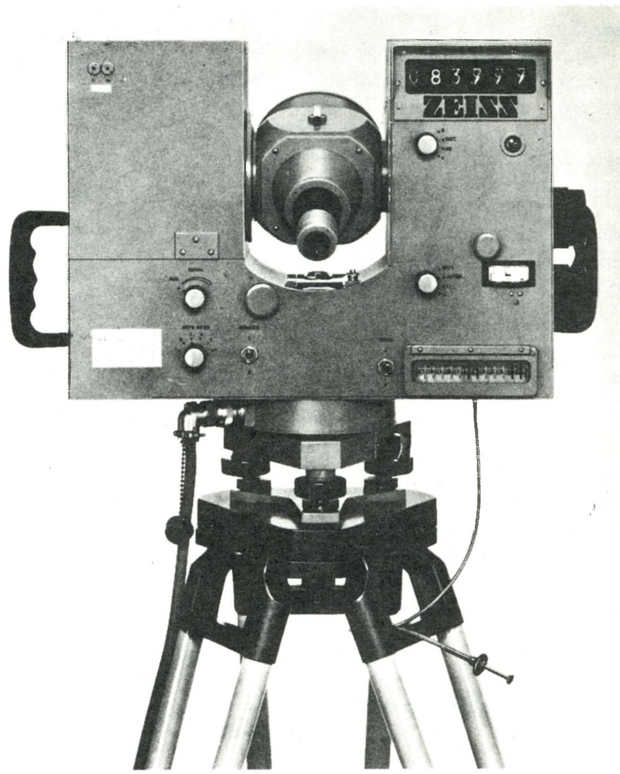
And Now for Something Completely Different

Reg Elta 14



The Reg Elta 14 Electronic Recording Tacheometer is a product of Carl Zeiss, of Oberkochen, West Germany, and is distributed in this country by Carl Zeiss Canada Ltd. of Don Mills, Ontario. According to the literature, it was the first of this relatively new generation of surveying instruments. The use of modern components and micro-technology has made it possible to create these instruments that combine high measuring accuracy and long range measurement with a quick and simple operation.

Like the AGA Geodimeter 710 featured in our last issue, the Reg Elta 14 measures the horizontal angle, vertical angle and slope distance. The measured data are displayed in digital form on Nixie tubes. Angles can be displayed in the 400 degree centesimal or 360 degree sexagesimal systems.

It too can record this data on a tape punch using any code between five and eight channels. Provision is also made to record twelve other coded figures, at the discretion of the operator.

A desirable accessory is the Zeiss Eltac.

The nucleus of the Eltac is a computer which is directly controlled by the Reg Elta. It can determine horizontal distances and height differences, taking into account the curvature of the earth and refraction. It can calculate the distance between two consecutively sighted points, and assists in setting-out from co-ordinates. If the instrument is set up over a random point, and two other points whose co-ordinates are known are sighted, the Eltac makes quick work of calculating the position of the random point.

The Ranging Unit

Although this article has been written principally to describe the angle measurement system within the instrument, a brief outline of the electronics involved in the electro-magnetic distance measuring unit is also included for interest.

In the E.D.M., the principle of phase measurement is used.

The transmitter is a semi-conductor diode made of gallium arsenide. The wavelengths of the radiation is in the infra-red region and is thus invisible to the human eye.

The transmitter sends out two modulated beams which are reflected back to a receiver in the measuring instrument. The first frequency; for precision measurement, provides an unambiguous result to ten metres; the second, for coarse measurement, to one thousand metres.

The detector used in the receiver is a photo-multiplier tube. For phase measurement, a voltage derived from the modulation, or reference, current is compared in phase with the output voltage of the photo-multiplier.

In the Reg Elta 14, there is an automatic electronic measurement, in which the phase shift is measured digitally by applying the two signals to a phasemeter.

The principle of the phasemeter is shown in Figure 1.

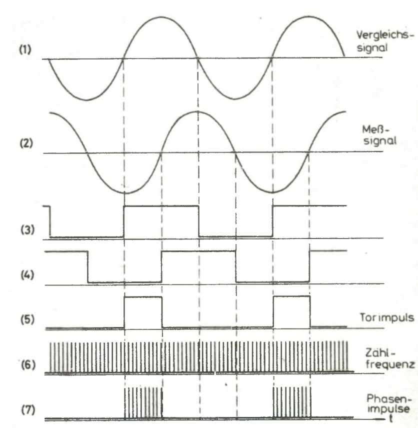


Fig. 1

The sinusoidal voltages of the reference signal (1) and the measuring signal (2) are converted into squarewave signals (3) and (4) by voltage comparators (trigger circuits). The positive edge of the reference signal makes a flipflop conductive. The positive edge of measurement signal resets this flipflop. Thus a pulse (5) is generated. This pulse controls a gating circuit to the input of which a sequence of pulses (6) is applied whose frequency is precisely known. As a result, pulse packages (7) appear at the output of the gating circuit. Use of the modulation wavelengths and proper selection of the counting frequency ensure that every pulse correspond to a distance of one centimetre for precise measurement or ten metres for coarse measurement.

The entire distance-measuring process is automatically controlled and monitored by programme control. Monitoring is necessary should the beam be interrupted, e.g. by vehicles. The phase values already determined are stored in a memory. As soon as the interruption is over, measurement is resumed. This system allows the measuring beam to be interrupted an infinite number of times so that observations can be made even across roads carrying dense traffic.

The Angle Measuring Unit

The mean square error of a direction measured in two telescope positions with the Reg Elta 14 is plus or minus 10cc (about three seconds of arc) in the horizontal plane, and plus or minus 15cc in the vertical plane.

A brief description of the measuring system for horizontal angles follows. The systems for horizontal and vertical angles in this instrument are basically of identical design and differ only in the automatic vertical-circle index compensator for zenith angles.

The method used to derive an angular measurement, however, is completely different from that used by the AGA Geodimeter 710.

Because the Geodimeter counts pulses of light passing through precisely marked tracks on a disc, it could be described as an analog theodolite. If such be the case, then the Reg Elta 14 could well be described as a digital theodolite.

Angle measurement in the Reg Elta is absolute. It is performed in two steps, a combination of electro-mechanical and photo-lithographic techniques of robust construction and proven reliability.

The First Step

In the first step, whole degree measurement, two discs, corresponding to the lower plate and upper plate of a regular transit, are each provided with 400 teeth around their circumferences. The teeth are on the top of the lower disc and on the bottom of the upper disc. These two geared discs are meshed with a very high accuracy. According to the information that I have, this is in the order of 0.0001 grad. By means of a clutch the operator separates the two discs, and by rotating them measures off full degree angles. During measurement, all teeth are in engagement; this guarantees angle measurements free from eccentricity errors.

An excerpt from the operating manual illustrates this further:-

"Disengage horizontal and vertical clutches by turning them clockwise to stop. Point instrument roughly at target with sighting collimator. Turn the clutches anti-clockwise to stop. Do not hold telescope and alidade when engaging the clutches."

The relative position of the geared discs is obtained from a code disc via contact springs.

The code disc is parallel to and in attachment with one geared disc; the contact springs are in attachment with the other geared disc. The code disc carries grad values from 000 to 399 in a combination binary-decimal (B.C.D.) code, in the form of a printed circuit.

BINARY EQUIVALENTS

1 —	1	9 —	1001
2 —	10	10 —	1010
3 —	11	11 —	1011
4 —	100	12 —	1100
5 —	101	13 —	1101
6 —	110	14 —	1110
7 —	111	15 —	1111
8 —	1000	16 —	10000

The contact springs pick-off the numbered position of the geared discs from the printed circuit pattern of conductive material on the code disc. There is thus electro-mechanical readout of the full grad value for the instrument pointing. Note that the coded disc has no influence on the accuracy of the measurement; it merely represents the numbering of the individual teeth of the toothed clutch.

A disc coded in this manner, but in pure binary, to show sixteen divisions of the circle is illustrated in Figure 2. It has four concentric tracks. The outside track, A, represents two to the power of zero, track B represents two, C two squared, and the inside track, D, two cubed, producing all combinations of four bits 0000 to 1111 i.e. sixteen sectors. In Figure 1 the black portions of the disc represent a logical 1 and the clear portions a logical 0.

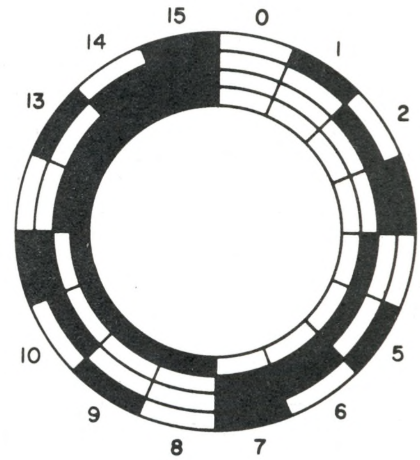


Fig. 2

The disc in the Reg Elta 14 has ten tracks, coded as shown in straight line form in Figure 3. As mentioned before, this is not in pure binary, but in a B.C.D. combination. I don't think that any of this needs further explanation. A couple of minutes study at the most and you will see how it works.

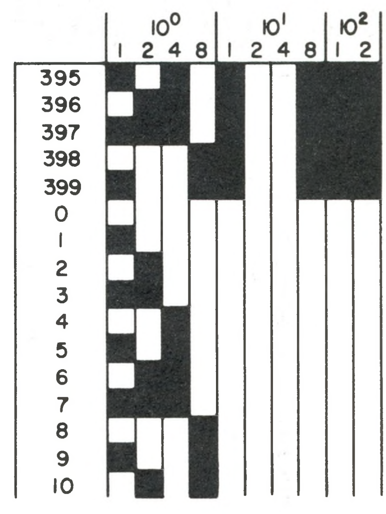


Fig. 3

The Second Step

In the second step, the telescope is pointed at the target from the whole grad position with the aid of a measuring wedge.

The wedge is made of glass. Rotation of the fine pointing slow motion knob by the operator, is translated by precision drives into a longitudinal movement of the wedge. The wedge is in abutment with a cam, which in turn causes the telescope to rotate about the standing axis; thus the wedge forms a mechanical link in the fine pointing operation within the instrument.

The range of interpolation is plus or minus 0.8 grad from the centre position.

The interpolation values are contained on the measuring wedge, once again in the form of B.C.D. coded graduations that in this case are read with light-emitting diodes and photo-detectors.

The codes on the wedge are as shown in Figure 4, and have fourteen tracks. Once again, tracks one to six and eight to thirteen are pretty well self explanatory.

To avoid reading errors at the transition points, electronic detents are provided in track seven. Track fourteen, if you haven't figured it out already, is to effectively tell the machine to deduct one unit from the grad value when a negative interpolation is read from the micrometer wedge.

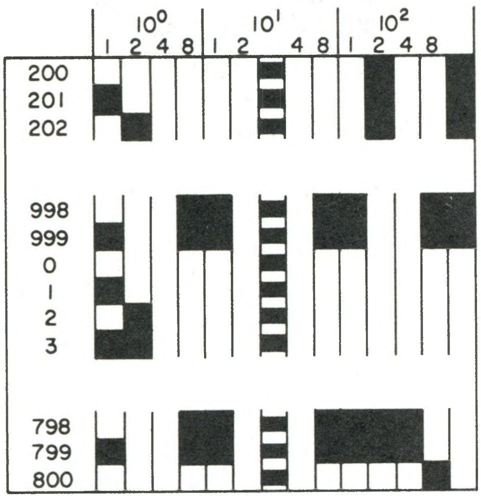


Fig. 4

Once the wedge and telescope have stopped moving, and the telescope is pointing at the target, the instrument is triggered with a cable release, just like on a camera. The interpolation reading is added to the grad reading to give the total directional value.

Conclusion

Because this instrument is so automatic and easy to operate, the manufacturers have deemed it necessary for it to check itself in very many ways.

To list a few of these, I have already mentioned that if the distance measuring signal level exceeds or falls short of certain threshold values, as when a vehicle crosses the line, measurement stops. If the voltage of the battery drops below a certain value, measurement is stopped and the display starts to flicker as a warning. If the angle-measurement circle clutch is not fully engaged. it is likewise impossible to measure.

A second set of spring contacts displaced by 200 grads on the main scale disc are connected electronically such that display of the coarse reading can only be effected when both sets of contacts give compatible whole grad readings. If the paper supply in the tape punch is exhausted or the tape breaks, this is indicated and the recording interrupted. In addition, all output data are checked for pseudo tracks (that is B.C.D. combinations which are impossible in this system). These may occur, for example, if the angle-interpolation illumination fails.

When you stop to consider that these machines are designed to operate anywhere in the world, in conditions of extreme humidity, in temperatures ranging between twenty below and sixty above and that they keep on operating year after year with reliability and speed, then I believe that they can truly be classed as modern wonders of our present day world.

I would like to acknowledge the assistance of Mr. R. Gilmore, of K. & E. of Canada Ltd. here in Ottawa, and Mr. K. Power of Carl Zeiss (Oberkochen) Ltd. of London, England for supplying me with technical data, and Mr. R. Grant of Surveys and Mapping, City Hall, Ottawa for the excellent diagrams. Mr. Grant also prepares the blocks and solutions for the crossword puzzles on a regular basis.