100mV and - 5V	Anticoïncidence circuit inclused for (α - β) or (α - cosmic) discrimination.	

Plug-in units	Pulse amplitude discriminator threshold range	Channel widths	Window stability
MSA-30	Between - 100mV and - 10V	0 - 1V and 0 - 10V	⩽5‰/V change versus input voltage fluctuations ⩽30mV variation according to threshold setting throughout to setting range

3.8. Ratemeters

Common specifications

Input circuit :
Impedance : ⩾ 1000Ω
Time constant : ⩾500μs
Pulse polarity : negative
Pulse amplitude : between -3V and -12V
Rise time : > 50ns

Output circuit :
Potentiometric : 0 - 50mV into ⩽ 500Ω
Galvanometric : between 1 and 11mA (max 10V)
Stability : ⩽1‰/°C between +10 and +45°C
Drift in 8 hours : ⩽ 1‰

Plug-in unit	LIN	LOG	Differential LIN	LIN-LOG
MILI-11	10cps - 3.10^4cps ratemetering time constant 1,3,10,30s			
MILID-11			10cps - 3.10^4cps overall accuracy ±2% of full scale	
MILO-31		1cps - 10^5 cps linearity ±10% between 1 and 2.10^4 cps ±20% between 2.10^4cps and 10^5cps.		
MILILO-11				10cps 3.10^4 cps LIN 0,1cps - 10^5 cps LOG identical specifications MILI and MILO

3.9. Scanning and adjustable alarm tripping

Plug-in unit	Scanning	Adjustable alarm tripping
MPS-30	Automatic analysis of gamma spectrum with MSA threshold level range 0 - 10V threshold linearity ± 0,5% Scanning rate one cycle every 15-30 or 60 minutes	
MDS-30		in association with MILI or MILO ratemeter plug-in unit to trip alarms upon ratemeter DC outputs attaining a number of channels 2 independant. tripping level adjustable from to 0 - 10V

4 - Digital plug in units

4.1. Scalers

Common specifications

Input circuit :
Time constant : ⩾ 500μs
Impedance : ⩾ 1000Ω

Input pulses :
Polarity : negative
Amplitude : between -3V and -12V
Rise time : ⩽ 500μs
Duration : ⩾ 25ns

Output circuit :
Impedance : ⩽50Ω

Output pulses :
Polarity : negative
Amplitude : between -5V and -7V
Duration a half maximum : between 0,4 and 0,6μs for resolving time 1μs and 25ns for resolving time 50ns.

DC or manual gating :
Closed 0 to -1V
Open -3V to -12V

Plug-in units :

Scaler M3D-11 - three decades resolving time $\lesssim 1\mu s$
Scaler M6D-11 - six decades resolving time $\lesssim 1\mu s$
Preset scaler M3DP-11 - three decades resolving time $\lesssim 1\mu s$
Printing scaler M6DI-11 - six decades resolving time $\lesssim 1\mu s$
Preset printing scaler M3DPI-11 - three decades resolving time $\lesssim 1\mu s$
Preset printing scaler M6DPI-11 - six decades resolving time $\lesssim 1\mu s$
Printing scaler M6DID-10 - six decades resolving time $\lesssim 50ns$.

4.2. Timers

Plug-in units :

- MHR-11 - tied to mains stability better than $\pm$ 1% clock period 10ms, 100ms, 1s and 10s.
- MHQ-11 - cristal pileted time base 100 Kcs period of two simultaneously available clock pulses 10, 10^2, 10^3s - 10, 10^2 and 10^3 ns.

4.3. Zero crossing and fast coincidences

Plug-in unit - MZC-40

Number channels : 2
Input impedance : $\gtrsim$ 1000Ω
Input amplitude : $\pm$ 10V
Adjustable delay : 0 à 200ns per channel
Resolving time coincidence : between 100 and 150ns
Time jitter : $\lesssim \pm$ 5ns

4.4. Slow coincidence

Plug-in unit : MC2V-11

Number channel : 2, with variable delay-line retardment between 0,1 and 4μs in steps of 0,1 μs
Input time constant $\gtrsim$ 500μs
Input impedance : $\gtrsim$ 1000Ω
Input polarity : negative
Input pulse amplitude : between -3 and -12V
Resolving time coincidence : 0,2 - 0,5 - 1 and 2μs
Time jitter : $\lesssim \pm$ 50ns
Output pulse amplitude to ground : between -5V and -7V
Counting control : by anti-coincidence channel also used as dc gate
Gating reponse : $\lesssim$ 0,5μs open or closed
Anti-coincidence pulse duration : 10μs.

Appendix II

1 - Pilot pulse units

PF20 and PF30

These units generate standard pulses controlling the operation of pulse shaper units either directly, or through programming or pulse-shifting units. They are normally equiped with oscillators but can also be operated by an external pulse generator signal. Three synchronized pulses are available at the rear of the unit, and a fourth at the front panel.

Unit	PF20	PF30
Fixed amplitude	+ 3V	+ 4V
Impedance	50 Ohms	50 Ohms
Rise time	5ns	5ns
Fall time	5ns	10ns
Length	35ns	15ns
Repetition rate	10p.p.s. to 10 Megapulses and single shot	100p.p.s. to 30 Megapulses and single-shot
Size (Renatran)	1/8	1/8

2 - Timer unit PB10

This unit is controlled by the pilot unit to deliver 10 pulses trains at adjustable pulse repetition rates. The pulses trains are available at two connectors at the rear, and used either to control pulse shaping unit directly, or through a pulse-delay unit. The first pulse in each train is available at a connector on the front panel.

Unit	PB10
Pulse height	+ 3V
Impedance	50 Ohms
Rise time	5ns
Fall time	5ns
Pulse length	35ns
Repetition rate, basic	10p.p.s. to 10 Megapulses/s
Size (Renatran)	1/8

3 - Pulse shaper units FIR30, FIR40, FIR50

These units are controlled by pilot pulses, either directly or through a programmer pulses or pulse-delay unit, to produce square pulses.

Subchassis	FIR30	FIR40	FIR50
Channels : two, synchronous	neg. and pos.	neg. and pos.	neg. and pos.
Fixed pulse height	5V	2,5 to 5V	10V
Impedance	50ohms	50 ohms	50 ohms
Rise time	5ns	10ns	10ns to 1ms
Fall time			
Fall time	5ns	10ns	10ns to 1ms
Min.pulse length	10ns	50ns	50ns
Max.pulse length	200μs	1ms	5ms
Max. prr	10MHz	10MHz	10MHz
Duty cycle	0,6:1	0,6:1	0,6:1
Pulse shift versus pilot pulse	from 60 ns to 5ms	from 50 ns to 5ms	
Size (Renatran)	1/8	1/8	1/8

4 - Delay unit - DP10

This unit delays pilot pulses. It is a 2-channel unit connected between a pilot and two pulse shaper units.

	DP10
Pulse height	+ 3V
Impedance	50 ohms
Rise time	5ns
Fall time	5ns
Max. p.r.r.	10MHz
Min. shift (lag)	50ns
Max. shift (lag)	5ms

5 - "Detector" pulse former units
FIP20, FIP30

These units shape inputs from a pilot chassis, programmer or pulse delay unit to produce output pulses of the type received from nuclear detectors.

Unit	FIP20	FIP30
Channels : two, synchronous	pos. and neg.	pos. and neg.
Pulse height	0 to 10V	5V
Impedance	50ohms	50 ohms
Rise time	15ns to 100ns	4ns
Fall time	100ns to 1µs	10 to 50 ns
Min. pulse length	50ns (at halfheight)	12ns (at halfheight)
Max. pulse length	1,2µs (at halfgeight)	30ns (at halfheight)
Max. p.r.r.	10MHz	25MHz
Duty cycle	0,5:1	0,5:1
Size (Renatran)	1/8	1/8

6 - Mixer units AM10 - AM20 - AM30

AM10
This unit has two separate channels : one mixes positive pulses received on three channels, the other mixing negative pulses received on three other channels. Coincident pulses are algebraically summated.

AM20
This unit mixes pulses appearing on four channels (-two positive, two negative). Coinciding pulses are algebraically summated.

AM30
This unit mixes pulses of both polarities appearing on two channels.

Subchassis	AM10	AM20	AM30
Intrinsic rise time	5ns	5ns	6ns
Input impedance	50 ohms	50 ohms	50 ohms
Output impedance	50 ohms	50 ohms	50 ohms
Gain	1	1	0,5
Max. accepted pulse length	10ms	10ms	d.c.
Output dynamic range	0 to 10V	-10V to +10V (20Vp-t-p)	-5V to +5V (10Vp-t-p)
Size (Renatran)	1/8	1/8	1/8

7 - Attenuator units
AT10 - AT20 - AT30

Frequency range dc to 1000MHz
Impedance 50Ω (nominal)
Maximum power dissipation 0,5 watt, overage
Maximum pulse voltage : 350 volts peak
Maximum insertion loss : less than 1,5dB at 1000MHz

AT 10

Two channels :
- one : attenuation range : 0 to 12 dB
  attenuation steps : 1dB
- second : attenuation range : 0 to 120 dB
  attenuation steps : 10dB

AT20

Two channels : attenuation range 0 to 12dB
attenuation steps : 1 dB

AT30

Two channels : attenuation range 0 to 120dB
attenuation steps : 10 dB

AT21

Frequency range : dc to 500 MHz
Impedance 50Ω (nominal)
Maximum power dissipation : 0,5watt overage
Maximum pulse voltage : 100V peak
Maximum insertion loss : less than 2dB at 500MHz

Two channels : attenuation range : 0 to 220dB
attenuation steps : 1dB

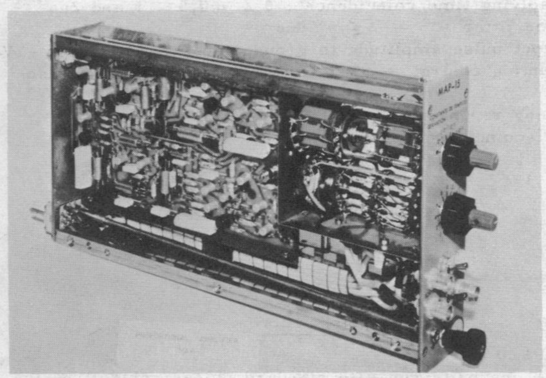

Fig. 1. Proportional amplifier map.

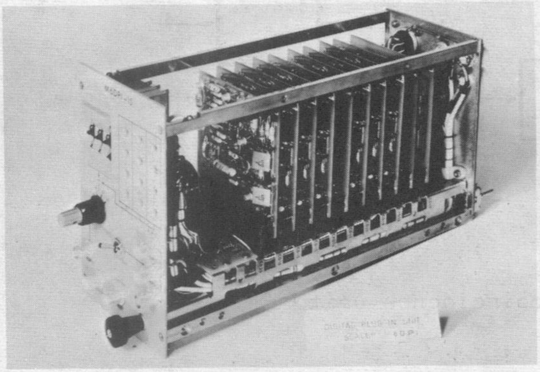

Fig. 2. Digital plug in unit scaler M6DPI.

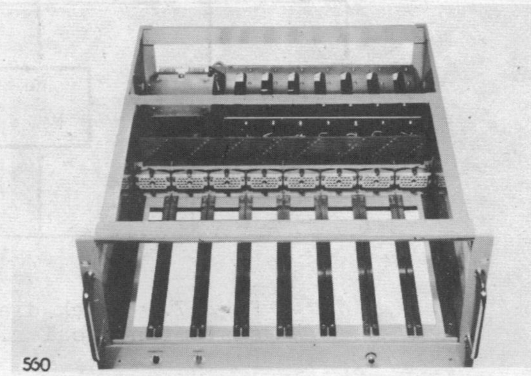

Fig. 3.

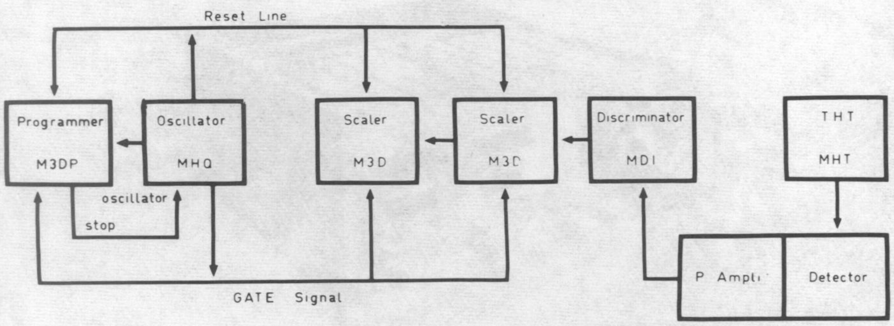

Fig. 4. Block diagram of manual scaler with preset time possibilty.

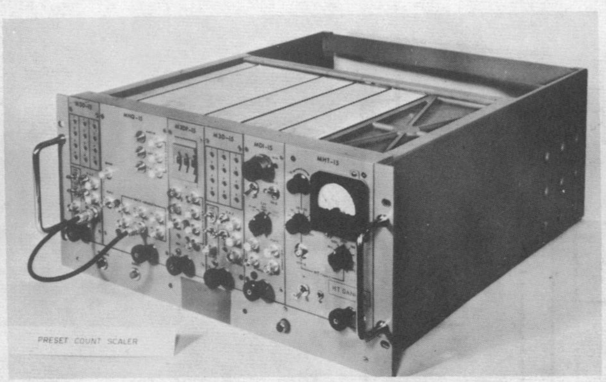

Fig. 5. Preset count scaler.

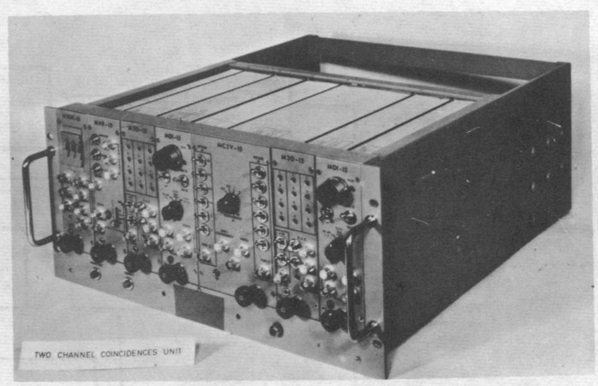

Fig. 6. Two channel coincidences unit.

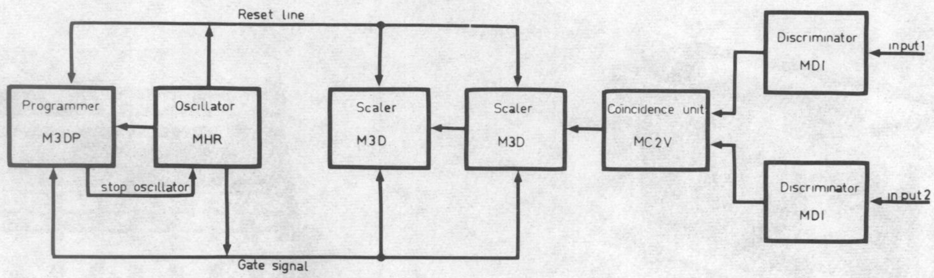

Fig. 7. Block diagram of coincidence unit system and scaler.

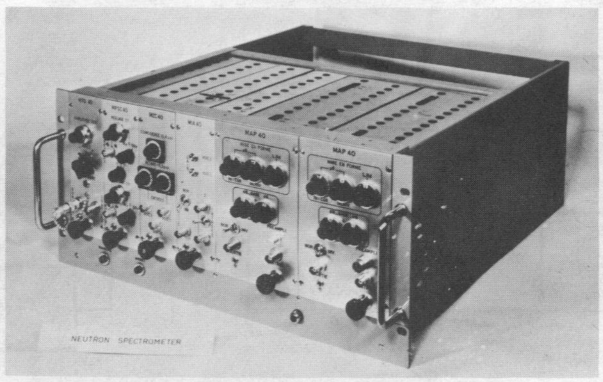

Fig. 8. Neutron spectrometer.

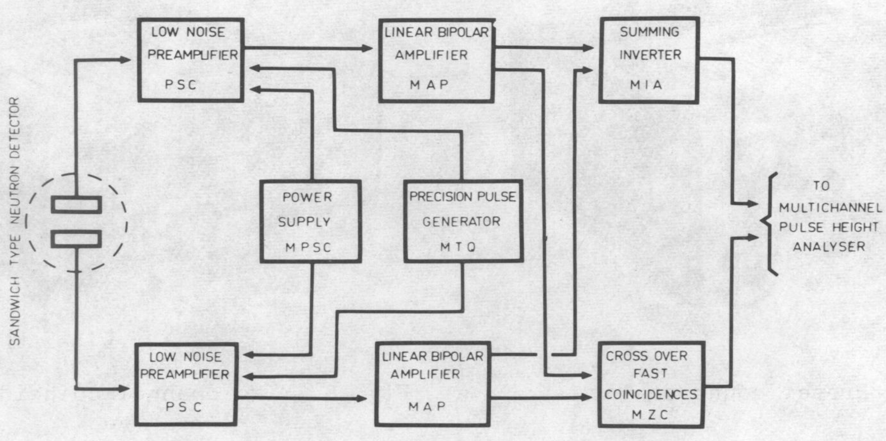

Fig. 9. Block diagram of neutron spectrometer system using sandwich detector.

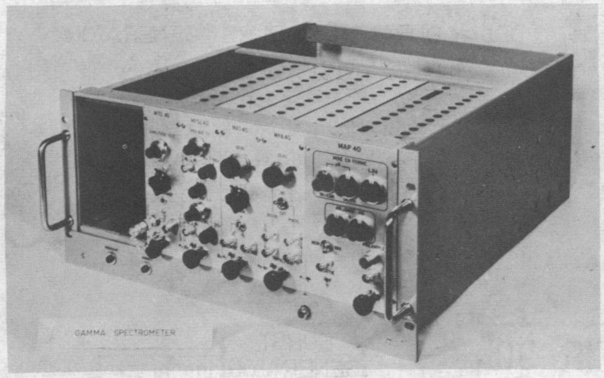

Fig. 10. Gamma spectrometer.

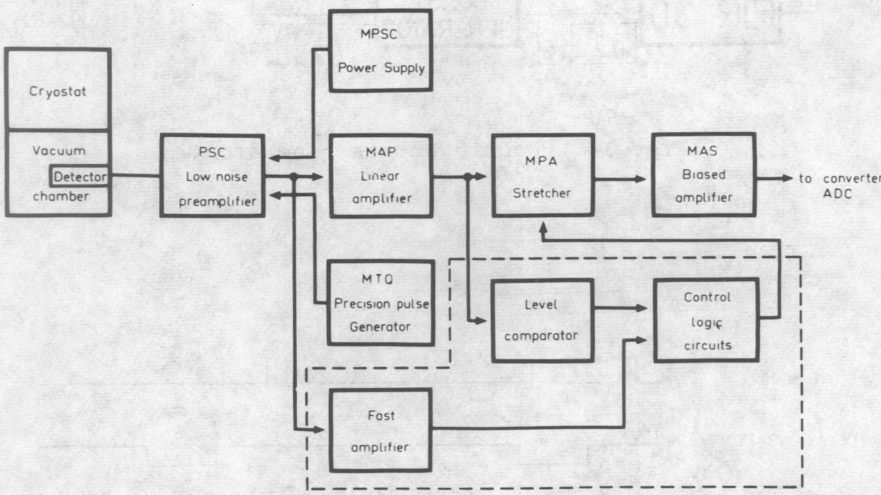

Fig. 11. Block diagram of γ spectrometer system using germanium solid state detector.

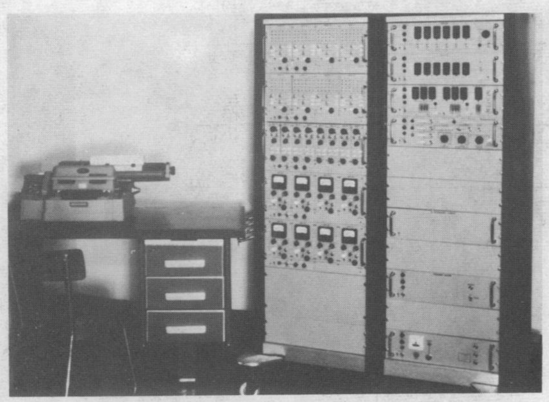

Fig. 12.

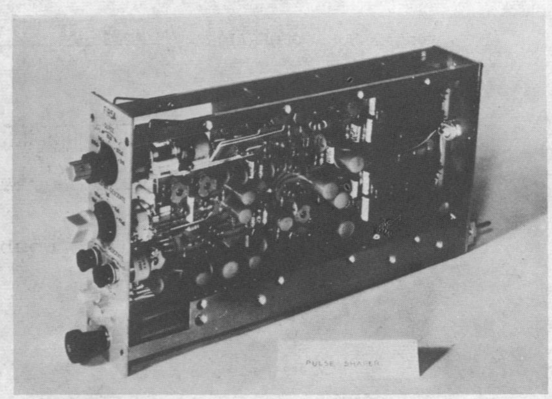

Fig. 13. Pulse shaper.

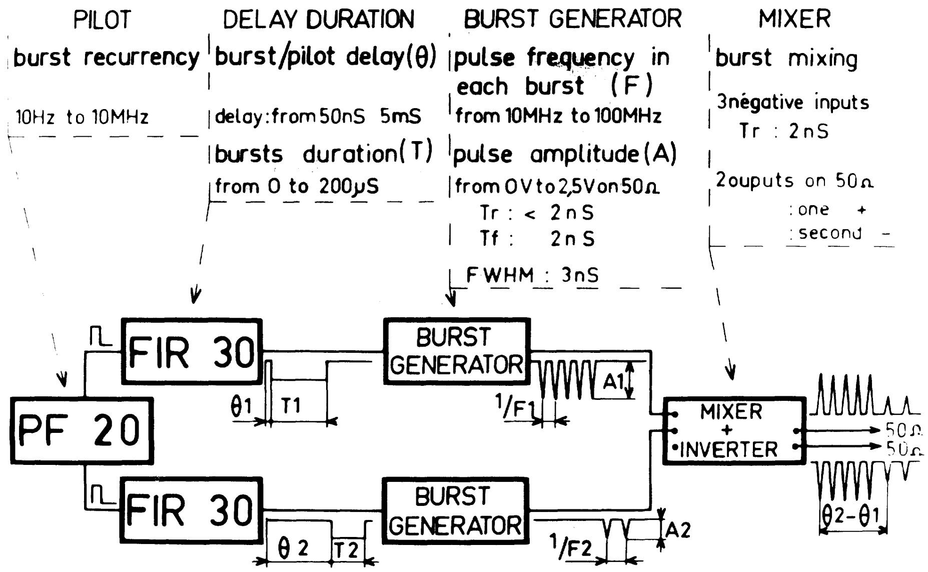

Fig. 14. Double bursts generator.

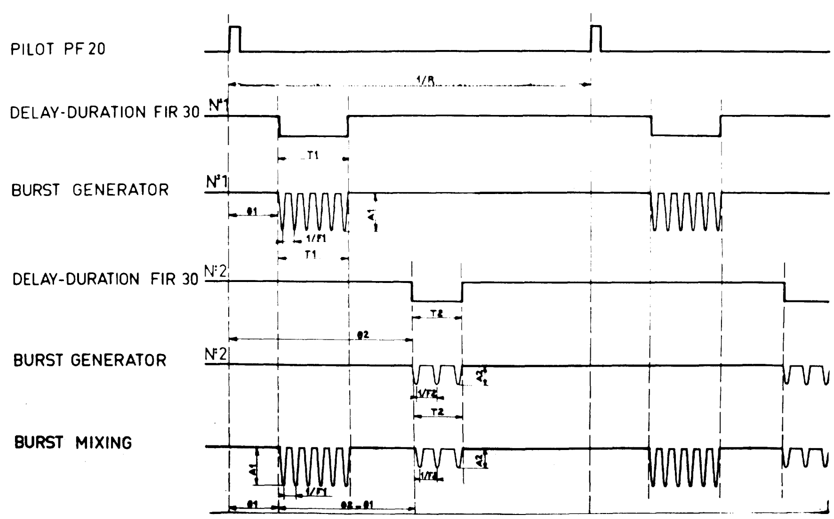

Fig. 15. Double bursts generator.

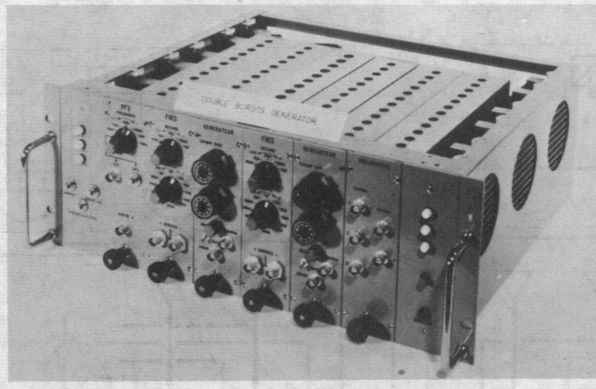

Fig. 16.

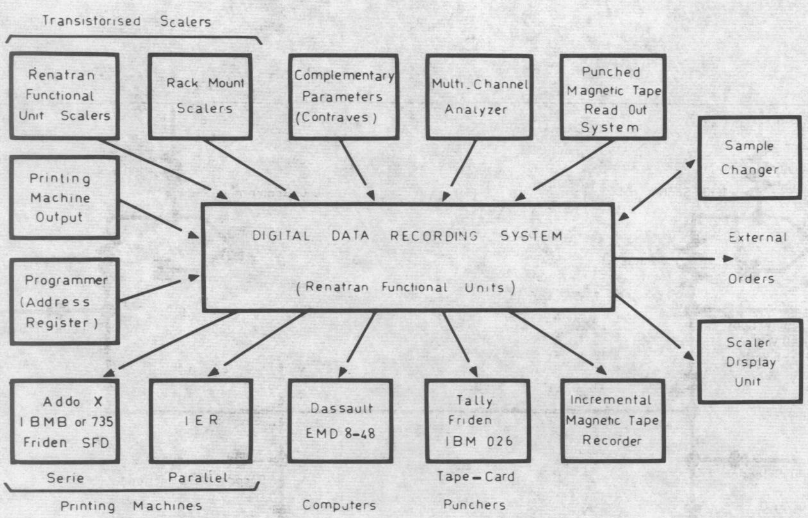

Fig. 17. Inputs--outputs.

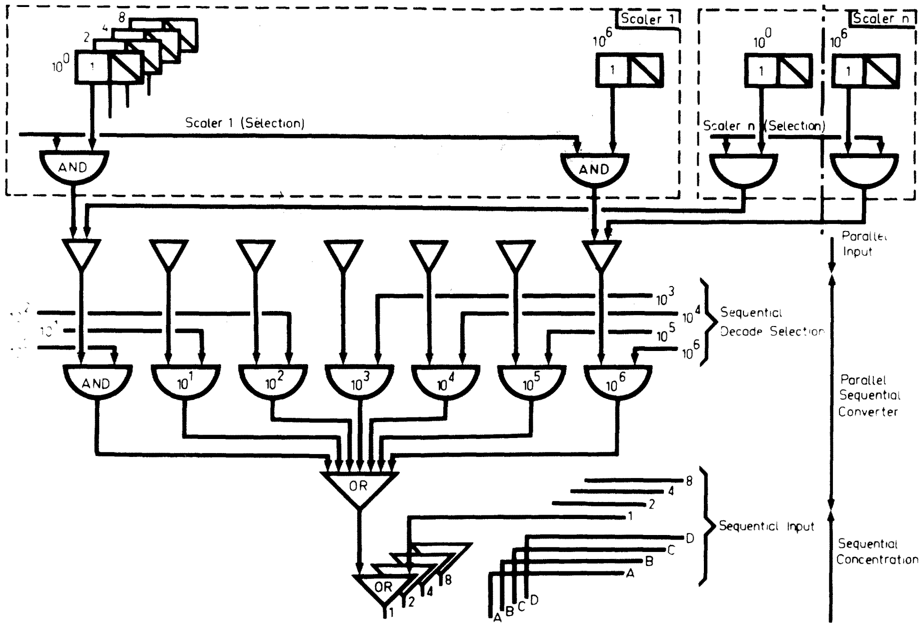

Fig. 18 (a).

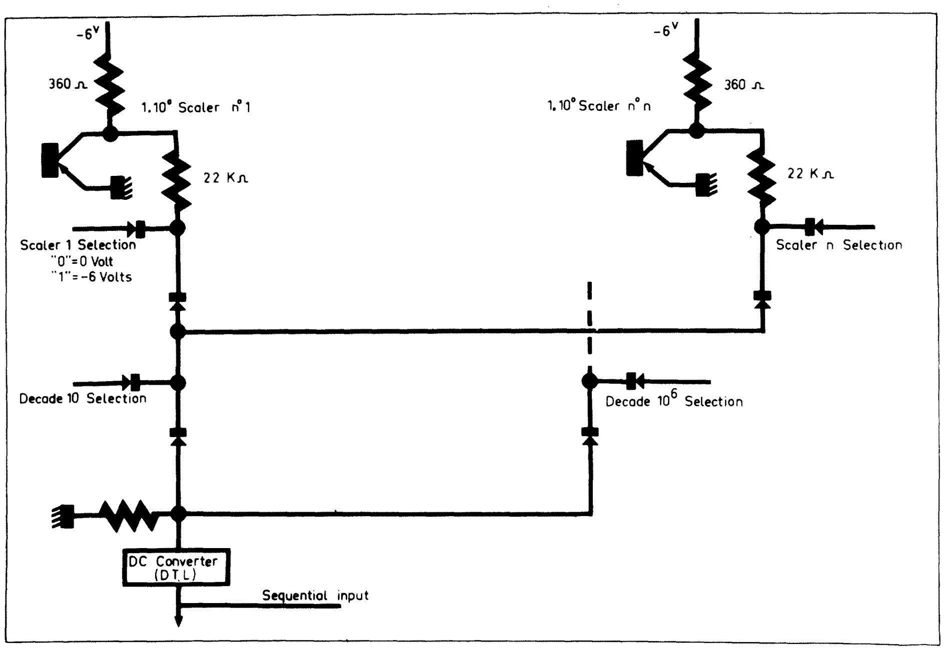

Fig. 18 (b). Data concentration.

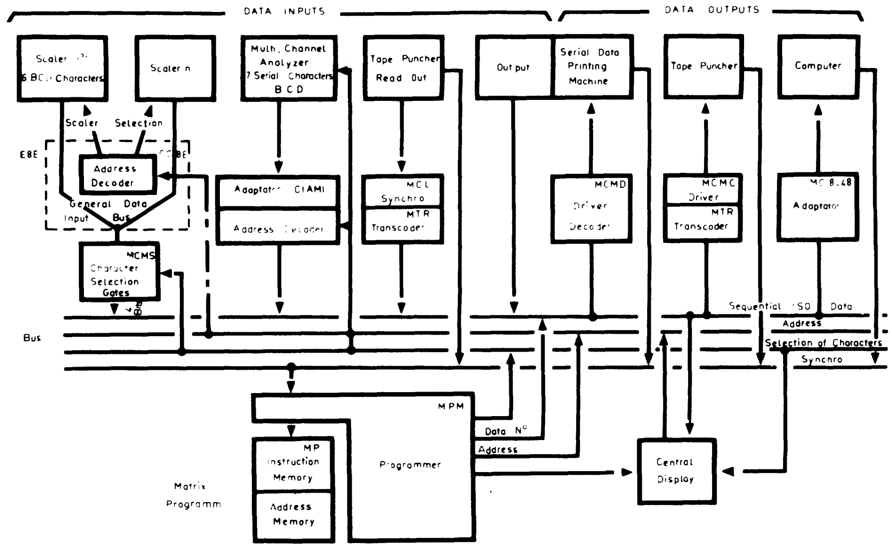

Fig. 19. General block diagram.

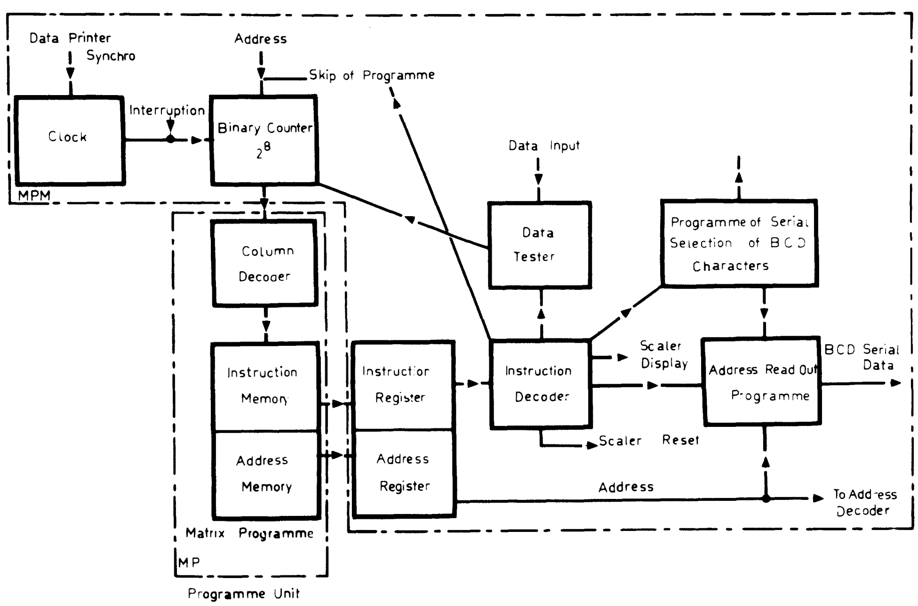

Fig. 20. Programmer--MPM and MP units.

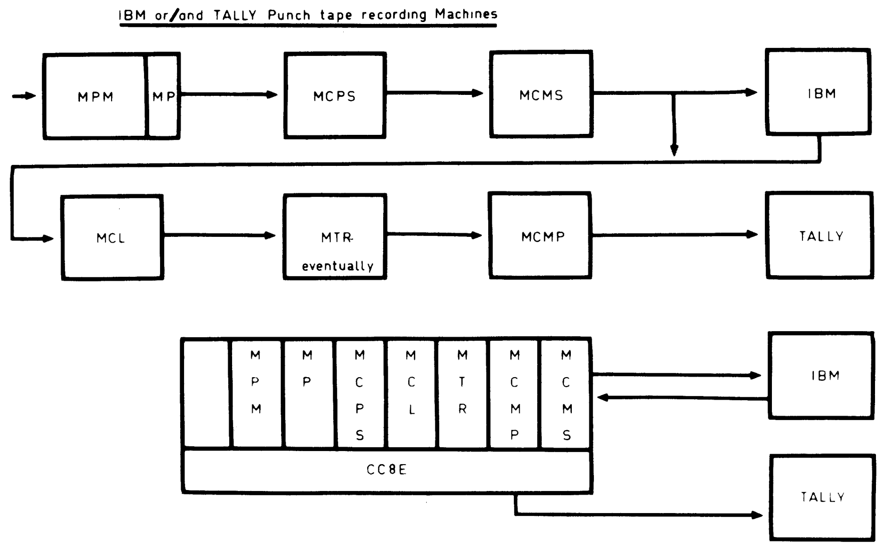

Fig. 21 (a). Examples of typical basic function unit utilisations.

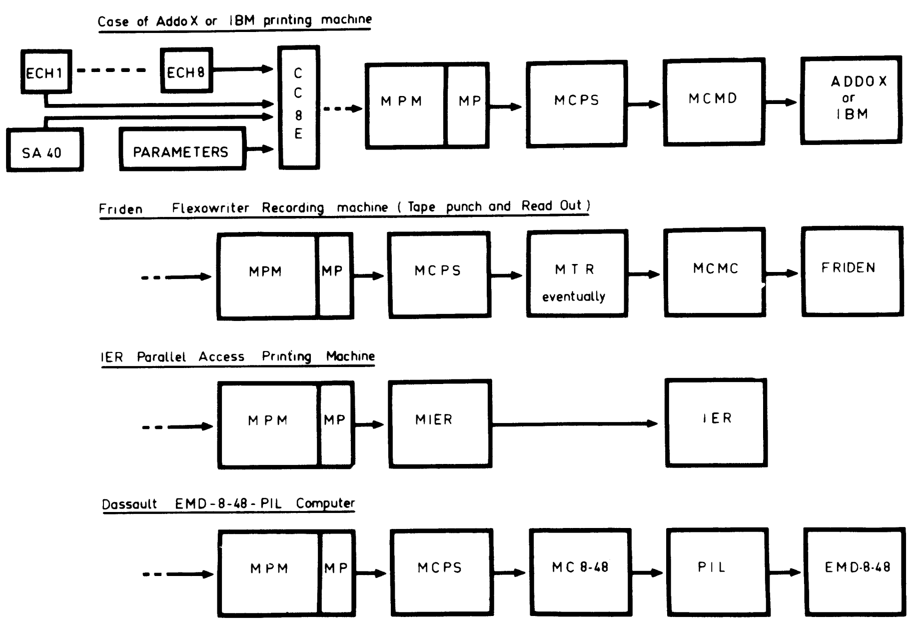

Fig. 21 (b).