

MECHANIZATION OF ENGINEERING DESIGN DATA

by

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(A paper presented at the midwinter meeting of the Engineering Graphics Division of the American Society for Engineering Education, January 18, 1962, at the University of Wisconsin, Madison, Wisconsin)

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INTRODUCTION

Originally, computers were used for scientific problem solving -- the long repetitive numerical calculations. Use of scientific computers began on a large scale towards the end of the Korean war.

Even though it was recognized that the scientific computer was capable of handling data for commercial operations, similar to punched card equipment, it wasn't until a few years later that computers were considered economically practical for commercial data processing.

The experience gained in scientific problem solving and in commercial data processing led into a new area that is now just receiving general recognition. This is the use of computers for the generation, storage and dissemination of engineering design data.

This design information has traditionally been in the form of drawings, art work, bills of material, and engineering specifications. The computer can aid the engineer in the preparation of this design data by relieving him of many noncreative and routine functions.

The form in which this data is presented shifts from hard copy or paper documents to magnetic tape, from pictorial drawings to tabulated lists, from hand drawn documents to documents prepared by printers and cathode ray tube displays.

As most of this data produced for the engineer is in digital form, manufacturing can use it to operate numerically controlled fabrication and test equipment. IBM has developed such a computer-oriented design mechanization system which is used in the design, release, and production of solid-state computers.

The initial effort in developing this system was to automate logic page printing and panel wiring. We started here because there were considerable gains in time and cost -- and this appeared to be an area where we had a

reasonable chance of success. The savings gained by this approach were then reinvested to help expand this system to its present-day capability, where we go from the engineer's design sketch to the production of wired panels and circuit cards under the control of computers and automatic control equipment.

SYSTEM DESCRIPTION

The engineer's design sketch, which is called the logic page sketch sheet (Fig. 1.), is the engineer's input to the computation laboratory. This sketch is drawn on a vellum sheet, which has guide lines of nonreproducible blue ink printed on the reverse side. This sheet is standardized throughout the company so as to insure consistent input to the computers.

The engineer uses this logic page sketch sheet to specify the logic or circuitry and physical data of the computer. To describe the logic of a large computer may require 1000 individual sketches. The other documents used to describe a computer are generated from the logic sketch sheets by the use of computer programs.

Information on the sketch sheet is transcribed into punched cards for input to a computer where a magnetic tape is produced containing all the information represented on the logic page sketch sheet. This tape is called the logic page master tape and is the basis for further computer processing.

Output

The first output produced from the master tape is a logic page (Fig. 2.) printed on the IBM 717 printer. This printed page is the master drawing used for furnishing copies to manufacturing and customer engineering.

The correctness of the information on the master tape is verified by visually checking the printed logic page with the original sketch. Any discrepancies must be corrected before further processing is done.

As all the circuit and physical information is contained on the master tape, it becomes possible to use the computer to check the design against established design rules. At this point in time we do not check whether the logic is correct or not, but we do check against 50 rules that apply to circuits, physical location, and format.

An errata list showing the deviations from the design rules is returned to the engineer so that he may correct his logic sheets. He submits the marked up logic sheet to the computing center where the master tape is updated and a new logic sheet returned to the engineer.

After the errata have been eliminated, the engineer will then request that manufacturing documents be produced.

One of these outputs is the circuit card location chart (Fig. 3.). This chart is also printed on the IBM 717 printer. It may not look like a typical assembly drawing, but all the information that is required is presented.

Another output is panel wiring information. On some of the earlier computers, drawings were used to show the actual wiring of a panel -- in fact, several drawings were necessary for each panel so that the wires could be distinguished by the wiring assembler.

The next step was the realization that wiring could be specified on a tabulated list. This was a big step forward in that wiring information could be on punched cards, changes could be easily made, and assembly time reduced. With the present system, panel wiring information is on magnetic tape.

Manufacturing processes the panel wiring tape on a computer to provide control tapes or punched cards for directing numerically controlled wire wrap and panel testing machines. A typical panel is shown in Fig. 4.

A third output is information for producing circuit card assemblies. As all circuit information is contained on the logic page master tape, information can be extracted for use in determining the printed-circuit wiring paths, component placement, and hole location. The computer output can be used to direct an art-work generator, component placement machine, and an automatic punch press.

Figure 5 is a twin card made by this process. Figure 6 is a drawing generated on the IBM 740 showing the layout of the printed circuit. Figure 7 shows the opposite side of the card indicating the placement of components.

TIME, COST, AND OTHER FACTORS

It is difficult to equate the use of computers on problems such as these with manpower or dollar savings because it is doubtful if they would have been undertaken in such a large degree by other means.

Panel Wiring

To create a panel wiring list, it is necessary to extract all connections identified on the logic page and sort the wiring out by panel. A panel may have up to 2000 wires. The wires must be routed so as to minimize overlap.

This reduces the electrical noise introduced by adjacent wires. If the noise criteria are exceeded, twisted wiring which has partial shielding is used; and if this does not satisfy the noise criteria, coaxial wire is specified. In connecting the various wires to form electrical nets, the connections to the pins must be considered since only a limited number of wires can be attached to each pin.

It would take several man-weeks to produce a panel list manually. There would be an unknown number of errors that would cause delays in manufacturing. The computer does this same operation in 30 minutes, providing accurate wiring information.

Twin Card Layout

One of the determining factors influencing the use of the twin card was the ability to lay out the card with the aid of a computer. Tests showed that it would take at least two weeks to lay out a card manually and then, even in this length of time, it might be found that it was impossible to do it at all. The computer can either lay out the card or tell that it cannot be laid out in just a few minutes.

STANDARDIZATION ASPECTS

This, then, is an example of a complex system of computer programs that form part of the operations in an engineering-manufacturing organization. For a system such as this to be successful, there has to be a high degree of standardization; there must be repetitive functions and there must be enough discipline exerted so that the maximum benefits can be obtained.

In planning and developing the IBM 7000 series solid-state computers, it was recognized that standardization of hardware was necessary if IBM was to produce the variety of computers that the market demanded. This standardization program actually expanded the productivity of the engineer, without impairing the flexibility of designs.

The standardization of hardware was on covers, frames, power supplies, cables, panels, and circuit cards. The engineer could then concentrate on the logical circuitry of his new computer without having to take the time and effort to redesign the associated hardware. This created a family of computers that looked alike but which are in actuality completely different products.

With the standardization of hardware, it then became practical -- if not even necessary -- to automate the engineering records. Developing a computer-oriented mechanization system, such as used at IBM, is expensive and could only be justified if it could be used on many products.

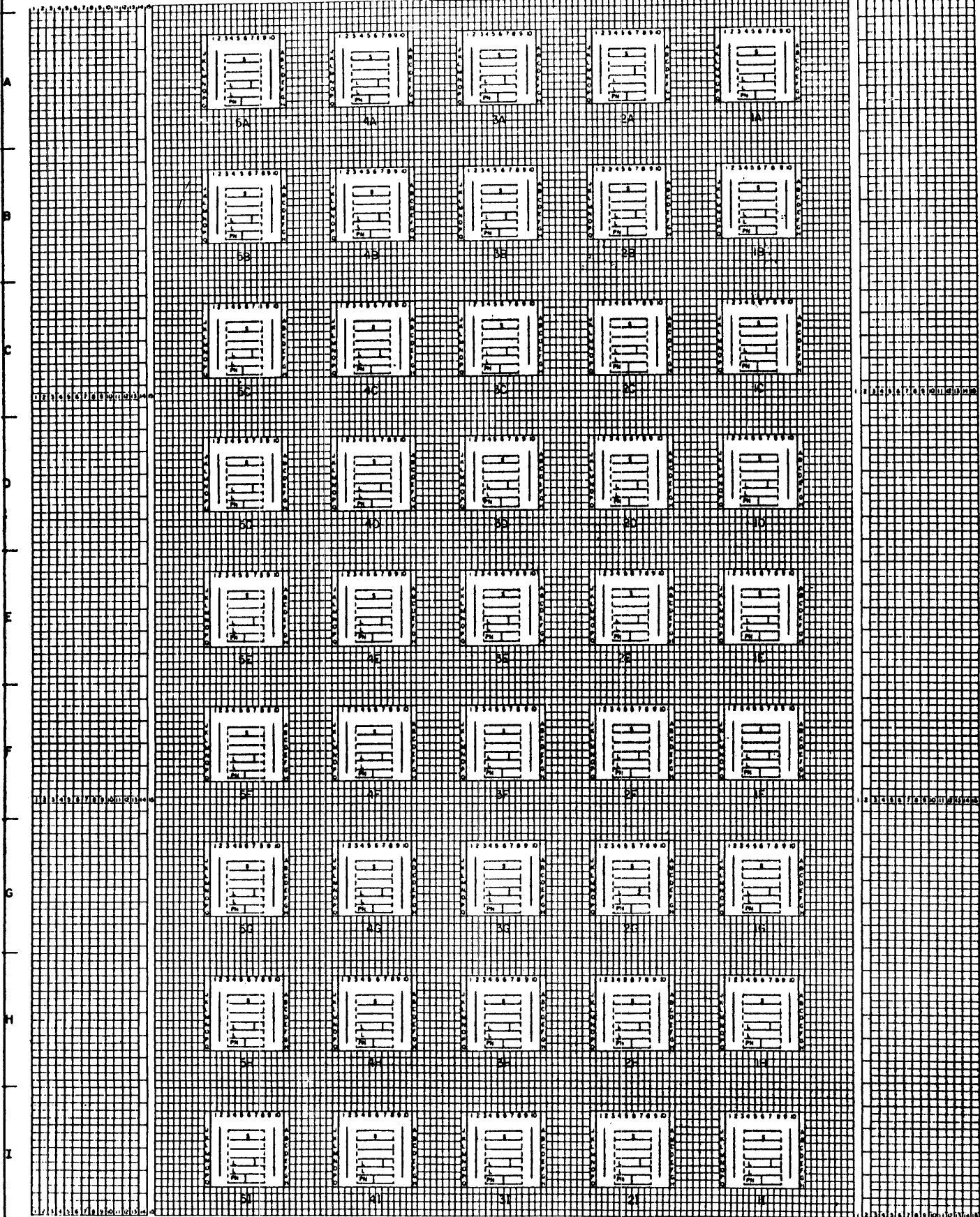
CONCLUSIONS

In developing a large scale computer, a tremendous amount of information must be generated and released to manufacturing before production can begin. On a large computer, there are 90,000 electrical connections, 12,000 circuit cards, tens of thousands of components, the hardware, cables, etc., that must be described. The computer system that processes this information gives accurate and consistent data that is in agreement with the original engineering documents.

The engineering data that is produced by this system is in digital form. This lends itself to automatic production and testing of products in manufacturing without extensive manual conversion of drawings into digital data. In this manner, the process of going from the engineer's hand drawn sketch to the finished panel is under automatic control of the computer and the fabricating equipment.

The programs that are used in this system are specifically designed to match the design and hardware characteristics of IBM's products. However, the concept of mechanizing engineering designs can be applied to other electrical equipment, to structures, to piping, and possibly to many other areas.

The work in automating engineering data has only started. This will not only expand into engineering and manufacturing processing areas, but will also be extended into inventory control, accounting, and purchasing systems.



COMMENTS _____ DESIGN _____ DATE _____ WITNESS _____ DATE _____ EC. NO. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33

Figure 1
Logic Sketch Sheet

	A	B	C	D	E	F	G	H	J	K
01										
02		DNYL 037135.1 04.01.08.1 2B	DDZX 037131.0 04.01.07.1 4I	DDZY 037130.8 04.01.08.1 4D		DDZY 037130.0 04.01.08.1 1W	DDZY 037128.6 04.01.05.1 2F	DDZY 037131.1 04.01.07.1 4E		
03	DDZY 037131.0 04.01.08.1 4F	DNYL 037135.1 04.01.08.1 2F	DNYL 037135.1 04.01.07.1 3I		DDZY 037128.4 04.01.08.1 4F	DDZY 037128.5 04.01.05.1 2G	DNYL 037135.1 04.01.07.1 3G	DNYL 037135.1 04.01.07.1 3E	DNYL 037138.0 04.01.07.1 5C	
04		DDZY 037128.6 04.01.04.1 4G		DDZY 037128.6 04.01.05.1 4A		DDZY 037128.6 04.01.05.1 4A		DDZY 037128.6 04.01.06.1 4B		
05	UH 037166.0 04.01.03.1 3I	DDZY 037128.6 04.01.04.1 4I	UH 037166.0 04.01.04.1 3F	DDZY 037128.4 04.01.05.1 4F	UH 037166.0 04.01.05.1 3C	DDZY 037128.6 04.01.06.1 4C	UH 037166.0 04.01.06.1 3C	DDZY 037128.6 04.01.06.1 4E	UH 037166.0 04.01.06.1 3I	
06		DDZY 037128.6 04.01.04.1 4H		DDZY 037128.6 04.01.05.1 4E		DDZY 037128.6 04.01.05.1 4H	DK 037114.0 04.01.07.1 5I	DDZY 037128.6 04.01.06.1 4H		
07	DDZY 037133.2 04.05.03.1 4E	DDZY 037130.0 04.01.04.1 2M		DDZY 037130.0 04.01.05.1 2E	DDZY 037133.2 04.05.03.1 4C	DDZY 037130.0 04.01.05.1 2H		DDZY 037130.0 04.01.06.1 2H	DDZY 037128.6 04.01.07.1 3F	
08	DEYV 037133.6 04.05.03.1 4F	DDZY 037128.5 04.01.04.1 2I		DDZY 037128.5 04.01.05.1 2F	DEZH 037131.5 04.05.03.1 1C	DDZY 037128.5 04.01.05.1 2C		DDZY 037128.5 04.01.06.1 2I	DDZY 037128.6 04.01.07.1 4C	
09		DDZY 037128.6 04.01.04.1 4H		DDZY 037128.6 04.01.05.1 4E	DDZY 037128.8 04.01.09.1 2G	DDZY 037128.6 04.01.05.1 4B	DG 037113.7 04.02.05.1 2H	DDZY 037128.6 04.01.06.1 4H	DDZY 037130.0 04.01.07.1 2F	
10	DEZH 037131.5 04.05.03.1 1D			DDZY 037130.4 04.01.09.1 2C	DDZY 037130.2 04.01.09.1 3C	UH 037166.0 04.01.08.1 5G	UH 037166.0 04.01.09.1 1D		DDZY 037128.6 04.01.07.1 2G	
11		DDZX 037131.0 04.01.04.1 1I		DDZY 037131.0 04.01.05.1 1F	DDZY 037130.4 04.01.09.1 2A	DDZY 037131.0 04.01.05.1 1C		DDZY 037131.0 04.01.06.1 1I	DDZY 037131.0 04.01.07.1 1C	
12	DDZY 037128.8 04.04.03.1 5A	DDZY 037128.8 04.04.02.1 5H	DDZY 037128.9 04.04.02.1 5F	DDZY 037128.8 04.04.02.1 5C	DDZY 037128.8 04.04.02.1 5A	DDZY 037128.8 04.04.01.1 5H	DDZY 037128.9 04.04.01.1 5E	DDZY 037128.8 04.04.01.1 5C	DDZY 037128.9 04.04.01.1 5A	
13	DDZY 037130.2 04.04.03.1 2B	DDZY 037130.2 04.04.02.1 4B	DG 037114.5 04.04.02.1 5G	DDZY 037130.2 04.04.02.1 2D	DDZY 037130.2 04.04.02.1 4D	DG 037113.7 04.04.01.1 1I	DG 037114.5 04.04.01.1 5F	DDZY 037130.2 04.04.01.1 4E	DG 037114.5 04.04.01.1 5B	
14	DG 037113.7 04.04.03.1 1B	DDZY 037130.2 04.04.02.1 2I	DDZY 037130.0 04.04.02.1 4F	DG 037113.7 04.04.02.1 1D	DDZY 037130.2 04.04.02.1 2A	DDZY 037130.2 04.04.01.1 2H	DDZY 037130.2 04.04.01.1 4I	DDZY 037130.2 04.04.01.1 2D	DDZY 037130.2 04.04.01.1 4D	

1

FIGURE 3

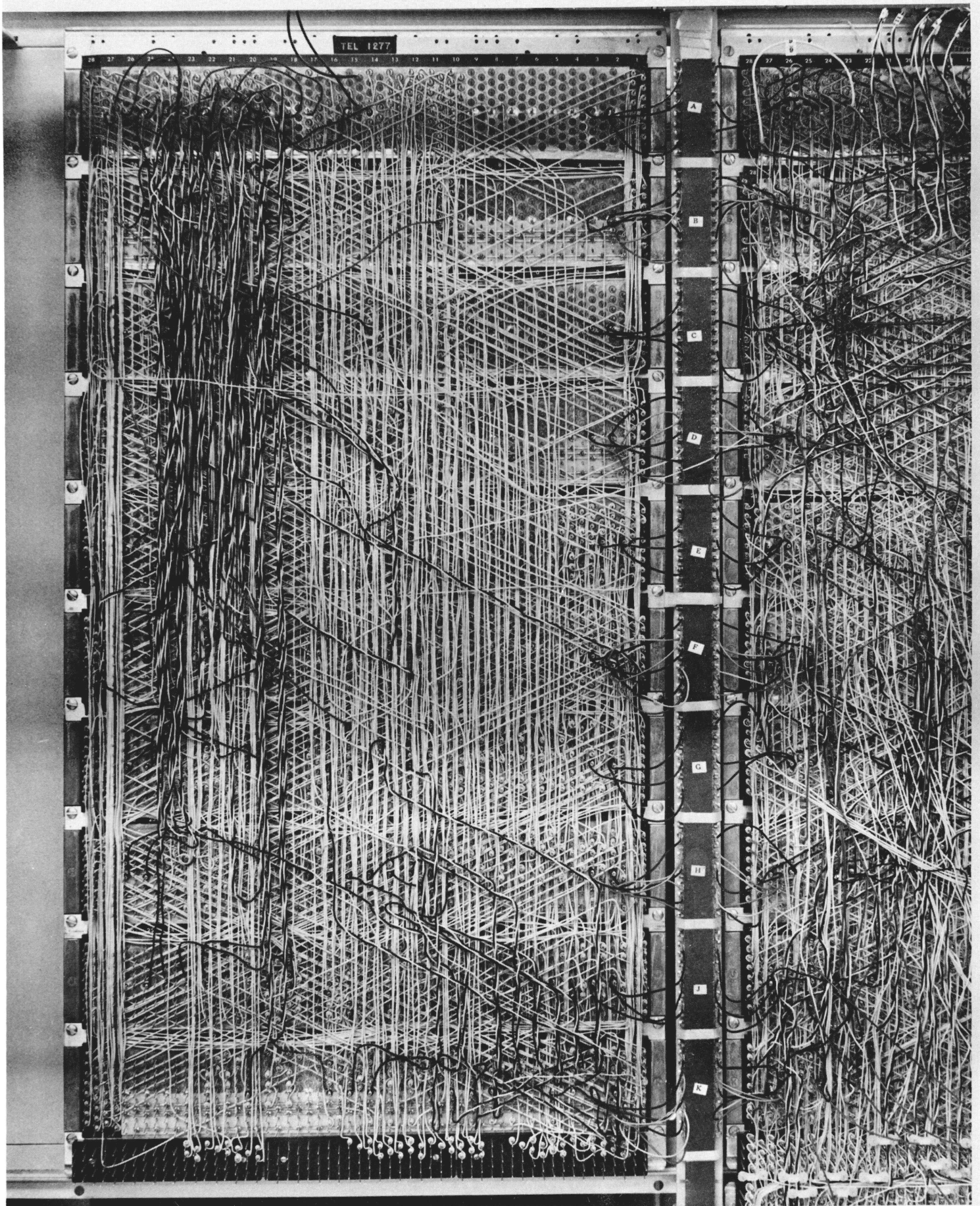


Figure 4

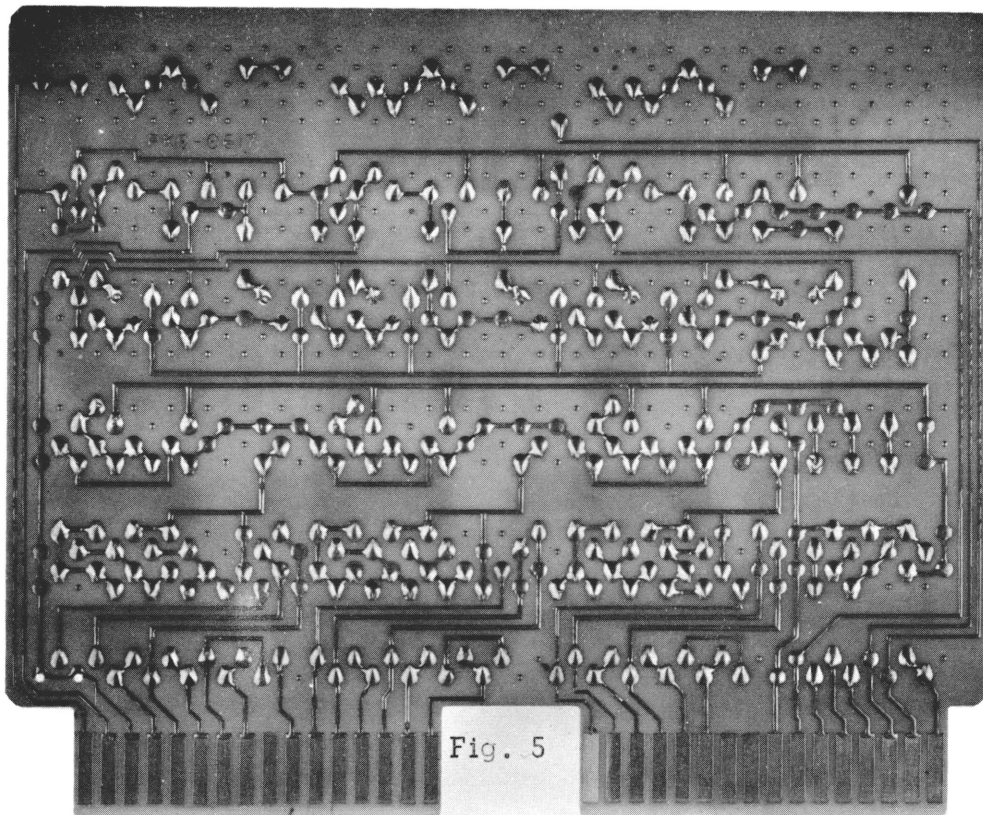
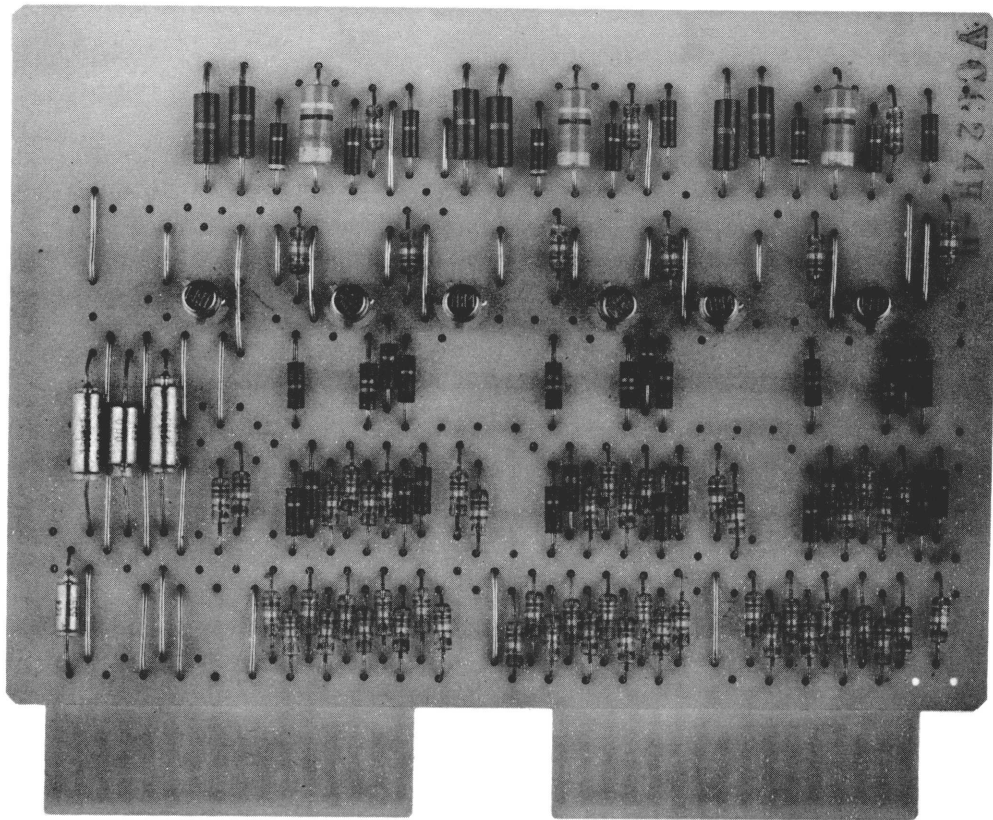


Fig. 5

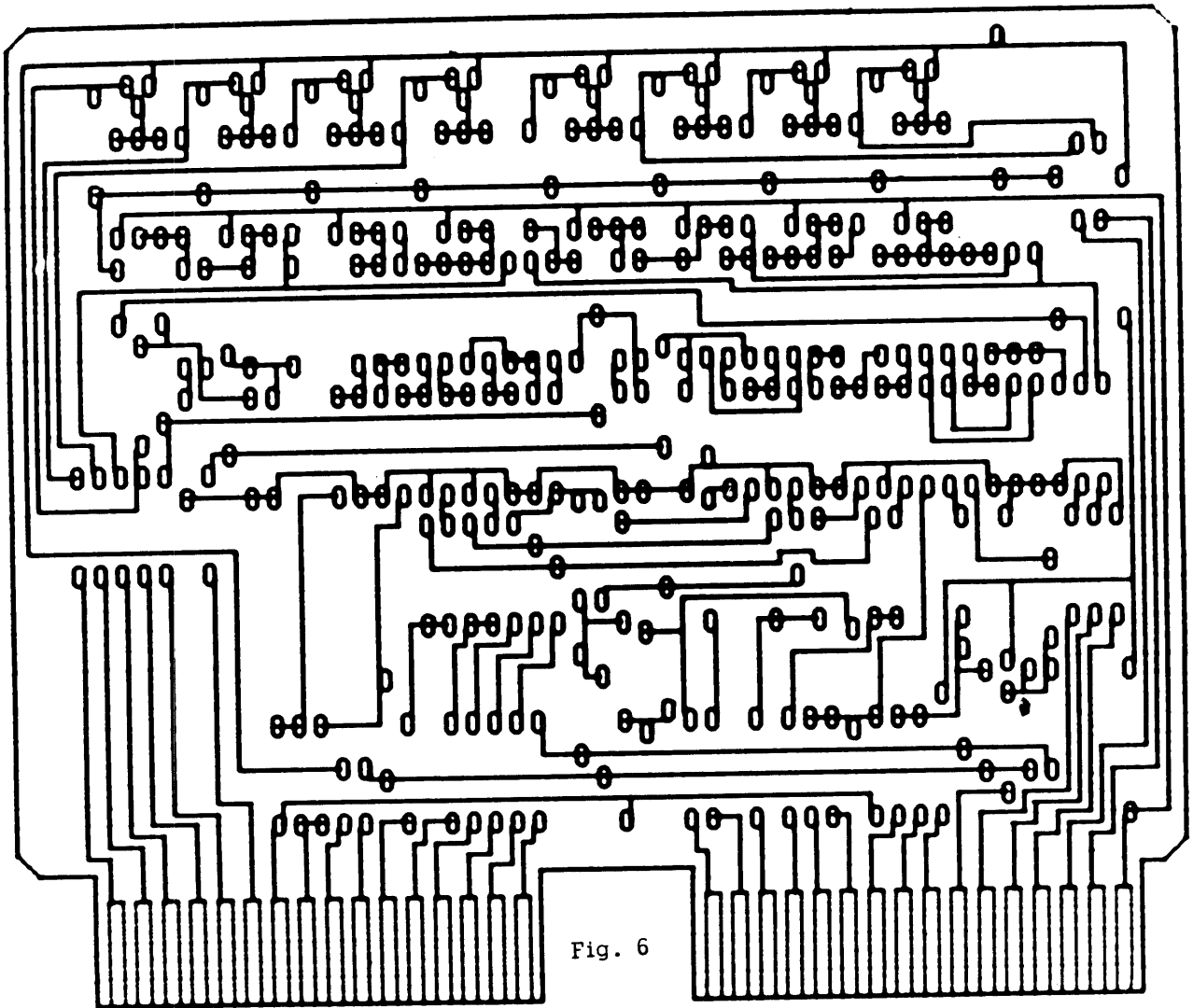


Fig. 6

