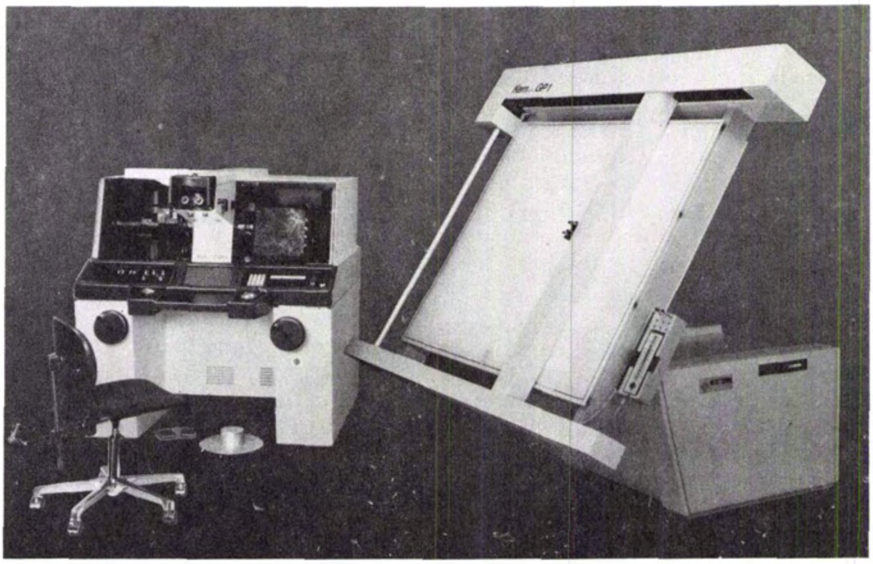

FRONTISPIECE. Kern DSR-1/GP-1 Digital Stereocompilation System.

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A Unique Concept in Analytical Plotters

Kern's new DSR-1 Digital Stereorestitution Instrument and GP-1 Graphics Peripheral.

(Abstract on next page)

INTRODUCTION

THE KERN DSR-1 Digital Stereorestitution Instrument and GP-1 Graphic Peripheral, together, comprise Kern's entry into the analytical stereoplotter marketplace. These two instruments work together to provide all the functions normally found on analog stereoplotters in addition to fulfilling the long-promised advantages of the analytical plotter.

The DSR-1 Digital Stereorestitution Instrument is a data collection device which provides the capabilities of an analytical stereoplotter, while the GP-1 Graphics Peripheral performs the map drawing function. The GP-1 works, not only in conjunction with the DSR-1, but also as a stand-alone intelligent *X,Y* plotter.

Kern has put together a unique system which cannot be adequately described by the term "analytical stereoplotter." It is, rather, a highly versatile equipment complement consisting of a digitally controlled stereorestitution instrument and an automatic *X, Y* precision plotting coordinatograph, named the Kern DSR-1 and the Kern GP-1, respectively. This system is enhanced and supported by a software complement which gives it a unique and advantageous flexibility.

The DSR-1 and GP-1 can stand alone or operate as intelligent terminals when connected to the user's existing computer. For users who wish to pool several stereoplotters together under the supervision of a single large computer, the DSR-1 can act as a terminal of this larger computer. The unique design of these instruments gives greater flexibility and upward mobility in configuring a system to meet the changing needs of a typical mapping organization. Figure 1 shows four common configurations.

Designing and building an analytical stereo-

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plotter today are no longer scientific problems. The real problem is to produce a viable instrument which can be integrated into existing mapping firms without disturbing their organizational structure. Kern has solved this problem by embracing the recently developed distributed computing concept to design an instrument which uses a maximum of off-the-shelf components, uses standard unmodified computers, and provides the flexibility, maintainability, and upgradability which will make it the workhorse of the industry for the next 20 years.

Technical Features of the DSR-1

A complete understanding of the DSR-1/GP-1 analytical stereoplotter necessitates an understanding of distributed processing as applied to instrument design. Therefore, an explanation of this principle precedes the instrument description.

Abstract: *The Kern DSR-1/GP-1 analytical stereocompilation system was designed to meet, with equal facility, the needs of every facet of the photogrammetric marketplace.*

The unique concept, which sets the DSR-1/GP-1 apart from other analytical plotters, is the highly distributed architecture of the electronic components. It is from this base that stem flexibility, upward mobility, maintainability, responsiveness, operator-friendly operation, and reasonable cost.

With regard to software, the latest concepts in structured programming and self-documenting data files has produced a flexible, operator-friendly system which is not only upgradable, but actually programmable by the end user.

Optically, mechanically, and electronically, judicious use of new technology, coupled with a century and a half of experience in the development and manufacture of analytical instruments, has produced a simple and reliable system. Technically, the DSR-1/GP-1 is a fine example of bringing a formerly experimental instrument into the light of day and creating a useful, functional instrument system designed for cost-effective, everyday production.

Distributed Processing

Distributed processing in instrument design can be defined as the technique which employs separate processors to handle specific computing tasks. An example from the DSR-1/GP-1 stereoplotter is the dedication of a computer to the task of controlling the GP-1 *X*, *Y* Plotter. This allows the GP-1 to become a separate instrument altogether, as well as to communicate with the DSR-1 for on-line plotting.

The advantages of distributed computing are many, provided the distribution is properly made, as the example of the GP-1 Graphic Peripheral demonstrates. It produces a more flexible instrument, uses smaller, less expensive computing elements, provides an easy solution to realtime constraints at a lower cost, and allows upgrading, module by module. Maintainability is also an important feature in complex systems such as analytical stereoplotters. A distributed processing system is inherently easier to troubleshoot, because each module is autonomous. It is smaller, simpler, and can be readily tested.

Naturally, judicious selection of distributed elements and arrangement of communication paths must be made at the outset, if all these benefits are to accrue to the user.

Design Parameters

There are always a number of design considerations which impact on a new development effort, and some of them are predictable, such as ease of use, maintainability, and reasonable cost. Normally, however, it is necessary to compromise in order to design a workable instrument. This is where distributed processing comes into the picture. With the advantages of flexibility, maintainability, and low cost, which its use delivers, one can set realistic goals for the instrument which need not be compromised.

In the case of the DSR-1/GP-1, the six major design parameters were operator friendliness, superior optics, high precision, flexibility, upgradability, and maintainability.

System Design Details

Since the DSR-1 Digital Stereorestitution Device and the GP-1 Graphics Peripheral are actually separate instruments, the design of each is discussed separately. For each instrument, the optics (DSR-1 only), mechanics, electronics, including distributed processing architecture, and, finally, the operational controls will be covered.

DSR-1 Design Details

The DSR-1 is a complex electro-optical-mechanical instrument, wherein all elements

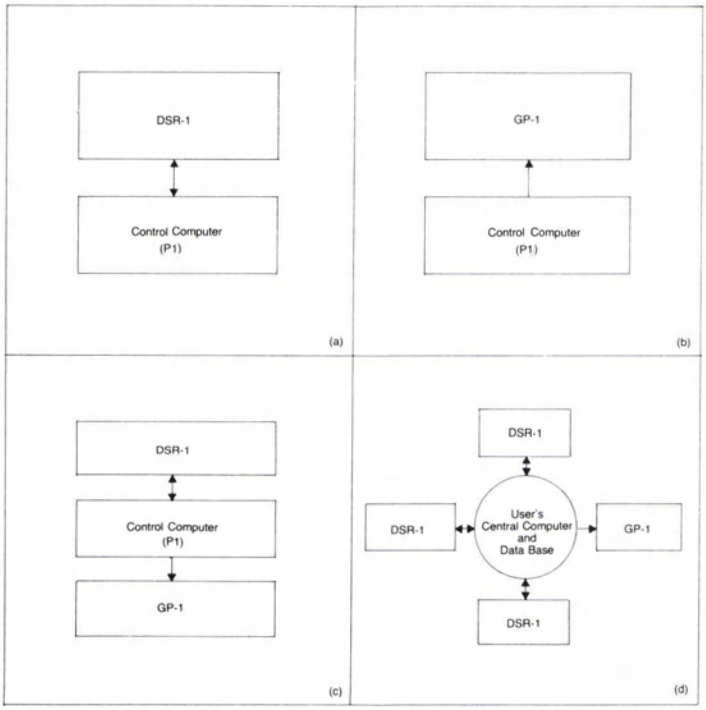


FIG. 1. Typical DSR-1/GP-1 system configurations: (a) DSR-1 stand-alone data collection station, (b) GP-1 stand-alone plotter, (c) conventional stereocompilation instrument, (d) pooled analytical plotter system.

must function together as a unified system in order to produce the desired result. Fortunately, with analytical stereorestitution devices, it is possible to solve each problem largely independently of the others.

DSR-1 OPTICAL DESIGN

The optical system of the DSR-1 was designed with the operator in mind. The following criteria were used in designing the optics: Large field of view, zoom magnification, 360° image rotation, image reversal (base-in, base-out), biocular viewing of each plate, individual squint adjustment, high image resolution, and adjustable floating mark size. Each of these items relate to the comfort and convenience of the operator. However, they have obvious effects on productivity as well. For this reason, it was decided to design the finest optical system that a century and a half of experience could produce.

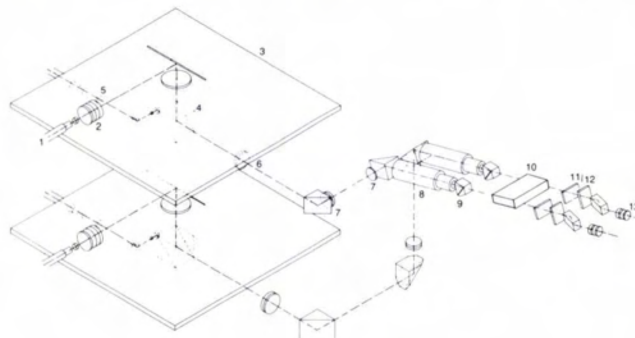
We begin our description of the DSR-1 optical system (Figure 2) with the illumination of the photographs and proceed toward the eyepiece, discussing each component along the optical path. The same elements are found in both left and right image paths.

A novel scheme using fiber optic bundles (1) provides individually variable illumination to each photograph from a single light source. This keeps the heat producing source away from the mechanical components, assuring thermal stability of the stages. A condenser lens (2) above the stageplate (3) provides the proper illumination for the optical system.

Immediately below the stageplate is a beam-splitter (4), which combines the image of the photograph with the floating mark. The white, circular floating mark is produced by a motorized iris diaphragm (5), which the operator can adjust to produce a mark from 20 to 200 micrometres in diameter. The illumination is individually variable and is provided by the same source as the plate illumination.

The combined light rays from the photograph and the floating mark next enter the objective (6), which produces a parallel beam of rays. These rays pass through more prisms (7) before entering the 1× to 4× zoom lens (8). The left and right zoom lenses are coupled to allow differential, as well as common, zooming.

After leaving the zoom lens, each beam passes through a Pechan prism (9), providing for 360° image rotation with indents at each 90° of rotation. A fine adjustment with ±30° range allows the rotation between left and right images to be matched.



1. Fiber Optics
2. Condensing Lens
3. Plate Carrier
4. Beam Splitter
5. Iris Diaphragm
6. Objective
7. Prisms
8. Zoom Lens
9. Dove Prism
10. Image Changer
11. Horizontal Phoria
12. Vertical Phoria
13. Eyepiece

FIG. 2. Kern DSR-1 optical system schematic.

Next in line is the image changer (10). This four-position optical element allows not only base-in and base-out (stereoscopic and pseudoscopic) viewing, but biocular viewing of each plate.

Just before entering the eyepieces, each image path contains separate horizontal (11) and vertical (12) squint adjustments. Prior experience with the PG2 analog instrument shows that this is a more convenient arrangement for the operator than the usual phoria wedges.

The 5× wide field eyepieces (13) which, together with the zoom lens, provide an overall magnification range of 5× to 20×, have an eye relief of 18.5 mm which provides for very comfortable viewing, even for eyeglass wearers.

The optical system of the DSR-1 provides unexcelled viewing conditions, both in terms of functionality and convenience. With a resolution of 68 line pairs per millimetre at 10×, the view is impeccable.

DSR-1 MECHANICAL DESIGN

Physically, the DSR-1 is a cubically-shaped instrument measuring about 1½ metres per side (see Frontispiece). The lower half of the instrument contains the electronic components, and the upper half contains the stageplates and optical system. The operator control panel and optical channel protrudes from the instrument's front side.

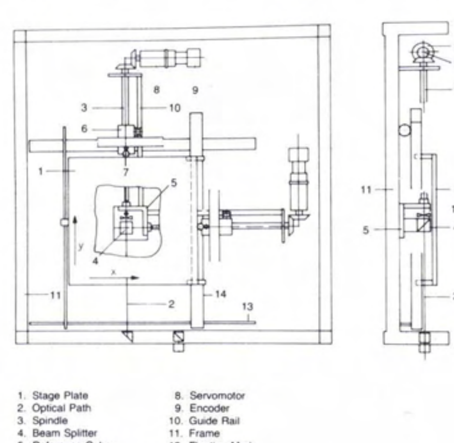
The stageplates are located one above the other, with sufficient room between for mounting of optics, floating mark, laser point-marker and, eventually, image correlation receptors. Provision was also made for a 25 by 48 cm (9 by 18 inch) stageplate option.

The intrinsic precision of an analytical stereorestitution instrument depends first and foremost on the design of the stage transport and measuring system. To ensure highest precision, even under adverse temperature conditions, the design of the DSR-1 stages complies very closely with Abbe's comparator principle.

Figure 3 shows the DSR-1 stageplate construction. Note the low profile and the coincidence of the measuring spindles with the optical system just millimetres below the stageplate.

The mechanical scheme behind the design of the X, Y stageplate focuses on a reference cube (5) rigidly attached to the frame of the instrument (11). This cube supports a beamsplitter (4) which merges the image of the photograph and the floating mark. It also supports one end of each precision spindle (3), one for each axis of motion.

The two spindles provide both motion and measuring functions for their respective axis, and, therefore, form the principal plane of measurement. Abbe stated that the photograph to be measured should lie in this plane to achieve highest



1. Stage Plate
2. Optical Path
3. Spindle
4. Beam Splitter
5. Reference Cube
6. Displacement Carriage
7. Bearing
8. Servomotor
9. Encoder
10. Guide Rail
11. Frame
12. Floating Mark
13. X-rail
14. Y-rail

FIG. 3. Kern DSR-1 stageplate construction schematic.

accuracy. This has nearly been achieved with the DSR-1. Components lying exactly on this plane are the floating mark (12), beamsplitter (4), guide rails (10), motors (8), and encoders (9). All other components, including the photocarrier (1), *X*-carriage (13), and *Y*-carriage (14), lie very close to the principal plane.

Movement of the photostage is achieved by use of a displacement carriage (6) attached to each spindle, which has a bearing (7) pressing against the edge of the stageplate. The entire stage surface is made from a glass plate, two edges of which have been ground to an exact right angle. When the motor turns the spindle, the displacement carriage pushes (or pulls) the stageplate in the appropriate direction. The displacement carriage serves both as displacement mechanism and measuring reference.

The use of rotary encoders providing one micrometre resolution has resulted in a simple design with close adherence to Abbe's comparator principle which, coupled with legendary Kern precision mechanics, has produced an extremely stable measuring system. DSR-1 stages are manufactured not to exceed $\pm 3\ \mu$m greatest error before calibration. The stageplates are calibrated by applying an affine (linear) transformation resulting from a least-squres fit to 25 grid points. Application of this calibration in real-time reduces the stageplate error to a maximum of $\pm 1\ \mu$m.

ELECTRONIC ARCHITECTURE OF THE DSR-1

The electronic architecture of the DSR-1 is based on the distributed computing concept. This concept was implemented using two different types of microprocessors, depending on the job to be done. Digital Equipment Corporation's LSI-11/2 based 16 bit microcomputers were chosen for major tasks, and Intel Corporation 8085 microprocessors were used for smaller tasks. Figure 4 shows the general layout of the distributed processing architecture, including the GP-1 plotter for continuity. The description of the plotter design will appear later in this paper.

The control computer (P1) is a PDP 11/03 with flexible disk storage or, optionally, a PDP 11/23 with hard disks. This computer stores the DSR-1 operating system and orchestrates the flow of communications between various elements of the DSR-1, GP-1 (if in use), and the operator. All application programs of the DSR-1 are processed by this computer. Discussion of these programs will be reserved for the section on software.

The plate processor (P2) has the job of maintaining the position of the stageplates as commanded by the central computer, or directly through the motions of the operator input devices. Its program is downloaded from P1 when the DSR-1 operating system is started up. It can drive the plates individually or in stereoscopic mode, depending on receipt of commands and parameters from the central computer. When in the stereoscopic viewing mode, this processor is capable of recomputing the plate coordinates on hand of manual inputs, and commanding the plates to move, 50 times each second. At the same time, it presents the present plate coordinates on the standard DEC parallel interface, which links it to the control computer. This update speed, along with the servo loop design, produces a very smooth

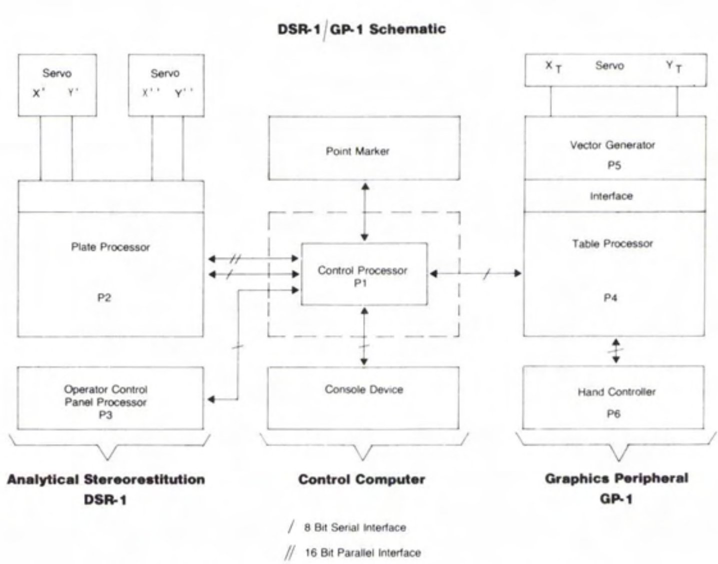


FIG. 4. Electronic architecture of the DSR-1 and GP-1.

plate movement, indistinguishable from the best analog instruments. The servo motors operate in a closed loop (Figure 4) which allows the plate processor to directly control the speed and acceleration of the plates independently of the servo amplifier circuit. The servo loop, however, performs its task without interference from the plate processor, and vice versa, allowing optimization of each component without regard to feedback problems. Experience has shown the wisdom, and effectiveness, of this approach.

The third (and final) processor used in the DSR-1 is the operator control panel (OCP) processor (P3). This Intel 8085 microprocessor has its program stored locally in read-only memory. The OCP displays messages from the control processor (P1) to the operator and returns operator keystroke commands. This communication is handled by the console processor, which is linked to the control processor by a serial interface. It emulates a standard alphanumeric CRT.

The three microprocessors of the DSR-1 work in concert to provide the performance of an analog instrument at a similar price level. At the same time, instrument complexity is dramatically reduced, thereby decreasing maintenance costs and increasing productivity.

LASER POINT-MARKER

An optional laser point marking device is available for the DSR-1. Its purpose, since the DSR-1 is ideally suited for aerotriangulation, is to provide visible marks for later use of the photographs with analog instruments. When the mark button is pressed, the Operator Control Panel processor (P3) sends this command to the control processor (P1) which, in turn, requests plate processor (P2) to offset the righthand plate by a calibrated distance (about 50 mm) in the *Y* direction. This places the image formerly at the floating mark directly under a laser, which then burns a small hole in the photographic emulsion. The plate then returns to its correct position. The offsetting of the plate prevents any possible eye contact with the laser beam.

When marking is complete, the laser mark created on the righthand photograph should be exactly centered on the measuring mark. If not, the operator may center the measuring mark over the laser mark and request recalibration. Subsequent laser marks will then be automatically offset according to this new calibration. The operator normally checks the calibration at the film edge before beginning to mark each new photograph.

DSR-1 CONTROLS

The DSR-1 controls consist of a computer console, the operator control panel (OCP), and the optical controls. In addition, there are two handwheels, a trackball, a foot disk, a height drum, and two footpedals. The model position indicator is also described here, although it cannot really be considered as a control device.

Optical Controls. The optical controls, while many, are simple and straightforward. The controls are visible (Figure 5) as knobs on the optical channel terminating in the eyepieces. Each has a different feel to make them easily recognizable to the operator. Taking them in the same order as the earlier discussion brings us first to the zoom lens control. This knob is on the right side of the optical channel, closest to the instrument body. When pressed inward, it controls differential zoom between the left and right image and, in its normal position, zooms both images simultaneously. The image rotation knobs are on the underside of the channel. Each image has its own independent knob, with indents at each 90° of rotation. There is also a fine adjustment knob on the right image for removal of differential kappa. The next control is a large knob on the right side of the channel. This is the image changer, which provides selection of biocular (left or right), stereoscopic (base-in), or pseudoscopic (base-out) viewing. Four small knobs make up the next set of controls, one on either side of the channel, and two underneath. These are the phoria (squint) adjustments. Each image has separate knobs for horizontal and vertical phoria. Finally come the eyepieces. The eyepiece holder contains the adjustment for interpupilary distance. The range is from 55 mm to 75 mm. As usual, the eyepieces themselves rotate to provide focusing. A related item is the headrest, which may be adjusted to provide the operator with the most comfortable viewing position.

Mechanical Controls. Following the line of our previous discussion, the mechanical controls shall be described here. Although there are really no mechanical controls in the conventional sense,

FIG. 5. Kern DSR-1 operator control panel.

this is an opportune place to discuss the manual motions, since they are not part of the operator control panel. Manual motion in each of the three orthogonal axes may be achieved by one of two devices. For motion in X or Y directions, either trackball or handwheel may be used and, for Z motion, either the footdisk or height drum may be selected. The selection is made by switches on the OCP. These devices are all connected to standard optical rotary encoders, which in turn drive up/down position counters connected to the plate processor. The two footpedals provide a means of notifying the OCP that a significant event has taken place. This information is relayed to the control processor for appropriate action, normally causing the present model coordinates to be plotted.

Before proceeding to the operator control panel, we will discuss the model position locator. This device, located to the operator's right above the control panel, allows the operator to see his present position in the model with respect to the whole area. It consists of a panel containing a grid of lights which illuminate to show the present position of the floating mark in the model. Over this plate, the operator places a print of the left photograph. The illuminated lightbulb will be visible through the print, allowing the operator not only to see his present position, but also the relative positions of other areas in the model.

Operator Control Panel (OCP). The operator control panel (Figure 5) consists of three sections: left, center, and right. The left portion gives the operator direct control of several instrument settings, while the center and right portions are inputs and outputs of processor P3, which communicates with the control computer (P1).

On the left portion of the OCP, there are separate controls for the illumination level of both images and both floating marks and for varying the floating mark size between 20 μm and 200 μm in diameter. There are also switches to select the manual drive device: handwheel or trackball for X and Y, height drum or footdisk for Z. These three switches also have off positions to ensure no input is produced from either device. Two other switches allow separate selection of manual motion speed at 1, 2, or 4 times the programmed rate for X, Y, and Z motion. The programmed rate is variable by the operator through the DSR-1 operating system. The center portion of the OCP consists of a 12-line menu display panel with pushbutton selectors located on both ends of each display line. This is the main communication area for the operator of the DSR-1. It is here that he selects the operations to be performed from the system menus and sees the results. On the right-hand portion of the OCP, there is a keypad for numerical data entry, 16 tag switches, and the optional point marking controls. The keypad is used only when the menu select keys will not do, such as identifying a control point for remeasurement during absolute orientation. The tag switches are used mainly for aerotriangulation, where identification of recorded data is necessary.

For the point marking option, a rotary dial is used to select the beam intensity. This is done by trial and error at the film edge, before actual marking begins. An on-off switch and an activation switch round out the controls for this option.

There is one other control device associated with the DSR-1. This is the control computer console device, a typical computer CRT terminal. The console device is used to initialize the operation of DSR-1 programs and to set up the DSR-1 before actual work on the instrument begins.

This completes the description of the controls associated with the DSR-1. They have been grouped functionally, in a logical and convenient manner. The controls are very simple, and while all necessary functions are provided, the operator control panel is not so complex as to be formidable or cluttered. Great care was taken to provide a most operator-friendly environment.

DSR-1 SOFTWARE ARCHITECTURE

Kern has taken a three-pronged attack to solving the software problem. First, by distributing the processing, and thereby the programming. Second, by programming the operating system in a structured high-level language, coupled with the use of self-documenting text files for storing parameters. Third, by modularizing the software stock, allowing the user to create his own programs.

Distributed processing implies distributed programming. With the stageplates, Operator Control Panel, and Graphic Peripheral, each having their own local processors, the programming task has also been divided. Each of these processors has its programs downloaded each time the system is powered up, resulting in a flexible software system which is not only programmable by Kern, but by the end user. This allows easy maintenance of the software and provides upward mobility of the software component for those users with special applications, such as panoramic or X-ray photography.

The DSR-1 Operating System, which resides in the Control Processor (P1), is written entirely in Pascal. Pascal was chosen because of its powerful control structures and largely self-documenting code. This greatly facilitates debugging and maintenance of programs. Together with Pascal, the use of text files to store data provides the flexibility and transparency which simplifies programming and maintenance.

The use of Pascal also lends to program modularity. For the most part, the DSR-1 Operating System consists of small programs which call one another and makes use of a program library for communicating with the plate processor. This library is provided to DSR-1 users using either FORTRAN or Pascal programming languages, thereby allowing them to write custom programs to provide special services to their customers, maintaining a spirit of competitiveness among firms. These programs may be called automatically from the DSR-1 Operating System, and when they finish, return control back to the system.

DSR-1 SOFTWARE STOCK

A considerable amount of software is required to make full use of an analytical plotter, but quantity does not make up for quality. At Kern, we have placed great emphasis on creating not only operator-friendly hardware, but operator-friendly software as well. Table 1 shows the range of software available for the Kern DSR-1.

The DSR-1 Operating System is built around the proven Kern menu approach used in the Kern DC2-B Digitizer Graphics Computer introduced in 1977. This approach provides a simple, logical progression for parameter entry and system operation. With the DSR-1, the managerial functions have been separated from the operational functions to provide even friendlier operation. Separating these functions saves the operator a great deal of time on multimodel projects and alleviates the need to frequently move between the computer CRT and stereoviewer.

During the managerial phase, fixed parameters such as map scale, flying height, camera calibration, and ground control coordinates are entered into the computer by means of the console CRT. The DSR-1 operating system stores these parameters on the disk in text files for later use during the operational phase. The managerial portion does not require use of the restitution instrument at all. It could, in fact, be run on another computer without tying up the DSR-1.

The operational portion deals with model setup and compilation. This includes instrument calibration, inner, relative, and absolute orientation, compilation (on-line with the GP-1 plotter), and data collection (recording data on disk files). The menus for this portion appear on the Operator Control Panel display device (see Figure 5) and consist mainly of various options which the operator selects. It is worth noting, at this time, that the operator is always in full control of the instrument, as he may move at any time through the menu pages to select the operation he wishes to perform. There are, however, interlocks built in to prevent the inexperienced operator from skipping necessary steps during model set up.

Another example of Kern's commitment to provide simple, easy to use software is shown by the data file structure used throughout the DSR-1 operating system. All data files are ASCII text files, which provide the greatest flexibility and convenience possible. Parameters are stored in these files as images of the menus which created them, providing a self-documenting system. Table 2 is a sample listing taken from the DSR-1 data file for camera calibration. Digital map data files optionally produced during the stereocompilation and aerotriangulation phases are also self-documenting text files.

TABLE 1. SOFTWARE STOCK OF KERN DSR-1/GP-1

DSR-1 OPERATING SYSTEM
Operational
INNER ORIENTATION
RELATIVE ORIENTATION
ABSOLUTE ORIENTATION
COMPILATION AND/OR DATA COLLECTION
INSTRUMENT TEST AND CALIBRATION
CROSS SECTION/PROFILING
AEROTRIANGULATION MEASUREMENT
BRIDGING
†* CLOSE RANGE/INDUSTRIAL
†* GDES 100 GRAPHIC DISPLAY AND INTERACTIVE EDITING STATION
†* MAPS 200 MINICOMPUTER AIDED PLOTTING STATION
†* GRADIS 2000 KERN/CONTRAVES INTERACTIVE GRAPHICS STATION
Managerial
JOB PARAMETER ENTRY/EDIT
* ANALYTICAL BLOCK ADJUSTMENT (JFK CONSULTANTS)
* MAPR JOB MANAGEMENT PROGRAM
* PLOT OFF-LINE PLOTTING PROGRAM
USER PROGRAMMING AIDS
RT-11 OPERATING SYSTEM (DIGITAL EQUIPMENT CORPORATION)
PLATE PROCESSOR COMMUNICATION ROUTINES
* DEC COMPILER (FORTRAN, BASIC, ETC.)
† PASCAL COMPILER (OREGON SOFTWARE)

* Available as an extra cost option
† Available second quarter 1982

GP-1 INSTRUMENT DESIGN

The GP-1 X, Y Plotter is a much simpler instrument than the DSR-1 and also more easily understood, so less detail of its design will be discussed. As with the DSR-1, the discussion will deal first with mechanical design, then electronics, and finally operator controls.

MECHANICAL DESIGN OF THE GP-1 GRAPHIC PERIPHERAL

The GP-1 consists of a tiltable plotting surface mounted on a base frame containing electronics

TABLE 2. SAMPLE DSR-1 OPERATING SYSTEM DATA FILE

Camera Number = 1
Camera Serial Number = 12345
Camera Type = Optical Systems, Inc.
Lens Type = Kern
Date of Calibration Report = 76/04/15
Principal Distance = 88.540 mm
Number of Fiducial Marks = 4
Shape of Fiducial Marks = Cross Arms
(dot, cross arms, wedge)

Fiducial #	Xmm	Ymm
1	−106.002	−106.002
2	−106.002	106.002
3	106.002	106.002
4	106.002	−106.002

Principal Point of AutoCollimation: −0.006 0.013 mm
Point of Best Symmetry: −0.009 0.013 mm

Distortion Information
Number of Semi-Diagonals = 4
Distortion Information Interval = 10 mm

Semi-Diagonal	Orientation	Distortion Values (1.16) in microns							
1	45 degrees	0	−18	−22	−4	25	45	54	54
		46	32	18	10	9	6	−9	−31
2	135 degrees	0	−18	−23	−7	21	42	54	52
		45	31	13	9	12	7	−11	−41
3	225 degrees	0	−19	−22	−8	21	44	55	52
		41	27	14	6	13	14	−2	−33
4	315 degrees	0	−18	−24	−7	22	44	52	48
		39	26	14	8	9	8	−9	−28
MEAN		0	−18	−23	−7	22	44	54	52
		43	29	15	8	11	9	−8	−33

(Frontispiece). The drawing carriage, with four pens, moves along the X-carriage which, in turn, is transported in the X direction. Motion is produced by servo motors which drive steel bands connected to the drawing carriage (for Y motion) and the ends of the X-carriage (for X motion). Both ends of the X-carriage are driven simultaneously by a single servo motor by means of an aluminum shaft at the left side of the drawing surface. The carriages are guided along precision surfaces by ballbearings. The drawing surface consists of a glass plate 1200 by 1400 mm in size. The glass is backlighted and contains imbedded wires to provide electrostatic holddown of the drafting media. The tilting mechanism is electrically controlled, allowing the surface to be positioned at any angle from horizontal to 60° inclined. An invar ruler is provided with each instrument for calibration purposes. Coefficients are analytically derived and used for real-time error correction.

The drawing head provides four tool holders, plus a microscope holder. The drafting tools available for use with the GP-1 are ballpens, Kern Prontograph technical pens, and Kern scribing needles.

The precision-built GP-1 Graphics Peripheral has a resolution and repeatability of 40 micrometres, while providing very fast throughput with its 0.6 g acceleration and 370 mm/sec drawing speed.

GP-1 ELECTRONIC ARCHITECTURE

The distributed processing concept has been carried through to the GP-1, where three processors are employed. The graphics processor (P4) is an LSI-11 which handles communication functions and drives the table via the vector generator (P5). This vector generator is an Intel 8085 microprocessor, as is the processor (P6) located in the handcontroller, which communicates with the operator.

An optional 9-track tape drive, controlled by the graphics processor (P4), provides for stand-alone operation of the GP-1 using pre-recorded data.

All of the intelligence associated with the GP-1, such as its symbols, line types, Leroy character set, and spline function, resides with the graphics processor. Using a separate vector processor to send appropriately timed pulses to the motors gives P4 enough time to handle these functions without

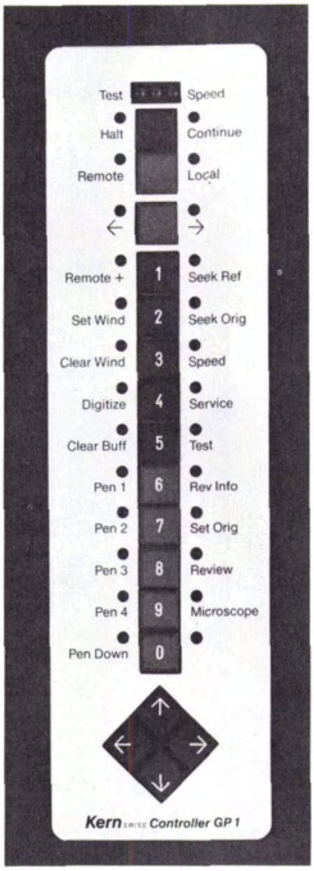


FIG. 6. Kern GP-1 handcontroller.

TABLE 3. KERN GP-1 HANDCONTROLLER

Functions	
Halt:	Causes immediate halt of plotter
Continue:	Cancels halt status
Seek Reference:	Advances pen to reference point
Set Window:	Defines a drawing window
Clear Window:	Cancels the set window
Seek Origin:	Advances pen to the drawing origin
Set Origin:	Makes current position the origin of drawing
Speed:	Sets new drawing speed
Digitize:	Sends plotter coordinates to computer
Clear Buffer:	Erases data buffers
Test:	Selects a test program
Reverse Information:	Step-back through up to last 64 plotted vectors
Pen 1:	Activates Pen 1
Pen 2:	Activates Pen 2
Pen 3:	Activates Pen 3
Pen 4:	Activates Pen 4
Microscope:	Moves microscope to drawing position
Pen Down:	Lowers active pen
✛ :	Joy stick for manual movement of pen

slowing down the plotting speed. The graphic processor communicates with its host computer, if any, by means of an RS232C interface.

GP-1 HANDCONTROLLER

The operator communicates with the graphics processor (P4) through the handcontroller (Figure 6). With this device, the operator can monitor and control data flow in the Kern GP-1. Keys are provided for command input, while pilot lamps and a three-digit LED display are used to indicate status. Active functions are indicated by illumination of the corresponding lamp. The functions provided include test patterns for diagnostic purposes, calibration, remote operation, and slew controls. The full range of functions are shown in Table 3.

This concludes the technical description of Kern's new DSR-1 Digital Stereorestitution module, and GP-1 Graphic Peripheral.

SUMMARY

The DSR-1/GP-1 analytical stereocompilation system was designed to meet, with equal facility, the needs of each facet of the photogrammetric marketplace. Such flexibility is required, in our opinion, because of the rapid evolution which the industry will undergo in the present decade.

The most noteworthy new concepts, ones which set the DSR-1/GP-1 system apart from other analytical plotters, are the highly distributed architecture of the electronic components and its software architecture. It is from this base that stem its flexibility, upward mobility, responsiveness, operator-friendly operation, and reasonable cost.

The technical design criteria of operator friendliness, superior optics, high precision, and flexibility were not only met, but surpassed, thanks to the many decades of experience in the area of precision mechanics, optics, and electronics, which the Kern name represents. The optics of the DSR-1 are truly superior in every respect. Mechanically, high conformance to the Abbe comparator principle in the plate carrier design has produced an extremely stable and precise mechanism. Electronically, judicious use of microprocessor technology and rigorous design standards have produced a simple and reliable system. Technically, the DSR-1/GP-1 is a fine example of bringing a formerly experimental instrument into the light of day and creating a useful, functional instrument designed for cost-effective, everyday production.

With analytical plotters now a practical reality, the digital computer will, necessarily, become the single greatest cause of organizational change in the mapping industry. In order to minimize this change and keep the organization on a solid footing, it is necessary to fully understand the capabilities of the computer and define precisely what input is required to obtain the hoped-for results. This is not a trivial matter, and if it is not understood, the photogrammetrist will eventually lose control of the mapmaking process to the computer scientist.

The future of photogrammetry is wide open. But, what will the outcome be? Will the computer scientists take over from photogrammetrists and cartographers? Will the digital map be many more decades in coming? Will existing photogrammetric firms flow with the tide to provide the customer with the kind of service he desires? Whatever happens, the DSR-1 will be there, its price and flexibility having guaranteed its future.

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(Invited 13 March 1981; received 22 October 1981)

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