technical memorandum Daresbury Laboratory

DL/CSE/TM16

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AN OPTO-COUPLER FOR THE SERIAL HIGHWAY

by

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1. INTRODUCTION

There is a general need for electrical isolation between racks of electronic instruments which are conected together by a signal cable, as an earth connection is formed which may increase the noise in analogue systems or increase the data error rate in digital systems.

There are several ways in which earth connections cause problems. There may be a d.c. offset due to the difference in earth conductor resistance, or induced transients due to the switching of electrical equipment, or there may be magnetic coupling due to the formation of a closed loop.

By breaking the continuity of the earth conductor of the signal cable isolation is achieved preventing the flow of interference current. Each set of equipment can then operate with reference to its own 'earth' and so reduce the probability of data errors.

Opto-isolators provide a means of electrical isolation of the signal cable. This note describes a CAMAC format module which is designed to provide isolation of the CAMAC SERIAL HIGHWAY, by means of fast opto-isolator circuits.

2. PRINCIPLES OF OPERATION

The CAMAC SERIAL HIGHWAY is specified by EUR 6100e(1). It is used to link racks of equipment together and consists of nine pairs of cables, one of which is the clock channel which strobes the data at 5 MHz. To provide isolation all nine channels need to be independently electrically isolated.

The opto-isolator chosen was the Hewlett Packard HCPL 2602(2) which has a fast data rate capability and, also, input protection against high voltage transients. Figure 1 shows the circuit diagram of the module. The circuit comprises of two opto-isolators, a 'D' type latch with preset and clear inputs, and an output line driver. Schottky diodes are employed on the inputs of the opto-isolator to improve the data rate. Two opto-isolators are used in order to change the input waveform as little as possible, as maintaining timing between channels is important.

3. CIRCUIT DESCRIPTION

The operation of the circuit is as follows: the differential signal is applied to the input of the two opto-isolators, E1A, the present driver opto-isolator and E1B, the clear driver opto-isolator, (fig.1). Due to the characteristics of the opto-isolator a positive going pulse applied to its input produces a narrower negative going pulse, i.e. inverts. Conversely a negative going pulse produces a wider positive going pulse, since the falling edge is delayed more than the rising edge. For this reason it is not possible to use a single opto-isolator at high data rates. To correct for the error the falling edge of the output of each opto-isolator is used. Figure 2 shows how the falling edges drive preset and clear inputs of the latch to produce a waveform with the same mark/space ratio as the input signal. An improvement in time jitter between channel can be achieved by selection and matching of the switching times of the opto-isolators. The latch Q output then drives the output line driver which produces the differential siganl for the line.

4. MEASUREMENT OF PROPAGATION DELAYS

The propagation delays of the HCPL 2602 were quoted in the data sheet from 45 to 75 ns, a range of 30 ns. This may be unimportant in single device applications, but for use in the serial highway the range has to be limited to a maximum, of 20 ns.

A test circuit was assembled to measure the propagation delays of 100 opto-isolators; the circuit diagram of the test circuit is shown in fig.3. The sample was purchased in four batches from four suppliers to ensure a random spread. Each device was identified with a number. Device No.1 was used as a reference.

The device under test was placed in the preset driver position and after a warm-up period, the circuit propagation delays tdpp' and tdpn' were measured at point B with respect to point A. This delay includes the line driver delay and also the inverter delay; their respective delays were subtracted from the measurement to give the true delays tdpp and tdpn. After each measurement the delay times of the reference were rechecked.

The procedure was followed for all 100 devices and then it was repeated in the clear driver position. Figures 4 and 5 show the delays preset position negative going edge, tdpn and clear position negative going edge, tdcn in histogram form.

From figs.4 and 5 it is possible to select a range of devices which would be well matched and be within the specification of 20 ns for use in the serial highway opto-coupler.

5. CONCLUSIONS

Figure 6 shows the maximum data rate possible without error of a single channel as a function of cable length. The cable used for the test was BICC twisted pair equipment wire Cat.No.6145-99-11, size 7/0.2, type 2. The graph shows two distinct regions for cables up to 50 m long, opto-isolator performance limits the operation to 10 mHz for longer cables skin effect losses limit the maximum data rate, which is a function of cable length, given by:

$$R \propto \frac{1}{L^2} \qquad \text{where } R = \text{maximum rate}, \quad L = \text{cable length}$$

From figs.4 and 5 it is possible to select devices for a module with matched delays. However, the actual delay of a complete module is of secondary importance to that of matching all channels. Therefore it should be possible to use virtually all devices.

Figures 7 and 8 show the superimposed output of all channels of the unit with selected and non-selected devices respectively after 100 m of cable.

If selection of devices is not desired a change to the design can be made by placing a D-type latch between the Q output of the flip-flop and the line driver in the data channels. A strobe from the clock channel latches the data simultaneously. This gives precise timing and also allows for the spread of opto-isolator delays.

6. SPECIFICATION

Input	-	Screw lockable 25 Pin Cannon Plug (isolated) conforming to EUR 6100
Output	-	Screw lockable 25 Pin Cannon Socket conforming to EUR 6100
Rate	-	up to 10 mHz.
Size	-	single width CAMAC.
Power	-	6 volts 600 mA.

ACKNOWLEDGEMENTS

I would like to thank Mr. G. Hughes and Dr. M. Przybylski for encouragement and help during the project and also for correcting the manuscript.

REFERENCES

1. EUR 6100e: Specification of the CAMAC highway and serial controller type L2.

2. Hewlett Packard. Optoelectronics Designers Catalogue 1980.

FIGURE CAPTIONS

Fig.1 Circuit diagram of the module.

Fig.2 Timing diagram of the operation of a single channel.

Fig.3 Circuit diagram of the test circuit used to measure the propagation delays of the opto-isolators.

Fig.4 Histogram of the propagation delays of the preset opto-isolator falling edge, Tdpn.

Fig.5 Histogram of the propagation delays of the clear opto-isolator falling edge, Tdcn.

Fig.6 Data rate as a function of cable length. Cable use twisted pair seven strand each 0.2 mn.

Fig.7 Output of all channels of module after 100 m of cable with selected devices.

Fig.8 Output of all channels of module after 100 m of cable with non-selectable devices.

Fig.9 Photograph of front panel of prototype unit.

Fig.10 Side view of prototype unit.

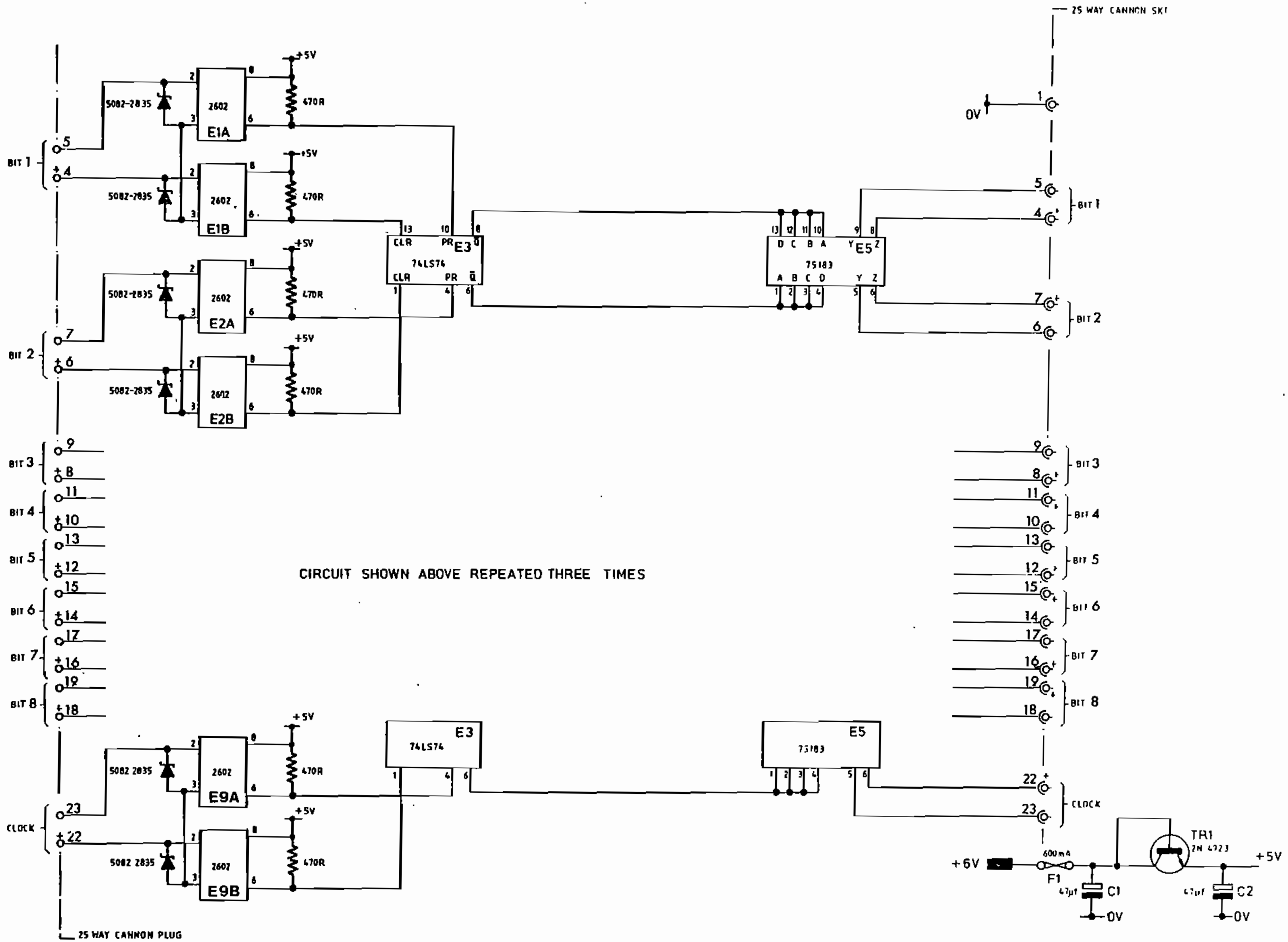
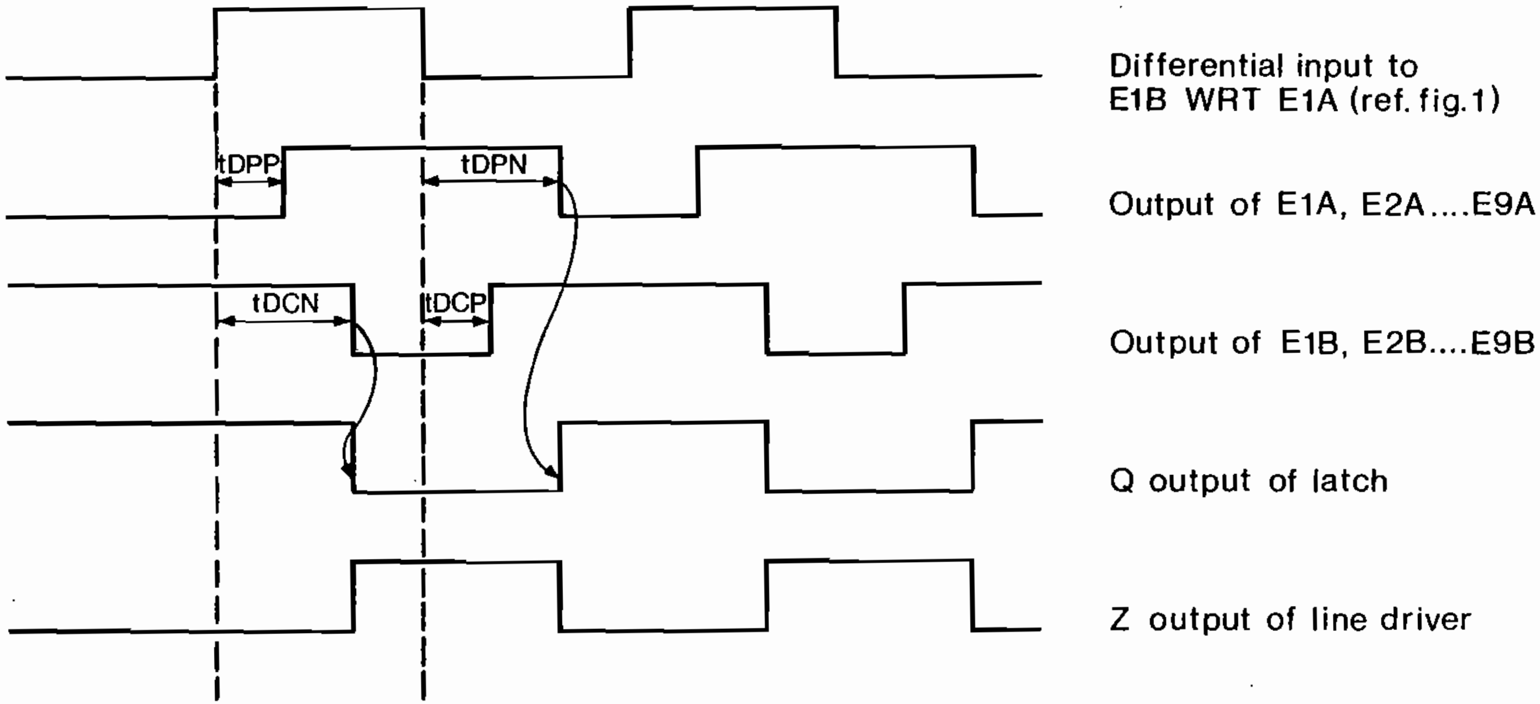
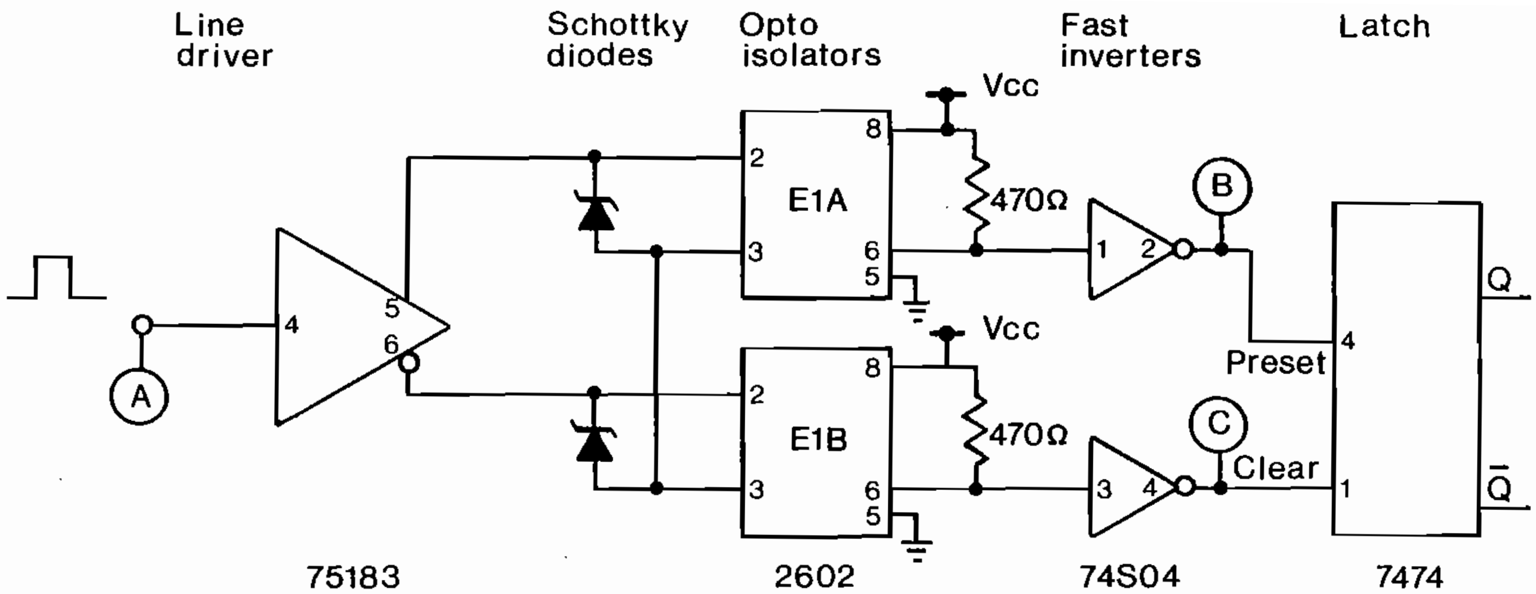

25 WAY CANNON SKT
0V
BIT 1
BIT 2
BIT 3
BIT 4
BIT 5
BIT 6
BIT 7
BIT 8
CLOCK
5082-2835
2602
E1A
E1B
E2A
E2B
E9A
E9B
+5V
470R
74LS74
E3
CLR
PR
75183
E5
CIRCUIT SHOWN ABOVE REPEATED THREE TIMES
+6V
600mA
F1
C1
C2
TR1
+5V
25 WAY CANNON PLUG

Fig. 1



Note: Propagation delays of latch and driver are ignored.

Fig. 2



Line driver
Schottky diodes
Opto isolators
Fast inverters
Latch
Vcc
8
2
E1A
470Ω
B
1
2
3
6
5
Q
4
5
4
6
A
Preset
Vcc
8
2
E1B
470Ω
C
Clear
3
6
5
3
4
1
Q̄
75183
2602
74S04
7474

Fig. 3

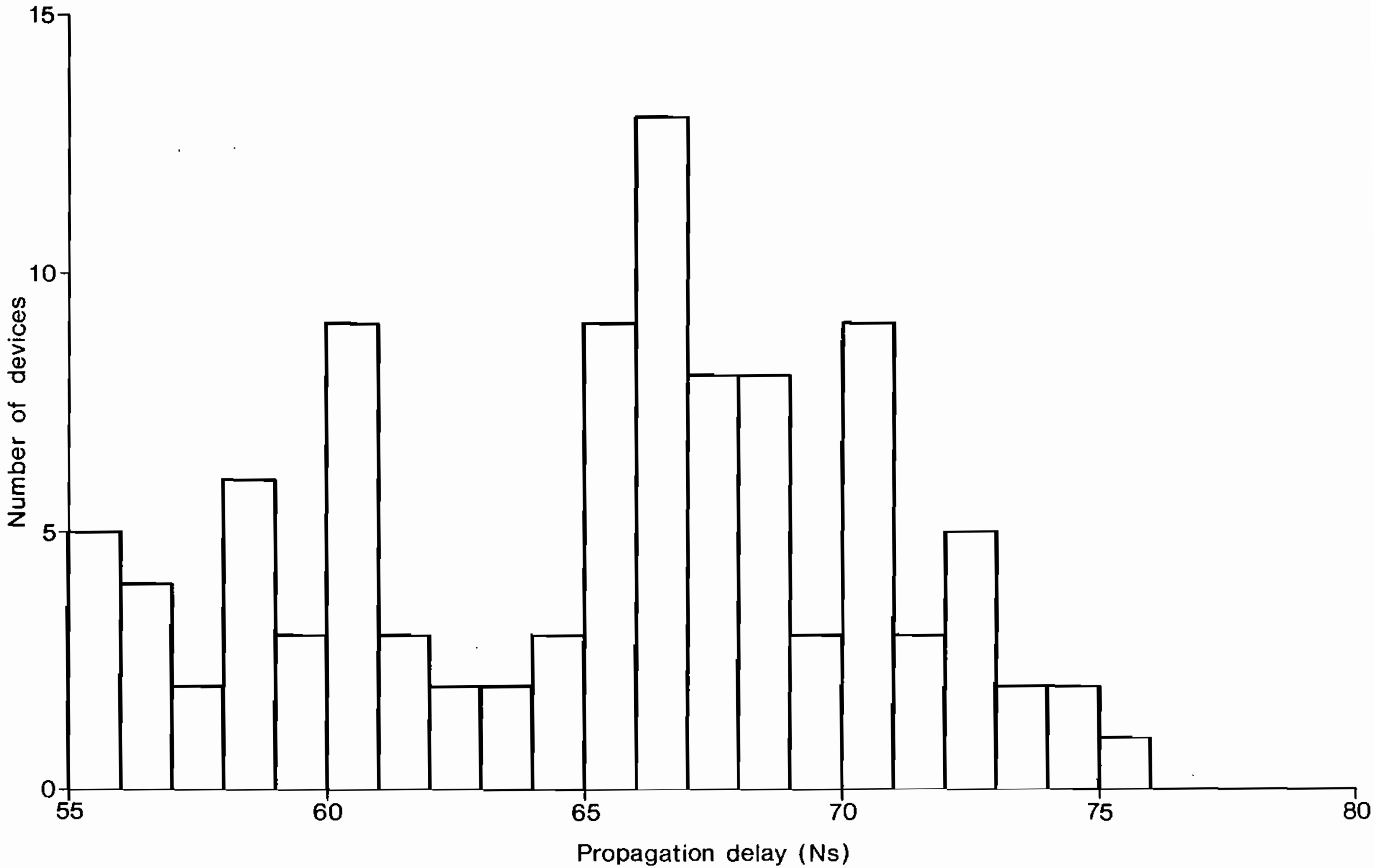
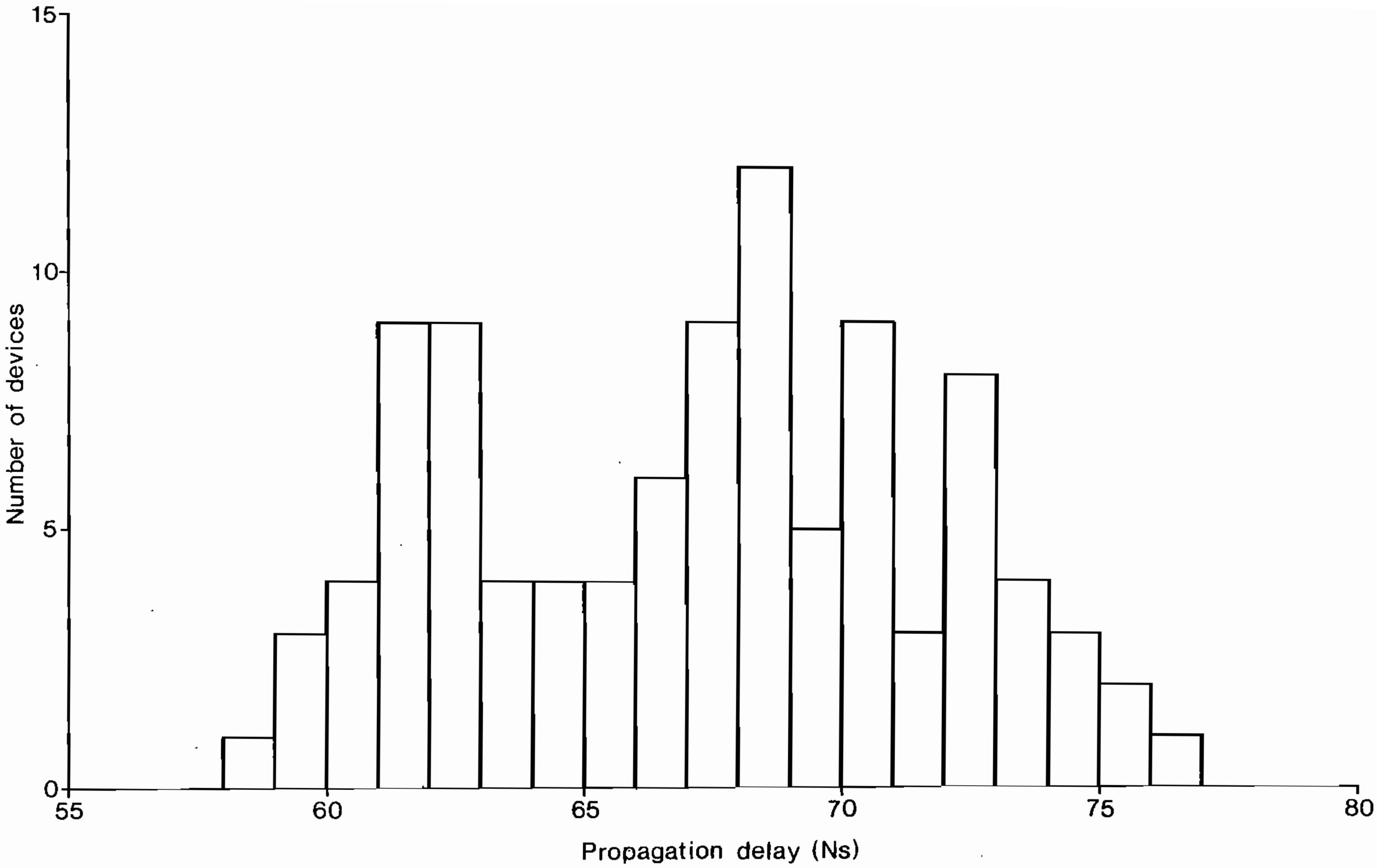

15
10
5
0
Number of devices
55
60
65
70
75
80
Propagation delay (Ns)

Fig. 4



15
10
5
0
Number of devices
55
60
65
70
75
80
Propagation delay (Ns)

Fig. 5

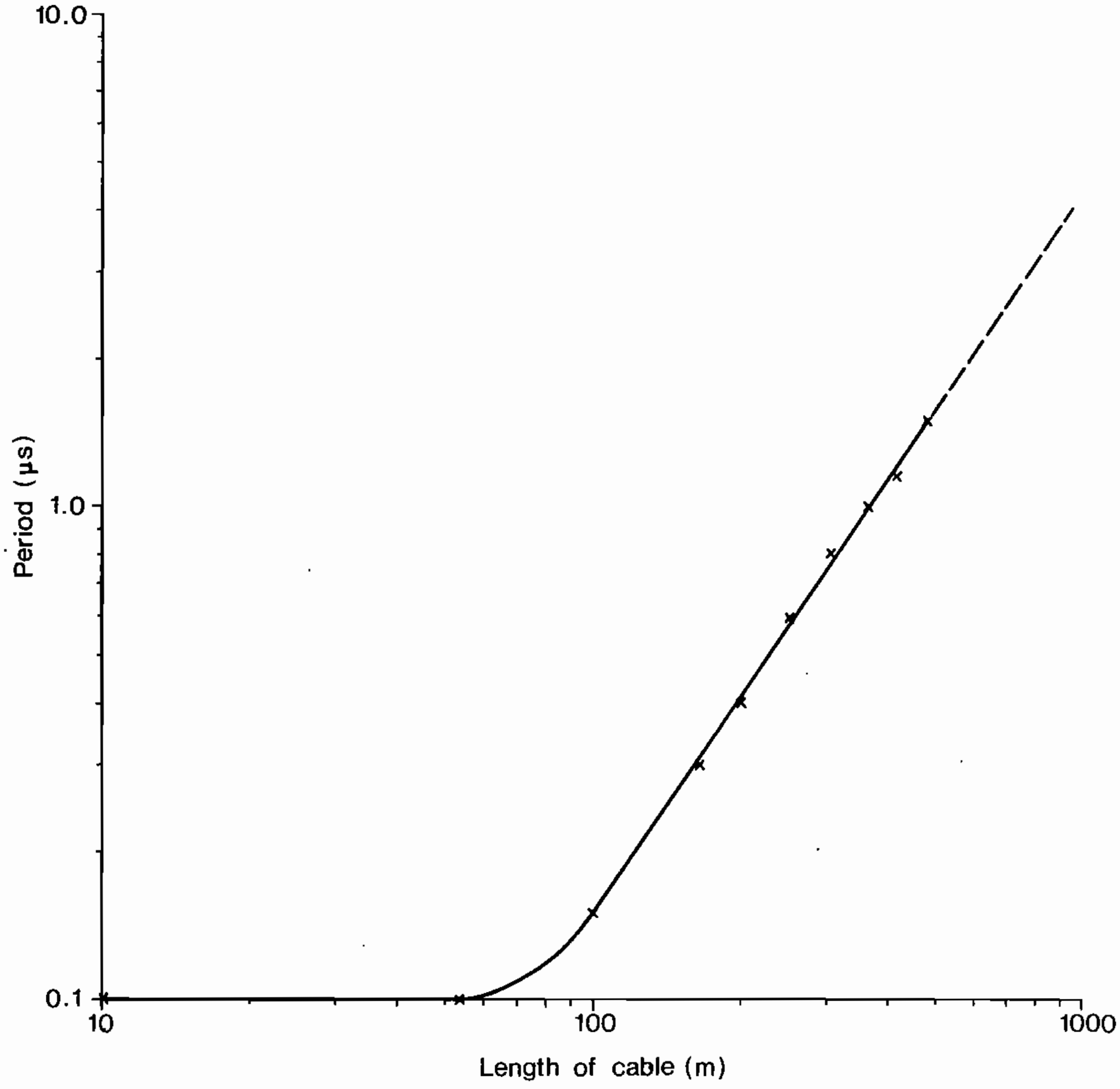


Fig. 6

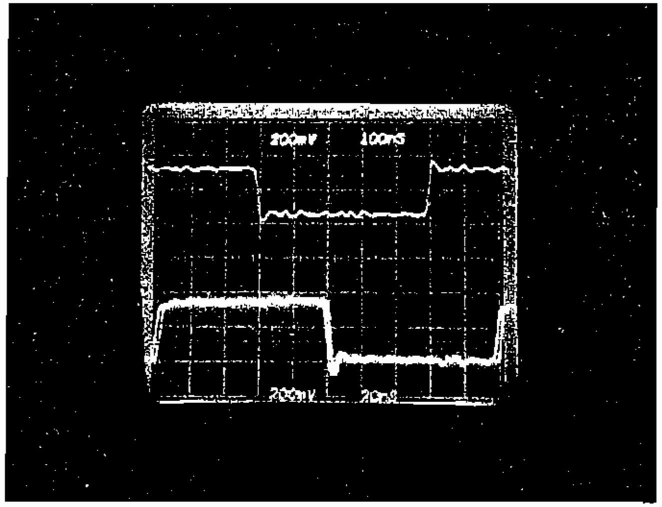


Fig.7

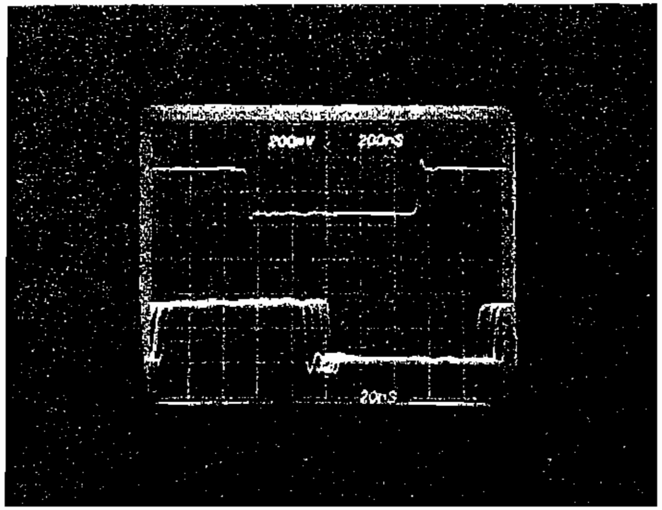


Fig.8

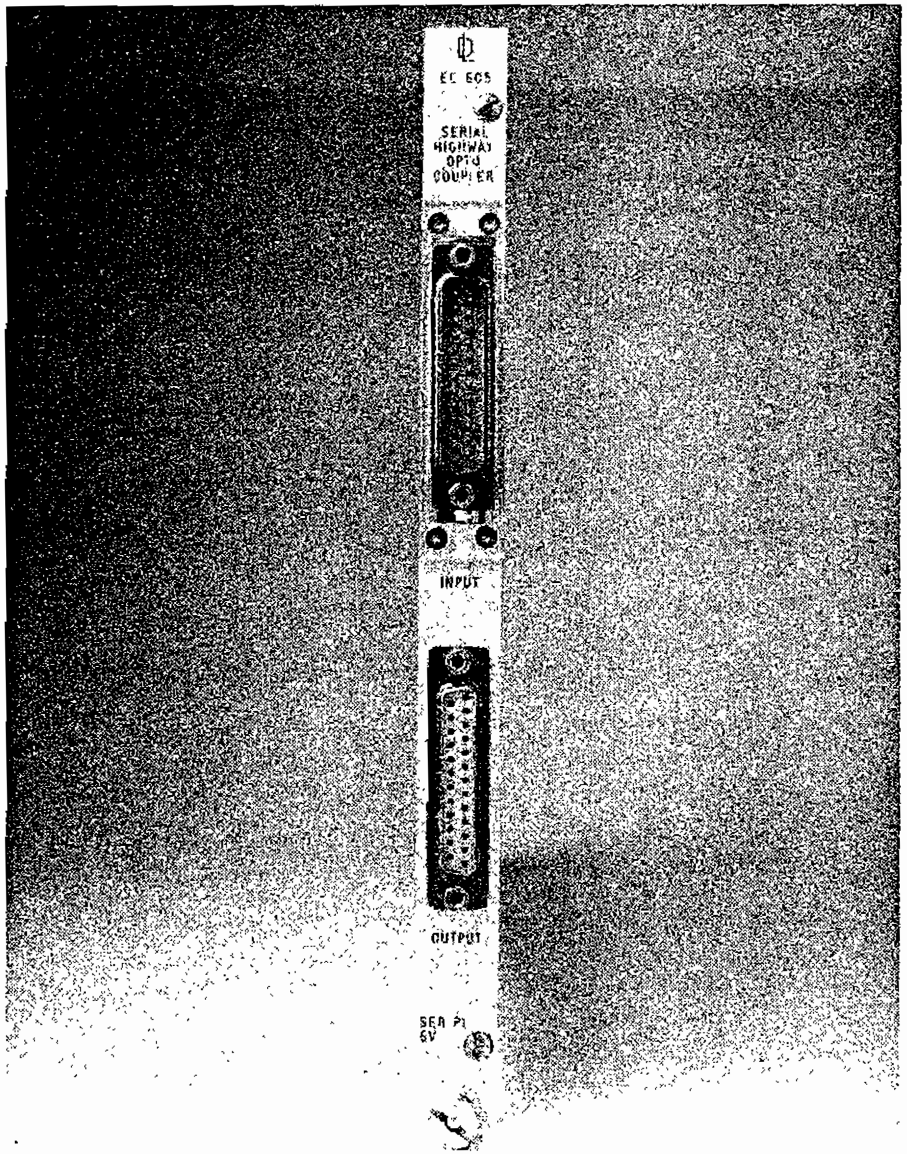


Fig. 9

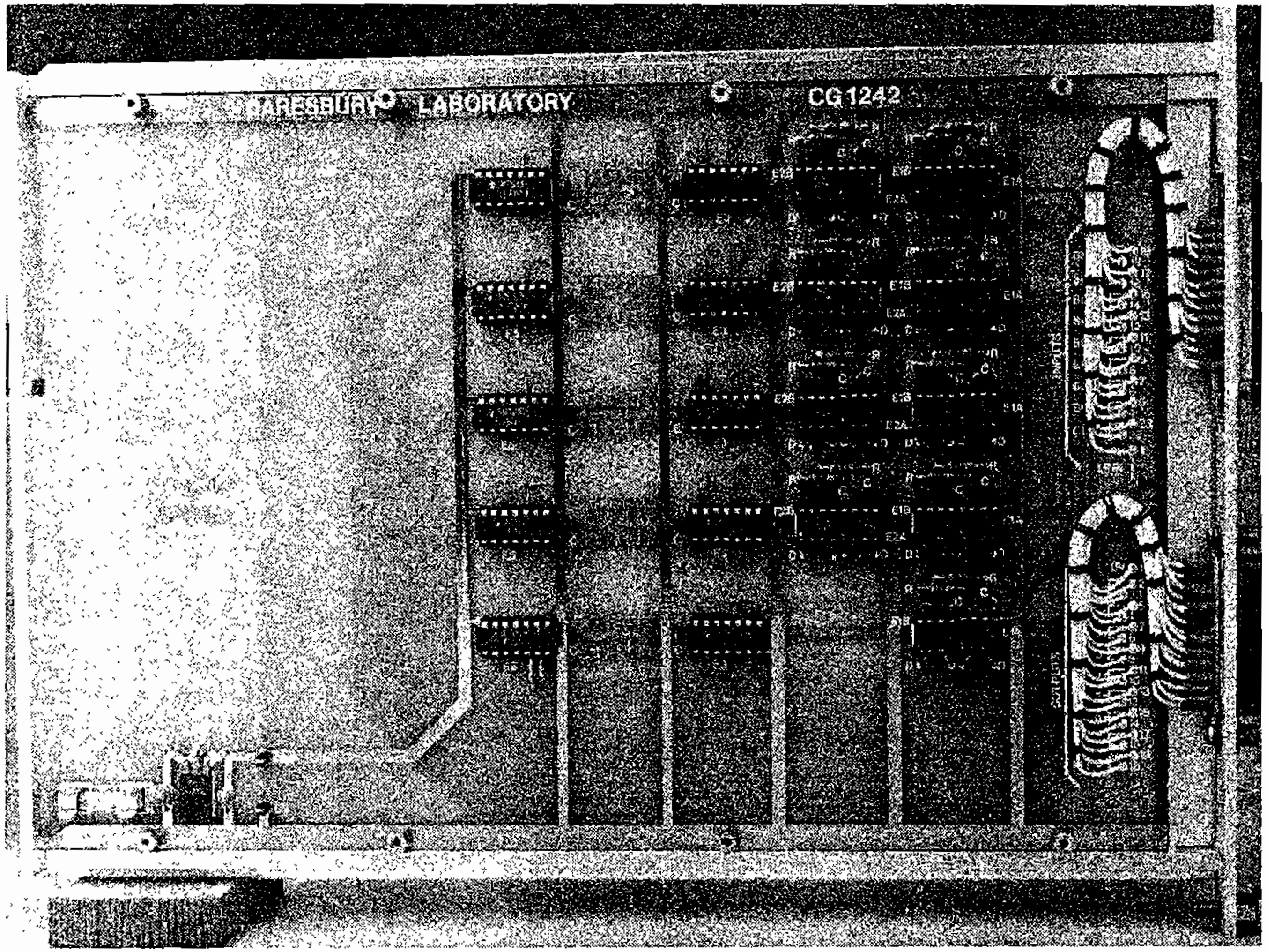


Fig.10