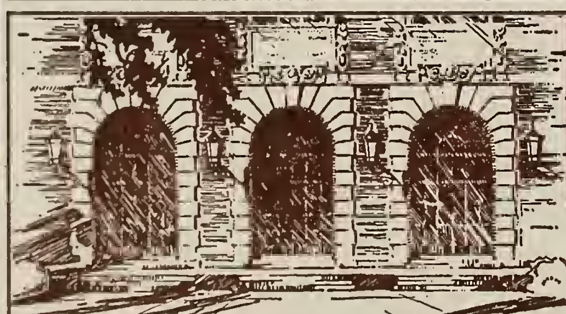

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RECORD OF ACHIEVEMENTS AND PLANS OF THE INFORMATION ENGINEERING LABORATORY

by

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March, 1973

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN · URBANA, ILLINOIS

RECORD OF ACHIEVEMENTS AND PLANS

OF THE

INFORMATION ENGINEERING LABORATORY

in the Department of Computer Science

of the University of Illinois at Urbana-Champaign

1955 - 1973

1. PREAMBLE

Under the direction of W. J. Poppelbaum the Hardware Research Group has grown from a 2-assistant 17K/annum endeavour in 1955 to a 35-assistant 400K/annum effort with back-up personnel and shop facilities (most of them University supported) capable of the most sophisticated work in computer engineering. Three additional faculty members are now involved in the group, viz Professors M. Faiman, W. J. Kubitz, and S. R. Ray.

After being charged with the circuit design of Illiac II (a machine which, in the early sixties, demonstrated speeds and reliabilities comparable to the present generation of commercial machines), the group dedicated itself to the exploration of uncommon forms of information processing. In the last ten years the group - funded mostly by the AEC and to a much smaller extent by ONR - has spearheaded innumerable "firsts," both in engineering principles and also in the actual building of prototypes of information processing machines using methods that industry is only just catching on to. A record of the highlights is given further down.

The success of the Hardware Research Group is largely due to the ideal combination of "education" and "research in uncommon forms of information processing":

1. It is essential for the future engineer to see how things are done in a real-life situation. [All Ph.D. and M.S. students (degrees in CS and EE) have been snapped up by industry and universities a long time before graduation, even in the slumping market a year ago].
2. Students are ideal - and cheap - researchers if the area is new enough: excellent theoretical background and flexible

thinking lead to a very rapid development of new principles and methods.

3. By actually building advanced equipment, at least on a small scale, all questions about the engineering validity of a simulation are circumvented: the proof of a new principle of information processing is a box doing what is advertised!

2. SOME STATISTICS

In the last ten years alone the Hardware Research Group has produced

Over fifty M.S. degrees

Over forty Ph.D. degrees

Over thirty scientific papers in journals

Over twenty conference papers

Over ten patents.

W. J. Poppelbaum's book "Computer Hardware Theory" is considered the standard text in the area and has been the choice of the "Library of Computer and Information Sciences" Book Club.

It might also be added that about 70% of all proposed projects were completed within the estimated time and that about another 20% were completed within 12 months of that date. The remaining 10% were either dropped (lack of personnel or funds) or ran into delays over 12 months (mostly because of long deliveries or breakdown of commercial equipment).

3. HIGHLIGHTS OF THE ACHIEVEMENTS OF THE HARDWARE RESEARCH GROUP 1955 - 1963 (ILLIAC II WORK)

1955 The world's first high speed dc-coupled computer (TRANCE) is tested.

1956 Development of low-swing non-saturating dc-coupled circuitry with current steering.

1957 Demonstration of a 20 nanosecond rise and fall time (3 nanosecond delay) flipflop to the AEC.

1958 Design of all circuits for the AU of Illiac II, including a fast flipflop-gate combination (F-Element).

1959 Design of the so-called flowflop-memory, using the average potential of a flipflop to control the sending or receiving of information. Design of variable topology circuits.

1960 Incorporation of the input/output multiplexer idea ("selector") into Illiac II.

1961 "Virtual load" circuits with 1 nanosecond rise and fall times are demonstrated. Speed independent circuit design is shown to be possible.

1962 The central portion of Illiac II is tested and shows the advertised 6 microsecond multiplication time.

1963 Illiac II calculates the largest known prime number: $2^{11213}-1$.

4. HIGHLIGHTS OF THE ACHIEVEMENTS AND PLANS OF THE HARDWARE RESEARCH GROUP 1964 - 1973 (UNCOMMON FORMS OF INFORMATION PROCESSING)

In order to facilitate perusal, the projects are grouped under the following headings:

1. Storage/Hybrid Techniques
2. Stochastic and Bundle Processing
3. Displays and Electro-Optics
4. Communication/Coding
5. World Models and Pattern Recognition
6. Electronic Prostheses.

The projects are presented with a succinct description. Specially important ones (either in magnitude or basic interest) are preceded by an asterisk. For completed projects, the year of completion is indicated after the name. For incompleted or proposed projects the following code is used:

IPST: In progress, just started

IPAC: In progress, almost complete

PRP: Proposed. To draw attention to them, the name is preceded by an arrow.

4.1 Storage/Hybrid Techniques

PHASTOR, (1964)

Here a time quantization is used to store (quantized) analog signals with up to 1000 steps.

* PARAMATRIX, (1965)

This project demonstrated the feasibility of on-line digital/analog processing of picture information. (See Figure 1).

EROS (Electronic Resistor Optical Switch), (1967)

Here a 4 x 4 phototransistor crossbar-switch is activated by a laser beam.

* POTENTIOMATRIX, (1968)

A 32 x 32 matrix of special flipflops is interconnected by resistors to solve potential problems with given boundary conditions.

RASER (Random/Serial), (1972)

A fast core memory is used to store random point inputs and to display them in raster-scan fashion after preprocessing (interpolation on magnification!).

4.2 Stochastic- and Bundle Processing

* POSTCOMP (Portable Stochastic Computer), (1964)

  Feasibility model to show that probabilities of appearance of pulses can represent numbers in a computer. (Multiplication by one AND!)

* BUM (Bundle Machine), (1966)

  Demonstrates that instead of probabilistic pulses one can use the probability of energizing a wire in a bundle. (See Figure 2).

RASCEL (Regular Array of Stochastic Computing Elements), (1968)

  In an 8 layer tree of stochastic computing elements, appropiate programming leads to the on-line evaluation of complicated functions. First remapping machine.

SABUMA (Safe Bundle Machine), (1972)

  Failsoft bundle machine with remapping and ratio representation. 90% destructible before error reaches 10%.

* TRANSFORMATRIX, (1972)

  The world's most parallel computer with 1024 arithmetic units to transform a 32 x 32 input picture into a 32 x 32 output picture in the most general linear transform (Fourier transform!).

* APE (Autonomous Processing Elements), (1972)

  This is a distributed computing system using small stochastic computers, energized by light energy and communicating on RF channels. (See Figure 3).

ERGODIC, (IPAC)

  In this project the two types of stochastic processing (meaning the representation of number by probabilities),

i.e. time stochastic processing and bundle processing, are merged to form a computer system which is both failsoft and indicates the confidence level at every point.

* HOLOMAR (Holographic Matrix Recognizer), (IPST)

The electrical equivalent of a hologram (products of stochastic signals in a matrix!) allows the recognition of patterns in a failsoft mode.

STORM (Stored Repertory Meteorologer), (IPST)

Here local rules about temperature, pressure, static on RF etc. vs the weather 12 hours ahead are incorporated in a stochastic computer using likelihoods.

→ VORTEX, (PRP)

In this project new stochastic input transducers are examined, e.g. a vortex generator for airflow and a counter of vortices (microphone!).

→ FLOSSIE (Flow Simulating Stochastic Integrating Engine), (PRP)

A two-dimensional network of "divergence cells" exchanges stochastic sequences according to the method of steepest descents and simulates (turbulent!) fluid flow.

4.3 Displays and Electro-Optics

ARTRIX, (1965)

Electronic "draftsman" using hybrid circuits and memotrons to draw line segments between given points, circles etc. (See Figure 4).

ELECTROLUMINESCENT DISPLAY, (1967)

First successful demonstration of a 28 x 28 EL panel with coincident voltage selection on a time-shared basis.

* TRICOLOR CARTOGRAPH, (1968)

Automatic coloring machine for the inside of boundaries indicated by a light pen and using a videodisc. (See Figure 5).

* OLFT (On-Line Fourier Transform), (1969)

Optical interference processing of an "instant transparency" created by the video signal charging a KDP-crystal. First machine capable of operating at TV rates with TV definition. (See Figure 6).

* BLAST (Binocular Lenticular Automatic Stereovision), (1971)

Here the electronic analog of the cylindrical lens 3D displays is obtained by switching alternately two cameras onto the special "cylindrical grating" target of a CRT.

* STEREOMATRIX, (IPAC)

This is an on-line display device in which the observer position is directly translated into the perspective of a three-dimensional laser display. (See Figure 7).

* PENTECOST (Penetration Tube Electronic Color System), (IPAC)

This is a color television system using a penetration control tube (switching between red and white) and using the Land effect to generate all intermediate colors. (See Figure 8).

LASCOT (Large Screen Color Television), (IPAC)

This is a low cost large-screen color television system using vibrating mirrors and electronic position correction.

→ TOPIC (Topographical Picture Information Compressor), (PRP)

Here grey-scale thresholds are used as "topographical curves" and their position - on each scan line - stored in a semiconductor memory.

→ SCRAM (Stochastic Communication Randomizer and Modulator), (PRP)

Here quasi stochastic sequences (controlled by a key word!) are used to scramble video signals on-line.

4.4 Communication/Coding

* ORBIT (On-line Reduced Bandwidth Information Transmission), (1969) /

This project explores bandwidth compression for line-drawings using an artificial waveform, whose sampled values give the distances of intersection with a scan-line. (See Figure 9).

VISTA (Variable Interlace Scan Television Apparatus), (1970)

Here the number of lines/frame is made a function of change. When summation over many (sparse-line) frames is done, a full definition picture appears. (See Figure 10).

PAGEN (Pattern Generator), (1971)

This pattern generator, used in conjunction with STEREOMATRIX, generates x(t), y(t), z(t) to display 3D polygons, cones etc.

OCOMO (Optical Correlation Modulation), (IPAC)

This is an on-line speech encoder and decoder system of particularly simple configuration using optical correlation.

* CM (Correlation Modulation), (IPST)

A generalized version of phase modulation using the time-shift between two (arbitrary) waveforms.

→ IPCM (Interstitial Pulse Code Modulation), (PRP)

Exploration of increasing the quality of transmission by using empty "slots" in PCM.

→ LASERPROBE, (PRP)

Examination of the use of a laser beam as a fire-detector, intrusion alarm (microphone) etc.

4.5 World Models and Pattern Recognition

* EIDOLYZER [Eidon (Grk for picture) Analyzer], (1970)

Demonstration of a color band sequence analyzer to identify landscapes. (See Figure 11).

LINDA (Line Drawing Analyzer), (IPAC)

Linda analyzes line drawings as a superposition of polygons and uses a vocabulary of shapes and positions to interpret the scene.

TELEMAZE, (IPAC)

This is a simulator for the control of a remote vehicle in those cases is which the feedback path cannot be closed in a reasonable amount of time. (See Figure 12).

FROG, (IPST)

Frog is a learning system in which the combination of stochastic processing and logical processing is obtained in the same circuitry.

→ ROBOMAIL, (PRP)

Design of a simple non-human robot following a laser beam to deliver mail and messages, open doors etc.

→ NORMAN (Normalizing Analyzer), (PRP)

An analyzer for polygons independent of shape, size and position using "stretching" by time division interpolation.

4.6 Electronic Prostheses

* CAECOTRON [Caecus (Lat. for blind)], (IPST)

Here a 16 x 16 video image is converted into a "tone picture" to obtain a visual prosthesis for the blind.

→ MUTORATOR, (PRP)

A Self-Scan Panel Display controlled by a modified stenographer's machine.

→ SURDOTRON [Surdus (Lat. for deaf)], (PRP)

A Voice-Print modification showing the frequency content as a function of time to replace lip reading.

→ ALPHATROL, (PRP)

A brainwave controlled (alpha or theta) decoder to manipulate devices for amputees.

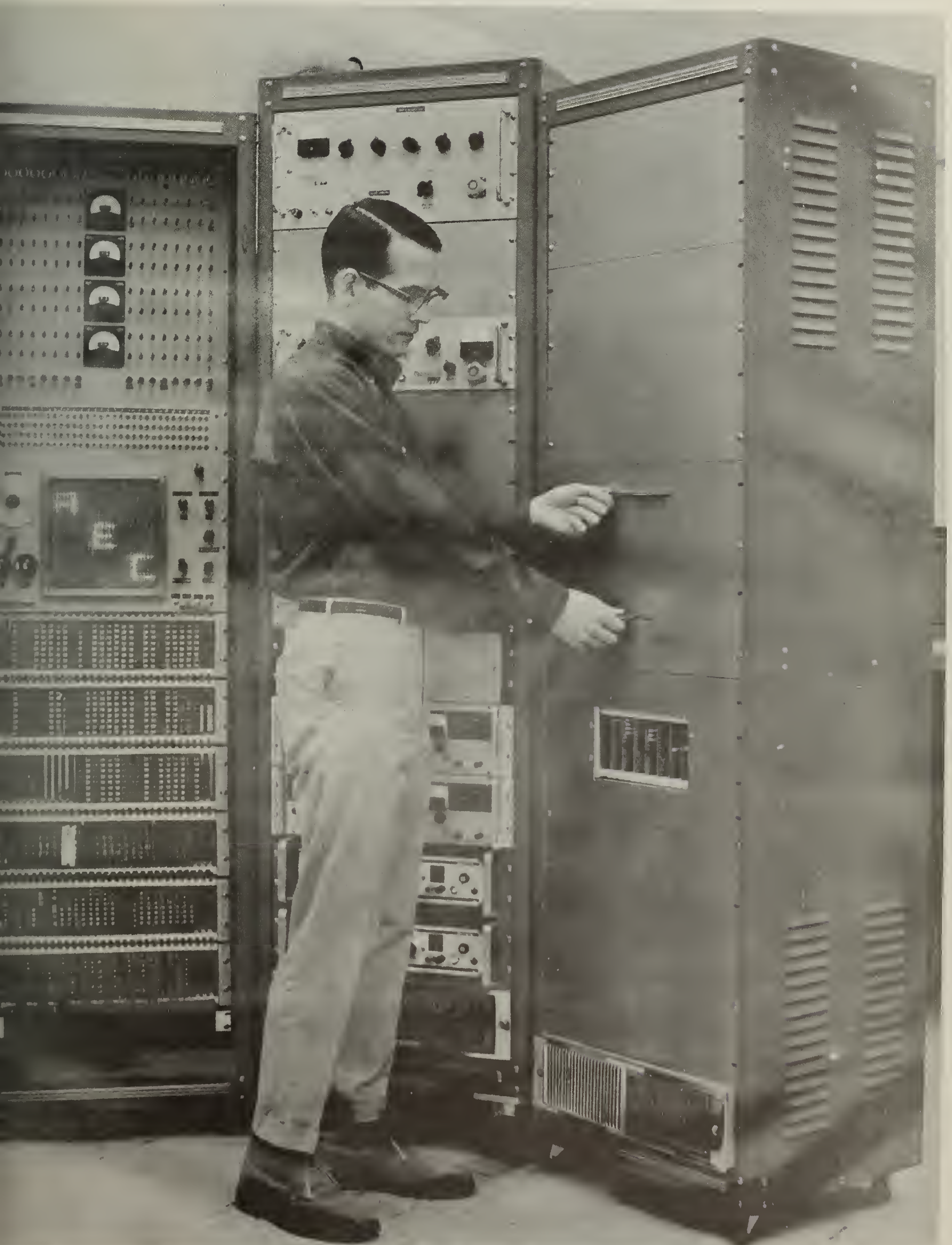


Figure 1. PARAMATRIX

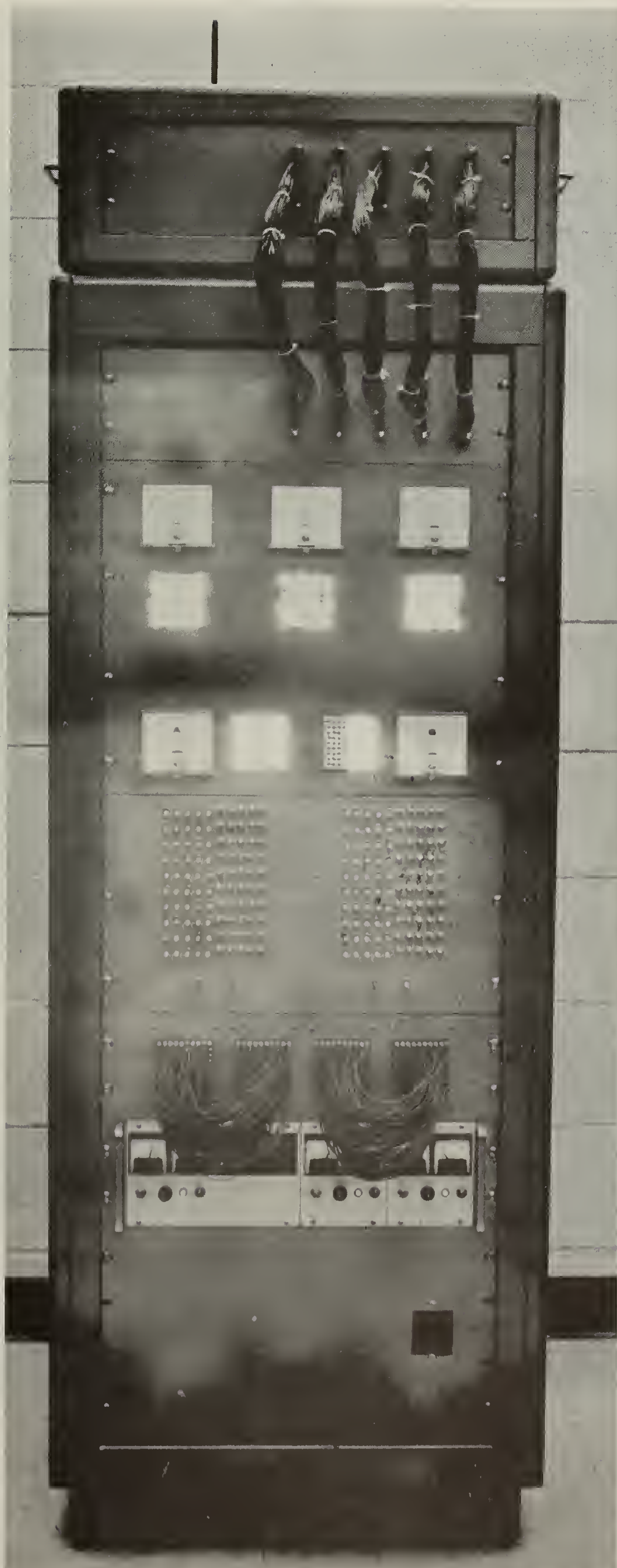


Figure 2. BUM

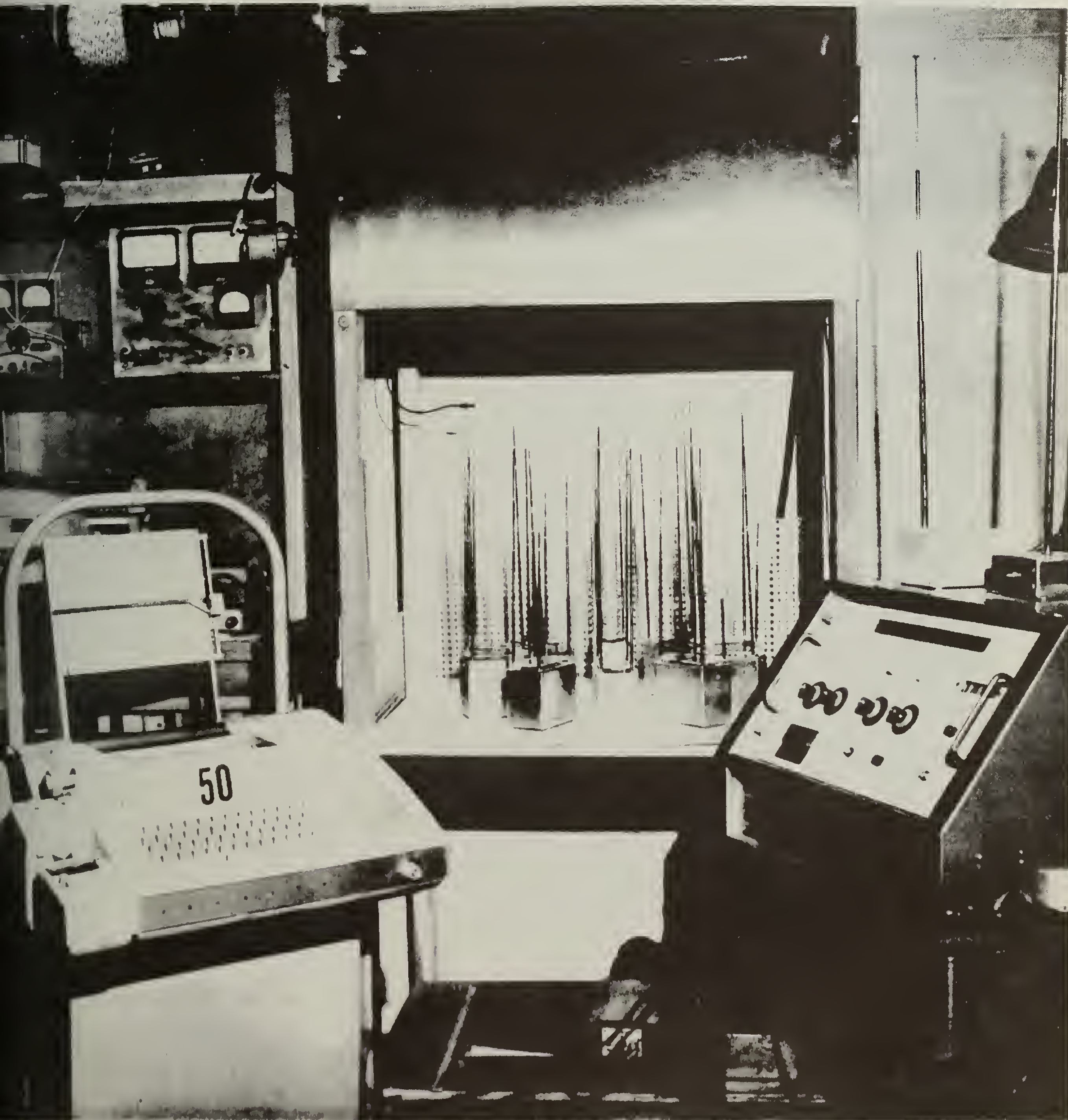


Figure 3. APE

Figure 4. ARTRIX SYSTEM

Figure 5. Tricolor Cartograph

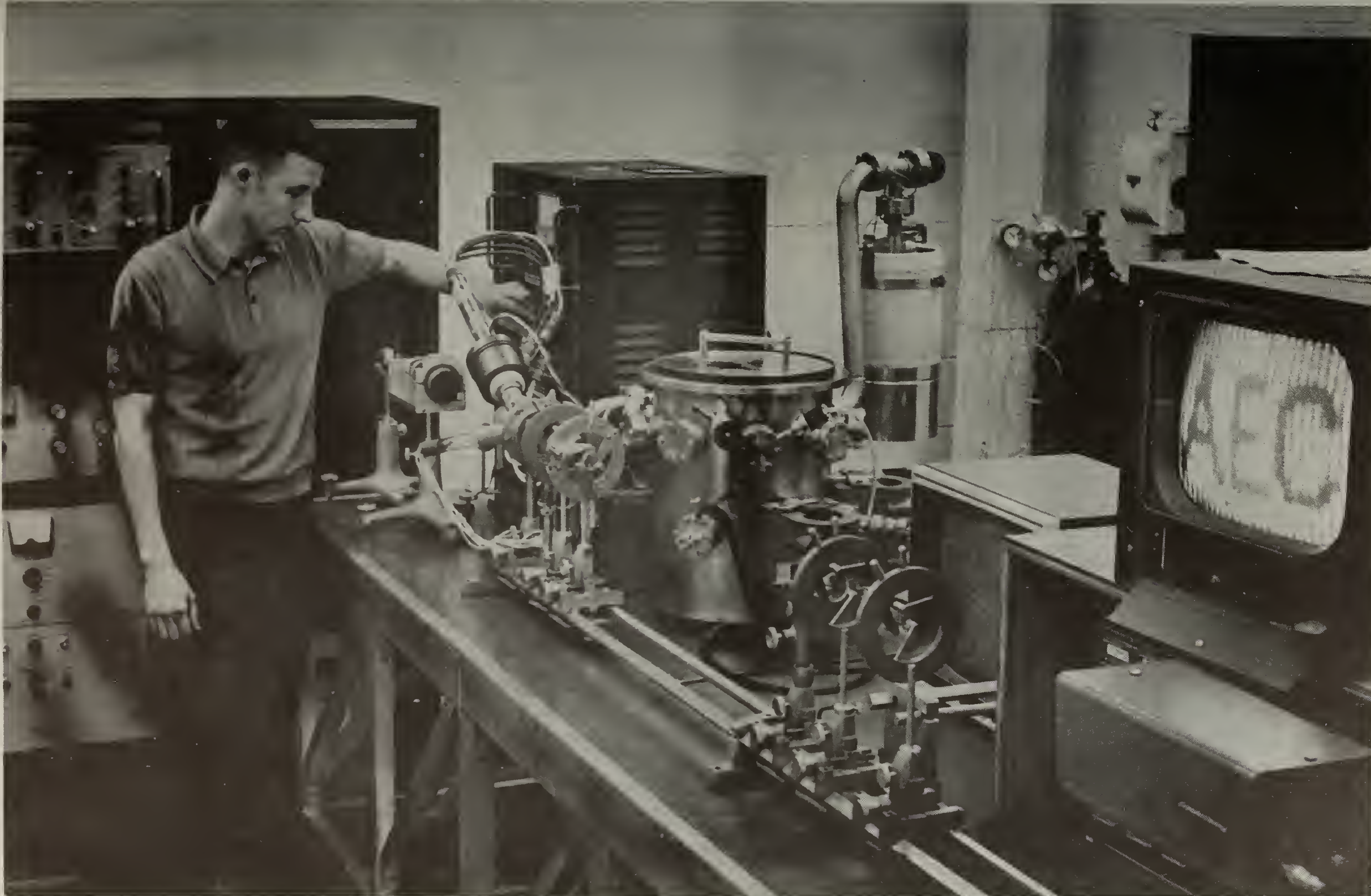


Figure 6. OLFT (On-Line Fourier Transform) System

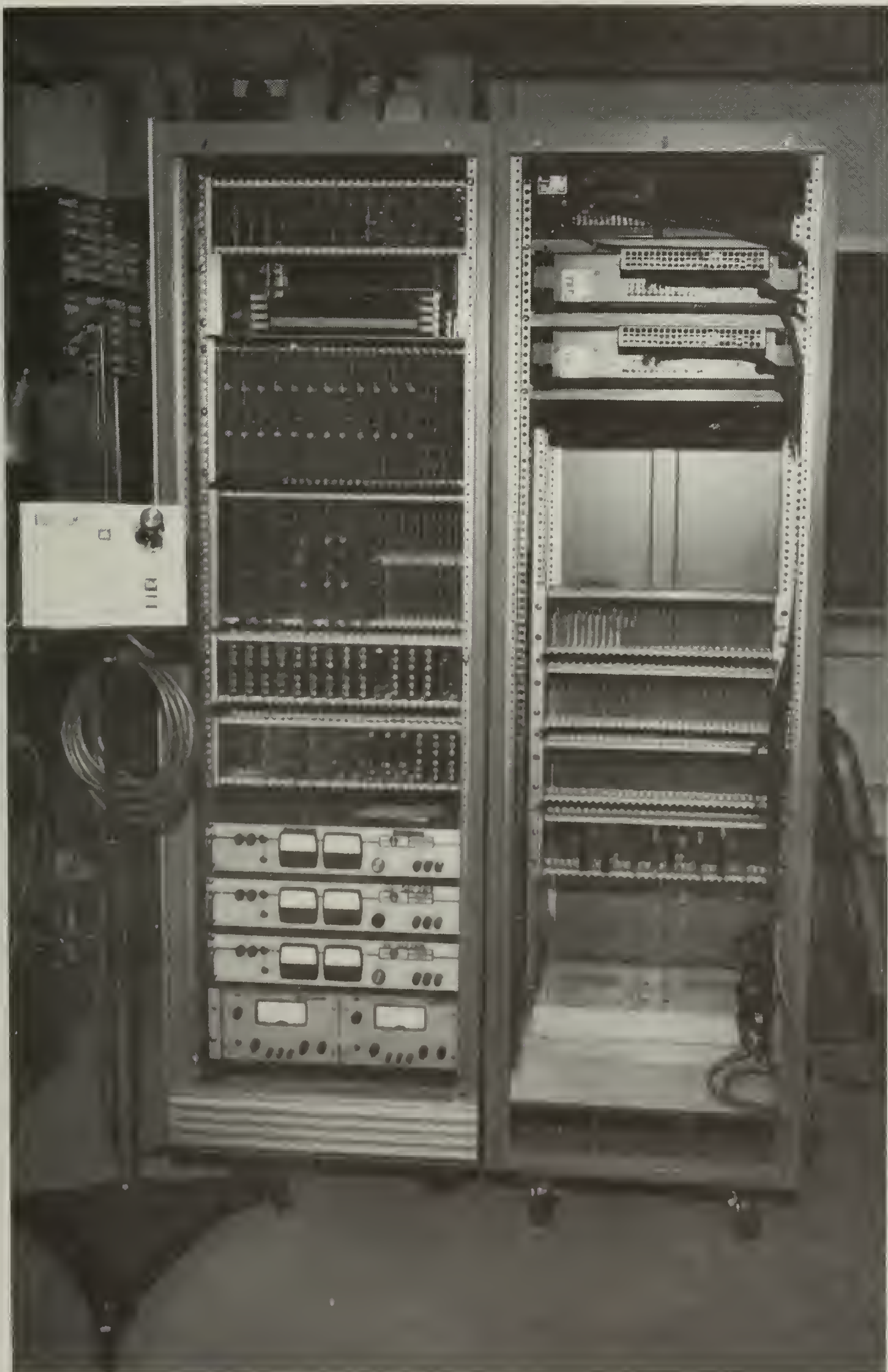


Figure 7. STEREOMATRIX

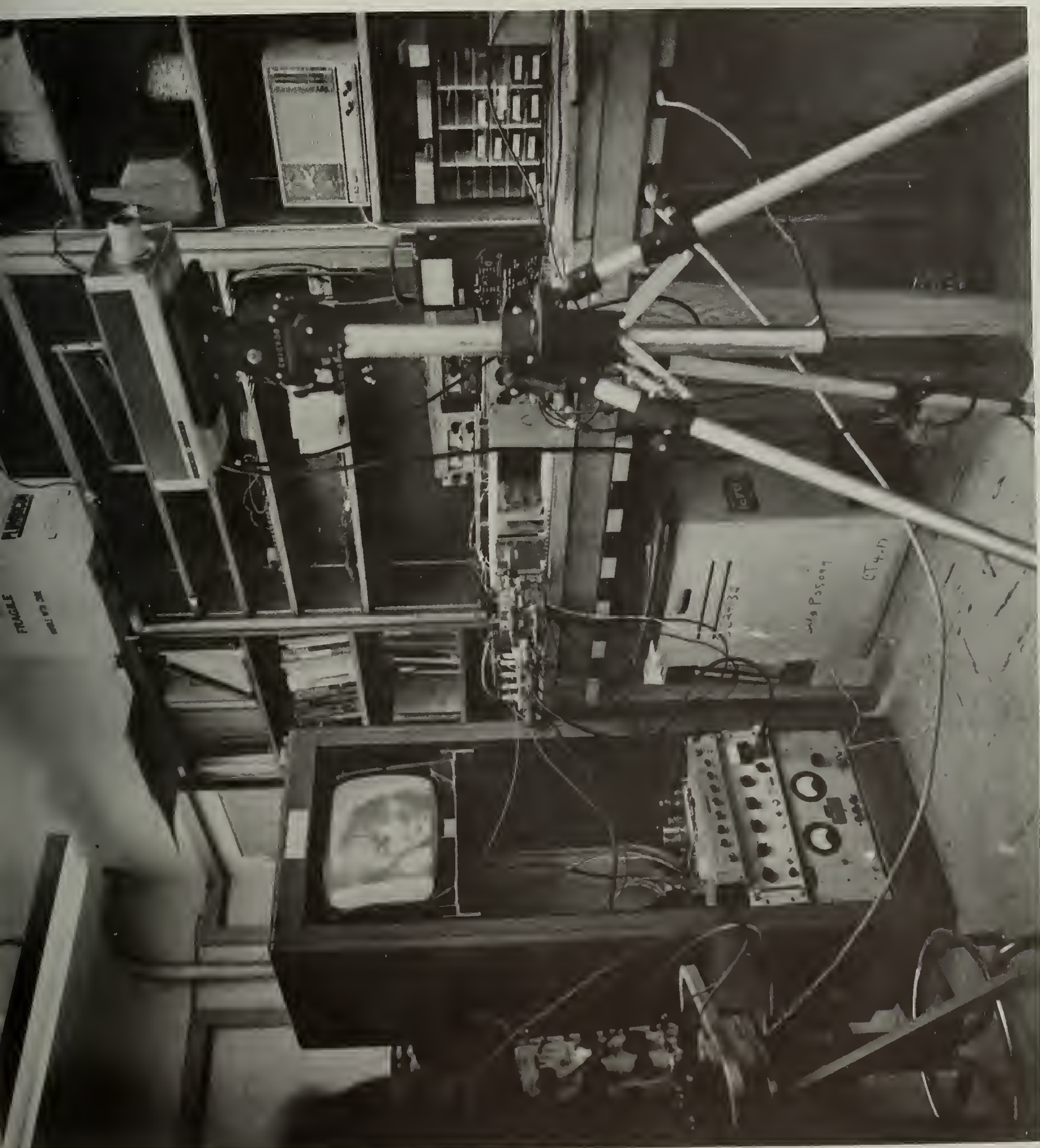
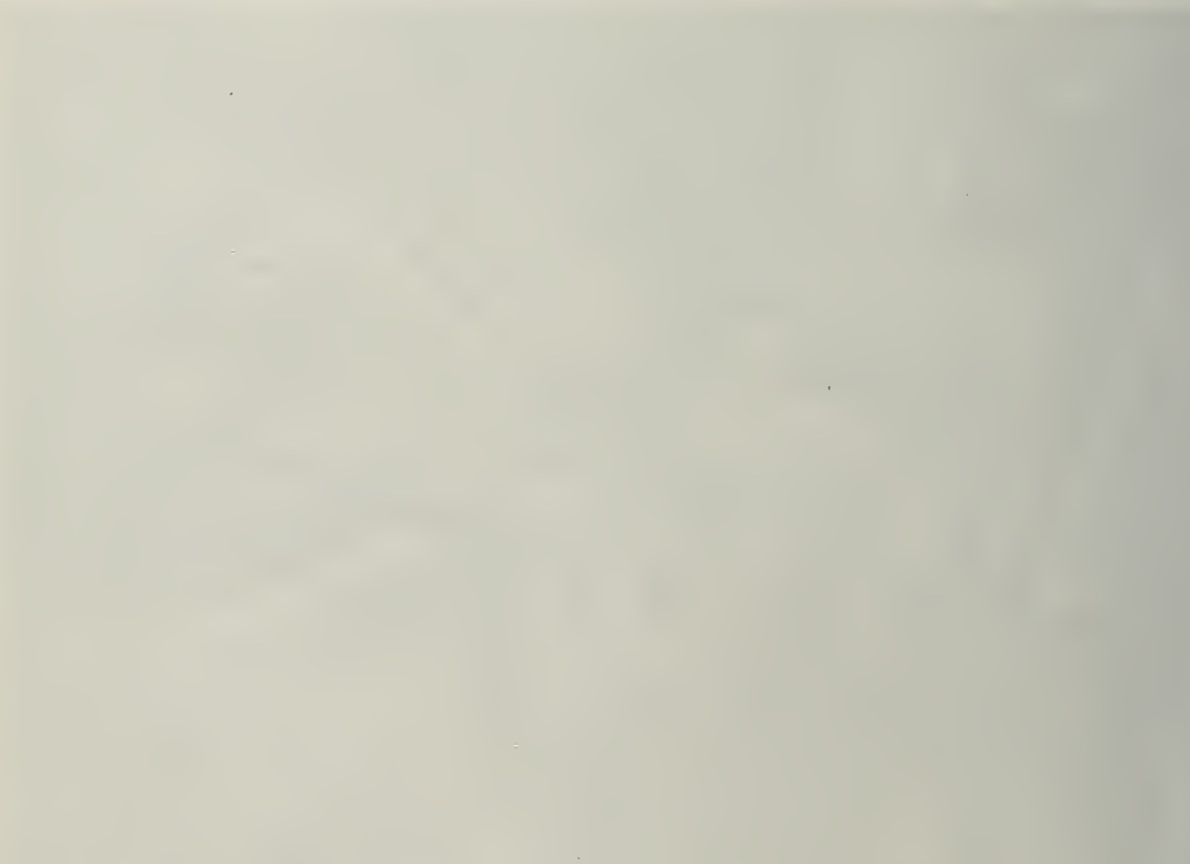


Figure 8. PENTECOST



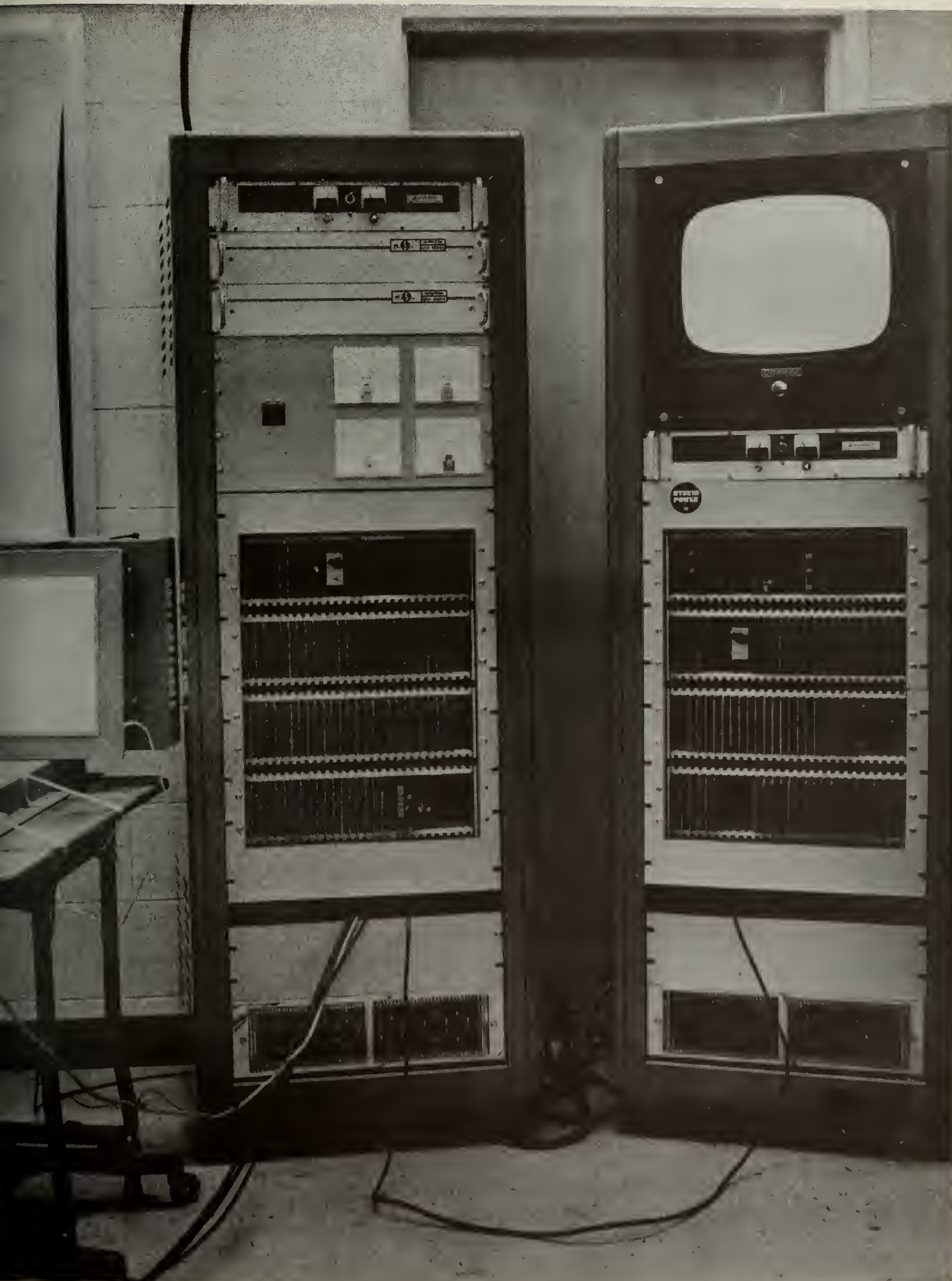


Figure 9. ORBIT

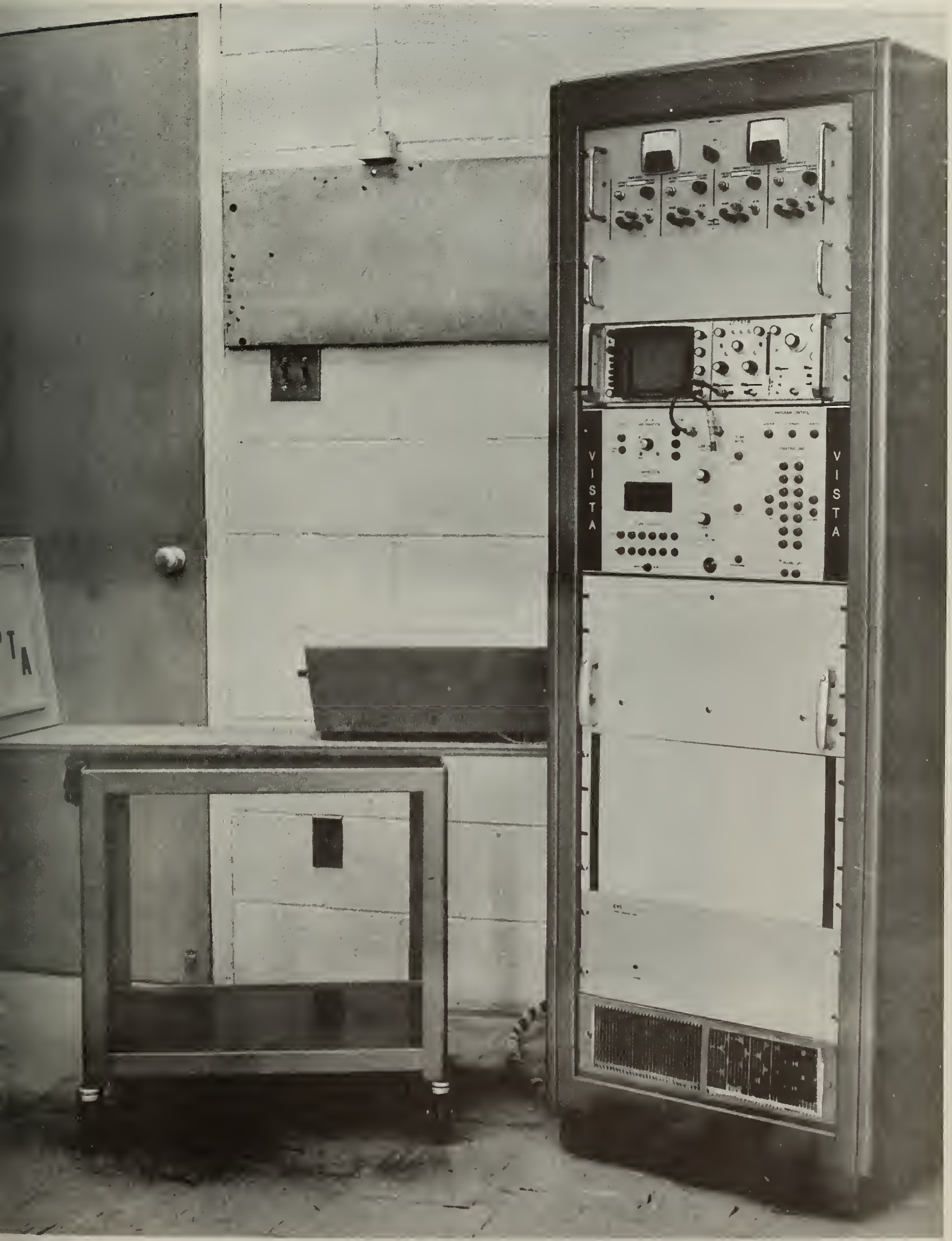


Figure 10. VISTA

Figure 11. EIDOLYZER

Figure 12. TELEMAZE

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Professor and Principal Investigator

Organization

Department of Computer Science
University of Illinois
Urbana, Illinois 61801

Signature	Date
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16. Abstracts

This report describes the work done in the Hardware Research Group in the Department of Computer Science of the University of Illinois in the period 1963 - 1973. It includes, therefore, work on the contract AEC 1469P and ONR N000 14-67-A-0305-0007. The areas convered are: On-Line Video Processing, Stochastic Computing, Electro-Optics, Pattern Recognition, and Display Devices. Photographs of the most important projects are included.

17. Key Words and Document Analysis. 17a. Descriptors

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17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

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