THE K & E VECTRON ELECTRONIC SURVEYING SYSTEM

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The K. & E. Electronic Surveying System consists of three basic modules (plus battery) —

a) Electronic Surveying Instrument with numeric keyboard,
b) AutoRanger E.D.M.,
c) Field Computer (with alphanumeric display)

These modules may be interconnected to meet a variety of needs, or any one can be used alone.

The AutoRanger E.D.M. mounts atop the standards of the Electronic Surveying Instrument, and is connected electrically to it. The surveying instrument and the E.D.M. have an eight digit gas discharge display, the computer has an L.E.D.

When range information is fed to the surveying instrument, a panel switch can select the display of any of the seven quantities (e.g. horizontal range) shown in Figure 1. For stand-alone use, range information may be entered through the keyboard.

Mechanically the Electronic Surveying Instrument is designed to plunge and reverse in the manner of a conventional surveying instrument. Resolution is .001 grad (both horizontally and vertically) with display in decimal degrees, degrees/minutes/seconds, grads or mills, selectable by switch. Vertical angles are automatically referenced to gravity. Resolution of the AutoRanger E.D.M. is 1 mm. Display in metres or feet is selectable by a panel switch. Normal operating range (with three reflectors) is one and a quarter miles.

The Field Computer is a powerful attachment permitting storage and recall of alphanumeric information and a variety of computational and control functions (e.g. traverse closure). When not in use, it may be hung on the tripod. With its own battery, it may be used as an independent computer.

The versatility of the complete system comes from the fact that the AutoRanger E.D.M., the Surveying Instrument and the Field Computer each contain microprocessors which communicate with one another as shown in Figure 2. Communication between modules is serialized to keep the cables flexible and the connectors simple and reliable.

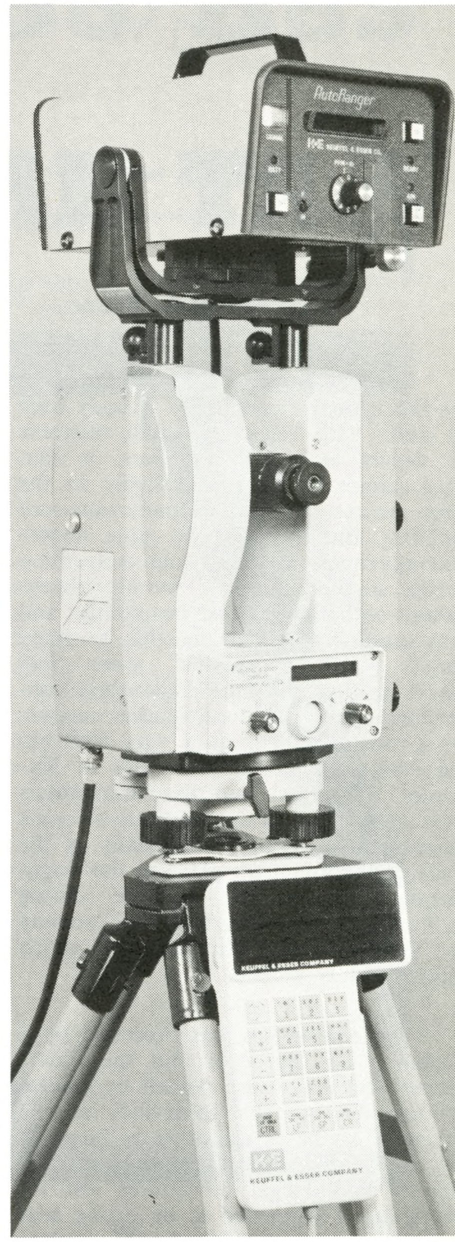
The system operates from -25°C to 54°C. Power is supplied from 12V rechargeable batteries. A two amp-hr. battery drives the AutoRanger E.D.M. for two hours or the Electronic Surveying Instrument (plus Field Computer) for up to three hours. Alternatively, a seven amp-hr battery (mounted on the tripod) drives the complete Electronic Surveying System for up to three and a half hours.

Electronic Surveying Instrument

The Electronic Surveying Instrument integrates precision optics and mechanics with electronic sensors and a microprocessor. Operationally, the Electronic Surveying Instrument has been made as similar to a conventional theodolite as possible. It plunges and reverses in the usual manner. Tangent and lock knobs are concentric for both axes and conveniently located at the right of the instrument. There is in addition an orientation clamp for the horizontal circle. The centre is of extremely high precision with ball bearings for both centering and thrust. The stub is standard. The alidade is a one-piece casing for increased stability; the plumb-line adjustment is externally accessible. The instrument is sealed against rain and dust.

Telescope optics of the highest quality provide a 30X erect image in a 1.4° field of view. The field is flat to the edge with no visible secondary colour. Minimum focus is 1.8m. Stadia addition constant is negligible down to 2.25m. Eye relief is a comfortable 8mm. Reticle illumination is an integral part of the instrument.

The front panel of the Electronic Surveying Instrument has an 8-character gas discharge display. The horizontal angle may be zeroed at any orientation simply by touching a panel button. Vertical angles are referenced automatically to gravity, with 90° as horizontal. Angle information is generated internally, but range information must be supplied externally either by direct connection to an AutoRanger E.D.M., or by manual entry through a keyboard attachment. When range information is provided, a panel switch can select for display any of the quantities shown in Figure 1.



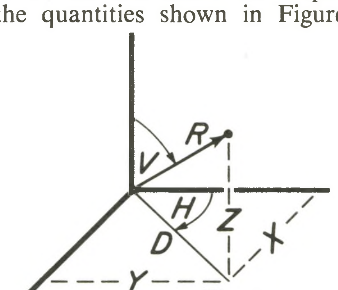


Fig. 1

R Slope range
H Horizontal angle
V Vertical angle
D Horizontal distance
X Departure
Y Latitude
Z Difference in elevation

The weatherproof hand-held numeric keyboard enhances the versatility of the Electronic Surveying Instrument by providing a link between the operator and the microprocessor. The keyboard allows:—

manual entry of range from a source not directly connected to the system;

presetting of horizontal angle values; arithmetic operations;

selection between two horizontal angle systems:

directional system with 360° as the maximum angle additive system

summation and averaging of horizontal angles;

averaging of vertical angles;

averaging of range readings.

The directional angle system is similar to that of a conventional theodolite which reads from 0° through 360°, increasing in the clockwise direction; however, with the Electronic Surveying Instrument the direction can be reversed and zero may be precisely set at any orientation.

The additive angle system reads from zero, increasing in either direction up to 9999°. A front panel switch selects the positive direction. Thus when angles are measured by repetition, the total repeated angle is displayed even when it exceeds 360°.

Field Computer

The Field Computer is a powerful accessory complete with a 40-key alphanumeric keyboard (including shift), a 9-character alphanumeric display, and random access storage for up to a day's surveying data. This module may be hand-held when operated and may be hung on the tripod when not in use. The display is a liquid crystal with highly visible characters 8mm in height plus the symbols °, ', ", g.

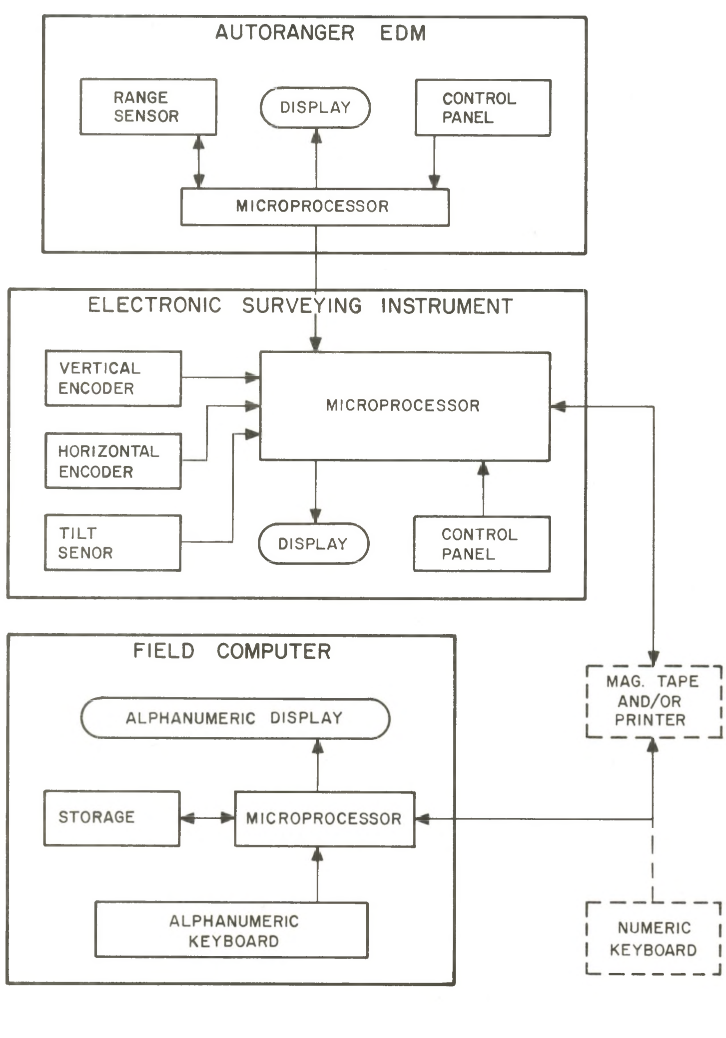


FIGURE 2.

The Field Computer can perform the same functions as the numeric keyboard plus many more. Of particular importance are the abilities to record without human transcription error, and to compute traverses in the field.

For recording and reviewing measurements, the concept is very simple: the Field Computer is a notebook with numbered lines. Each line may include:

Line No. .... assigned by computer (event counter)

any of these data can be recorded.

The format is easily specified via the keyboard.

R
H
V
D
Z
Y
X

Alphanumeric — entered via the keyboard, and may include B.S. No., information Target No., H.I., etc, and descriptive notes.

Any of the stored data can be recalled via the keyboard for display.

For traverse computations (open or closed), the concept is also simple: in addition to the X, Y, Z system with its origin at the Surveying Instrument, there is an X', Y', Z' system which can be located wherever the operator wishes by specifying the coordinates of the starting point and the beginning azimuth. The X', Y', Z' coordinates of any point can be called up for display. The coordinates will appear if the point has been tied to the origin by the traverse.

By closing on the starting point or a point of known coordinates, the error of closure can be computed by the Field Recorder before the surveyor leaves the field. The Field Computer may then be disconnected and transported to the office. Alternatively, the contents may be dumped onto magnetic tape or transmitted to the office by telephone.

Angle encoders

The patented angle encoders are optical and employ a doubling principle that yields two electrical cycles for each one-division movement of the circle. The use of optical doubling permits the circle to be coarse enough so that tolerances on the sensor assembly are very reasonable. Depth of focus exceeds .05mm; clearance is .9mm. The sensor assembly includes the light source, and it faces the circle from one side only. Rated life of the source exceeds 10,000 hours. Wide variation in light intensity is tolerable.

The encoders are incremental in .020 grad increments; interpolation to .001 grad is absolute. This combination allows direct verification of performance: the interpolar can be checked by turning the tangent screw slowly through any .020 grad interval; the incremental system can be checked by repetition.

An incremental encoder was chosen rather than an absolute encoder for two principal reasons. Firstly, in an incremental system repeatability is a very strong indication of proper performance, whereas in an absolute system errors frequently repeat. Secondly, far fewer sensors are required in an incremental encoder thus enhancing reliability. The fact that an absolute encoder has no limitation on slewing speed was not a consideration since the slew speed of the incremental encoders exceeds 5 rev/sec.

Being basically incremental, the vertical encoder requires an absolute reference to the vertical axis of the theodolite. This reference need only be precise enough to reliably identify one particular .020 grad interval, not a tight requirement. Once the telescope has been passed through a horizontal position to pick up this reference, the vertical angle is automatically referred to gravity with the addition of information from the tilt sensor described below.

Tilt sensor

To eliminate the need for precise leveling of the theodolite under most circumstances, a tilt sensor is incorporated into the alidade. Vertical angles are automatically corrected for tilt of the alidade up to plus or minus 200 arc seconds.

Mechanically, the tlit sensor consists of an air-damped pendulum well caged against shock. The pendulum was chosen over the alternative liquid system as being a well-proven technology with better assurance of long-term stability and more reliable performance over a wide range of temperature.

Electrically, the tilt sensor is completely solid-state. The design, although simple, was chosen primarily for its stability. The null point is immune to drifts in all electrical components except two solid-state switches which have excellent long-term stability.

Sensitivity of the tilt sensor is better than .0001°. Preliminary results indicate that overall accuracy over the full temperature range (-25°C to 54°C) and over the full tilt range (+—200 arc sec) will be better than .001°.

Tilt compensation can, of course, be checked directly by tilting the alidade; the vertical angle to a fixed point should not change. Reference to gravity can be checked in the conventional manner by sighting at a fixed target with the telescope direct and reversed; the two vertical angles should total 360°.