Confidential

# W W A M PROJECT N° 7002

## FINAL REPORT

January 1960

Development Engineeri

IBM France

Company Confidential

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SUMMARY

This project involved :

- Logical design of a transistorized accounting machine and its connection to I/O units developed in Germany

- Design of circuits, packaging and framing (no standards being available from the U.S. at that time)

- Construction, debugging and test of a prototype.

Although it was decided to discontinue the WWAM project, the following items may prove useful for other projects :

New ideas developed in logical design.

Circuit design (even with SMS philosophy, all special circuits developed in France will benefit from the experience gained in the WWAM project and particularly memory driving and memory temperature regulation control).

Packaging design : Since the appearance of SMS, the COCA (card on card packaging arrangement) is no longer used ; it may however become useful again, for new types of circuits where the number of I/O connections must be greater and the shortest possible.

Packaging and circuits were used for different plate models while the SMS parts were not available in France.

Training of engineers and technicians on problems encountered during the construction and debugging of average size transistorized machine.


Nota. The reference materials may be requested from Mr. J. Donne, Documentation Dept., 20 avenue du Général Michel-Bizot, Paris 12e

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# PROJECT DESCRIPTION AND OBJECTIVES

## I - INITIAL OBJECTIVE

The early developments began in 1955 and the active phase of the development started in the middle of 1956.

The program covered the design of an electronic card operated calculating/accounting machine. The main objective was to fill the gap between the present accounting machine and the EDPM, that is to say to cover two different markets with the same machine system.

a) Accounting machines functionally equivalent to the 407, but operating at a higher speed range.

b) Accounting machines with optional calculating ability.

The maximum machine was to be composed of :

1 Processing Unit
1 Slave Print Unit ) with various operating speeds
1 or 2 Slave Read Units )
0 or 1 Reader Punch Unit
1 Summary Punch Attachment with Read Back Checking.

All these units beingcapable of working simultaneously.

The processing unit was to be highly expandable.

Since the I/O units were to be designed and built in Germany, the French Engineering Dept was concerned only with the Processing Unit and I/O control circuit design.

The project development included :

- Logical design
- Procurement of components, including transistors
- Adaptation of circuits and packaging being developed in the U.S. for the 750 project (these were to become Standard by the end of 1956).
- Construction and test of 3 prototypes.

## II - FIRST CHANGE IN THE OBJECTIVES

In the beginning of 1957, the 750 circuits and packaging were discarded and no more standards were available from the U.S.

Therefore, it was decided to add the design and test of packaging and circuits which would best fit our requirements to the present objectives, taking the possibilities of European vendors for transistors, diodes and printed circuits into account.

At the same time, for cost and time considerations, it was decided to restrict the project temporarily to the construction and test of three prototypes made up of :

1 - Processing unit

1 - 300 CPM, 300 LPM Slave Reader Printer

1 - Summary Punch Attachment

taking into account that the philosophy of the project would always permit returning to the preliminary objectives.

## III - SECOND CHANGE IN THE OBJECTIVES

During 1958, it was decided that no more development would occur on the project, except the work in the completion phase, i.e.

- Construction and test of model 1
- Construction and test of a built-in transistorized oscilloscope
- Model 2 packaging and circuits

Therefore, work has been stopped in other areas :

- construction and test of models 2 and 3
- possible outgrowth of the program.

Debugging of model 1 was completed in March 1959 and its test was stopped in December 1959.

## IV - REFERENCE MATERIAL

- Project File (World Wide Accounting Machine, Project n° F 7002).

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# LOGICAL DESIGN, MACHINE ORGANIZATION AND COST ESTIMATE

## I - GENERAL

Work on this area included, first, system design (1955-56-57), then design of model 1 (1957-58) and modifications further to Model 1 debugging (1958-59).

Work has also been done on an explanatory basis only, on possible outgrowth of the program :

- stored program
- tape attachment
- use of other types of print units
- low cost minimum WWAM
- multiple input system
- calculating equipment composed of a modified Processing unit and a Reader Punch
- modified WWAM for Giro problem (this became a separate project).

The main new features discovered are well known and have proven to be very valuable even in other projects. These are :

- elaborated system of Print Editing including easy character insertion
- complete integration of all accounting functions into the processing unit, including Read Editing, Print Editing, Zero suppression, etc.
- variable word length combined with two address operations
- extensive use of time sharing interlock to perform Read, Print, and Punch buffering functions without any special memory
- program branching facilities
- new multiplication system
- new parallel to serial input system including checking.

## - MACHINE ORGANIZATION AND COST

As explained under "project description and objectives", the same program was in fact intended to fulfil two different requirements (basic accounting machine and calculating ability). It has been tried to have only one type of machine organization and to be able to grow from the minimum to the maximum machine by field installation. This led to the following consequences :

1) All devices appearing in the expanded versions were integrated into the basic machine design in order to be easily installed when required. This led to a basic machine cost increase (increase of component count, frame dimensions, power supply requirements, etc.).

2) Control panel programming was preferred to the stored program because it is less expensive below a certain machine size. (This machine size is highly dependent on the transistor to ferrite cost ratio and to the cost of memory control circuits).

Because the maximum machine had to be an expanded version of the basic one, the control panel system was used also for the maximum machine.

Thus, the requirement of using the same machine for both different markets led to a cost increase of both basic machine (consequence 1) and maximum machine (consequence 2).

Note. The study of a stored program version was undertaken when the completion of model 1 logical design and implementation allowed having some available manpower. This study was interrupted when the WWAM project was limited to Model 1 test.

## I - COST ESTIMATING PROBLEMS

It is to be recalled that no standard circuits nor packaging were at this time available from the U.S., so that we had to develop and estimate our own ones. This had two consequences :

1) We could not benefit from a low cost estimate due to mass production because we could count only on the WWAM production.

2) Consequently, this inconvenient was compensated for designing the cheapest circuits and packaging for WWAM production, taking into account Machine organization, European vendors, European components, and supposing the WWAM would be produced in Europe.

This made it difficult to have a convenient cost estimate of the same machine produced in the U.S., since problems are different there (different components, charges, etc.). In fact, the cheapest solution in Europe cannot be the cheapest one in the U.S.

## - REFERENCE MATERIAL

- Syracuse university joint meeting, June 20, 1956
  "The IBM World Wide Accounting Machine" by Mr. E. Estrems

- World Trade Symposium on Research and Development, Paris, January 9-10, 1957
  "WWAM Philosophy" by Mr. E. Estrems
  "WWAM Logic" by Mr. M. Papo

- World Trade Symposium in Zurich, February 26-27, 1958
  "Overlapping without buffer" by Mr. P. Duvochel
  "Electronic paper carriage control" by Mr. M. Bensoussan

- "The IBM World Wide Accounting Machine" by Messrs. F. Underwood and E. Estrems

- Final specifications of the WWAM by WTC Product Planning, dated February 20, 1958

- Engineering manual WWAM Processing Unit

- Model 1 WWAM Logical Diagram

- Cost estimate : "WWAM Accounting System (300 I/O) Europe and USA", dated June 6, 1957

- Processing unit WWAM Cost Estimate by IBM France Estimating Dept. dated February 5, 1958

- Idem dated November 7, 1958.

## PACKAGING DESIGN

### - TYPE 750 PACKAGING

The card on card packaging arrangement (C.O.C.A) used in the WWAM is derived from the packaging designed in 1956 in the U.S. for type 750 machine. Here is a short description of the 750.packaging.

#### Machine lay out.

The disposition and general presentation of the machine are to be similar to those of the 608.

#### Logic card.

In the 750 Packaging the logic card measures approximately 10" x 11". The circuits are printed on both sides with metallized holes. For all the cards, there is only one type of "hole pattern" (see figure 1).

Connections are made by means of 48 gold plated contacts on both sides (the socket is the same as that used in the 608). In addition, the card contains 32 test points.

The card contains 5 rows of 34 positions which are spaced .25" apart.

Voltage distribution is accomplished by printed circuits. All voltages are allotted to one end of the rows. In each row, they are brought about by circuit cards.

The distance between each logic card is .75". Due to the dimensions of the cards a relatively large number of cards having identical printed circuits was expected.

Circuit card.

The circuit card is wire wrapped to the logic card. The card is 1.5" inch long ; the length varies according to the type of circuit.

The circuit card is printed on both sides with metallized holes ; one side serves for the distribution of the voltages on the card itself and fo the following circuit card, the other side serves for the connection of the circuit elements.

Each end of the card is used to insure the continuity of the voltage distribution in the row. This occupies the place of two elements per card. For each card type the hole pattern is different so as to assure a suitable voltage distribution to the circuit.

In order to insure the circuit card to logic card connection as well as a distribution of the voltages, the number of wire wraps to be made in order to connect a card is at least 17 and at most 21.

Because of the variable length of the circuit cards and the fixed length of the logic card a certain space may be lost by the card, which appreciably increases the number of logic cards necessary in the machine and as a consequence the number of connectors.

- CARD ON CARD ARRANGEMENT (Model I version)

The first price estimation made in 1957 showed that the price of the machine was too high and this was due especially to the packaging and more particularly to the gold plated contact connectors. In addition, at this time, the 750 Packaging was abandoned in the U.S. and no new packaging was available. For this reason, the study of the card on card packaging was decided upon.

The major aim of the study was to eliminate the gold plated contacts, to use circuit cards printed on one side only and to increase the ratio of useful surface to total surface for logic cards.

Machine lay out.

The machine is divided into three mean parts (see fig. 2).

- The center contains : in front, the control panel, the indicators panel and the relay gates ; back, power supply and hook up connectors (shoes) (see fig. 3).

- Left side (see fig. 4) contains the timing, the memory and the data flow.

- Right side contains the circuits for the control panel.

Each of the sides is composed of two rows of 14 frames placed vertically. This makes a total of 112 logic cards in the machine.

The logic cards are mounted on metallic frames. Each frame supports two cards. Edge connectors similar in type to those used in the 604 are mounted on the logic cards. The connection between these cards is no longer made by the gold plated contacts but by AMP standard tin plated taper pins.

In order that the cables may be distributed in the machine without providing for clearance loops and without damaging the cables, the logic card frames are connected to the machine as seen fig. 5. Pivoting of the card permits access to all circuit points without cutting off the voltages ; that permits debugging without changing the state of the circuits. Moreover, accessibility of all circuit points permits knowing the state of each element of the circuit before dismounting of the unit.

The frames are made so that the cards may be separated through an angle of 90° from each other, in order to make both sides of logic cards available to permit possible changes in the machine logic. In this way, the wire wrap pins are so made so that wires may be soldered directly to them on the inner side of the cards (see fig. 6).

The distance between two logic cards is .75".

Indicator Panel.

The indicators used are of the DM 160 type so that they are directly controlled by the logical signals without intermediate transistors.

They are mounted on a printed circuit panel. The connection between the gate of the DM 160 and the wires is made by a technique similar to that used for the indicators in the SMS.

The light guide placed in the front permits a good presentation of the unit and better lighting.

Logic card.

The dimensions of the logic cards are approximately 14" x 25". They contain 7 rows which can receive 90 elements each and one row which can receive 84 (see fig.7). The total number of elements which can be mounted on each card is 714 taking into consideration that a transistor takes the place of two elements as well as 2 W resistors and capacitors greater than .22 uF.

The pitch is .25", the length of the elements cannot be greater than 1".

Fifteen edge connectors having 20 positions each can be mounted on each card. The normal number of edge connectors is 9 per card, that is 180 connection positions.

The circuits used in the WWAM have a variable load resistance to be chosen among possible values according to the position of the circuit in the machine ; in order to avoid a great number of circuit cards, the load resistors are mounted directly on the logic cards.

As in the 750 Packaging the circuit cards are wire wrapped to the logic cards.

The logic card is printed on both sides, one side serves mainly for voltage distribution and the other for signals.

There is only one hole pattern for logic cards.

Normally, the connection between the two sides is made by metallized holes. Since the metallization technique was not sufficiently developed in France at the time of WWAM 1 assembly, the metallized holes were replaced by metallic eyelets soldered on both sides of the card.

For the 109 logic cards mounted on the machine there are 52 different printed circuits. 20 to 25% of the card is left available for possible logic changes.

Storage Packaging.

The memory packaging uses the same system as circuit packaging, that is to say : small cards wire wrapped on logic cards.

The small card is approximately 10.5" long and 6" wide and printed on both sides. It may include 1 input or output matrix (80 cores) or 80 main memory positions (560 cores).

A logic card may include 2 I/O matrix cards or 3 main memory cards.

Circuit Cards.

Circuit cards are printed only on one side. There is only one hole pattern.

In order to simplify manufacturing problems, only one card length exists up to component assembly. The card contains 30 elements : on such a card one trigger and one 3 way AND circuit or 4 inverter and one 2 way OR circuit or 7 emitter followers and one 2 way AND circuit etc. are mounted.

After assembly and dip-soldering, the cards are cut out with a jig-saw in order to obtain the desired basic circuit cards.

With reference to the 750 circuit cards, the width of the card is decreased from 1.5 inch to 1.33 inch ; the variable length is decreased .5 inch (elimination of voltage distributions).

The number of wire wraps to be made is at least 3 and at most 12.

The pitch is .25". The length of the elements which can be inserted is .7". Elements having a length of 1 inch can be however used on condition there is no wire wrap in the row where this element is connected.

The height of the elements cannot be greater than .4".

## II - IMPROVEMENTS TO CARD ON CARD ARRANGEMENT

Coca Packaging on WWAM 1 has brought to light the following inconveniences :

1) There is not enough space between two neighbouring logic cards.

2) During the debugging there is a danger of short circuit between logic cards and the frame.

3) Dry soldering and cutting of printed circuits occur at the place of wire wrap pins.

A new version of packaging was designed to solve these problems ; some additional minor improvements were also added. This version will be described now.

### Machine lay out.

Further to the publications of the first SMS standard 2-3-1502-0 dated January 2, 1958 (see fig. 8), it was decided to mount the new machine in standard dimension 33 x 33 x 33" cubes (note 1). Because of the dimensions of the logic cards, they can only be mounted on one side of the cube : the back side can serve for receiving hook up connectors (shoes), wire contact relays and duo relays, output transistors, power supply etc. (see fig. 9).

Only one helicoïdal blower is necessary per cube.

The frame of the logic cards is of a molded material in order to avoid the danger of short circuits (see fig. 10). The form of the gate is designed to protect the cables. The space between the logic cards goes to 1.4" which permits mounting elements of a height of .5" on the circuit cards. The voltages are bus distributed which permits easy and complete insulation of one or several logic cards during debugging (see fig. 11).

An individual system allows fixing each logic card assembly in the open or closed position.

In order to allow logic changes on both sides of the card, logic cards are pivoted around the frame shaft (see fig. 12).

Note 1. It would have been preferable to use the 33 x 33 x 29 cube ; the 29 inch length would be sufficient for permitting logic cards to be placed on the front of the machine and placing relay gates, transistor gates, etc, on the back.

Logic cards.

Dimensions have been slightly modified : they are now 23 x 15".

In the WWAM model 1 logic cards, the metallized holes had been replaced by round eyelets which are commercially produced in series. The diameter of the eyelet heads was almost equal to the diameters of the printed circuit lands and for this reason a number of poor solderings appeared during debugging. The other defect was cutting of the printed circuit at the junction of printed wire and land, this being due to the torque caused by the wire wrap tool on the wire wrap terminal.

In order to avoid this inconvenience, the hole pattern of the circuit card has been modified. Instead of the round holes also used in the 750 packaging, oblong holes are made and this avoids rotation of the wire wrap pins at the time the circuit cards are placed.

The eyelets have been also replaced by oblong ones the dimensions of which are compatible with the new form of the land used. The latter is square in order to have a greater surface than the round one, and consequently greater adherence to the base.

The second modification made to the logic cards is the direction of the rows on them (see fig. 13). In the first model they are parallel to the wider dimension of the card which causes a loss of circuit places : this is due to the fact that it is possible to pass only one wire through two holes. The number of wires going towards the connectors is very great in certain parts of the cards and for this reason it was necessary to go through the holes and consequently to limit the number of circuit cards on the logic card.

These rows are therefore at the present time parallel to the narrow sides of the card. There are 670 elements per card arranged in 11 rows of 53 elements and 2 rows of 43 elements.

Circuit Card.

The dimensions of the circuit card are almost equivalent to those of the first model of the WWAM. Just as for the logic cards the holes are oblong and the printed circuit lands are square.

## V - CONCLUSION

Coca Packaging offers the advantage of adaptability to any type of circuit whatever due to the large number of inputs and outputs and the possibility of mounting elements on the logic cards.

Because of the circuit card design, which allows the card to vary in dimensions according to the circuit itself, no space is lost.

Since a logic card contains the load resistors, the number of different printed circuits is extremely low. WWAM number 1 containe only 26 circuit cards and 52 different logic cards.

The packaging concentration is identical to that of the SMS, supposing that on the average 15 elements are mounted per SMS card and that one transistor takes up the place of 2 elements.

In a packaging which uses several circuits on the same card, 5 to 10% of these circuits are lost in order to avoid complicating the wiring of the back panel. This inconvenience does not exist in the COCA Packaging since each circuit card contains only one circuit. The packaging concentration is therefore so much the greater.

Only one tool is necessary for piercing logic cards and circuit cards since the hole pattern is identical.

Mounting circuit cards on logic cards is quite long because it is necessary to wire wrap the circuits between them ; on the other hand wiring of the edge connectors is quite quick.

Presuming that transistor defects are very low, it is of interest not to increase the number of defects by contact troubles. This is the reason why semi permanent contacts are used. On the other hand, debugging by substitution is practically impossible with this type of packaging.

## V - REFERENCE MATERIAL

- WWAM Packaging by Mr. B. Corby (paper presented at IBM Engineering Symposium held in Paris on January 1957).

- New Packaging for transistorized machines by Mr. B. Corby (paper presented at IBM Engineering Symposium held in Zurich on February 1958).

- Collated material concerning COCA Packaging (french edition).

CM/ml/827

# CIRCUIT DESIGN

## - ABSTRACT

Initially the W.W.A.M. had to be built with circuits designed for the 750 project, excepting the memory and timing circuits.

The 750 project being stopped, the decision was taken early in 1957 to design a special circuit standard for the W.W.A.M. project.

The first circuit standard worked out for W.W.A.M. Model 1 had to be modified for Model II because of modifications made by Philips to transistor specifications.

The Model II circuits are considered as W.W.A.M. standard circuits (see ref. 1).

In the meantime, plate models of data flow, core memory, input and output devices have been built and tested by the circuit group.

This paper reports on circuit design and tests made on the W.W.A.M. and the different plate models. It reports also on transistorized oscilloscope design, this oscilloscope being destinated to be plugged into W.W.A.M. Model II.

## - CIRCUIT DESIGN PHILOSOPHY

The goal of the study was a circuit standard for a middle speed range machine, the W.W.A.M. digit time being 20 µs. In circuit design, we paid special attention to reliability and low price.

In presence of the high transistor-to-diode price ratio, the choice was made of a voltage mode passive diode logic, transistor circuits being intended for current and/or level regeneration.

The nominal value of 10 V (between ground and - 10 V) was taken for the logic signal.

The machine voltages were chosen to obtain a maximum efficiency with the adopted logic (see ref. 2).

In order to decrease the number of transistors in the machine, the load resistors had to be calculated separately according to the requirements of each circuit. The W.W.A.M. packaging was suitable to this solution, the load resistors being packaged on the logic cards (see W.W.A.M. Packaging).

A simple implementation method has been worked out, allowing easy circuit matching (see ref. 2). These rules take into account not only the normal case but also some special cases allowing appreciable current savings.

A method for delay estimation in logic circuits has also been elaborated.

As well in circuit design as in the implementation rules, extreme care was taken in view of reliability. All malfunctioning possibilities were taken into account and all circuits were calculated in such a manner that the power dissipated into transistors and diodes could never reach a dangerous value. The worst case of voltages and components values was considered for each circuit design.

## VOLTAGES AND COMPONENTS

### Voltages

The following voltages are used in the W.W.A.M. circuits : the tolerances and the main application are given for each voltage :

| | |
|---|---|
| + 50 ± 2,5 V | AND circuits |
| + 10 ± 0,7 V | AND circuits and NPN type current amplifiers |
| + 3 ± 0,5 V | Triggers and NPN emitter follower |
| Ground | Logical signal upper level |
| - 5 ± 0,55 V | Level setters |
| - 10 ± 0,7 V | Logical signal lower level |

| | |
|---|---|
| - 13 ± 0,8 V | PNP emitter follower |
| - 20 ± 1 V | OR circuits and PNP type current amplifiers |
| - 60 ± 3 V | OR circuits |

Transistors

Special transistor specifications were carried out for the W.W.A.M. circuits in collaboration with Philips.

The PNP transistor is a 901 type.

The NPN transistor is a 951 type.

Power transistors used in the W.W.A.M. are OC 16 type Philips transistors.

Diodes

Philips diodes OA7 and OA9 corresponding to the AA and AJ U.S. diode specifications were used.

Resistors

The resistors used are ± 2 % type. The demonstration was made that the use of ± 2 % resistors allowed lowering the machine price by decreasing the transistor number.

All other components are standard ones.

- LOGIC CIRCUITS

Passive AND and OR circuits, triggers and regeneration circuits belong to this group.

Trigger

The trigger is a 2 transistor non saturated type. Two trigger-gates were designed : a 5 µs gate used in logic and a high speed 2 µs gate used in the timing ring.

Regeneration circuits

Following circuits have been designed :

- PNP 20 V inverter
- PNP 60 V inverter
- PNP low current inverter
- NPN 20 V inverter
- NPN 60 V inverter
- NPN low current inverter

- PNP emitter follower
- NPN emitter follower

- Non inverting level setter, PNP type output
- Non inverting level setter, NPN type output

- Inverting level setter, PNP type output
- Inverting level setter, NPN type output

Only the inverting and non inverting level setters are two transistor circuits.

CONTROL PANEL CIRCUITS

Special circuits had to be designed for control panel crossing because of high value of straight capacitance due to the control panel wiring.

The emitter hub, passive circuit, changes the 10 V logic signal into a current mode type signal allowing to decrease delays in control panel crossing.

The receiving hub, PNP inverter type circuit, regenerates a normal 10 V signal.

As the emitter hubs number is much larger than the receiving hubs one, the solution adopted is the most economical and also the most reliable.

## - CORE MEMORY CIRCUITS

The W.W.A.M. core memory had a 2880 alphanumeric digit capacity. (10 x 8 x 6 x 6 = 2880)

The driving system adopted was a two half-current selection system involving transistorized read and write drivers, common switches and inhibit drivers. A special temperature regulation system, piloted by the output signal of a reference ferrite set was designed (see ref. 3).

The total number of driving circuits for the maximum storage capacity is :

- 12 read drivers
- 12 write drivers
- 7 inhibit drivers
- 18 switches

A symmetrical feedback amplifier with incorporated threshold was designed as a sensing device.

## - INPUT CIRCUITS

The W.W.A.M. input device is a 300 CPM card reader. The card is read row by row, and each row is transferred into an 80 ferrite core buffer. A special current driver was designed for this purpose, allowing the simultaneous switching of 80 ferrites in parallel, across brush contacts. All the buffer cores are first put into the one state and the read current switches off the ferrites corresponding to a hole in the card row (see ref. 3).

The buffer is then scanned and the cores remaining in the one state are read by regulated memory drivers. The information contained in the buffer is transferred into the main storage and all buffer cores are set again in the one state.

This system allows using a non-regulated driver as card read-driver.

## III-OUTPUT CIRCUITS

The output circuits purpose is to transfer the information from the core memory to the control magnets of print or punch devices.

The Model I output circuits are different for print and punch so that a transistor solution and a tube solution may both be tested. The punch magnets were driven by coil driver-latches controlled by the nominal 10 V signal. A thyratron matrix controlled by a trigger ring was designed for the stick printer. The use of vacuum tube circuits in the printer involved the need of special circuits in the electronic unit, able to drive tube amplifiers across the connection cable.

The system adopted for the Model II involves output core buffers, each core of the buffer controlling directly a coil driver latch. The cores used in the output buffers are the same as in the main storage and are written by the same drivers. A special driver, able to switch simultaneously 120 cores, was designed for translating the information held in a buffer to the coil driver latches.

## - MISCELLANEOUS CIRCUITS

Some other circuits, like selectors, single-shots, multivibrators, integrators, were also designed for the two W.W.A.M. models.

## - PLATE MODELS

In parallel with the circuit design work, plate models of the core memory, data flow, input and output devices were built and tested. All these models built separately, were interconnected in order to form a small calculator with punched cards input and output possibilities. A data flow model was also built with current mode circuits.

All these models were tested by the French Product Test Group (see ref. 4).

## I - TESTS AND RESULTS ON W.W.A.M. CIRCUITS

The tests made on W.W.A.M. Model I circuits, as well by Product Test on the plate models as by the circuit group on the Model I, showed a very high reliability on all circuits.

Specially, allowable voltages variations are much larger than the tolerance given in the paragraphe 3 (see ref. 4).

Only very few modifications had to be made on Model I circuits and implementation.

Very detailed tests were made by the circuit group on the memory and temperature regulation system of the Model I (see ref. 5). These tests were made in the worst noise (delta signal) case and with temperature variation from 10°C to 52°C.

These tests showed a good efficiency and reliability of the system.

As the W.W.A.M. project was stopped before the construction of the Model II, the corresponding circuits could not be tested on a complete machine. However, these circuits are used on an engineering model with satisfactory results.

## I - TRANSISTORIZED OSCILLOSCOPE (figure 14)

A pluggable oscilloscope has been forecasted for the debugging and maintenance of the W.W.A.M. Model II. For this purpose, the study of a transistorized oscilloscope using the same components as in the machine circuits, was undertaken.

The main difficulties encountered were :

- the problems of stability of high gain and high input impedance DC amplifiers
- the high voltage shifts needed for the CR tube control

These difficulties being solved, a prototype of the oscilloscope was built and tested. It presented the following characteristics :

| | | |
|---|---|---|
| Vertical amplifier : | Input impedance | : 1 Mégohm |
| | Sensibility | : 1 to 100 V/cm |
| | Bandwidth | : 1 Mc/s |
| | Rise time | : 0,3 µs |
| Sweeping speeds : | 1 µs/cm - 5 ms/cm | |
| Delaying sweep : | The normal sweep can be delayed from 0 to 100 ms | |
| Triggering mode : | Internal or external, normal or delayed. | |

The CR tube used was the Philips DG 13-34 tube. The regulated power supplies were incorporated in the model.

This oscilloscope was presented at the Engineering Symposium in Stuttgart in April 1959 and was the subject of a technical film in July 1959.

## I-REFERENCE

1) "Standard circuit à transistors" (in French) by the Electronic Circuitry Design Group. July 1958.

2) "Bases of a passive logic transistor circuit standard" by A. Mestre. Report presented at the Engineering Symposium in Zurich in February 1958.

3) "Temperature compensation for the core memory" by A. Mestre. March 17, 1959. Report presented at the ITL Circuit Design Group meeting.

4) "Compte-rendu final de l'essai de l'unité data flow de la W.W.A.M." . Essai n° 01/1433 by the French Product Test Group. Sept. 3, 1959.

5) "Essais des circuits de la mémoire de la W.W.A.M.". Internal report by the Electronic Circuitry Design Group. July 1959.

AP/cm/822

## POWER SUPPLY DESIGN

The W.W.A.M. Model I power supply is the first important supply unit designed in the French Laboratory for transistorized machines.

The adopted solution (no series regulation) appeared to be rather voluminous and expensive, to obtain the required tolerances. Therefore, this solution is no more used.

The unit included over voltage, under voltage and over current protections.

To avoid voltage drop, a magnetic system has been developed for over current protection. This system is satisfactory, but sensitive to shocks.

Filtering problem had led to investigate new types of capacitors, which are used in the present power supplies.

The influence of cable wiring on voltage drops and ripple has been studied.

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## MODEL I REALIZATION

### I - PLATE MODEL

A plate model of the data flow including input/output circuits was first built. It was used to test the convenience of basic circuits, logical design, implementation rules, etc.

It was then used to train members of CE Department and of Product Test Department.

(Refer to the "Circuit" chapter).

### II - SPECIFICATIONS

The model 1 included all devices foreseen in the maximum model. In addition, the memory size (2880 positions) which is bigger than necessary was chosen to verify the limits of the memory driving system designed for the W.W.A.M.

Note that punch control circuits were transistorized, while print controls were implemented with tube circuits; this has been decided in order not to delay the time schedule, to allow an easier test of the reader printer in Germany, and to compare the two different systems. Model II would have been completely transistorized.

### III - LOGICAL DESIGN (January to September 1957).

A logical diagram with AND, OR invertor etc., symbols, was first designed, starting from preliminary studies, and taking care of input/output devices, work on basic circuits, machine specifications, cost considerations, etc. Each modification, with its reason why, was described on a "modification card". The card number was written close to the modification itself on the reference drawing.

The logical diagram was used to explain the machine to three members of the Customer Engineering Department, which wrote a machine description (first Customer Engineering Manual) and drafted summary diagrams for each function.

This allowed to verify the logic diagram.

Note

The circuit packaging and machine lay-out were designed at the same time.

I - IMPLEMENTATION (September to December 1957)

The logical diagram was then implemented with effective basic circuits, using and checking the implementation rules established by the circuit group. (No time delays were calculated exactly, except in the critical areas. Tests on model I would have allowed to check the time calculation rules).

The circuitry was then distributed into the 109 logic cards. This distribution was made so as to obtain :

- the best configuration for understanding and debugging
- the minimum number of logic card types (52)
- the minimum number and length of interconnection cables

- WIRING DIAGRAM

The logic card printed circuit drawings were established by engineers in order to determine the best implementation method; in fact, technicians could now be used.

The definitive wiring diagram was then drawn by referring to logic card and cable drawings. Comparison with the first diagram allowed to check at the same time the logic card, cable and wiring diagram drawings.

I - ASSEMBLY AND POWER ON (until August 1958)

A tester was designed and built to check the circuit cards before their assembly. (It was used later on during all debugging and test period).

All logic card assemblies were mounted before being tested (except memory cards).

The power was set ON on the timing clock logic card and this card was DC tested. Then, the same process was applied to a second card, etc.

The power cables, although present, were not connected to the cards not yet tested; unfortunately, the terminals of these power cables made contact at haphazard with the signal edge connectors and this destroyed a lot of transistors and diodes. Some of them were replaced during the power ON and DC test phase, but a lot of others was only found during machine debugging.

Note

The memory cards were tested separately.

- DEBUGGING AND MODIFICATIONS (August 1958 to May 1959)

a) Processing Unit

Debugging began after power ON and DC test phase and reader printer connection.

It was conducted partly by the member of Customer Engineering Department which had written the machine notice.

During debugging, all incidents were noticed on an "historic report" composed of 109 sections (one per logic card).

In addition, the "modification card" system was still used.

Fig. 15 is a summary of the debugging phase. The great majority of troubles were :

- bad or cold solder joints (refer to "Packaging" chapter). They were often intermittent, and so very long to be found.
- defective transistors and diodes due to shorts at the power ON phase (refer to the hereabove paragraph).

These troubles could be avoided in another model (refer to the next paragraph).

The debugging was completed at the end of January 1959. It showed the need of some modifications to correct the few mistakes of logical design, and to improve the functioning and maintenance facilities. The modifications occurred mainly in the following areas :

- noise eliminations
- selector pick-up ( a necessary sampling was forgotten).
- read, print, punch control
- reader printer interlock. (The reader printer was built in Germany. This made it difficult to have all interlocks up to date before this unit was sent to France).
- step by step functioning and stop by check (mainly to allow easier trouble shooting)
- carriage skip device . (Tests of several control panels indicated that some modifications were necessary in special cases).

These modifications were made between February and May 1959, on all reference drawings and then on the machine itself. The back panel changes were made by replacing printed lines by wires on the back of the logic cards.

b) Input-output unit

Although the principle of stick printer is, in our opinion, valuable, the model I was not sufficiently reliable. For that reason, we decided to build an input-output robot, in order not to delay the processing unit debugging and test during the reader printer repair or maintenance.

This robot was a 150 LPM type 421 reader printer. The interconnection circuits were designed so that neither the processing nor the 421 be modified; they were implemented with tube circuits and placed into a separate cabinet.

## II- COMPARISON WITH AN ENGINEERING MODEL USING THE PACKAGING AND CIRCUITS FORESEEN FOR W.W.A.M. MODEL II

Although this model does not belong to the W.W.A.M. project, we shall briefly discuss its debugging. This is of interest because improvements, which have been found necessary during W.W.A.M. model I debugging, have been taken into consideration. Fig. 16 is a summary of the engineering model power ON and debugging periods.

The engineering model is composed of 886 transistors, 2010 diodes and 26 logic cards.

The W.W.A.M. model I is composed of 3667 transistors, 14054 diodes and 109 logic cards.

Even taking care of the difference in size, it is seen that there are much less defective transistors, diodes, and solder joints.

## X- W.W.A.M. SERVICEABILITY (Summary of the opinion acquired after W.W.A.M. model I debugging and test).

The following takes into account the opinion of the members of Customer Engineering Department in charge of the test of these models.

### 1. Maintenance philosoply

We had to choose between two possible ways of maintenance :

a) to allow for easy circuit card insertion and disconnection. This would lead to choose at a reliable but expensive gold contact connector, or an inexpensive mechanical connector with rather low reliability.

b) to provide for a semi-permanent, gas tight connection between circuit and logic cards, thus keeping a high reliability at low cost. This implies some limitations on maintenance technics. Taking into account the high expected reliability of transistors and diodes, we have chosen the second solution.

2. Trouble shooting

a) Inconvenients

- because the basic card connections are semi-permanent, debugging by substitution is longer and less easy than with a pluggable card system. (However, it can be still used at the logic card input/output level, because the cable terminals are taper pins). Thus, many troubles have to be found either by the use of a voltmeter in step by step run, or, sometimes, by the use of an oscilloscope when the trouble appears only in normal run.

Note that, anyway, debugging by substitution presents very often less interest in serial machines, such as W.W.A.M. In fact, only few logical configurations are repeated a great number of times.

- the preceding implies a good knowledge of the machine for some intermittent troubles, since the Customer Engineer hesitates to systematically replace a great number of basic circuit cards.

- the back of the circuit cards is not visible and so an accidental short between circuit and logic card is not immediately noticed.

The two following inconvenients are not peculiar to the W.W.A.M. system :

- Care must be taken to provide for a convenient test probe in order to avoid accidental shorts. (This is general to all voltage mode transistorized machines).

- The implementation rules allow, in special cases, by appreciable current savings, to decrease the number of regeneration transistors. Care has been taken in those cases not to decrease the reliability, but, when a trouble occurs, it is more difficult to determine the defective component. Use of these rules must be therefore limited to the machine areas where a great number of transistors can be saved during the machine implementation.

b) Advantages

- Immediate access to all logic card input/output connections, without moving any part other than covers.

- Accessibility of all components and input/output of circuit cards without switching the power OFF (except for the memory array) and without needing any kind of extender card. This allows to keep the trouble conditions during trouble shooting.

- Circuit card and logic card input/output and all components are located on the same logic card side, which allows any test on a given logic card without having to move.

- It is possible to disconnect only one entry for any AND and OR circuits. This possibility has been used very often during the machine debugging.

- Circuit configuration allows to have a more easily understood wiring diagram because it remains very close to the logical diagram (very few inversions).

- The circuits are very reliable.

- The possibility to repeat the same function by having a 1 program step loop is useful for debugging.

- It could be possible to design the circuit cards in such a manner that insertion of a circuit card of incorrect type be impossible.

c) Conclusion

The inconvenient of semi-permanent connections is balançed by the good accessibility and the possibility of testing all components without switching the power OFF.

The main advantage of the W.W.A.M. packaging, i.e. high reliability contacts, could not be verified on model I because of defective solder joints. This would be avoided in the definitive version.

Note that the contact resistor of a wire wrapped connection does not change for a number up to 100 successive disconnections and connections.

3. Engineering Change

Cutting the printed circuits and soldering wires on the back of the logic cards appeared as an easy way for engineering change.

. PROGRAMMATION FACILITY (Summary of the opinion acquired after W.W.A.M. model 1 test).

Several control panels have been programmed to test the processing unit. One of them has been programmed in collaboration with the Product Planning.(Salary calculation problem, including edition of the formula lines).

The following facilities have been verified:

It appeared that a given problem requires on W.W.A.M. a number of control panel wires much lower than on present accounting machine (programmation by exception).

For instance, a given problem (schedule of the Electronic Design Department) requires 406 control panel wires on 421, and 93 wires on W.W.A.M.

- A second problem (schedule by project, and horizontal man/month count) requires two runs on 421 and a total of 953 control panel wires. The same problem requires only one run and 336 wires on W.W.A.M., An additional calculation (vertical man/month count), impossible on 421, is performed on the same run by adding 80 wires.

- Functions are performed one after the other with branching facilities. No tricks are necessary, even for intricate problem.

- The programmer is not requested to have a detailed knowledge of machine timing and pulse durations.

- Control panels are easily checked by display panel, step by step advance, and print display.

All of these advantages, and the variable word length possibility, make that any problem is programmed more easily and rapidly than in present accounting machines. Moreover, the customer training period is lower.

## I - MODEL I TESTS

### a) Circuits

Because the W.W.A.M. project was discarded, we have preferred not to test systematically the time delays and voltage signals, and to spend more time on memory control circuit tests. This has been decided because the latter circuits may be useful for other projects.

For results of these tests, refer to the "Circuit Design" chapter.

### b) Customer test

One month test under customer's conditions has been done in order to determine if the W.W.A.M. model I may eventually be used, as is, for accounting applications in the Laboratory.

Since the reader printer was not safe enough, the 421 robot was used for input/output.

The summary of these tests is :

- number of machine running hours : 283 (40 days)

- number of calculated cards : 440 000

- number of printed lines : approximately 2 200 000

- number of troubles repaired on W.W.A.M. :

  - 1 defective transistor
  - 1 cold solder
  - 1 disconnected wire at the power supply outlet

- number of W.W.A.M. stops due to troubles not repaired : 18

  5 of them are due to a wrong functioning of the read checking device (the read function is correct)

  11 of them consist of machine stops by data flow error detection (1)

  2 of them are "no print" (1)

  (1) These machine stops did not prevent the machine work to go on, after machine reset. These troubles are difficult to repair because they are intermittent ones. Special care will be taken in other projects to allow easier debugging after a stop by error check, even if this leads to a cost increase :

  a) the read check device should allow to localize the defective column, if any.

  b) the data flow check should stop the machine at the defective memory cycle rather than at the next one.

- In addition to W.W.A.M. troubles, there were 14 machine stops due to troubles in the input/output robot. 11 out of these 14 were repaired; the 3 other were intermittent. It must be reminded that this robot was built only to allow the W.W.A.M. debugging and test during the reader printer repair; it was designed not as a normal input/output unit, but so as to modify neither the W.W.A.M., nor the 421. Should these conditions not taken into consideration, the robot could be easily modified so as to be more reliable.

## - REFERENCE MATERIAL

### 1. Records on model I history

- Model I logical diagram reference drawings # 1 to # 13

- Model I modification cards # 1 to # 1149

- Model I historic report

  The documents hereabove cannot be reproduced.

- Model I wiring diagram

- All model I parts, printed circuit, sub-assembly, assembly, and reference drawings.

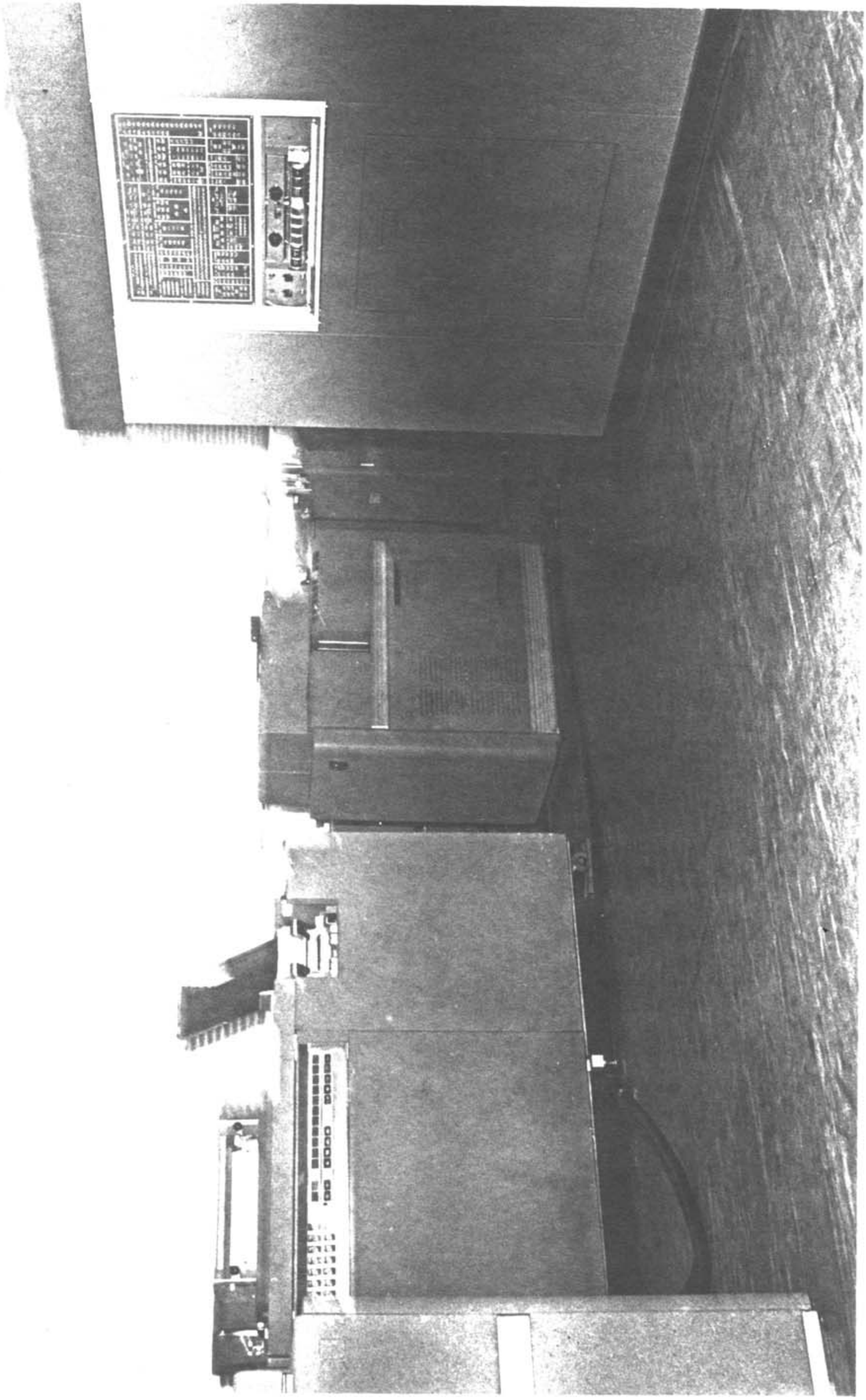
2. Records on tests

- Salary calculation problem. Program description

- Essai n° 01/1433, Unité à transistors data flow de W.W.A.M.

- Essai n°01/1503 Processing Unit W.W.A.M.

BC/cm/825



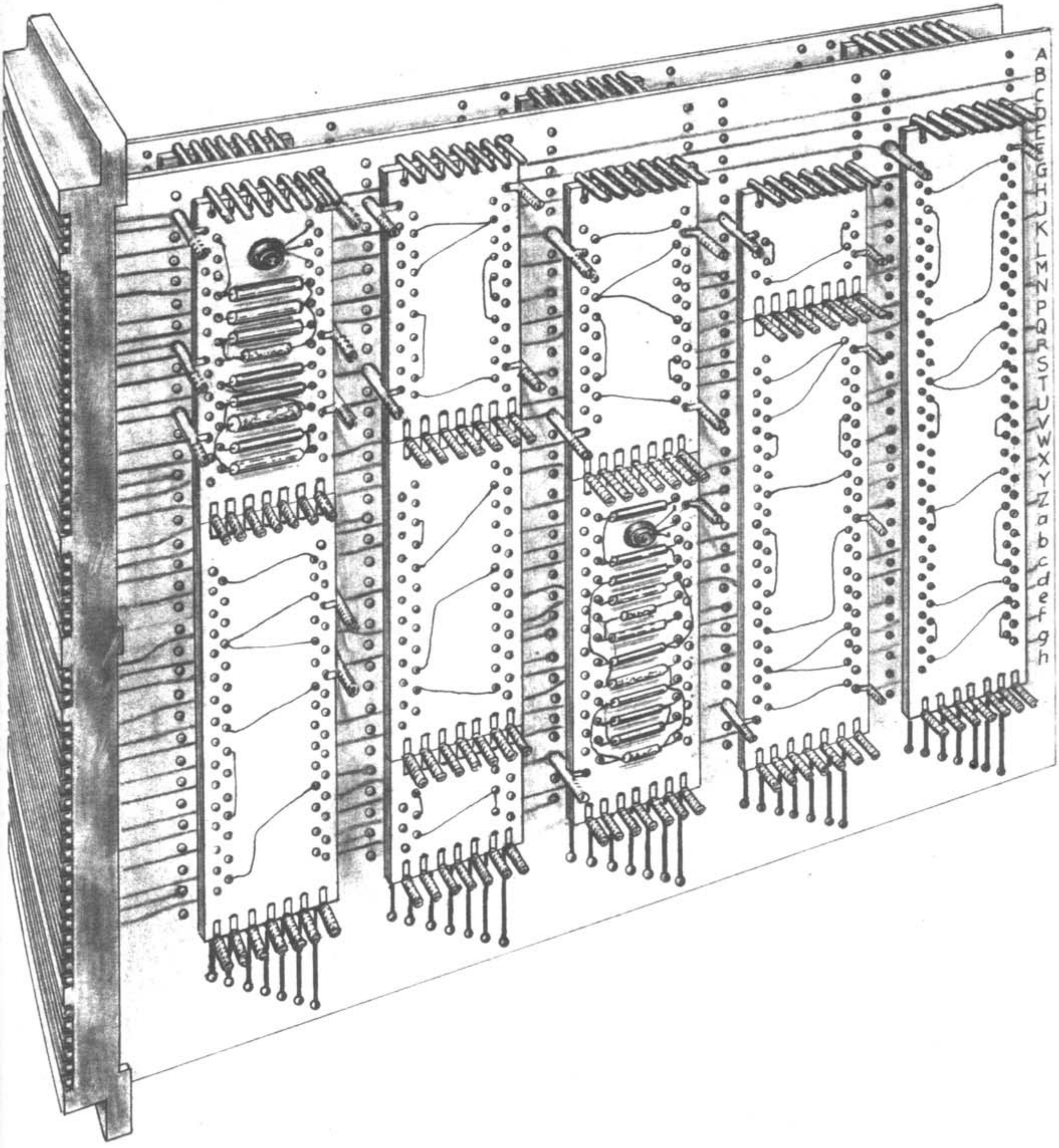
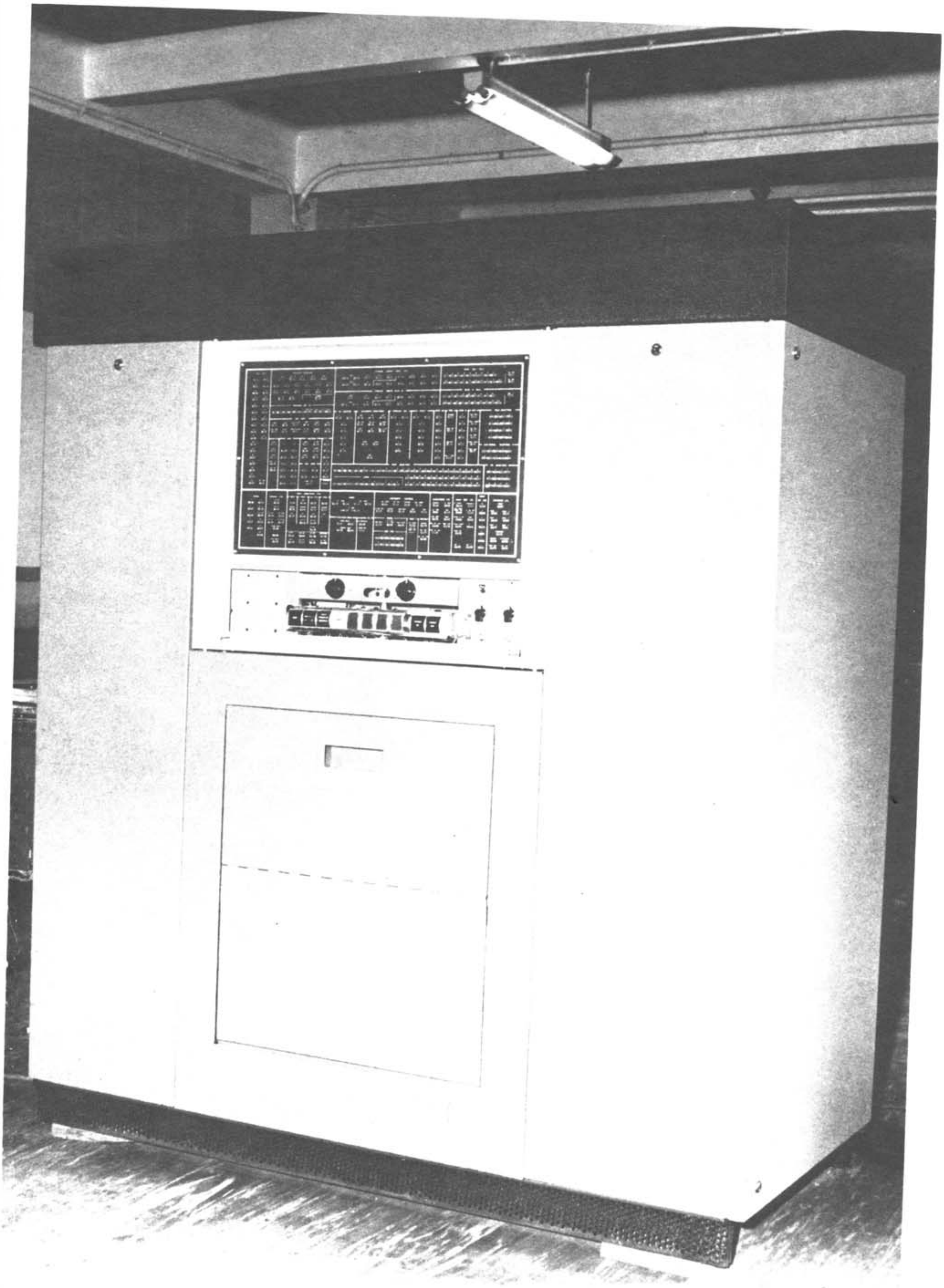
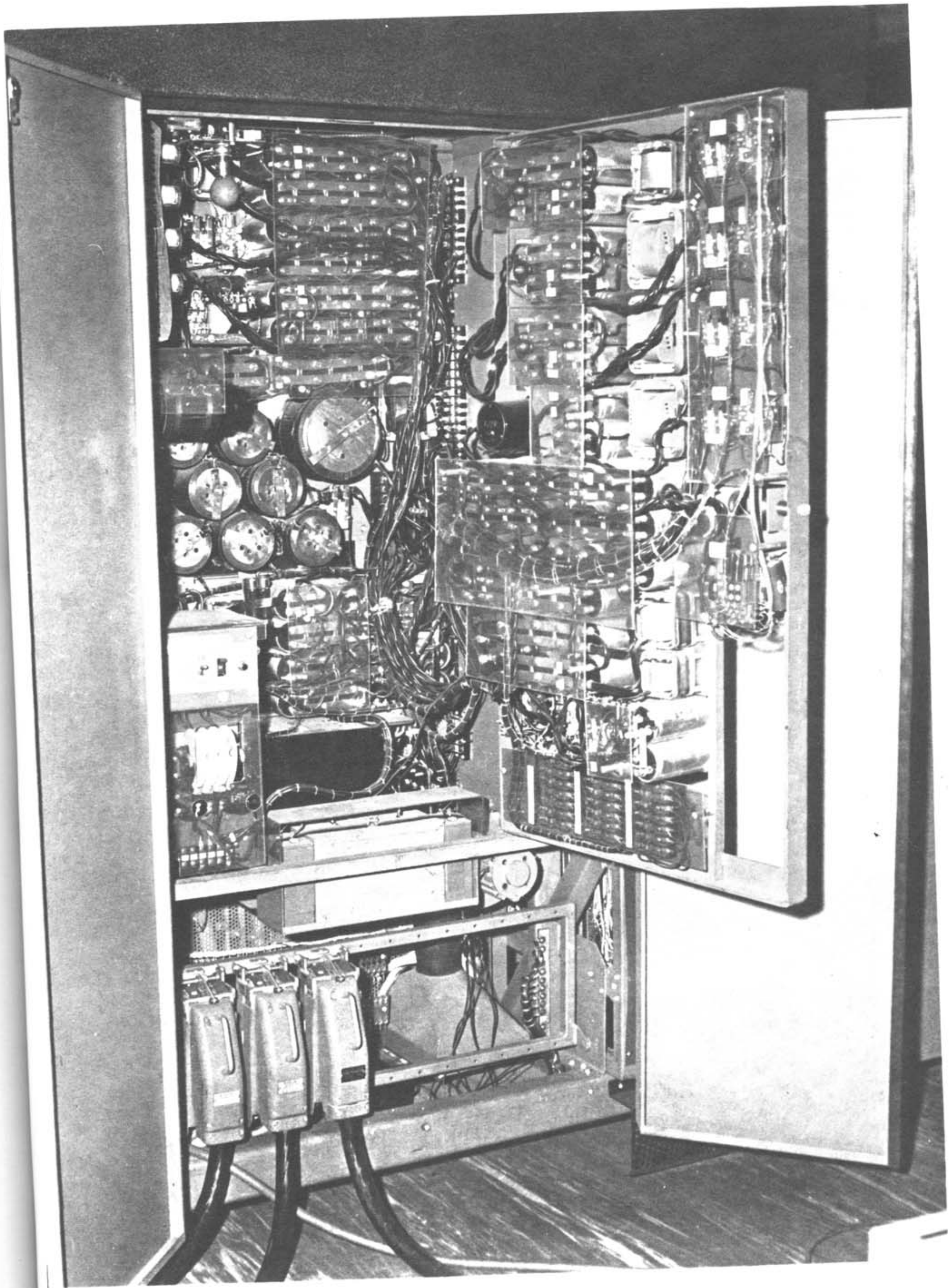



*Fig. 1*





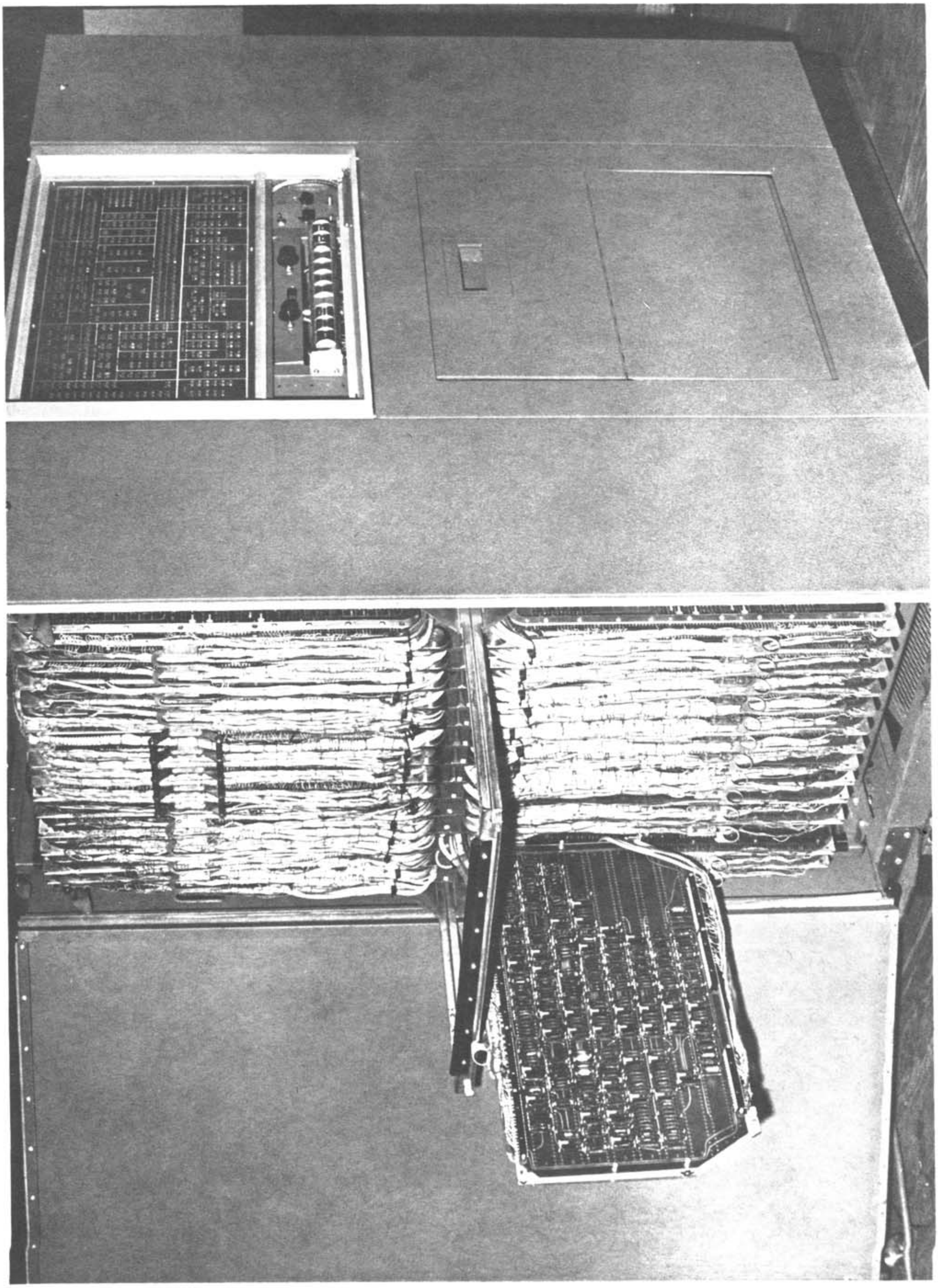
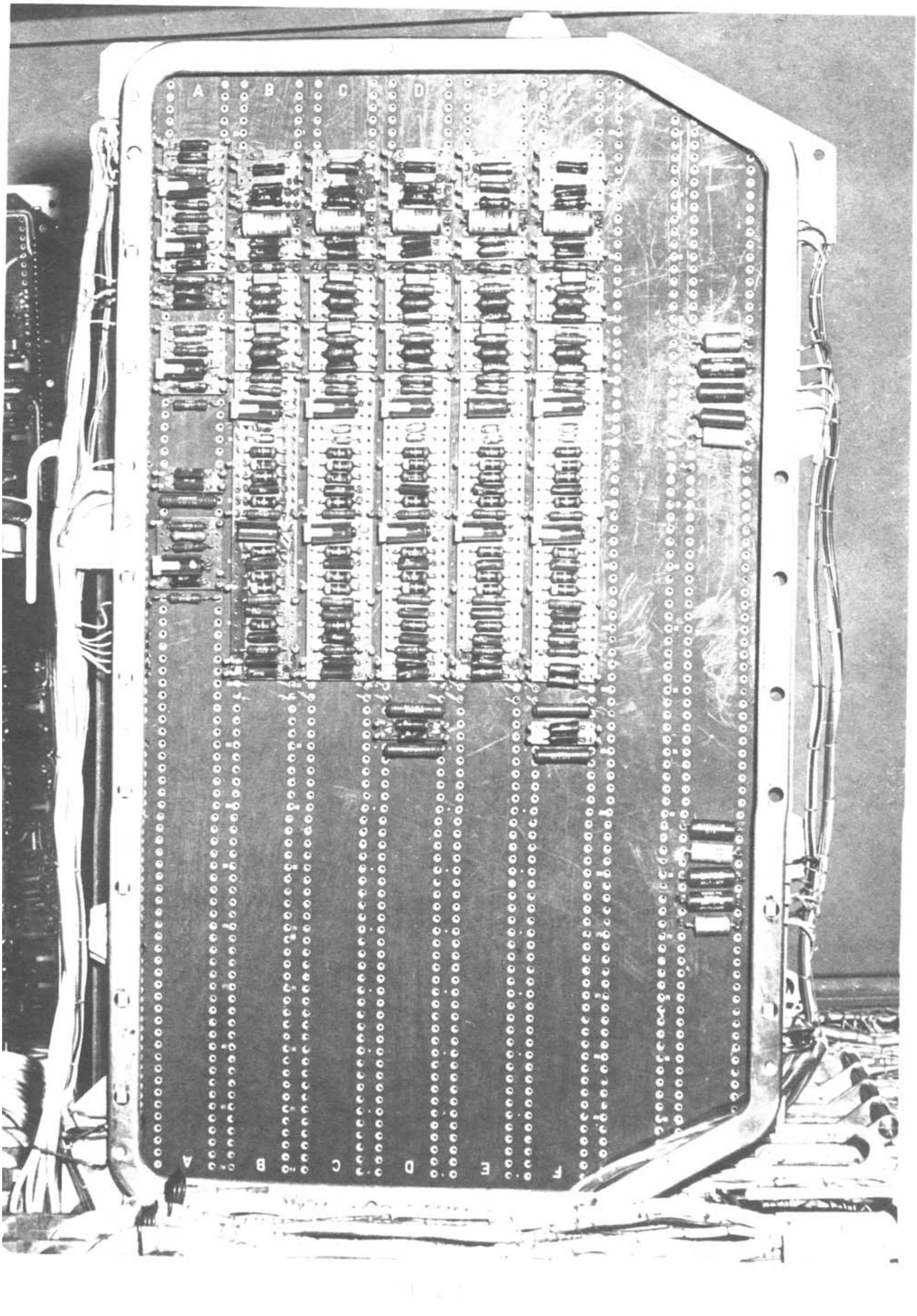


FIG. 4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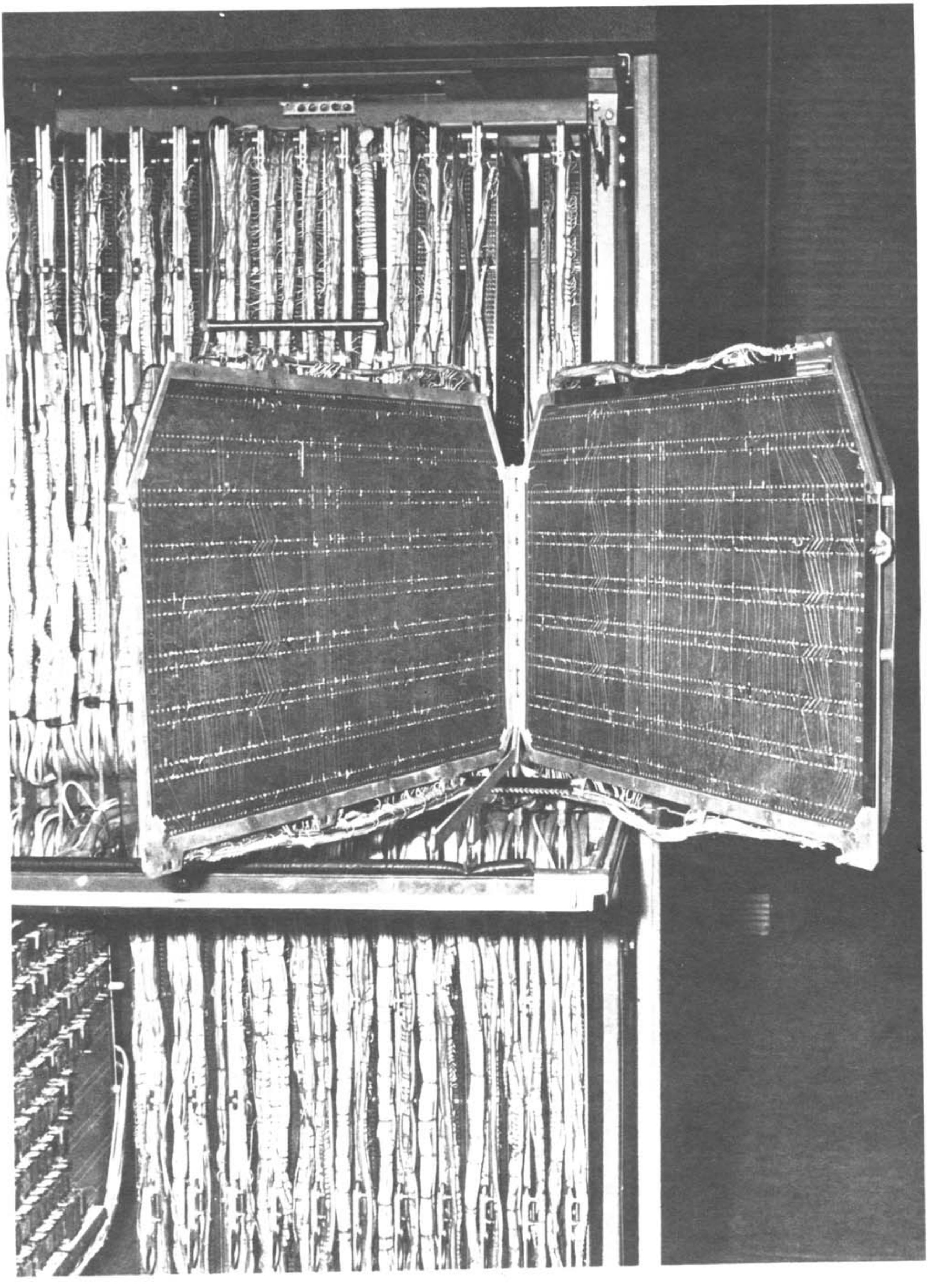
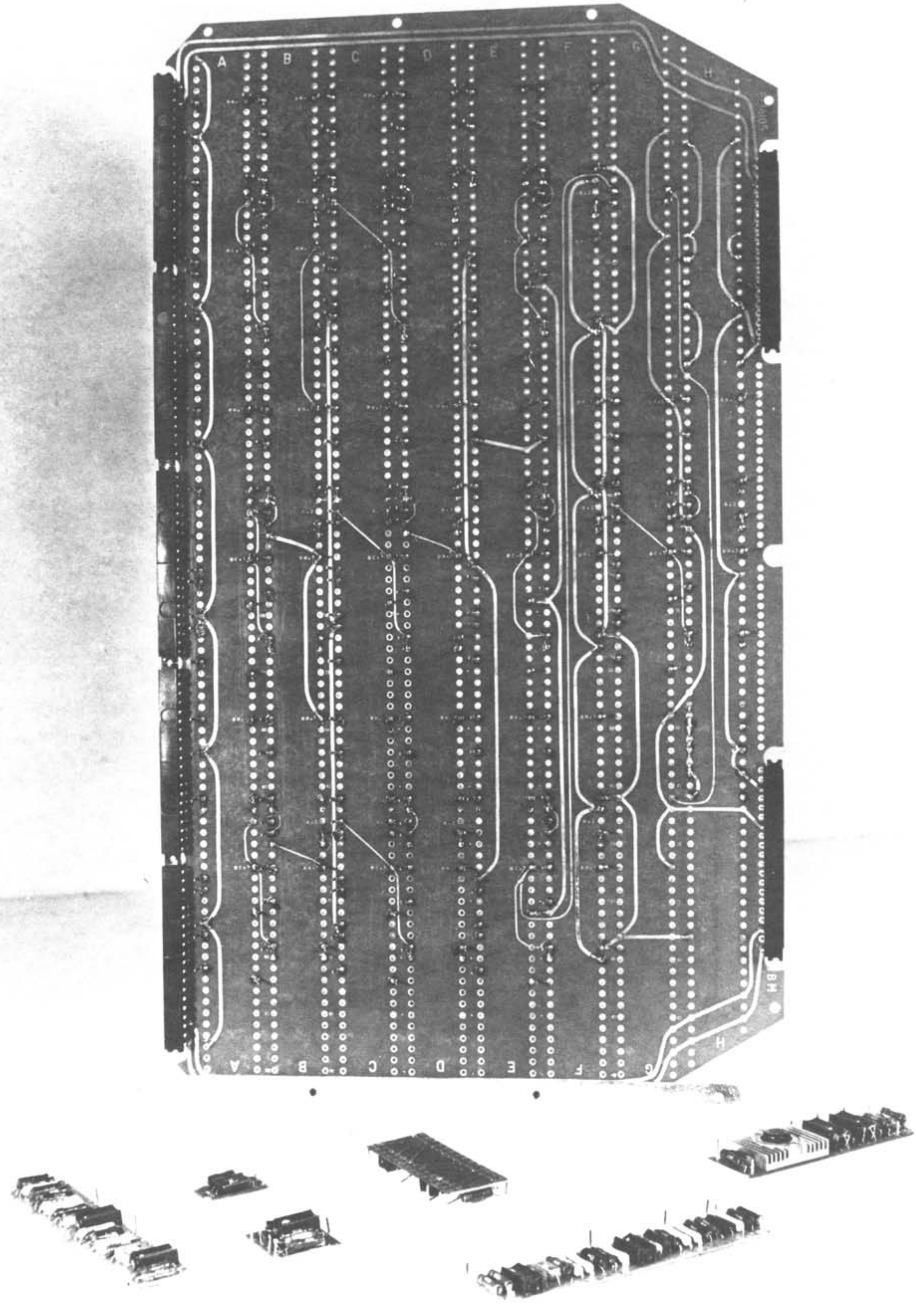


FIG. 5




7

# STANDARD FRAME ASSEMBLY

MODEL

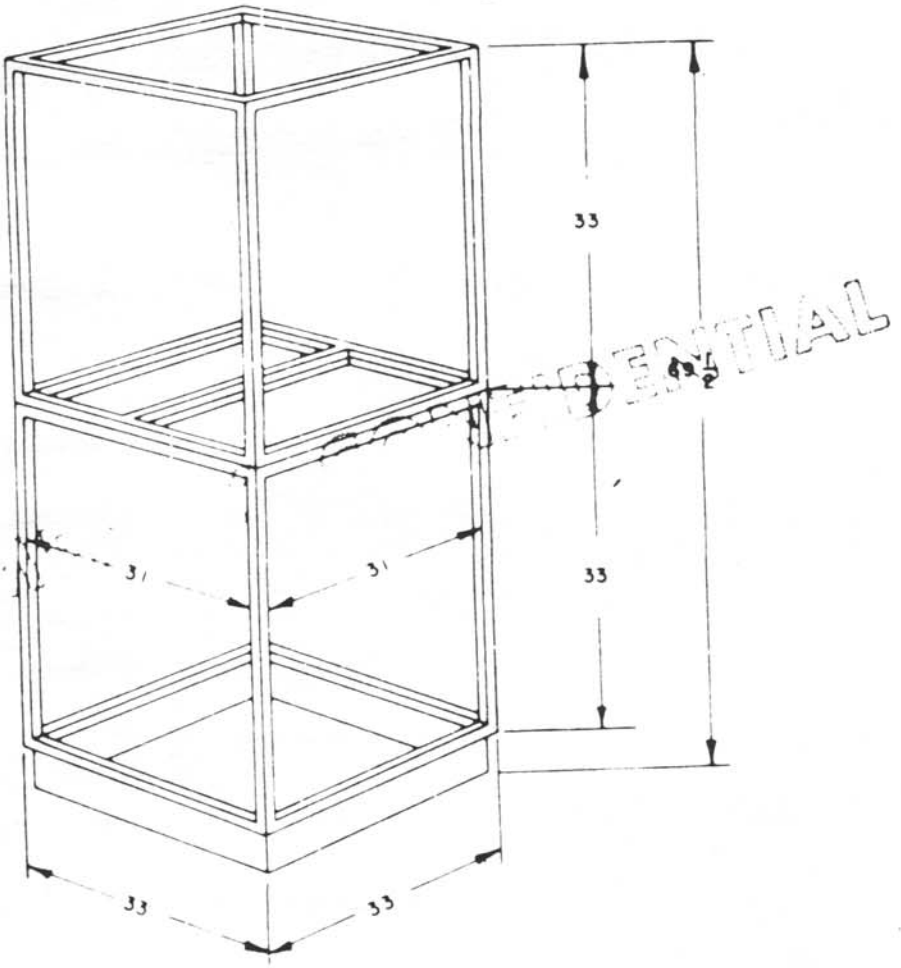



Fig 2 S M S FRAME ASSEMBLY



FIG. 8

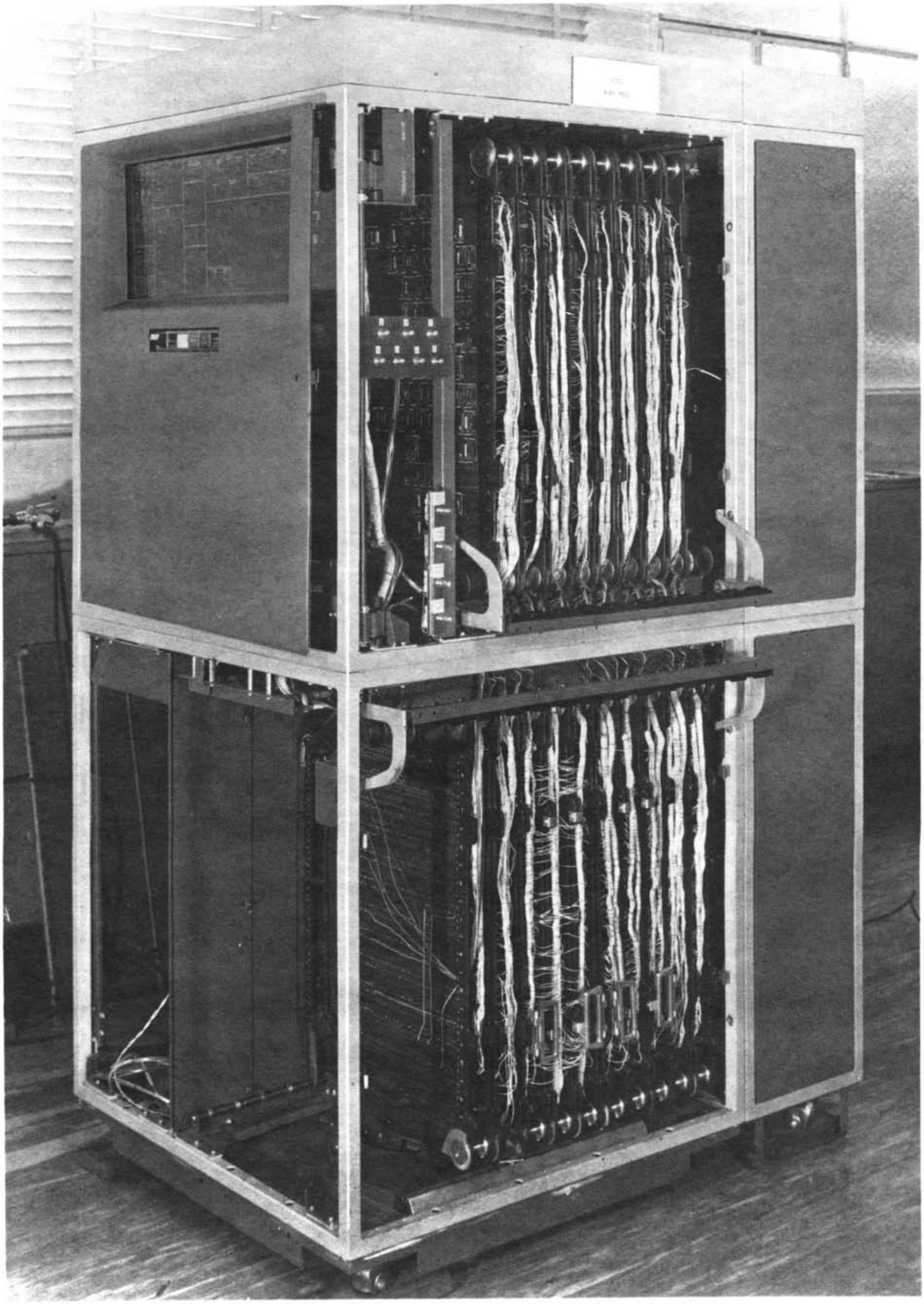
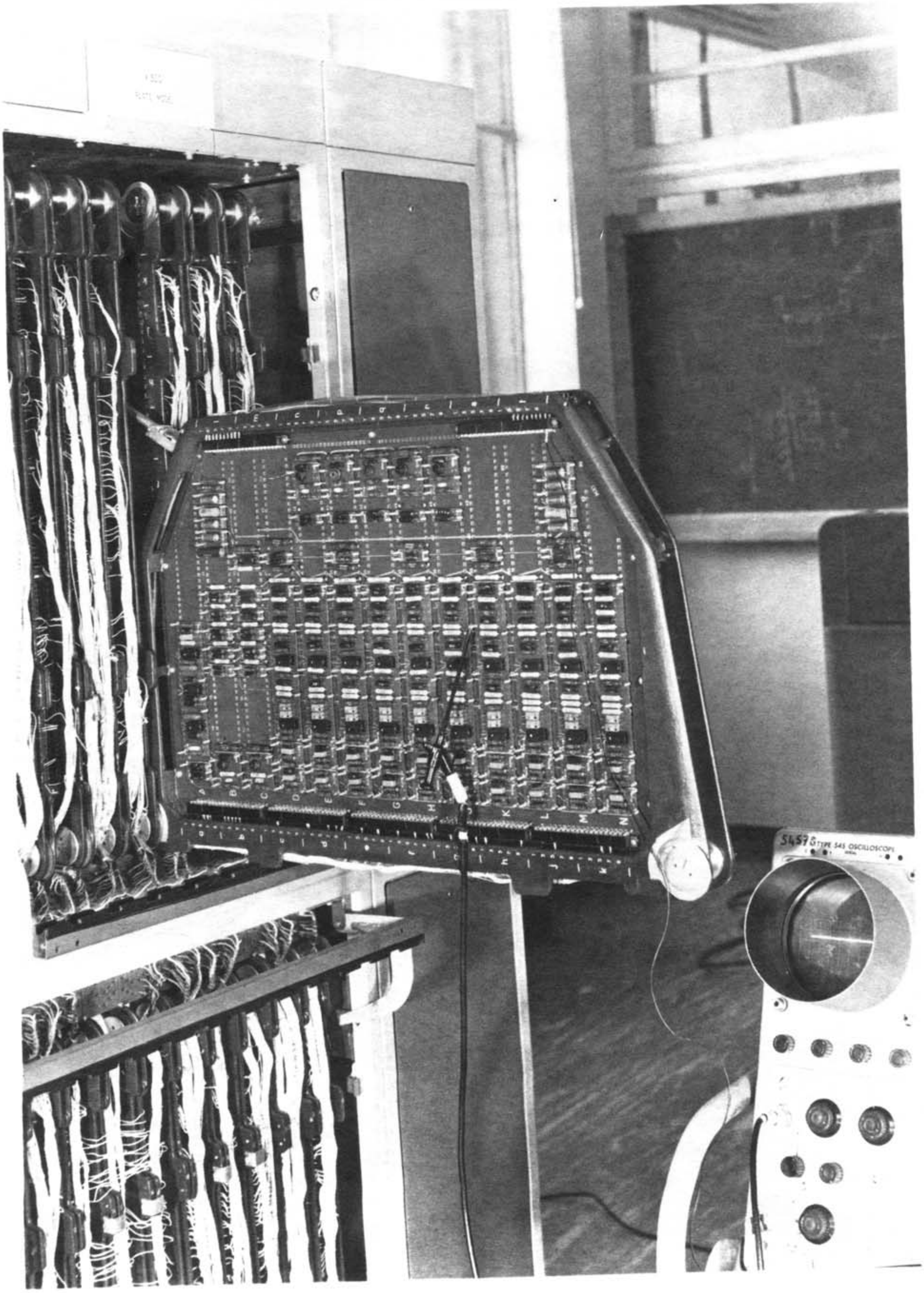


FIG. 9


TYPE 545 OSCILLOSCOPE

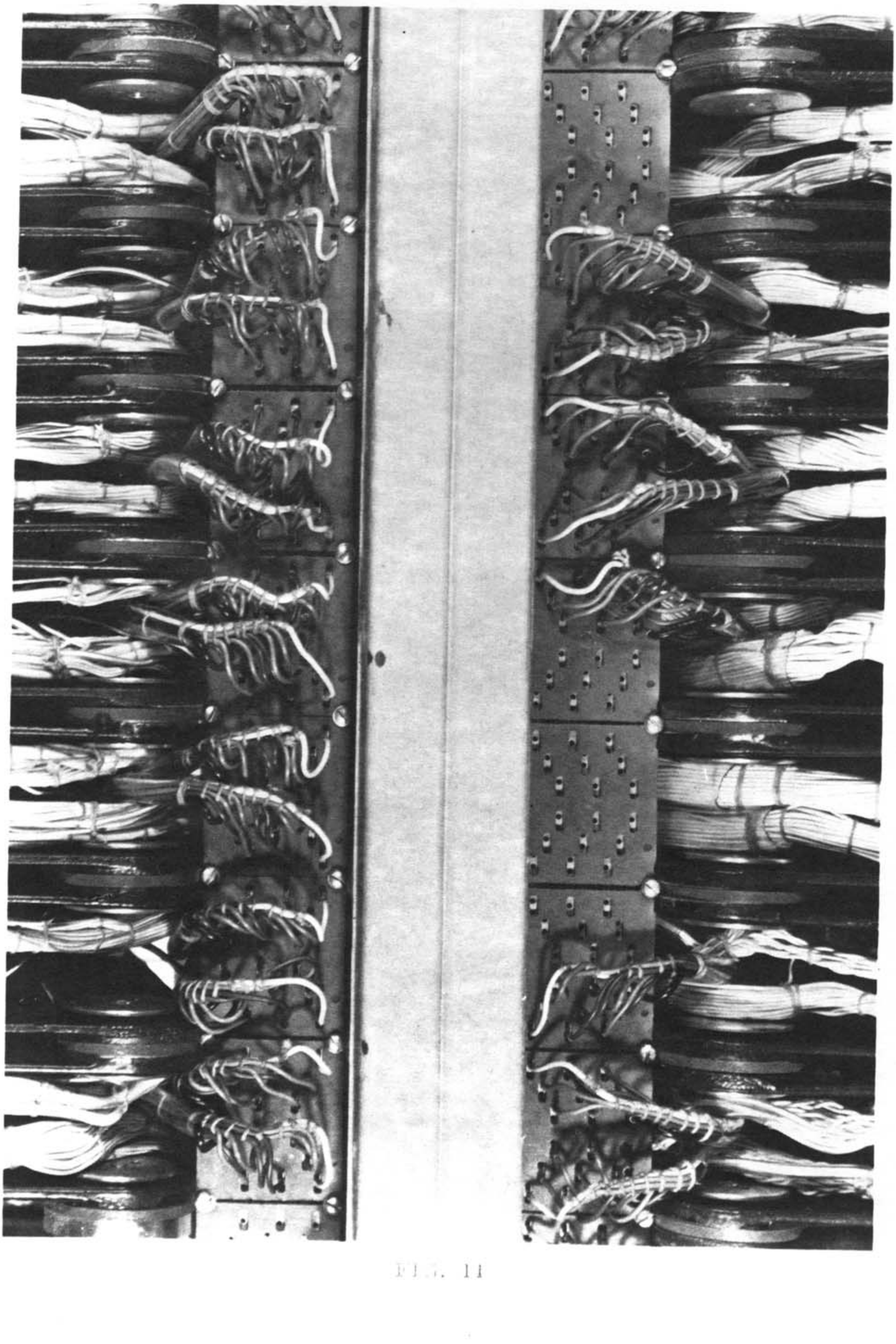


FIG. 11

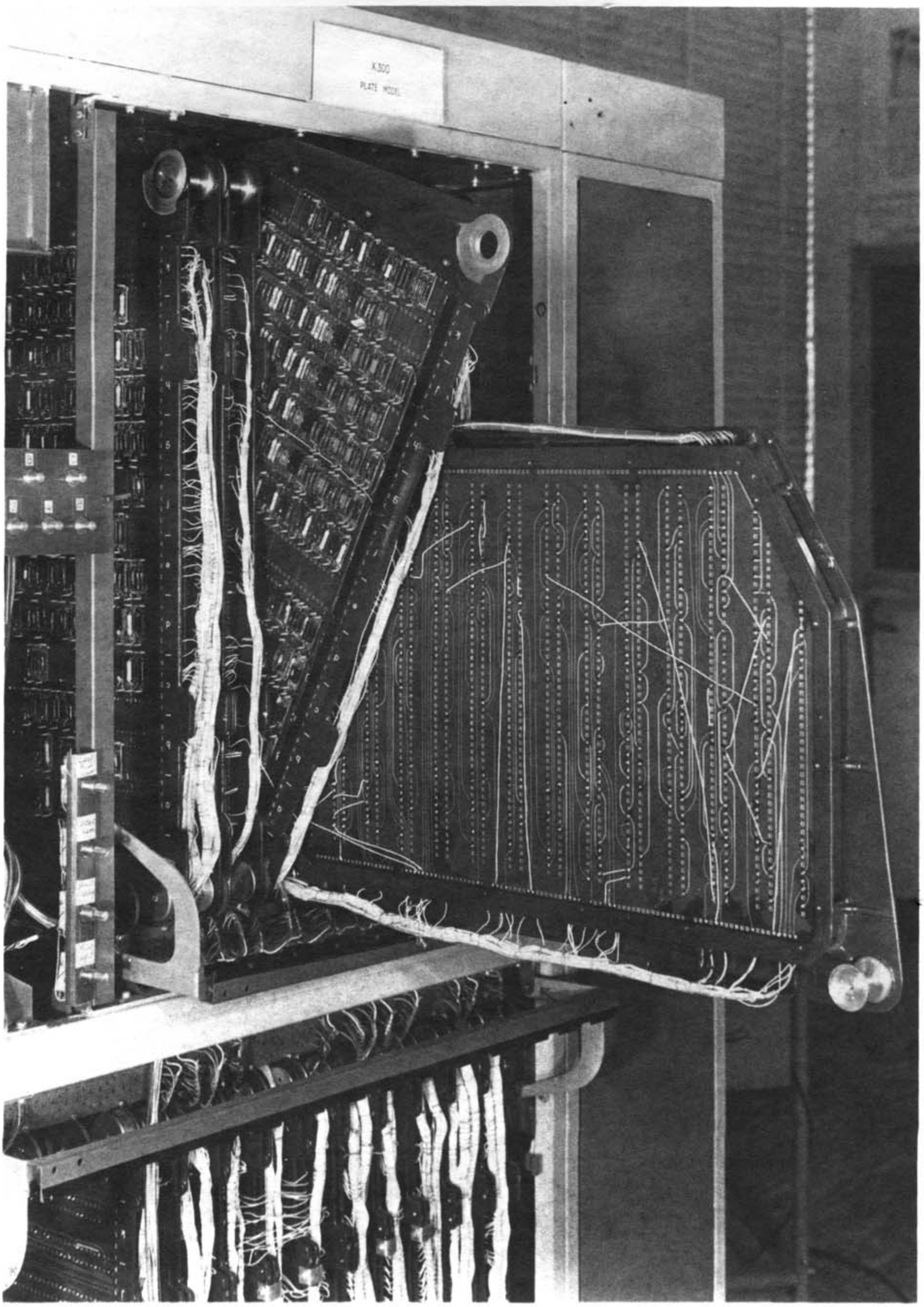



FIG. 12

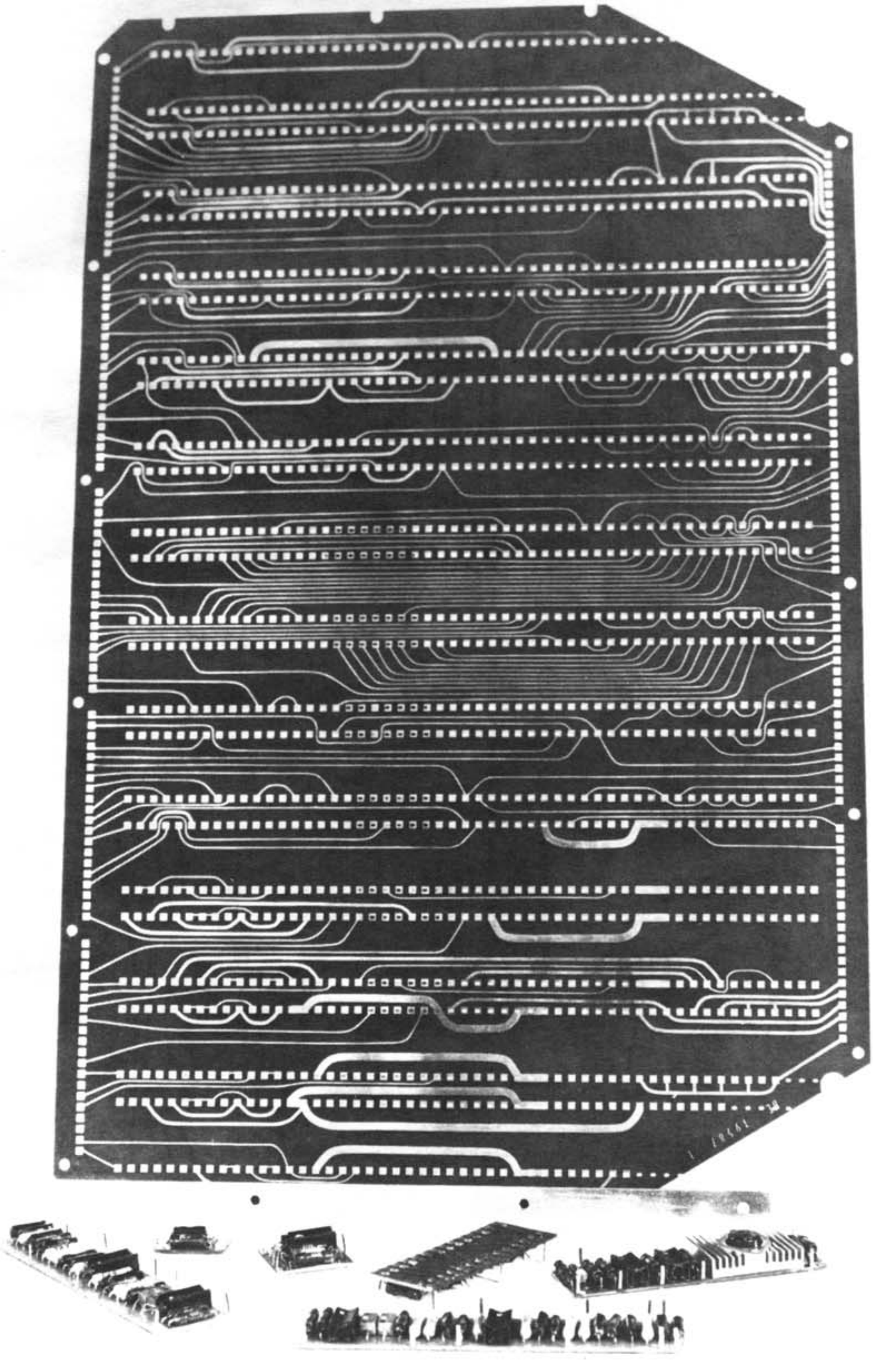
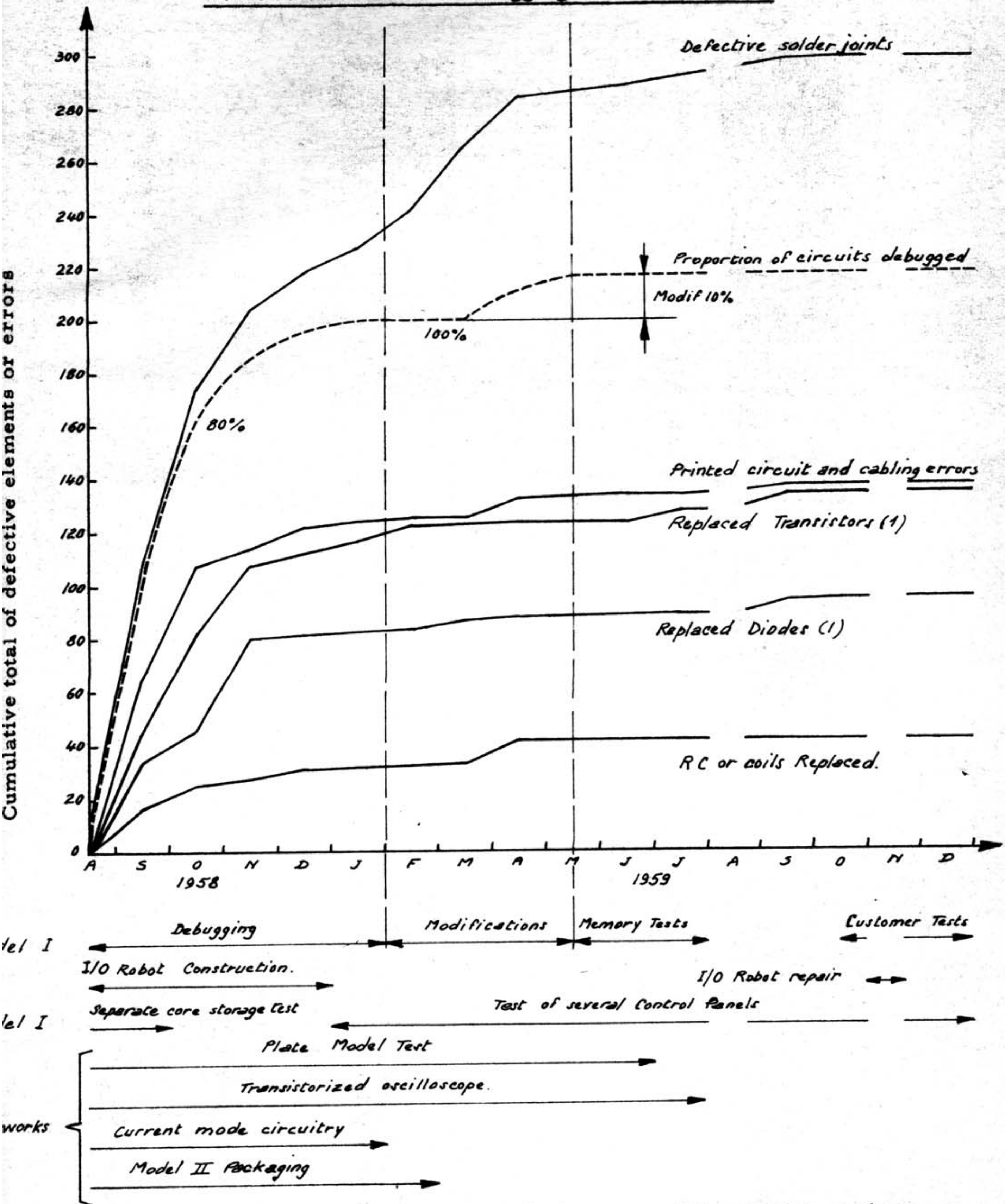


FIG. 13

## Figure 15

**W. W. A. M. Model 1 - Debugging and Test Periods**

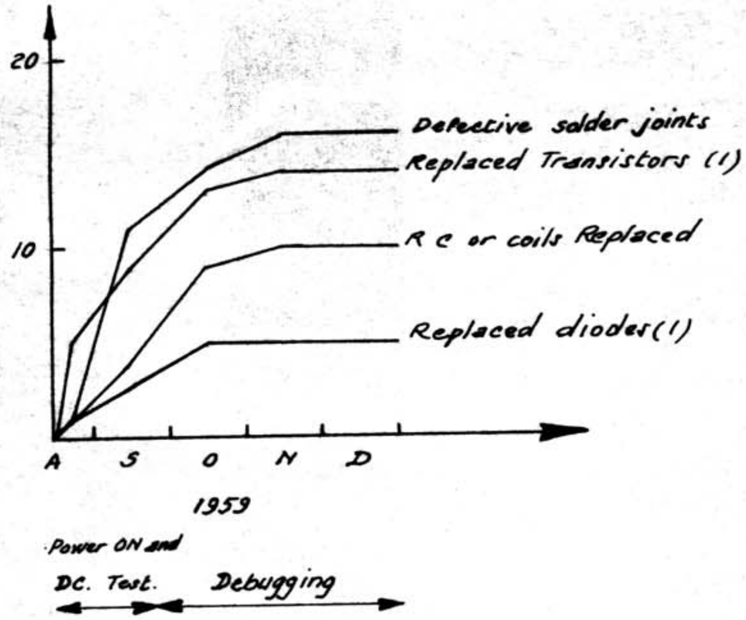



(1) Not including those replaced during power ON and DC test phase. The majority of transistors and diodes replaced has become defective further to accidental shorts during debugging.

## Figure 16

## Engineering Model using Circuits and Packaging foreseen for WWAM Model II

## DC Test and Debugging Periods




(1) The majority of transistors and diodes replaced has become defective further to accidental shorts during debugging.

Note : The scale chosen takes into account the number of components so that figure 16 may be directly superposed to figure 15.