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A REMOTE SENSING SYSTEM FOR A NATIONWIDE DATA-BANK

H. DELL FOSTER, JACOB BOS, AND WILLIAM C. RICHIE

H. Dell Foster Co.

I. INTRODUCTION

Our present-day society is rapidly changing and these changes are directly impacting the map-making industry. Present-day maps become obsolete as soon as they are completed because of population increases, agricultural trends, energy production, and general land use changes which alter the appearance of the land.

It is clear that maps of today will, in a not too distant future, have only historical and pictorial value just like the medieval maps of the 16th and 17th centuries.

In the present-day design of resource development schemes, the essential problem for each country is the skillful management and utilization of all available assets--human and material--to provide the basis for a continuous economic expansion.

This implies the urgent need for an ongoing search in a well coordinated effort by government and private enterprise, for the creation of sound and reliable projects.

The solving of these complex problems can only be optimized when sufficient reliable, and up-to-date information on resources is available and accessible to decision makers.

In many countries, data is available only at random or hidden in heterogenous form. The fastest way to create access to resource data is to make use of the fact that most of it fits in a geographic framework with an absolute coordinate system for information retrieval of geology and mining, land-use patterns, urban development, communication systems, civil engineering, etc. This paper describes the overall Remote Sensing System which provides the general framework to accomplish this task.

The Keuffel and Esser Company has recognized this continuing and growing need. The acquisition of the H. Dell Foster Company in 1975 provided a means to sponsor the development of a complete concept in modern data-base mapping and map compilation. This subsidiary has developed a complete systems strategy and nearly all elements of the system are commercially available.

The K&E/H. DELL FOSTER COMPANY's Remote Sensing System is an integrated set of instruments which utilize mini-computers and opto-mechanical techniques to process remotely sensed data. The system is composed of eight instruments.

1. The instruments use aerial photography as their primary input and produce a digital data file on magnetic tape (or other machine readable source) which compiles the information in an assembly line type sequential work flow.

2. The data files consist of a series of X-Y-Z real world coordinates with coding separating them into descriptive primary levels and line type identification. The primary coordinates serve as the primary identifiers to attach thematic or descriptive data for information retrieval from the data base through an information management system resident at the users master computer center.

The cartographer or map makers task has now expanded to furnishing the absolute structure and identifiers for a random access geographic data base.

II. GENERAL INFORMATION AND WORK FLOW OF THE SYSTEM

1. SYSTEMS INPUT

Figure 1 represents the functional relationships of the various components of the RSS system. Input information can be categorized as:

A. Aerial Photography

B. Field Control Identification

C. Existing Graphic Information

D. Thematic Information

E. Source Input Data

1) Airborne Sensors
2) Ground Sensors
3) Survey and Geodetic Data
4) Field Notes and Samples
5) Source Files and Records
6) Computer Files

These inputs are used in the following manner:

A and B. Aerial Photography and Field Control Identification. The RSS system facilitates the production of the basic graphic manuscript by using the RSS-500 and

RSS-600 to measure and identify the ground control points. These points are input to the Analytic Data Processor for use by the aero-triangulation program to produce a base control manuscript or a listing for use by the RSS-300 Numerical Stereo Compiler.

C. Existing Graphical Information. Existing graphical information is converted into computer processable form by the RSS-400 digitizing table. This information can be coordinate keyed and has the capability to be alpha-numeric in nature.

D. Thematic Information. Alpha-numeric information associated with coordinates may be entered directly into the data-bank by the use of the operator's console of the mini-computer.

2. SYSTEMS OUTPUT

The field and computed control output from the Analytic Data Processor is used by the RSS-300 Numerical Stereo Compiler to produce earth profiles (X, Y, Z coordinates in UTM or State Plane). These profiles serve as a digital terrain model which is structured, extendable and maintainable. The profiles are recorded on magnetic tape and then used by the RSS-900 Numerical Orthophotoscope to produce a photograph which has aircraft tip and tilt as well as relief distortions removed. These orthophotos are used as input by the RSS-400 Graphic input stations.

The RSS-700 Automatic Digital Drafting machine is a vector plotter which can produce line drawings of the traditional type. The input for the RSS-700 is obtained from the Analytic Data Processor. The Analytic Data Processor has a Cathode Ray Tube capable of graphics as well as alpha-numerics. All graphical data input to the system (from the RSS-400, RSS-300, RSS-600 and thematic data entered at the keyboard is edited and confirmed by the Analytic Data Processor and its related software. After confirmation, data may be plotted or committed to magnetic tape for data banking.

The output of the system is two files:

A. Graphic Manuscript File is composed of:

1) Graphic maps of any level.
2) Registered color separations.
3) Computer compiled contoured maps.
4) Planimetric rectified pictomaps or mosaics.
5) Cross-section and plan profile sheets.
6) Oblique and perspective visualization.

B. Digital Data Bank File is composed of:

1) Easting relief profiles.
2) Geodetic and Survey Control.
3) Street center lines.
4) Housing and classification.
5) Agriculture planimetry.
6) Forestry planimetry.
7) Drainage and Hydrology.
8) Water body planimetry.
9) Soils classification.
10) Land use classification.
11) Ownership identifier.
12) Utility net layout.
13) Foliage and vegetation.
14) Cultural physical symbol.
15) Annotation levels.

Figure 2 is a representation of some of the possible levels of data banks.

III. RSS SYSTEM APPLICATION

1. GENERAL CONSIDERATION

The H. Dell Foster Co. RSS system can accomplish the data acquisition, reduction, edit and storage for a national geographic data bank. A basic mapping unit of 70,000 square kilometers is assumed to develop the equipment requirements for a country of 750,000 square kilometers. A photography scale of 1:75000, acquired by a standard wide angle camera, is used for both aerial triangulation and geographic data base compilation. Equations (1) through (5) indicate the analysis criterion.

$$p_w = p_p \cdot p_s \cdot (1-p_q) \text{ km.} \quad (1)$$
$$p_l = p_p \cdot p_s \cdot (1-p_r) \text{ km.} \quad (2)$$
$$A = p_w \cdot p_l \text{ sq. km.} \quad (3)$$

where

p_w = Net photogrammetric model lateral dimension in KM.
p_l = Net photogrammetric model longitudinal dimension in KM.
p_p = Photograph dimension in meters.
p_q = Percentage of lateral overlap.
p_r = Percentage of longitudinal overlap.
p_s = Photographic scale divided by 10^3.
A = Area of photogrammetric model in KM^2.

$$N_u = \frac{G}{A} \quad (4)$$

N_u = Total the number of photographs required uncorrected.
G = Ground area to be mapped.
A = Area of photogrammetric model in KM^2.

$$N_c = \frac{N_u}{.85} \quad (5)$$

N_c = Number of photographs required corrected for navigational errors, weather problems and etc.

Using the previously mentioned photographic scale of 1:75000 and 70,000 square kilometers as a basic mapping unit, Equations (1) through (5) produce the following results:

N_c = 925 photographs

2. PRODUCTION USING THE RSS SYSTEM

A. Analytic Compiler Operation.

1) Aerial Triangulation.
It is estimated that the RSS-300 II can produce 25 photogrammetric models per day, hence 925 models will require 37 days.

2) Digital Terrain Models.
It is estimated that the production rate for the RSS-300 II for producing digital terrain models is 5 per day. Hence, 925 models will require 185 days.

B. Orthophoto Production. The RSS-900 Numerical Orthophotoscope will produce 14 models per day, therefore, 925 models will require 66 days.

C. Digitizing Orthophotos.

1) Urban Areas. It is projected that an average of 10% of a country will be used in the conventional stereoplotter manner for this function. The 7000 square kilometers will require 70 days.

2) The RSS-400. Graphic input terminal can be used to digitize at the 1:25000 scale of the orthophoto enlargements. The remaining 63,000 sq. km. requiring 735 working days.

3. THE PROJECTION OF THE TIME REQUIREMENTS FOR 3)B) 1 to 3 INTO EQUIPMENT RESULTS IN THE FOLLOWING FOR A 5 YEAR PROJECT IN A 750,000 SQUARE KILOMETER COUNTRY.

A. Three (3) RSS-300 II Numerical Stereo Compiler.

B. One (1) RSS-900 Numerical Orthophotoscope.

C. Three (3) Graphic Edit Stations consisting of:

3 RSS-400 Digitizers
1 Analytic Data Processor
1 RSS-700 Automatic Digital Plotter

IV. CONCLUSION

The K&E/H. Dell Foster RSS National Data Banking system provides all the system components to acquire, edit, update, and produce a source data bank for a country. These instruments have compatible outputs and are supplied with installation, maintenance, training, and software for a total turn-key system.

APPENDIX

The RSS System components required to develop a nation-wide data-bank will be described in this section.

RSS-300 NUMERICAL STEREO COMPILER (FIGURE 3)

1. OPTICAL

   High Resolution Optics, 150 L.P.M. at 45X;
   Image Viewing Area at 10X magnification is 0.7 in (18mm) Dia;
   High/Low Stereo Bridging capability through independent zoom optics;
   Base-in, Base-out, and full capability to view either stage through each eyepiece.

2. OPERATOR FEATURES

   Observation area of 10" x 10" (25.4 cm x 25.4 cm) photo size;
   Computer generated setup for interior; relative and absolute orientation.

3. ELECTRONICS

   Automatic scanning and positioning with variable speed at any azimuth for digital terrain data acquisition;
   Digital recording in any coordinate system;
   Correction for camera distortion, earth curvature, comparator calibration;
   One micrometer resolution.

RSS-400 MULTIPLE GRAPHIC INPUT TERMINALS (FIGURE 4)

1. INPUT

   Five volts quadrature square wave;
   X and Y displays of six digits;
   60 inch per second slew rate;
   Real-time scaling for X and Y from 0.0000 to 9.9999.

2. OUTPUT

   RSS-232, ASCII, 11-9600 BAUD or current loop;
   Optional card punch, paper tape and magnetic tape interfaces.

RSS-700 AUTOMATIC DIGITAL DRAFTING (FIGURE 5)

1. INPUT

   RS-232-C, ASCII, 110-9600 BAUD;
   Speed 35 inches/second max.;
   Resolution, .001";
   Precision, .006" RMS;
   Repeatability, ±.003".

2. OUTPUT

   Three position, universal drafting head will accept ballpoint and wet ink. Head may be placed on either side of drafting arm. Vacuum hold-down available.

RSS-900 NUMERICAL ORTHOPHOTOSCOPE (PRELIMINARY) (FIGURE 6)

1. DATA INPUT

   Original aerial negative, 9" x 9", format; any focal length;
   Seven or nine channel magnetic tape--
   Aerial film or plates.

2. DATA OUTPUT

   3.0X Negative size to 6.0X size;
   46 x 46 inch easel exposure scan range with vacuum hold-down;
   Variable exposure scan direction at any azimuth;
   Mini-computer real-time control.

ANALYTIC DATA PROCESSOR (FIGURE 7)

32K, 16 bit, Data General 3/12 computer;
10 megabyte disk;
Tektronix 4014 CRT;
Nine track, 800/1600 BPI magnetic tape;
Four line asynchronous multiplexer.

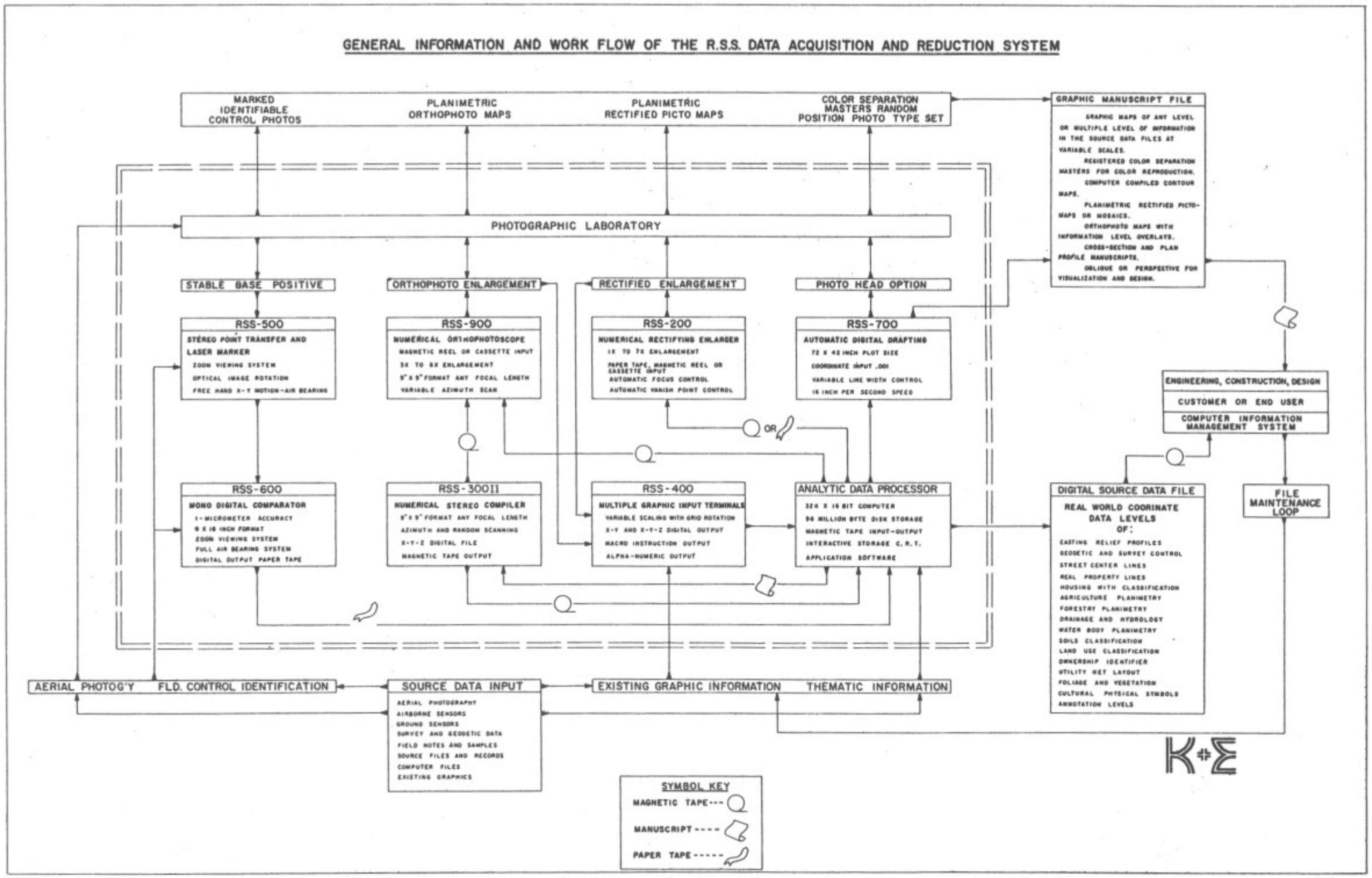
GENERAL INFORMATION AND WORK FLOW OF THE R.S.S. DATA ACQUISITION AND REDUCTION SYSTEM
MARKED IDENTIFIABLE CONTROL PHOTOS
PLANIMETRIC ORTHOPHOTO MAPS
PLANIMETRIC RECTIFIED PICTO MAPS
COLOR SEPARATION MASTERS RANDOM POSITION PHOTO TYPE SET
GRAPHIC MANUSCRIPT FILE
GRAPHIC MAPS OF ANY LEVEL OR MULTIPLE LEVEL OF INFORMATION IN THE SOURCE DATA FILES AT VARIABLE SCALES.
REGISTERED COLOR SEPARATION MASTERS FOR COLOR REPRODUCTION.
COMPUTER COMPILED CONTOUR MAPS.
PLANIMETRIC RECTIFIED PICTO-MAPS OR MOSAICS.
ORTHOPHOTO MAPS WITH INFORMATION LEVEL OVERLAYS.
CROSS-SECTION AND PLAN PROFILE MANUSCRIPTS.
OBLIQUE OR PERSPECTIVE FOR VISUALIZATION AND DESIGN.
PHOTOGRAPHIC LABORATORY
STABLE BASE POSITIVE
ORTHOPHOTO ENLARGEMENT
RECTIFIED ENLARGEMENT
PHOTO HEAD OPTION
RSS-500
STEREO POINT TRANSFER AND LASER MARKER
ZOOM VIEWING SYSTEM
OPTICAL IMAGE ROTATION
FREE HAND X-Y MOTION-AIR BEARING
RSS-900
NUMERICAL ORTHOPHOTOSCOPE
MAGNETIC REEL OR CASSETTE INPUT
3X TO 6X ENLARGEMENT
9" X 9" FORMAT ANY FOCAL LENGTH
VARIABLE AZIMUTH SCAN
RSS-200
NUMERICAL RECTIFYING ENLARGER
1X TO 7X ENLARGEMENT
PAPER TAPE, MAGNETIC REEL OR CASSETTE INPUT
AUTOMATIC FOCUS CONTROL
AUTOMATIC VANISH POINT CONTROL
RSS-700
AUTOMATIC DIGITAL DRAFTING
72 X 42 INCH PLOT SIZE
COORDINATE INPUT .001
VARIABLE LINE WIDTH CONTROL
16 INCH PER SECOND SPEED
ENGINEERING, CONSTRUCTION, DESIGN
CUSTOMER OR END USER
COMPUTER INFORMATION MANAGEMENT SYSTEM
OR
RSS-600
MONO DIGITAL COMPARATOR
1-MICROMETER ACCURACY
9 X 18 INCH FORMAT
ZOOM VIEWING SYSTEM
FULL AIR BEARING SYSTEM
DIGITAL OUTPUT PAPER TAPE
RSS-300II
NUMERICAL STEREO COMPILER
9" X 9" FORMAT ANY FOCAL LENGTH
AZIMUTH AND RANDOM SCANNING
X-Y-Z DIGITAL FILE
MAGNETIC TAPE OUTPUT
RSS-400
MULTIPLE GRAPHIC INPUT TERMINALS
VARIABLE SCALING WITH GRID ROTATION
X-Y AND X-Y-Z DIGITAL OUTPUT
MACRO INSTRUCTION OUTPUT
ALPHA-NUMERIC OUTPUT
ANALYTIC DATA PROCESSOR
32K X 16 BIT COMPUTER
96 MILLION BYTE DISK STORAGE
MAGNETIC TAPE INPUT-OUTPUT
INTERACTIVE STORAGE C.R.T.
APPLICATION SOFTWARE
DIGITAL SOURCE DATA FILE
REAL WORLD COORINATE DATA LEVELS OF:
EASTING RELIEF PROFILES
GEODETIC AND SURVEY CONTROL
STREET CENTER LINES
REAL PROPERTY LINES
HOUSING WITH CLASSIFICATION
AGRICULTURE PLANIMETRY
FORESTRY PLANIMETRY
DRAINAGE AND HYDROLOGY
WATER BODY PLANIMETRY
SOILS CLASSIFICATION
LAND USE CLASSIFICATION
OWNERSHIP IDENTIFIER
UTILITY NET LAYOUT
FOLIAGE AND VEGETATION
CULTURAL PHYSICAL SYMBOLS
ANNOTATION LEVELS
FILE MAINTENANCE LOOP
AERIAL PHOTOG'Y
FLD. CONTROL IDENTIFICATION
SOURCE DATA INPUT
AERIAL PHOTOGRAPHY
AIRBORNE SENSORS
GROUND SENSORS
SURVEY AND GEODETIC DATA
FIELD NOTES AND SAMPLES
SOURCE FILES AND RECORDS
COMPUTER FILES
EXISTING GRAPHICS
EXISTING GRAPHIC INFORMATION
THEMATIC INFORMATION
K+E
SYMBOL KEY
MAGNETIC TAPE---
MANUSCRIPT----
PAPER TAPE-----

Figure 1

MULTI-LAYER MAPPING SYSTEM

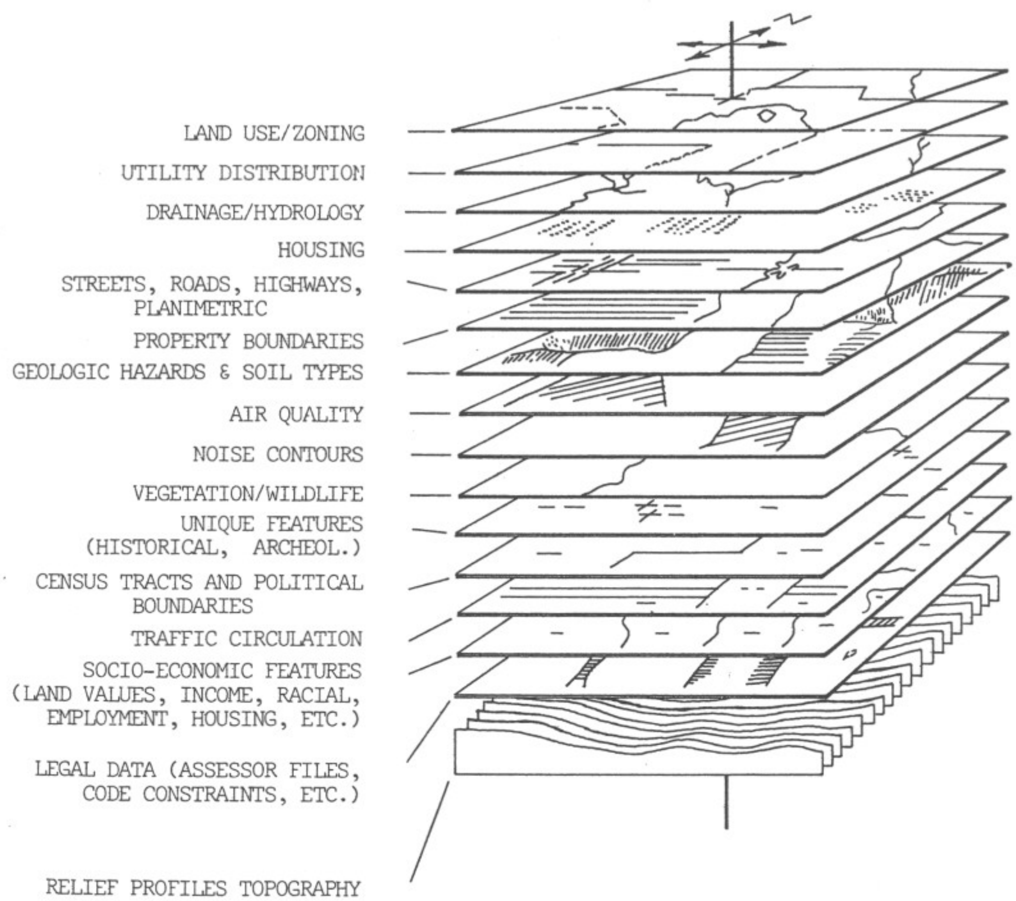

Figure 2

RSS-300 II NUMERICAL STEREO COMPILER

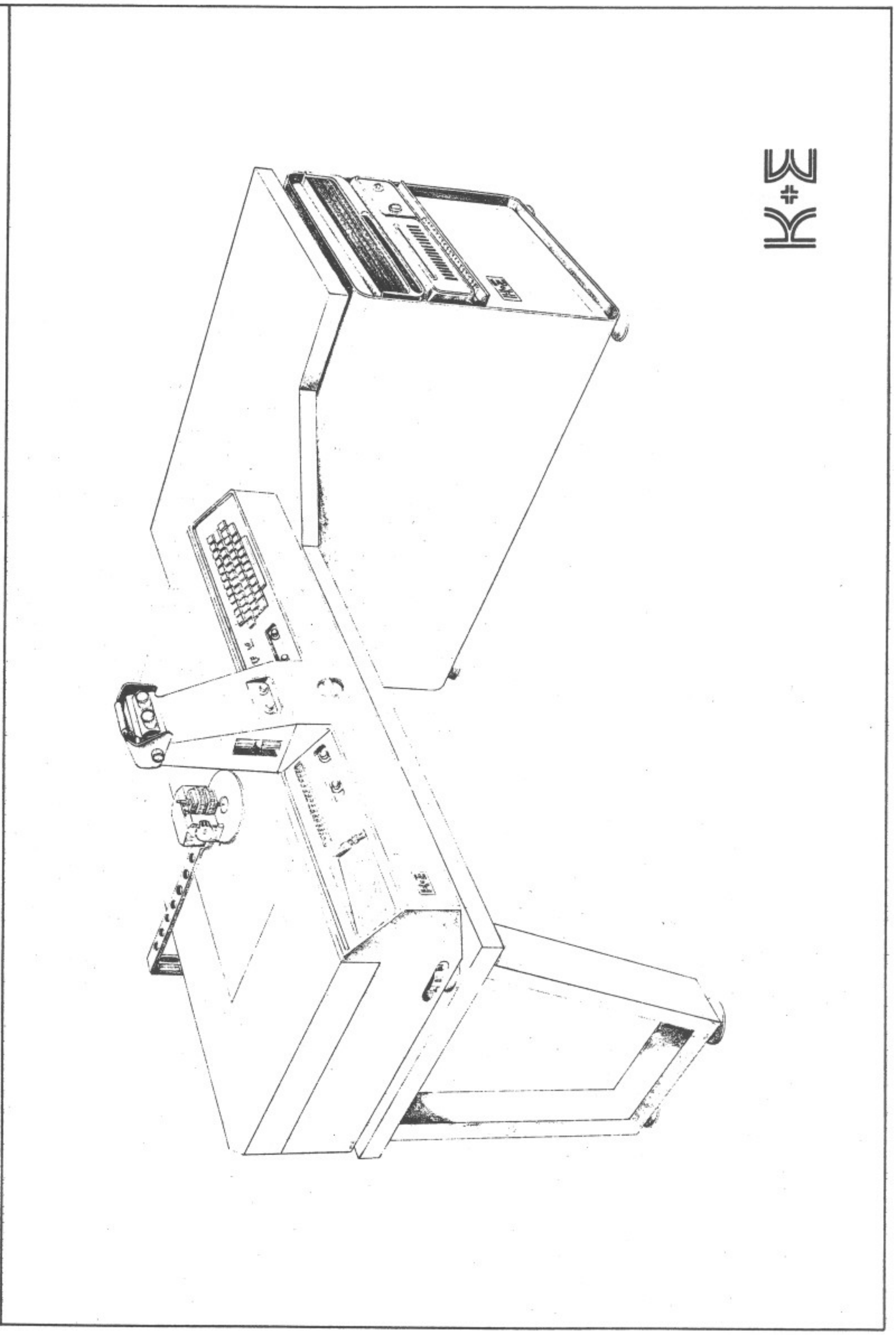

Figure 3

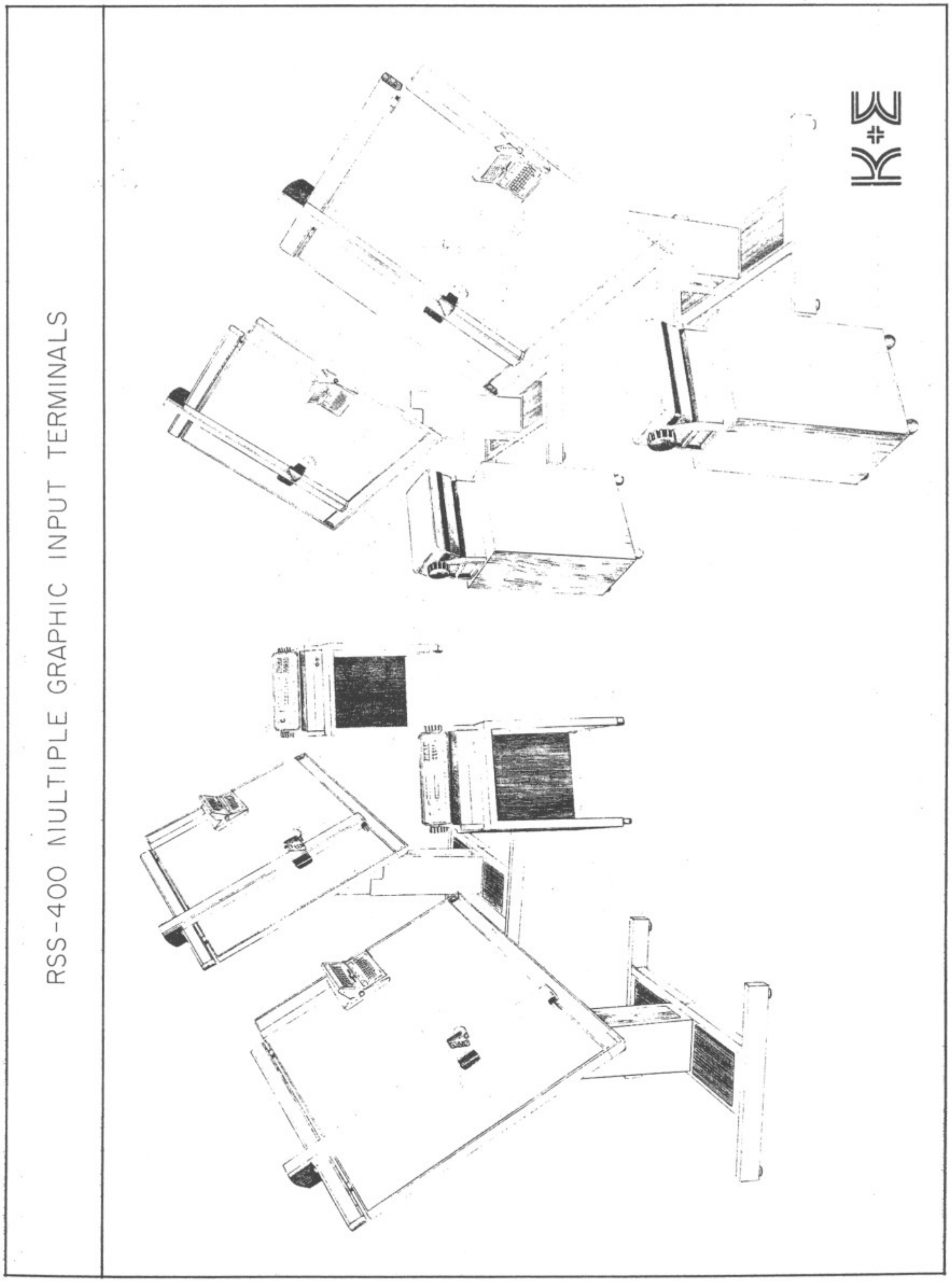

Figure 4

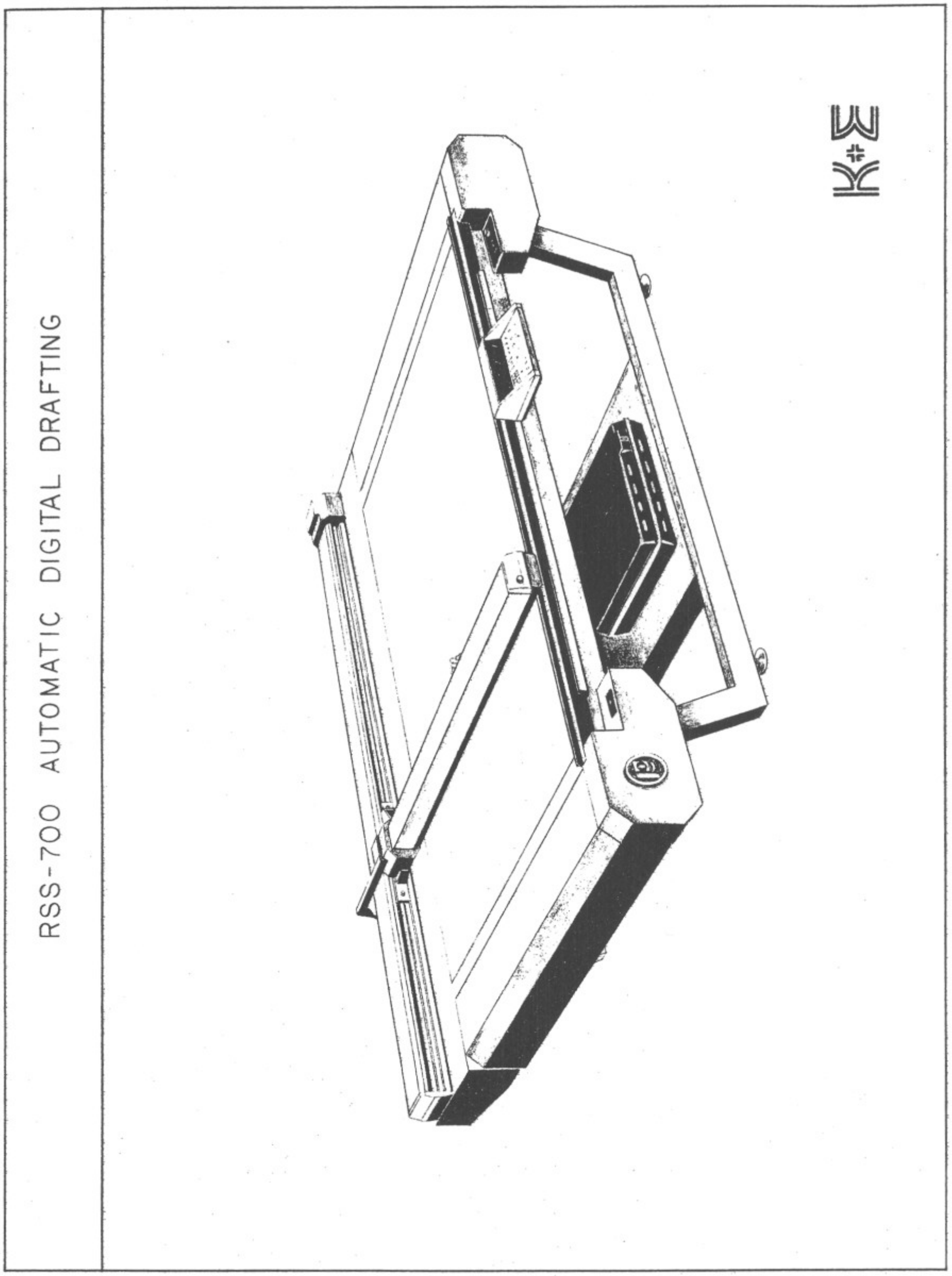

Figure 5

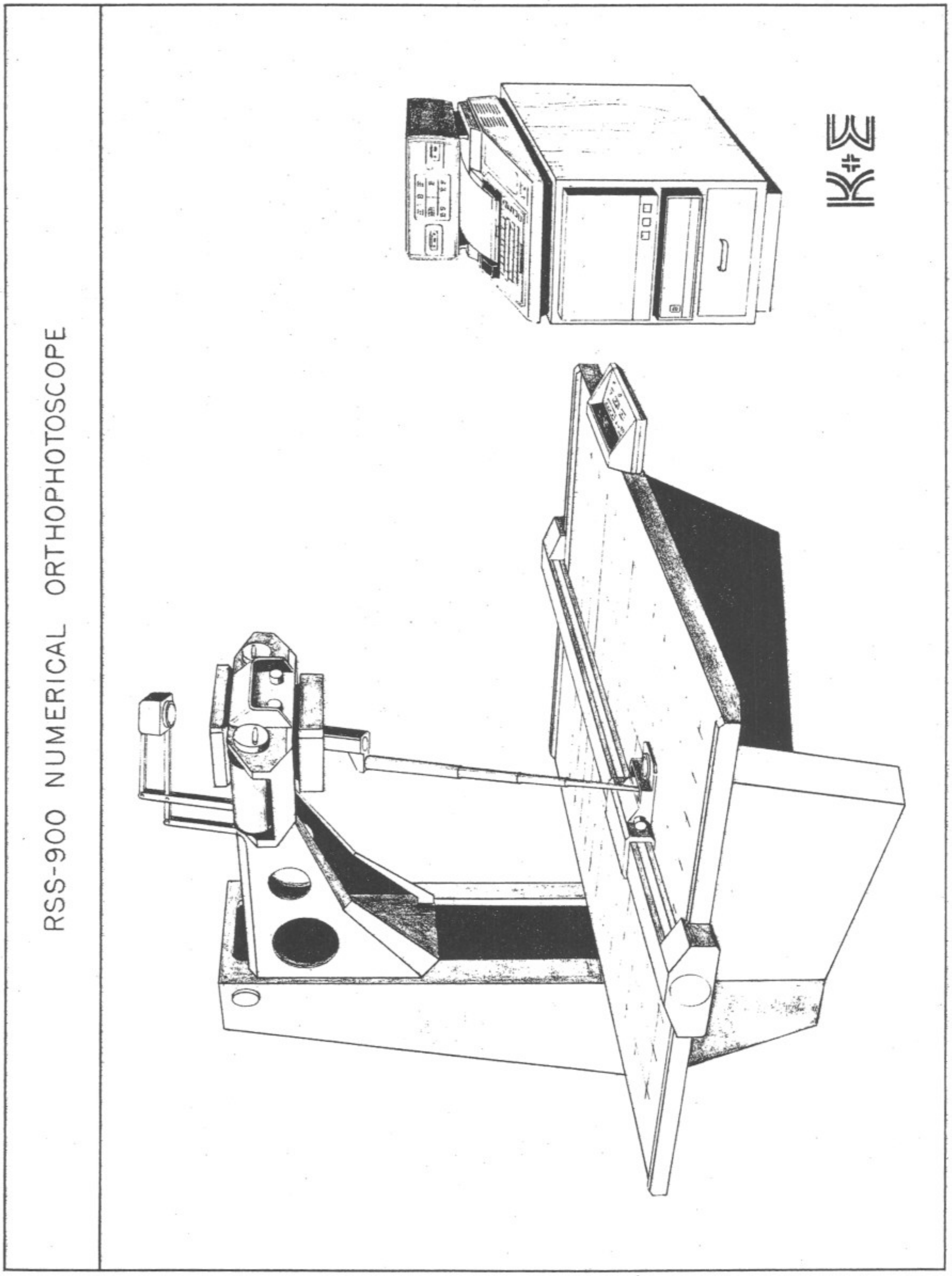

Figure 6

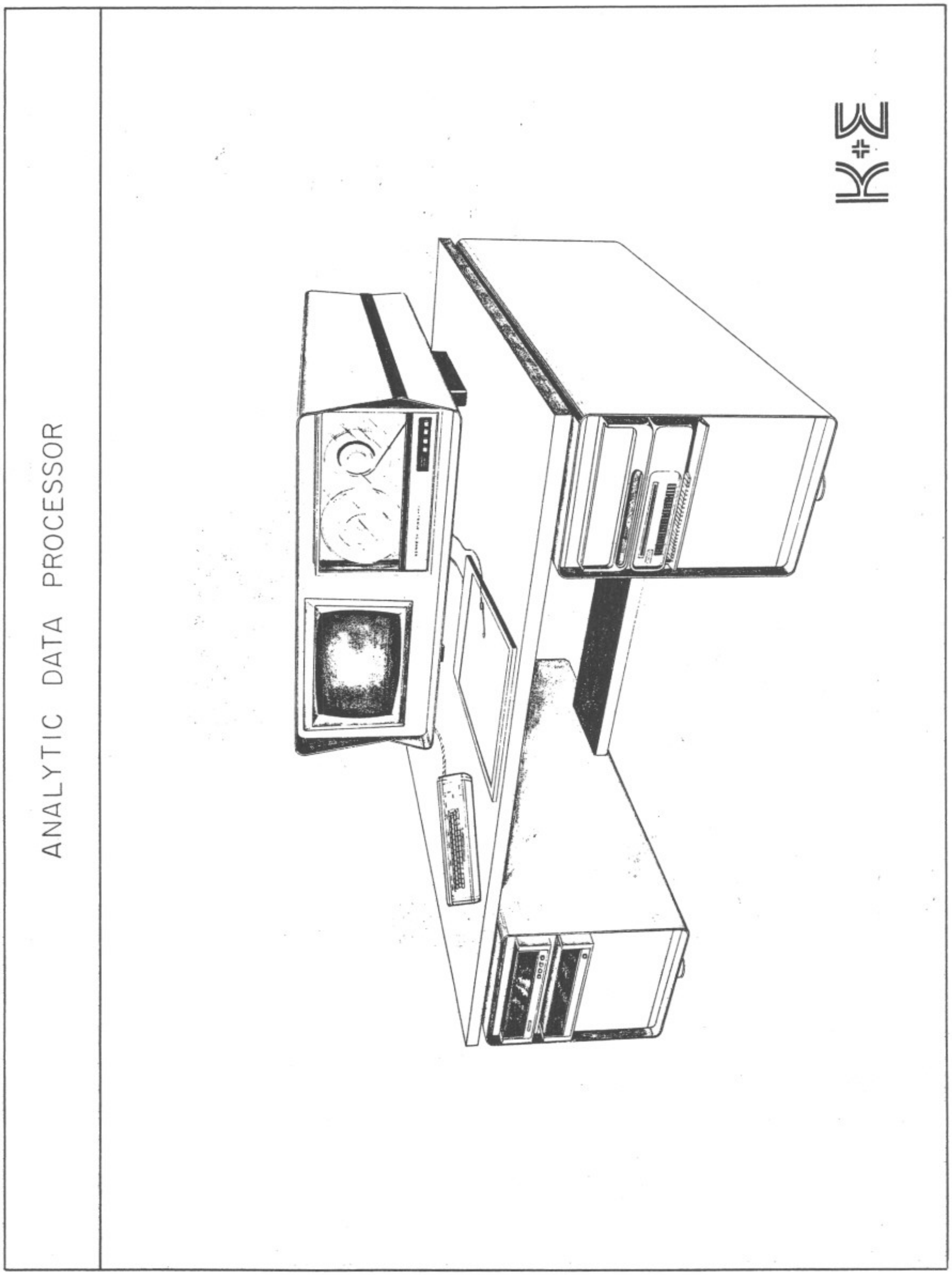

Figure 7

In 1963, H. Dell Foster founded the H. Dell Foster Co. and was its President until the merger on June 10, 1975 with K&E, Morristown, New Jersey. Presently, he is Vice-President, Engineering and Development of K&E/H. Dell Foster Co. In 1975, he was presented the Photogrammetric Award for Engineering Achievement in Photogrammetry by the American Society of Photogrammetry in recognition of his continuous efforts in the development of modern computerized mapping systems. Before founding his own company, he worked as a photo mapping pilot and after that he was a full time consultant for 2 years with Aero Service Corporation.

William C. Richie holds B.S., M.S., and PhD. degrees in Electrical Engineering from the University of Texas at Austin. He has been Computer Center Director and Director of the Computer Science Educational Program at Trinity University, San Antonio, Texas (1965-1969); Vice-President, Research, Computer Knowledge Corporation (1969-1972); Vice-President, Earth Data Corporation (1972-1975); Manager, Electronics & Systems Engineering, H. Dell Foster Co. His research specialties are automatic control and information theory.

Mr. J. Bos graduated as a civil engineer in Rotterdam, Netherlands. Subsequently, he worked at the Dutch Ministry of Public Works, and soon became involved in the production of large air survey contracts abroad, including a mission to Papua, New Guinea. Next, he studied at Delft University majoring in photogrammetry. After World War II, he joined the Aerial Survey Division of KLM Royal Dutch Airlines in many management functions including a 3½ year assignment as project manager at Bandung University, Indonesia for air survey technical assistance. He was finally appointed President of KLM Aerocarto. Large air survey contracts in the Middle and Far East were executed, introducing in these areas high altitude photography using a Lear Jet. In 1973, he retired and in 1975 came to the U.S. to assist H. Dell Foster as a Consultant for foreign marketing which he continued after the merger of the H. Dell Foster Co. with K&E, Morristown, New Jersey.