CONSTRUCTING AND MANIPULATING COLOR IMAGERY FROM DIGITAL DATA

by

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INTRODUCTION

The University Centers of Excellence were the leaders in the devlopment of airborne scanner systems, the related data processing and the application of this data. When the Earth Observations Division at the Manned Spacecraft Center decided to use airborne scanners, much of the technology resulting from the work at these centers was utilized. One of the more significant areas in thich this technology was advanced by MSC was in the development of more sophisticated Data Analysis Station (DAS) Equipment which allows complex manipulation and subsequent idsplay of the sensor output. A major consideration for the new DAS was to have an interactive system which would aid investigators, who were not computer oriented, in examining the data.

EQUIPMENT

The Bendix Corporation developed the 24 band multispectral scanner system (MSS) and a DAS (Fig. 1) which are now at MSC. A second DAS (Fig. 2) was developed by Aerojet General primarily for use with the Passive Microwave Imaging System (PMIS). The manufacturers of these two DAS supplied both the hardware and the software for these systems. The following is a listing of the basic units which make up the DAS's. Some of these units are shared between the two systems.

a. An Ampex FR1900 14-track wide-band tape unit.

b. An ASR-33 teletypewriter.

c. A Systems Engineering Laboratories 810B computer with 16K word memory, 2 digital tape controller units and 3 separate digital magnetic tape units.

d. An operator console containing a color display device.

e. A multi-bay rack assembly containing a 9 inch strip film recorder and system control logic.

f. A 1000-line-per-minute line printer.

g. A 600-card-per-minute card reader.

h. An 800 character numeric display terminal which can be used interactively with the system.

FUNCTIONS OF DAS

Figure 3 shows the MS DAS console and Figure 4 is of the PMIS DAS console with the interactive display terminal on the right. Figure 5 shows how sensor data is processed in the DAS to cut down on the volume of data being handled by the large scale computers. Data from these larger computers comes back to the DAS for display and film recording. The DAS is used to perform the following functions on scanner data:

1. Editing of flight tapes by transferring to 9 track tape only that portion of the data to be studied in detail. Training sample selection is a practical application of editing.

2. Screening flight tapes (or other processed tapes) by creating black and white or color imagery on the T.V.

3. Producing hard copy in the form of film transparencies in color or black and white.

4. Outputting data on the line printer.

Item 2 is the principle part of the discussion in this paper.

After the analog PCM tape from the scanner has been read a tape interface unit converts this to digital data and it is input to the computer. Figure 6 shows how the computer can then convert the sensor based data to color signal data using any of a number of algorithms designed for this purpose. The DAS system then records this processed data on a disc after going through a buffer unit. The disc then feeds the T.V. display through the digital to analog converter.

DATA FORMAT

MS DAS

On the MS DAS the software algorithms must produce color signal data in the format required by the disk. The format is a 5-bit word which allows for 32 distinct values (0-31). The relative intensity of a particular color signal is dictated by the 5-bit color signal word. A word of all zeros produces no signal for that color while a word of all 1's produces a maximum intensity. Values between 0 and 31 produce a proportional brightness. Thus at each addressable element on the T.V., the data stored on the disk controls the color presentation by specifying the intensity of each of the three colors. Since the disk holds one T.V. frame of data each new scan line that is sent to the disk replaces the oldest scan line. The vertical synchronization signal is adjusted automatically so that the new data appears at the top of the screen. This creates a moving scene effect as would be experienced while looking downward through an aircraft window. The rate at which the scene appears to move past the window is determined by the speed at which the computer formats new lines and sends them to the disk.

PMIS DAS

The method used by the PMIS DAS is somewhat different but uses the same principle. A major difference is that while the MS DAS provides for 32 possible intensities for each color the PMIS DAS provides for 16 levels of green, eight of red and four of blue. This seems to be about as many levels as the eye can distinguish as shown in Figure 7.

DATA SOURCES

Many data sources suitable for color imagery on the DAS are now available or in development. The DAS requires that the data be on either a 14 track PCM tape compatible with the Ampex FR1900 or on a 9-track 800 BPI digital tape. Data recorded on other types of tapes must be converted. Analog tapes for example, must be digitized before coming to the DAS. To date, color imagery has been generated from the Bendix 24 channel scanner and from RS14 Infrared Scanner data digitized at MSC. In addition, aerial photos have been digitized on a microdensitometer and subsequently displayed.

COLOR IMAGE CONSTRUCTION

MSDAS

Three specific algorithms are used when processing data with the MS DAS. All of these algorithms are based on a function which is a linear combination of the data channels. This function is called linear transformation (LT) and is of the form:

$$LT = A_0 + A_1C_1 + A_2C_2 + \cdots\cdots A_{24}C_{24}$$

where A's are coefficients and the C's represent sensor values of the designated channels.

One algorithm is called Normal Linear Transformation and is simply three separate linear transformations where the intensity for a CRT gun (I) is proportional to the linear transformation LT

I_R proportional to LT_1

I_G proportional to LT_2

I_B proportional to LT_3

Figure 8 is an example of outputs from this time manipulation. The red display, is of a thermal IR channel (9.3-9.8 µm) from the 24-band scanner. The green display, Figure 9, is of a near IR channel (1.18-1.30 µm) and the blue display, Figure 10, is of the blue channel (.46-.50 µm). Figure 11 shows the combined display. Figure 12 shows one channel of data using a linear transformation to get different intensities of blue. Figure 13 shows this same channel of data after the table of color codes has been applied to the different signal levels.

Another algorithm is called Contrast Enhancement. This algorithm uses only 1 linear transformation. Theresult of the linear transformation is then used as an index to a table of pre-defined color codes.

I_R = RED (LT) i.e. the LTth RED value

I_G = GREEN (LT)

I_B = BLUE (LT)

Figure 12 shows one channel of data using a linear transformation to achieve different intensities of blue. Figure 13 shows this same channel of data after the table of color codes has been applied to the different signal levels.

A third algorithm is called Linear Discriminant. It uses three linear transformations but the intensities are either zero or the maximum depending upon whether the result of the transformation meets a given threshold

$$I_R = 0 \text{ if } LT_1 < THRESH_1 \qquad I_R = 31 \text{ if } LT_1 \geq THRESH_1$$

$$I_G = 0 \text{ if } LT_2 < THRESH_2 \qquad I_G = 31 \text{ if } LT_2 \geq THRESH_2$$

$$I_B = 0 \text{ if } LT_3 < THRESH_3 \qquad I_B = 31 \text{ if } LT_3 \geq THRESH_3$$

Figures 14 (9.3-9.8 m), 15 (1.18-1.30 m), and 16 (.46-.50 m) show data which is above the treshold for these three channels. Figure 17 shows the combined display. White is produced when all 3 channels exceed the treshold. When only the red and green channels exceed this limit yellow is displayed. Where blue and red exceed the limit magenta results and when blue and green exceed the limit the cyan portion of the image (oil tanks) is shown.

PMIS-DAS

The PMIS DAS is used with a program called Color Study which is similar to Contrast Enhancement. The user can very easily define his own color tables with the numeric display terminal. The PMIS scanner had not been flown at the time this paper was written and so none of the data was available for publication. Data from other sensors has been displayed on this DAS in the absence of PMIS data.

Figure 18 shows 2 color charts made up on the interactive console for the Color Study program. The bottom portion shows all 512 possible colors which may be called upon to generate a color chart.

The data for the image in Figure 19 came from digitizing the two analog channels of the RS14 infrared scanner (3.0-5.5 µm and 8-14 µm). The channels are displayed side by side using the same color chart for each. Thus the color differences shown represent actual signal differences between the two channels.

Figure 20 is another example of imagery using the Color Study program. The data was obtained by digitizing infrared color film with a microdensitometer and recording on tape.

The imagery in Figure 21 was produced by a simulation study of temperatures in Trinity Bay. Figure 22 represents the same input data applied to a different color chart.

SUMMARY

The comparison of Figures 21 and 22 adequately demonstrate how much easier it is to distinguish different colors than it is to distinguish shades of grey or in this case shades of green.

All of these examples show what a capable and flexible tool for principle investigators the DAS is and how it can be applied to a large variety of sensors.

Future plans call for processing data from sensors such as the PMIS, the Scanning Imaging Spectroradiometer (SIS), the Skylab S-192 multispectral scanner, and the ERTS systems.

FIGURE LEGENDS

Figure 1

Figure 2

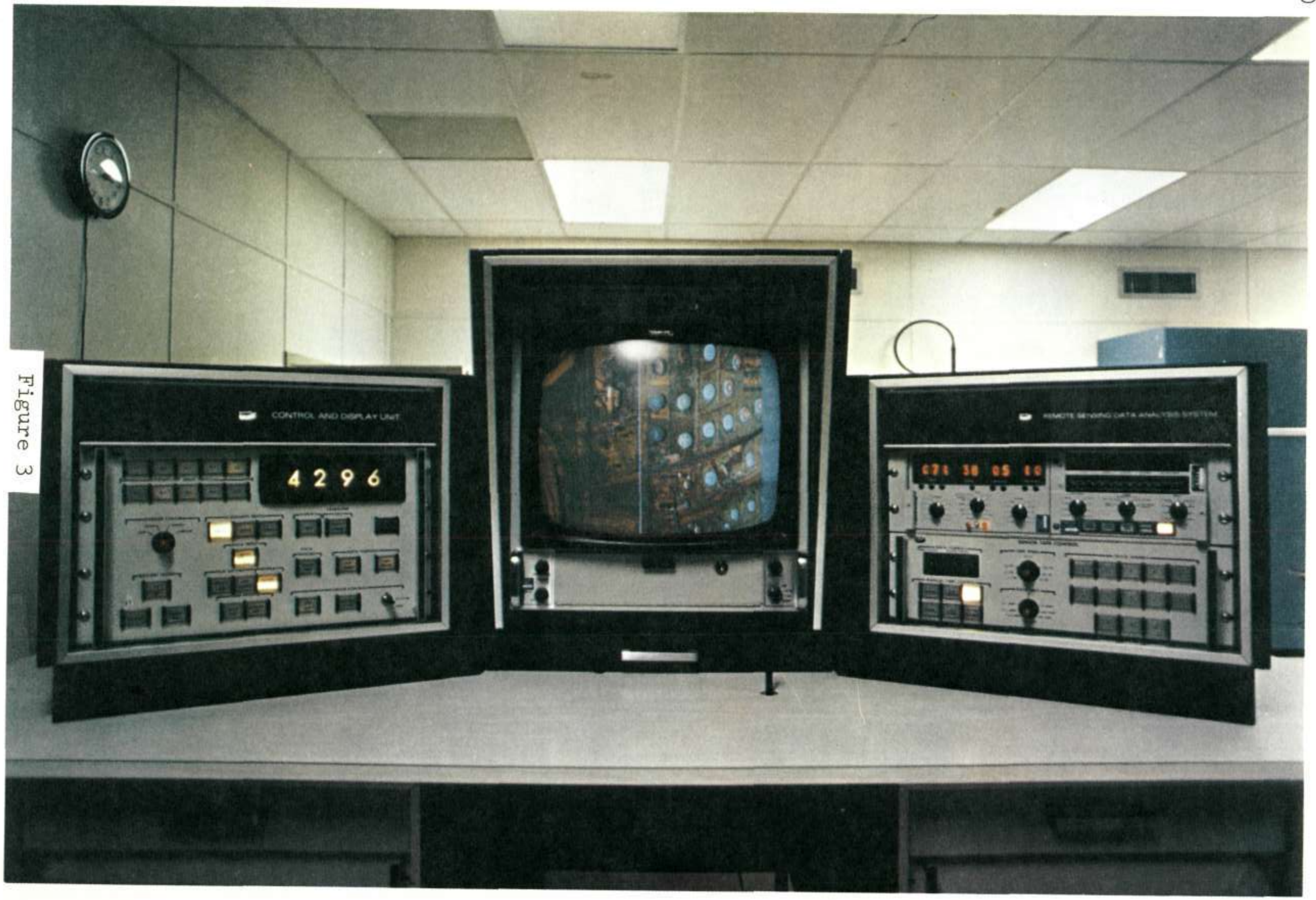

CONTROL AND DISPLAY UNIT
4296
REMOTE SENSING DATA ANALYSIS SYSTEM

Figure 3

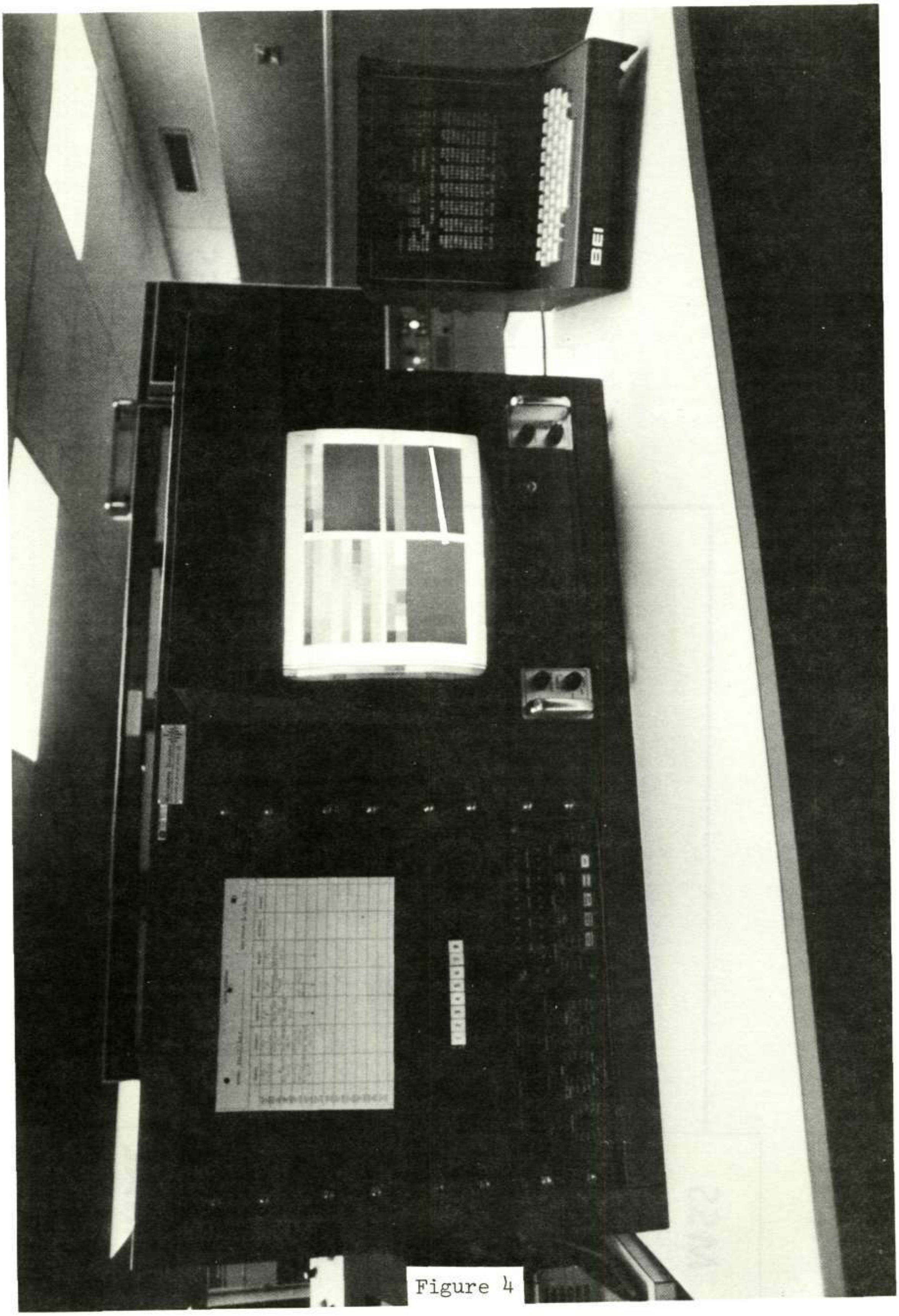
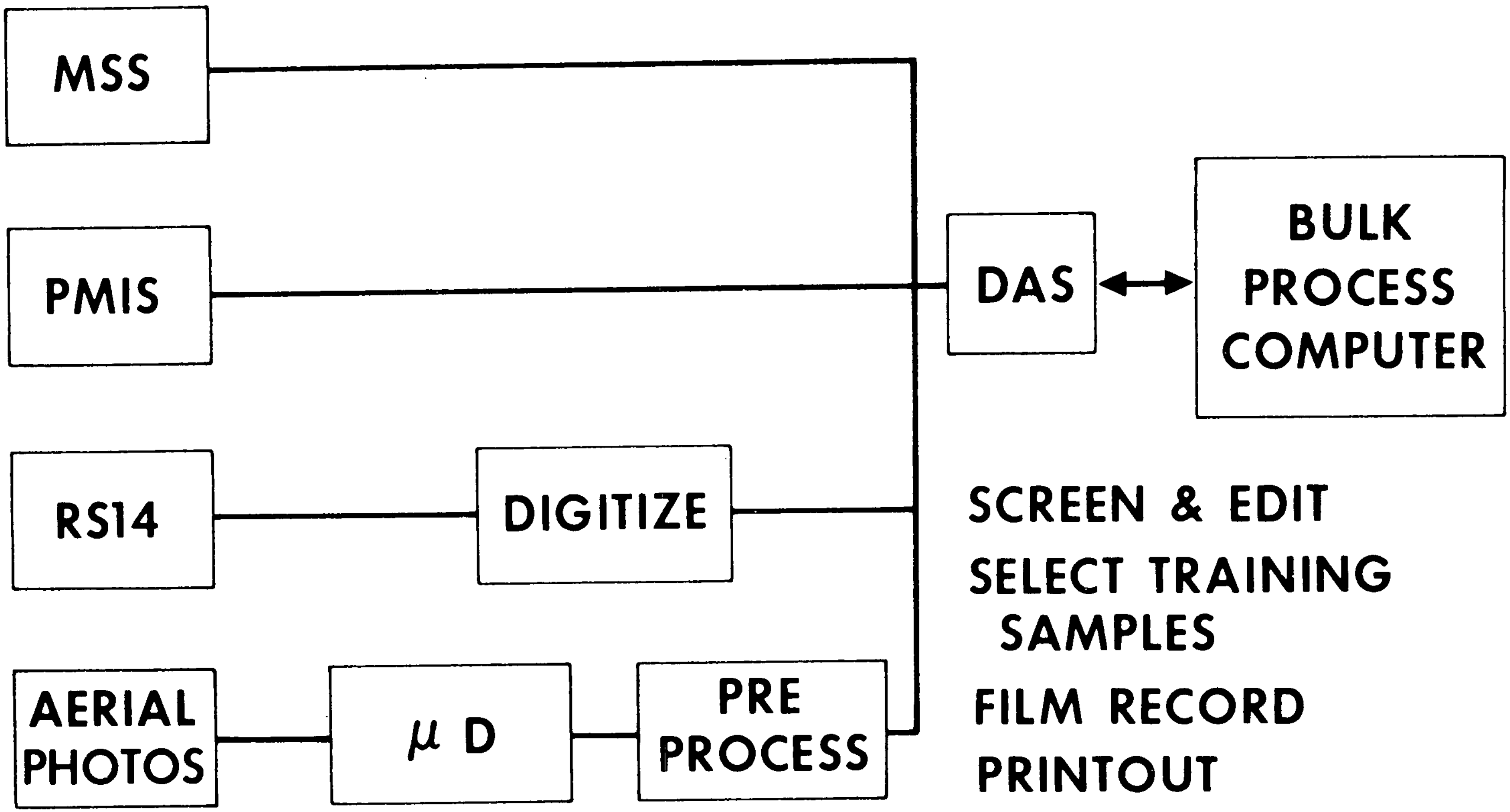


Figure 4



MSS
PMIS
RS14
DIGITIZE
AERIAL PHOTOS
μ D
PRE PROCESS
DAS
BULK PROCESS COMPUTER
SCREEN & EDIT
SELECT TRAINING SAMPLES
FILM RECORD
PRINTOUT

Figure 5

DAS DATA FLOW

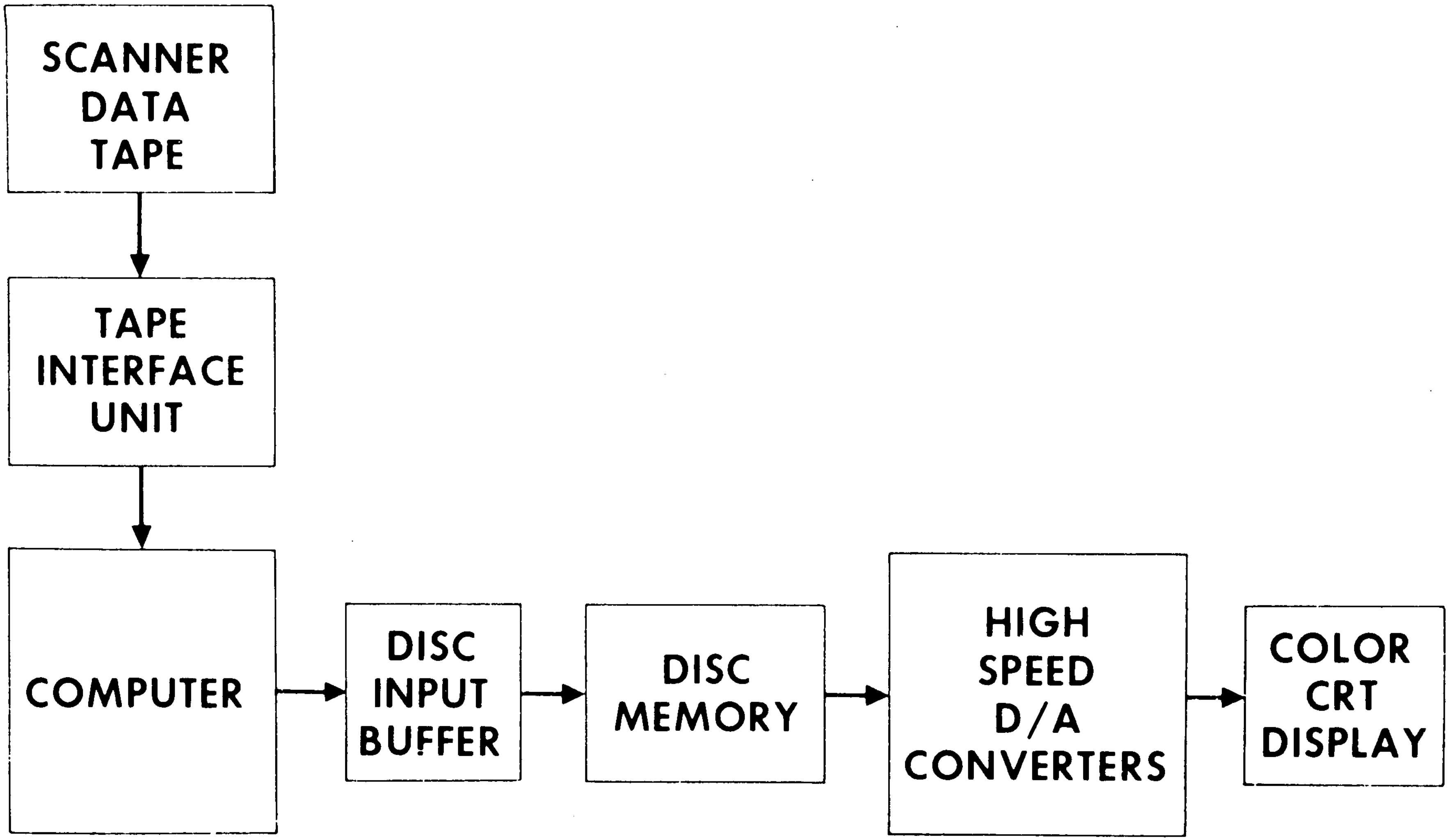


Figure 6

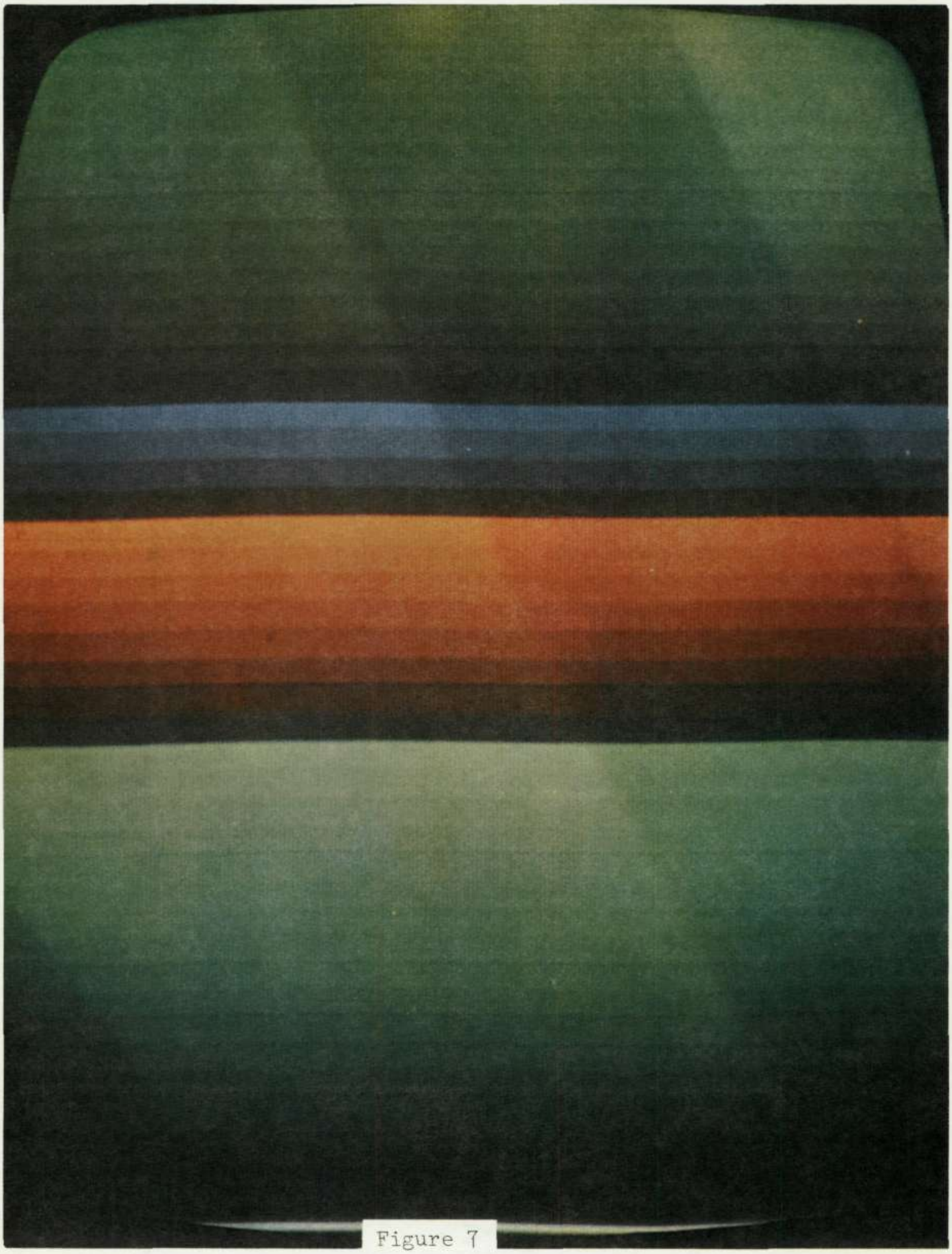


Figure 7

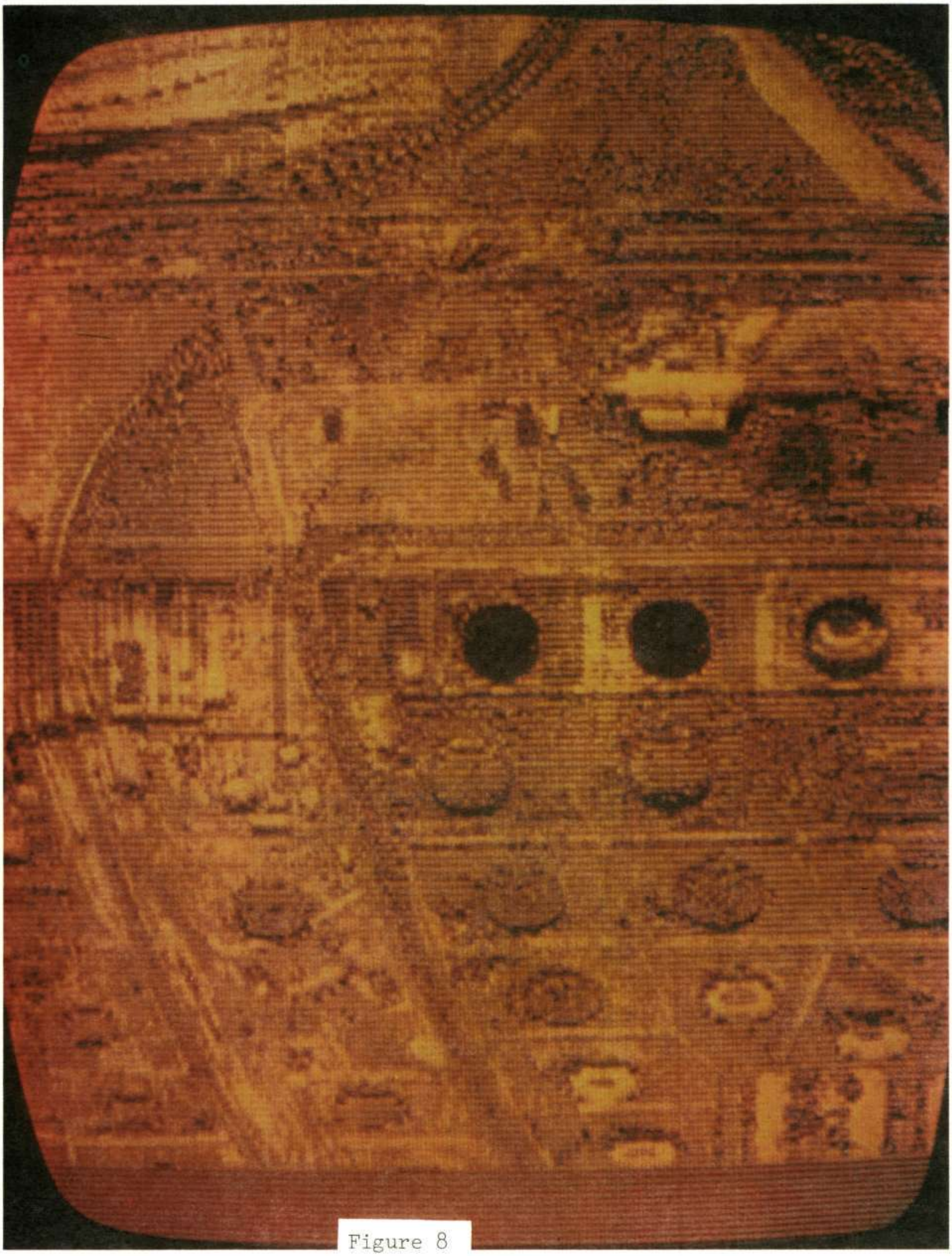


Figure 8

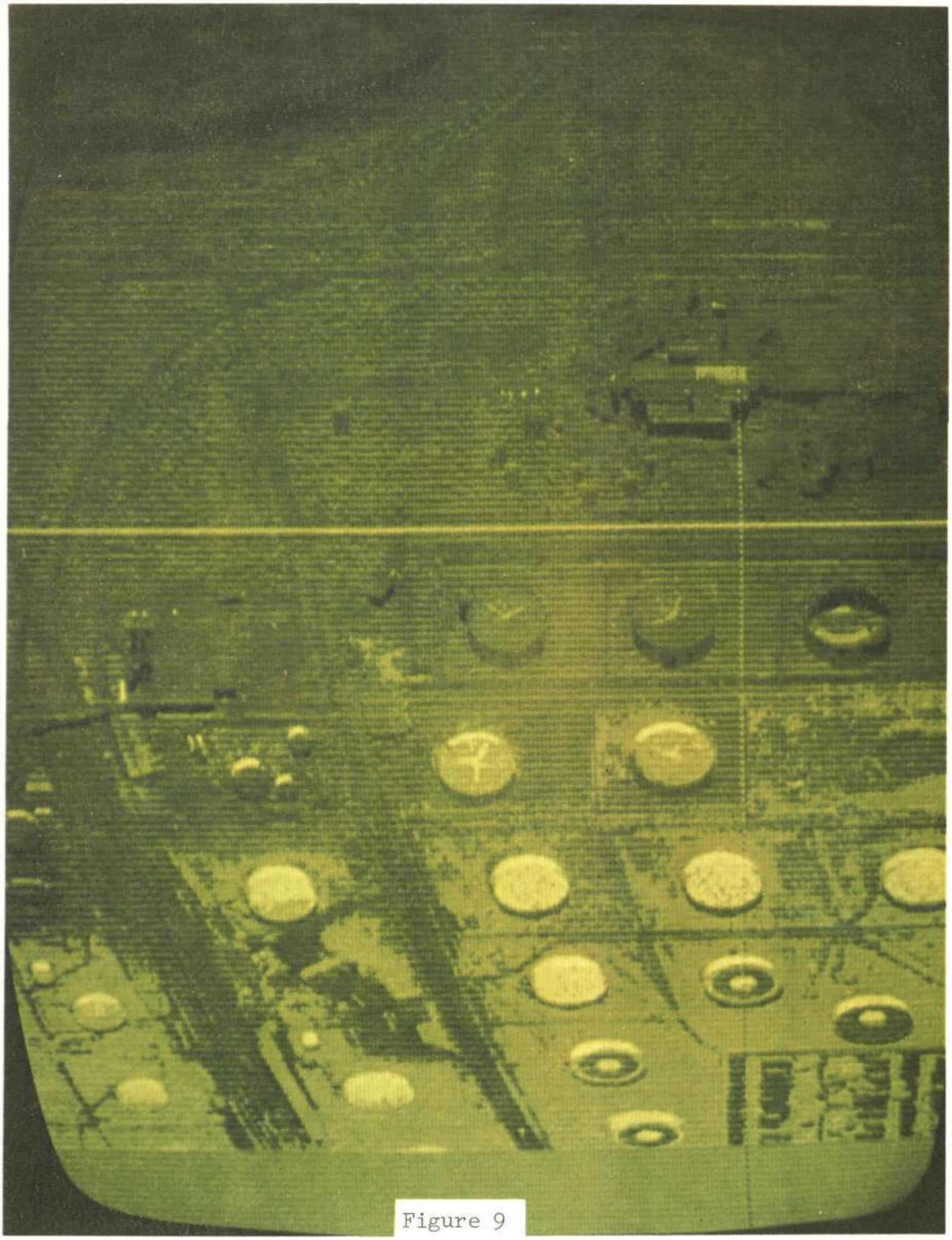


Figure 9

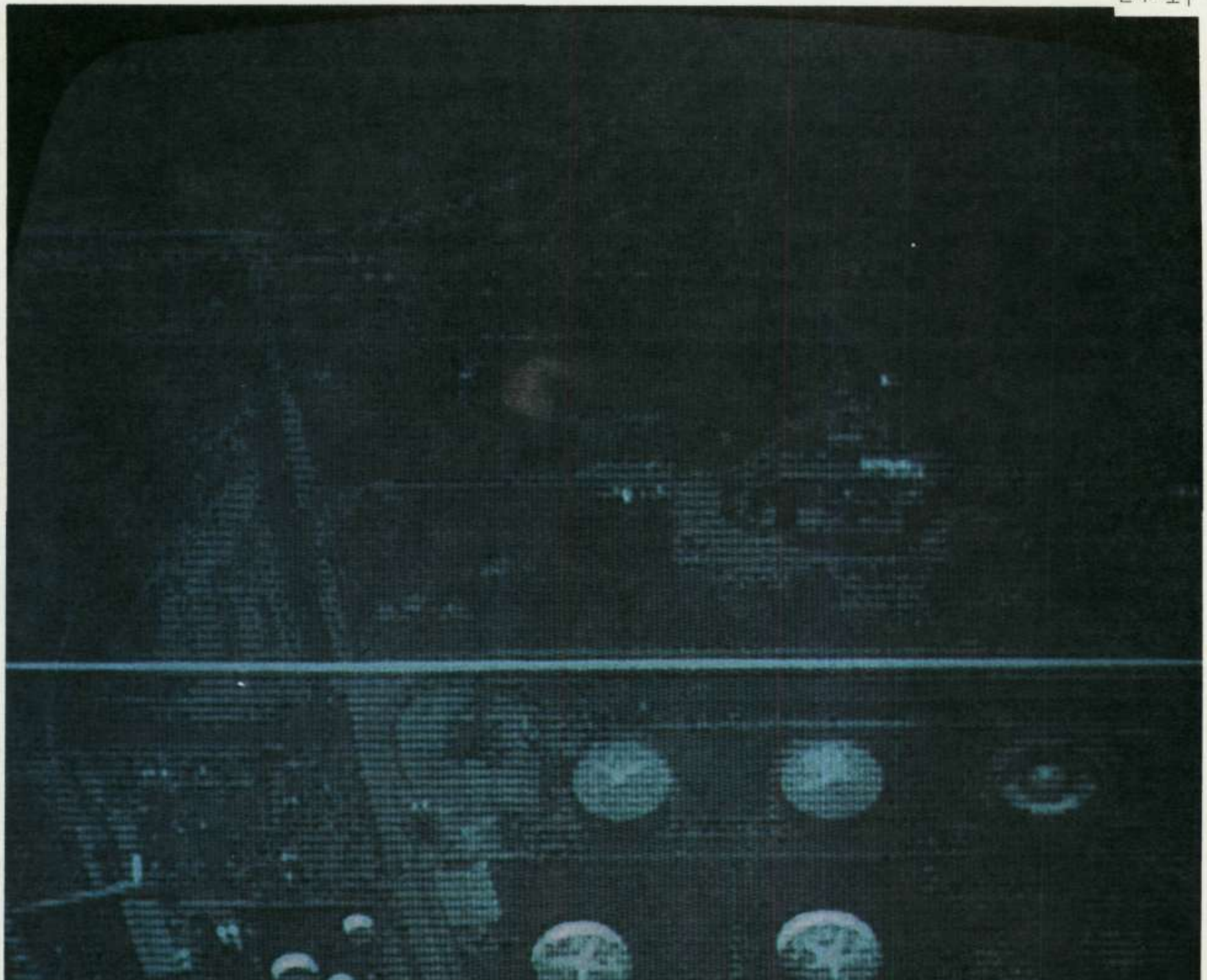


Figure 10

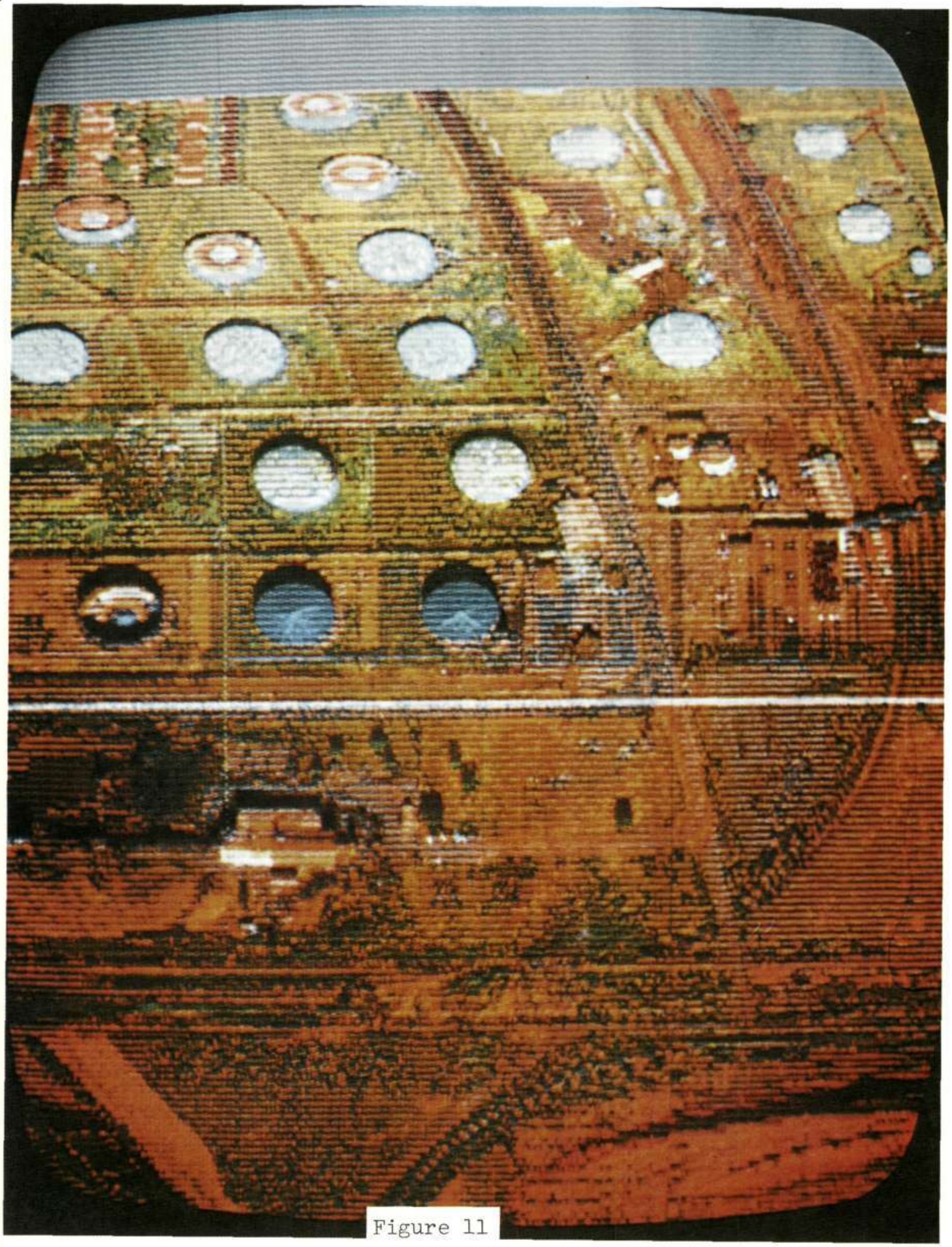


Figure 11

Figure 12

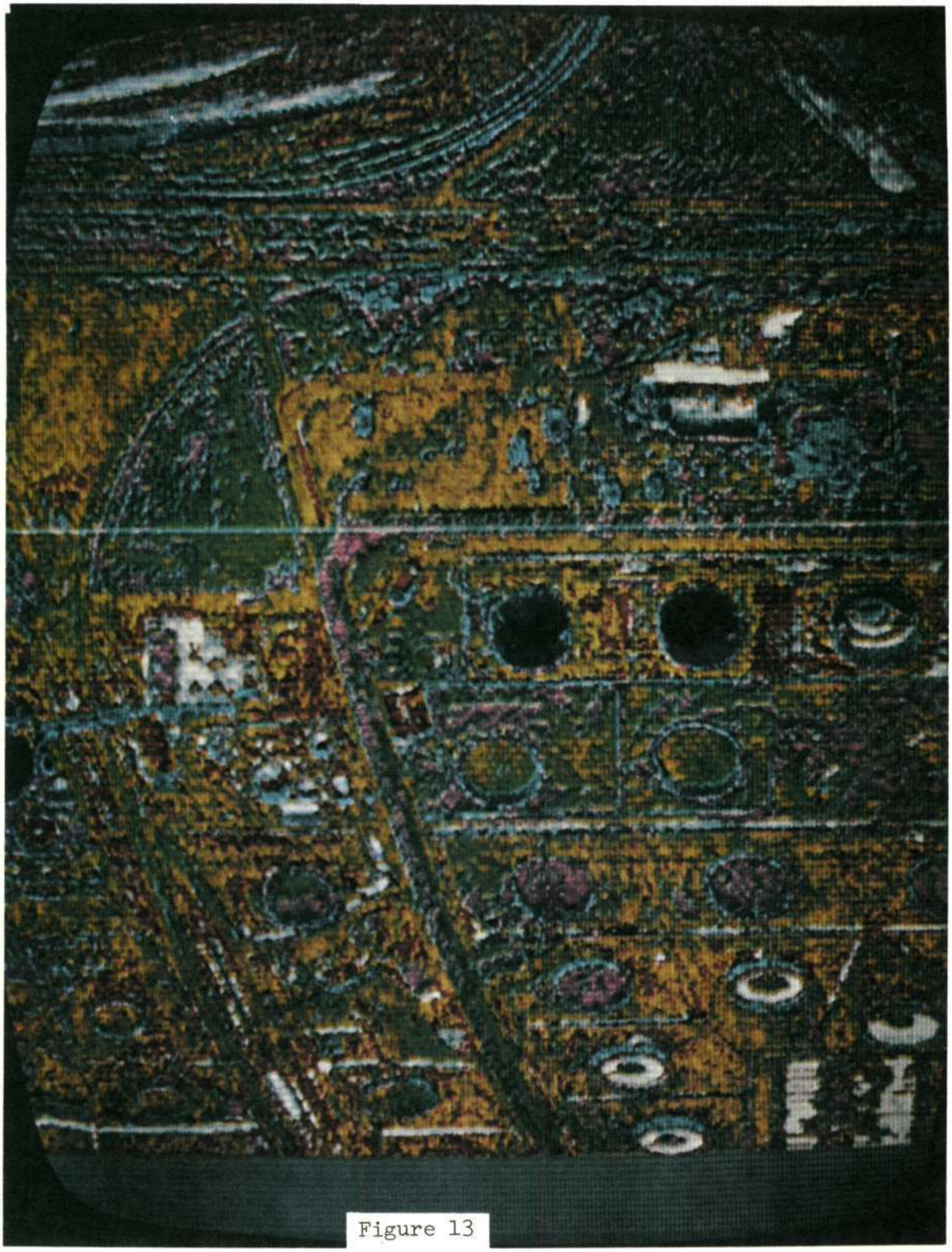


Figure 13

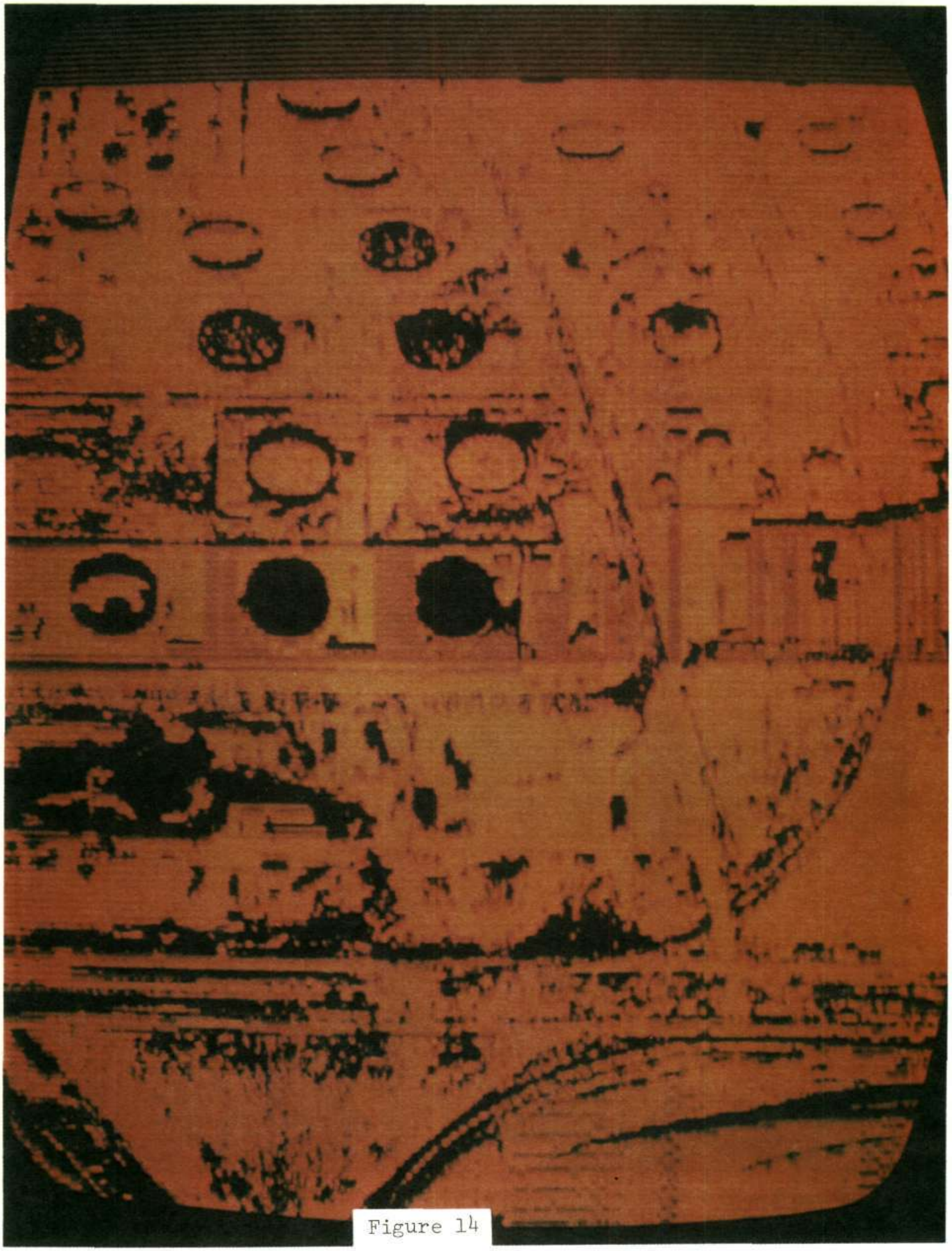


Figure 14

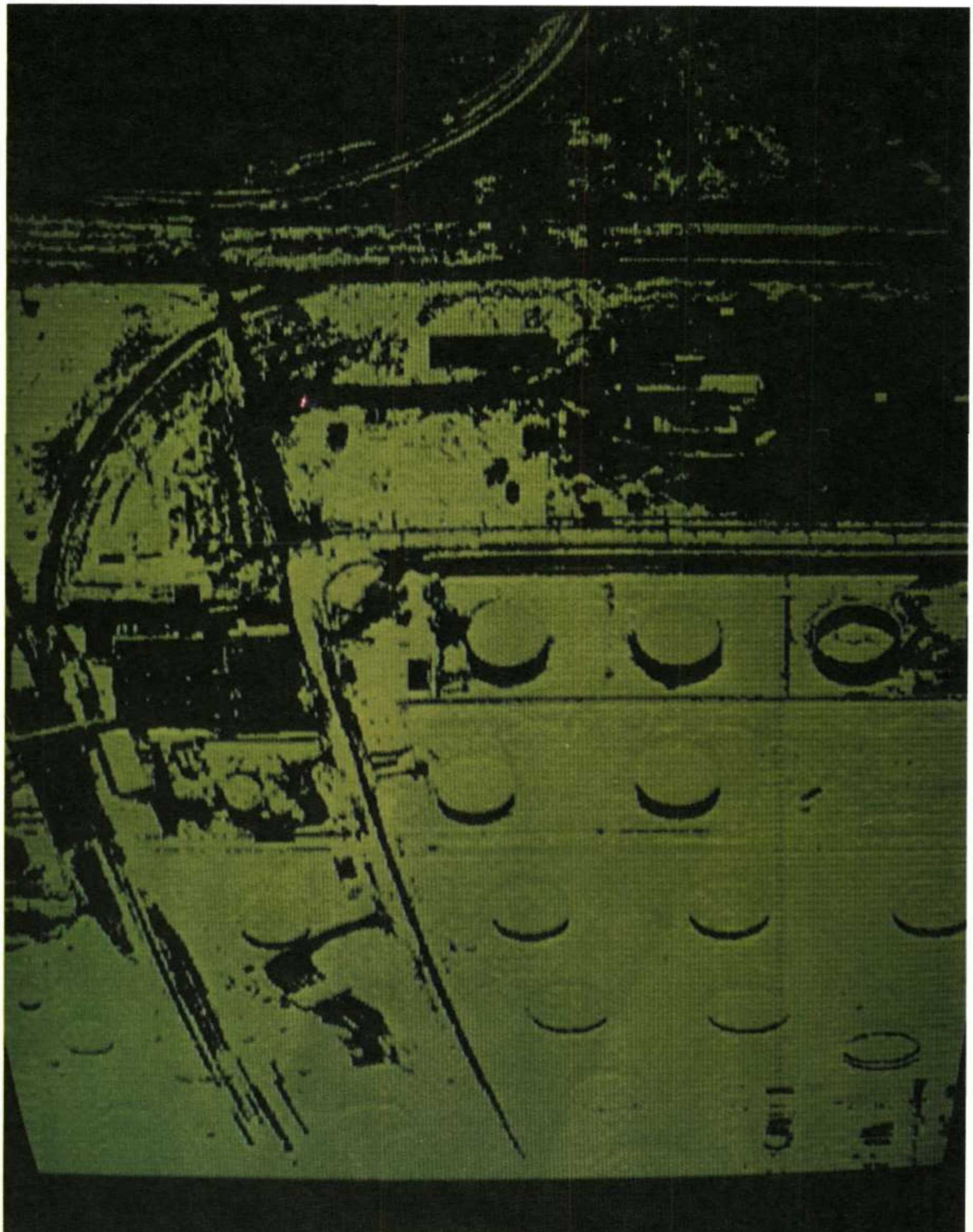


Figure 15

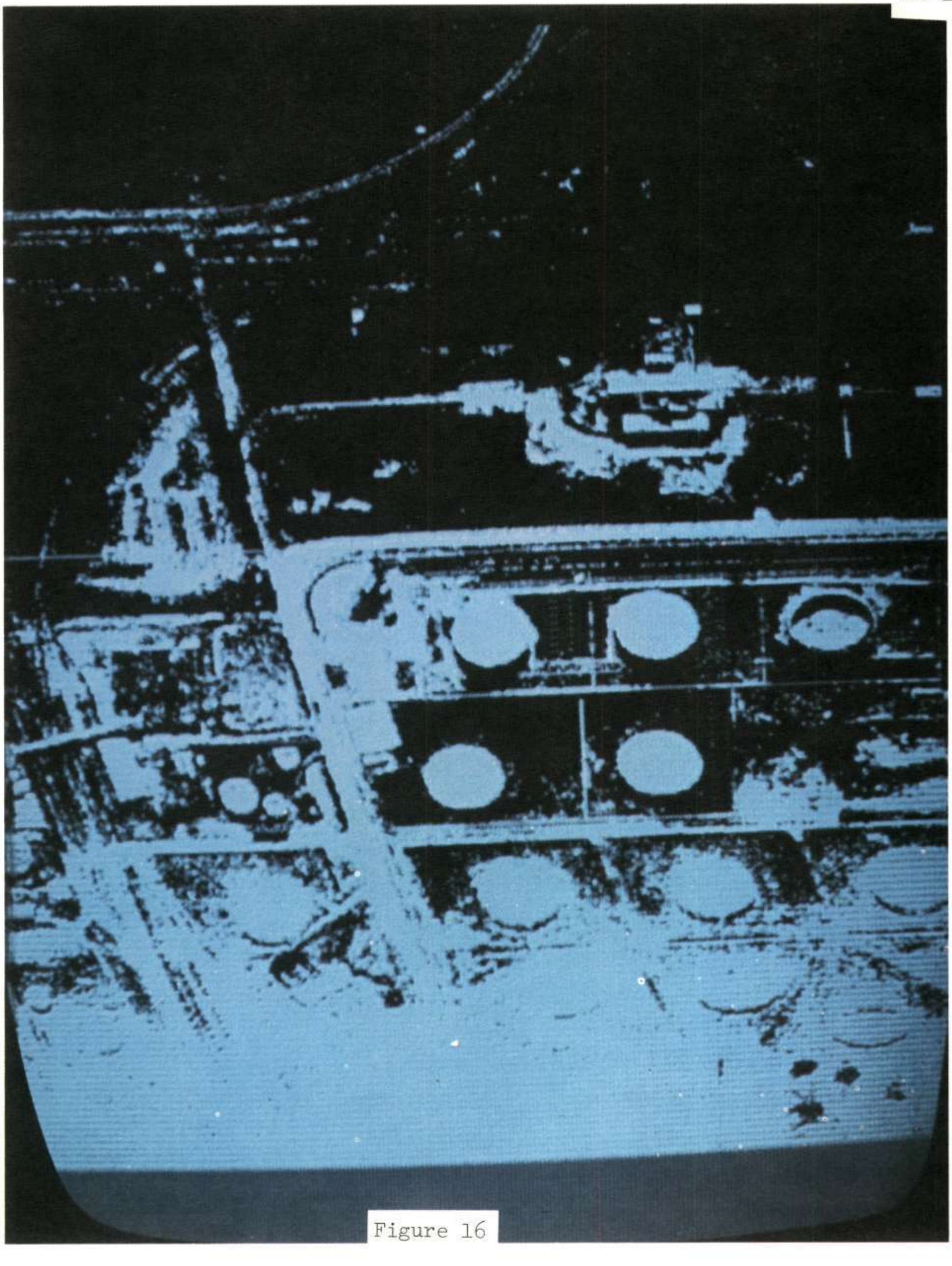


Figure 16

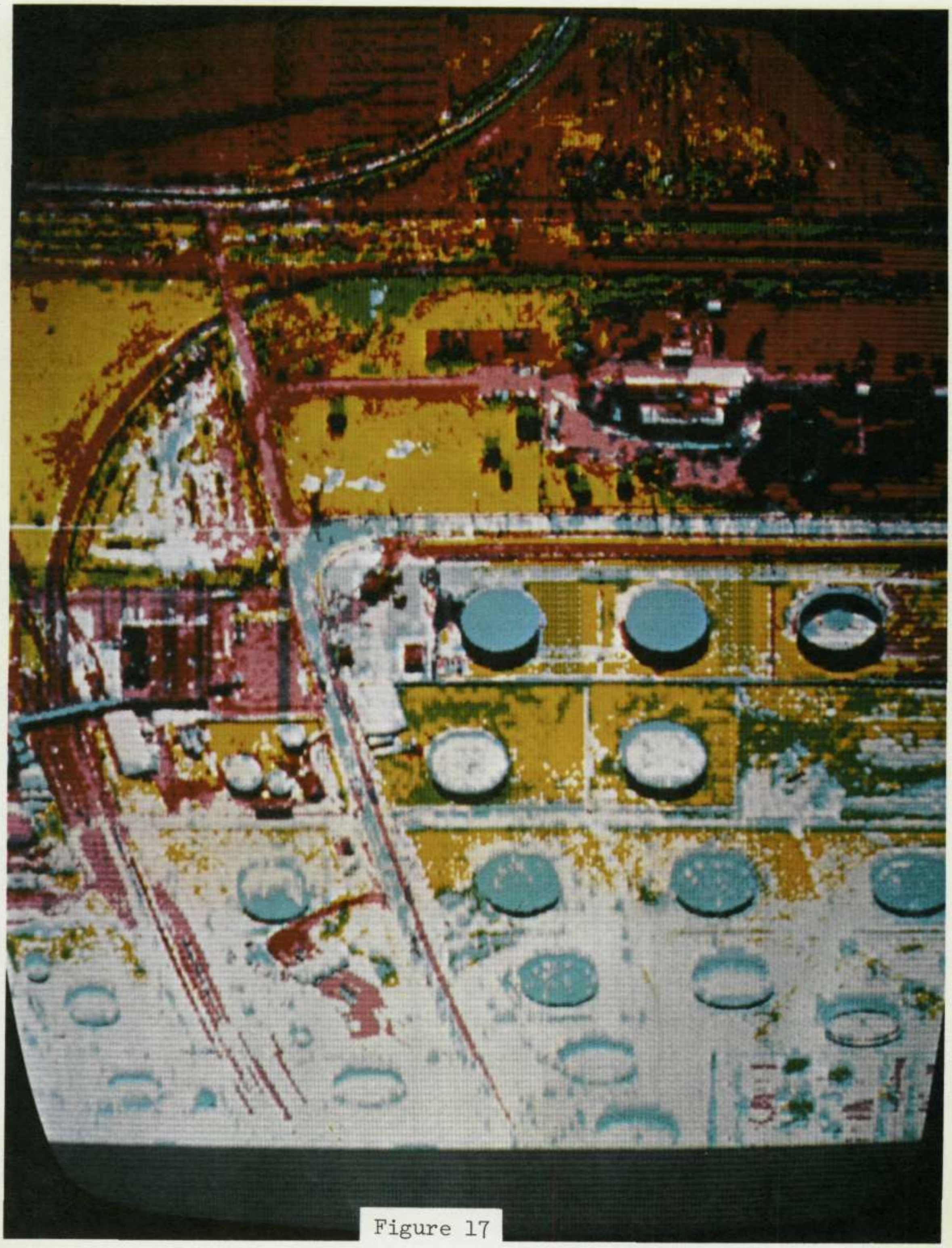


Figure 17

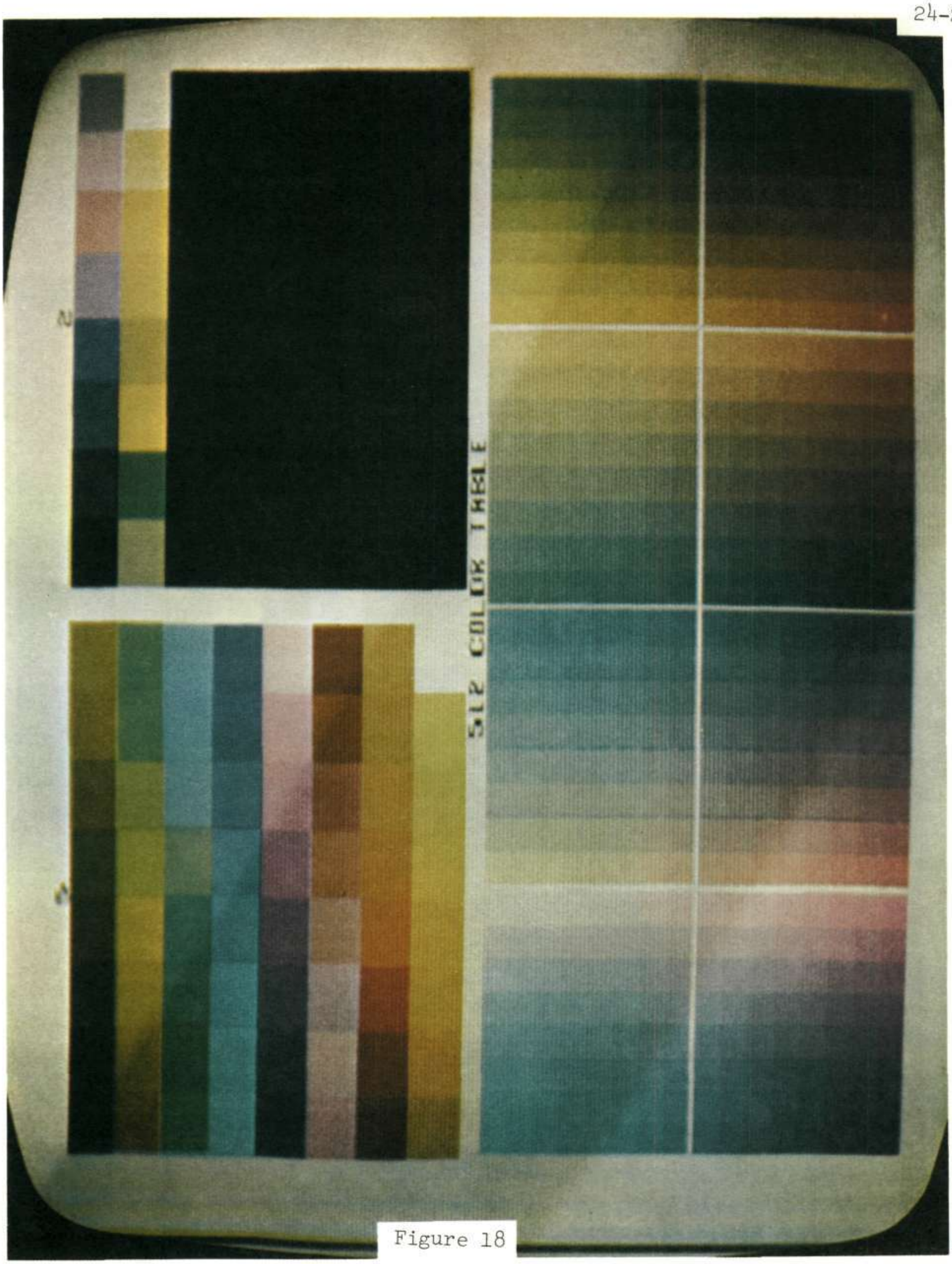


Figure 18

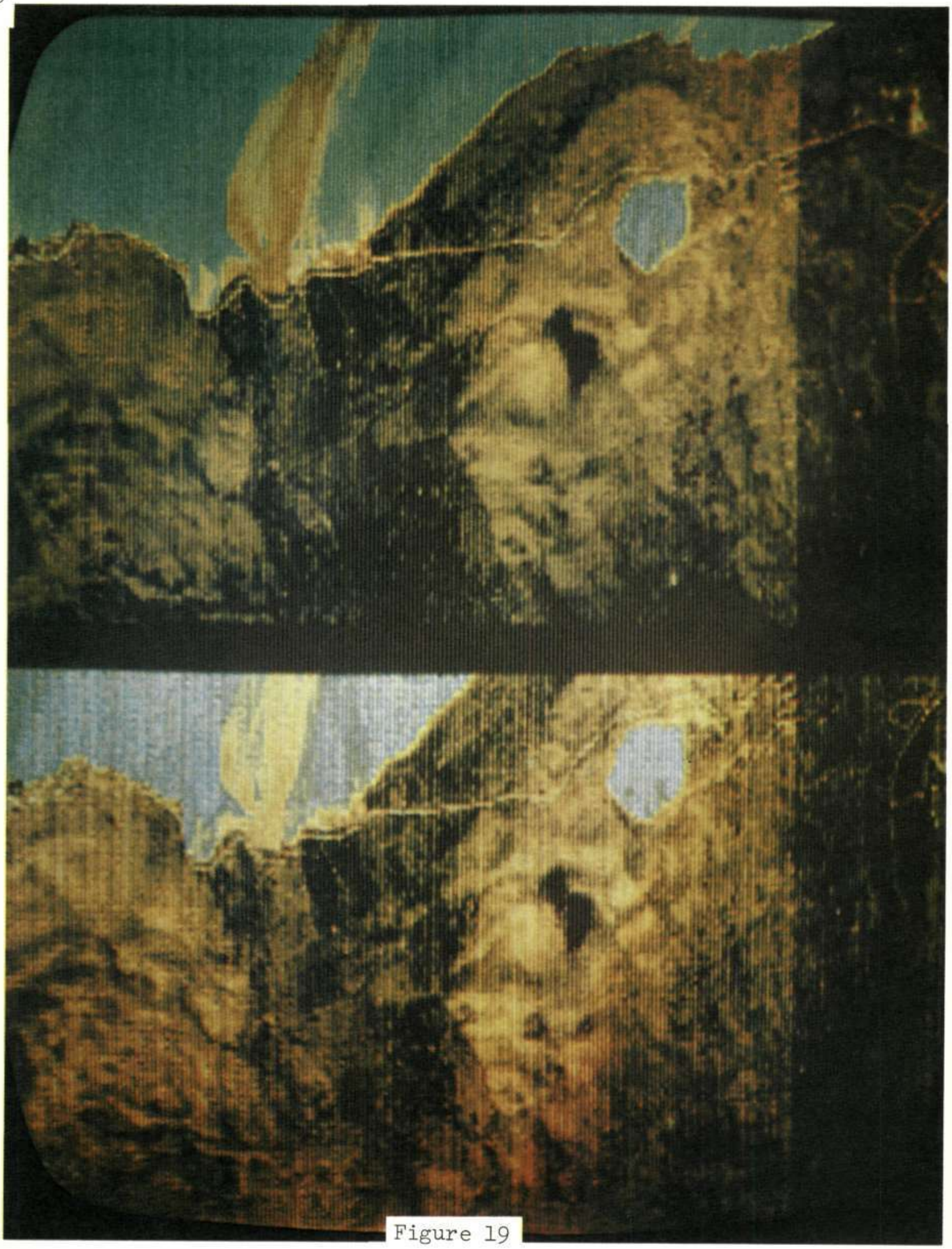


Figure 19

Figure 20

Figure 21

Figure 22