Advance Surveying

INTRODUCTION

Surveying is basic to engineering. Before any engineering work can be started we must prepare a plan or map of the area showing topographical details. This involves both horizontal and vertical measurements.

- **DEFINITION**

Surveying it is art and science of making measurements of relative position of point on earth surface that on drawing them down to scale natural or art facial feature will be exhibited in their correct horizontal or vertical relationship.

- **Theodolites**

The theodolite is a very useful instrument for engineers, It is used primarily for measuring horizontal and vertical angles. However the instrument can be used for other purposes like

(i) Prolonging a line,

(ii) Measuring distances indirectly. and

(iii) Levelling..

Theodolites these days are all transit theodolites. Here the line

of sight can ' be rotated in a vertical plane through 180= about its horizontal axis. This is known as transitting and hence the name "transit". Theodolites can be brondl)' classified us

(i) Vernier theodolites.

(ii) (ii) Precise 'optical theodolites.

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As the name suggests. in vernier theodolites verniers are used to measure accurately the horizontal and vertical angles. Generally 20" vernier theodolites are used. '

The precise optical theodolites uses an optical system to read both horizontal and vertical circles. The precision of angles can' be as high as 1".

There are basically two types of theodolite,

1- The optical microptic type.

2- The electronic digital type.

Both of which are capable of resolving angles to 1′, 20″, 1″ or 0.1″ of arc, depending upon the accuracy requirements of the work in hand the finesse of selecting an instrument specific to the survey tolerances is usually overridden by the commercial aspects of the company and a 1″ instrument may be used for all work.

When one considers that 1″ of arc subtends 1 mm in 200 m, it is sufficiently accurate for practically all work carried out in engineering.

Figure 1 show a typical theodolite, whilst Figure 2 shows the main components of the new obsolete vernier-type theodolite. This exploded diagram enables the relationships of the various parts to be more clearly understood along with the relationships of the main axes. In a correctly adjusted instrument these axes should all be normal to each other, with their point of intersection being the point about which the angles are measured.

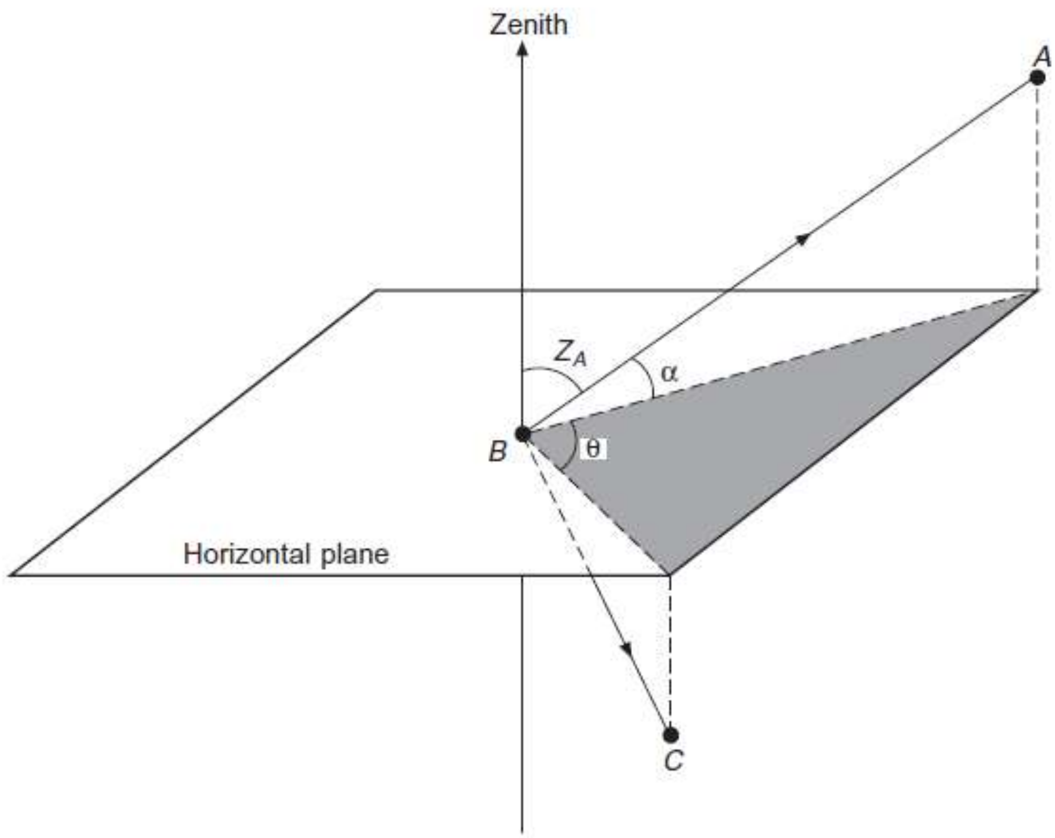

Fig. 4.1

The basic features of a typical theodolite are, with reference to Figure 2, as follows:

(1) The trivet stage forming the base of the instrument connects it to the tripod head.

(2) The tribrach supports the rest of the instrument and with reference to the plate bubble can be
levelled using the footscrews which act against the fixed trivet stage.

(3) The lower plate carries the horizontal circle which is made of glass, with graduations from 0°
to 360° photographically etched around the perimeter

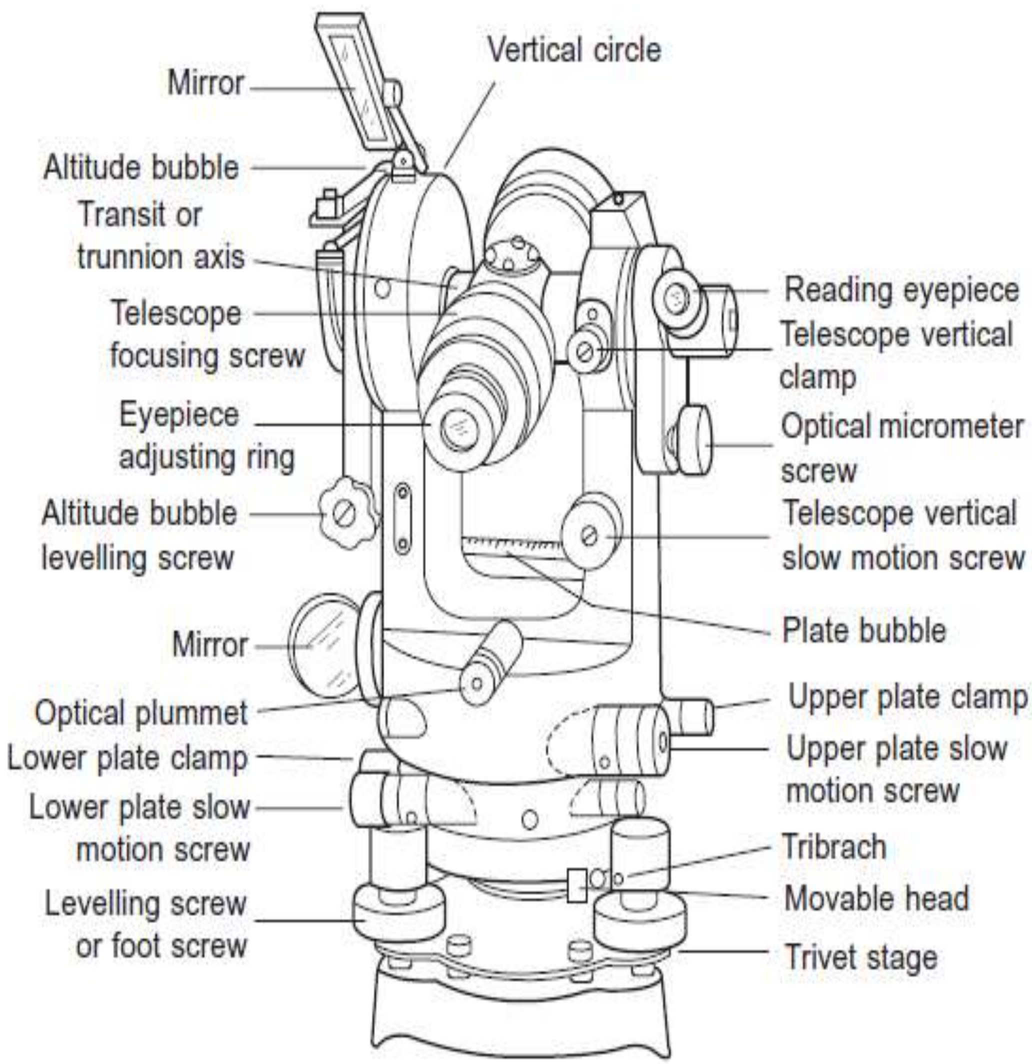

Fig. 4.2

(4) The upper plate carries the horizontal circle index and fits concentric with the lower plate.

(5) The plate bubble is attached to the upper plate and when centred, using the footscrews, establishes the instrument axis vertical. Some modern digital or electronic theodolites have replaced the spirit bubble with an electronic bubble.

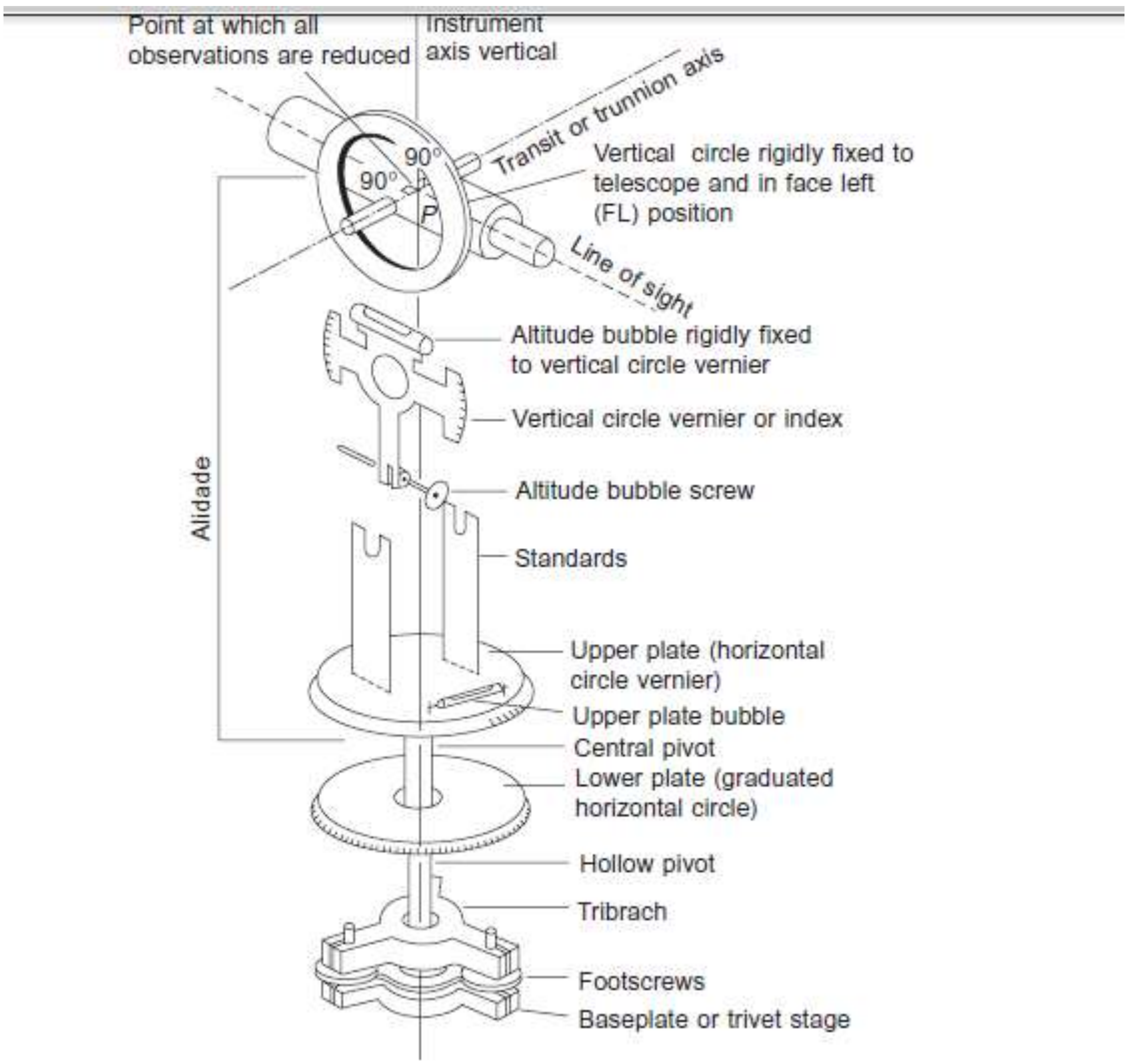

Figure 3 simplified vernier theodolite

(6) The upper plate also carries the standards which support the telescope by means of its transit axis. The standards are tall enough to allow the telescope to be fully rotated about its transit axis.

(7) The vertical circle similar in construction to the horizontal circle is fixed to the telescope axis and rotates with rotation of the telescope.

(8) The vertical circle index, against which the vertical angles are measured, is set normal to gravity by means of (a) an altitude bubble attached to it, or (b) an automatic compensator. The latter method is now universally employed in modern theodolites.

(9) The lower plate clamp (Figure 2) enables the horizontal circle to be clamped into a fixed position. The lower plate slow motion screw permits slow movement of the theodolite around its vertical axis, when the lower plate clamp is clamped. Most modern theodolites have replaced the lower plate clamp and slow motion screw with a horizontal circle-setting screw.

This single screw rotates the horizontal circle to any reading required.

(10) Similarly, the upper plate clamp and slow motion screw have the same effect on the horizontal circle index.

(11) The telescope clamp and slow motion screw fix and allow fine movement of the telescope in the vertical plane.

(12) The altitude bubble screw centers the altitude bubble, which, as it is attached to the vertical circle index, establishes it horizontal prior to reading the vertical circle. As stated in (8), this is now done by means of an automatic compensator.

(13) The optical plummet, built into either the base of the instrument or the tribrach (Figure 4.13), enables the instrument to be centered precisely over the survey point. The line of sight through the plummet is coincident with the vertical axis of the instrument.

(14) The telescopes are similar to those of the optical level but usually shorter in length. They also possess rifle sights or collimators for initial pointing.

Reading systems

The theodolite circles are generally read by means of a small auxiliary reading telescope at the side of the main telescope (Figure 2). The small circular mirrors, as shown in Figure 2, reflect light into the complex system of lenses and prisms used to read the circles.

There are basically three reading systems in use at the present time.

(a) Optical scale reading.

(b) Optical micrometer reading.

(c) Electronic digital display.

The optical scale reading system

Optical scale reading is generally used on theodolites with a resolution of 20″ or less. Both horizontal and vertical scales are simultaneously displayed and are read directly with the aid of the auxiliary telescope. The telescope used to give the direct reading may be a ‘line microscope’ or a ‘scale microscope’. The line microscope uses a fine line etched onto the graticule as an index against which to read the circle.

The scale microscope has a scale in its image plane, whose length corresponds to the line separation of the graduated circle. Figure 4 illustrates this type of reading system and shows the scale from 0′ to 60′ equal in scale of one degree on the circle. This type of instrument is frequently referred to as a direct-reading theodolite and, at best, can be read, by estimation, to 20″.

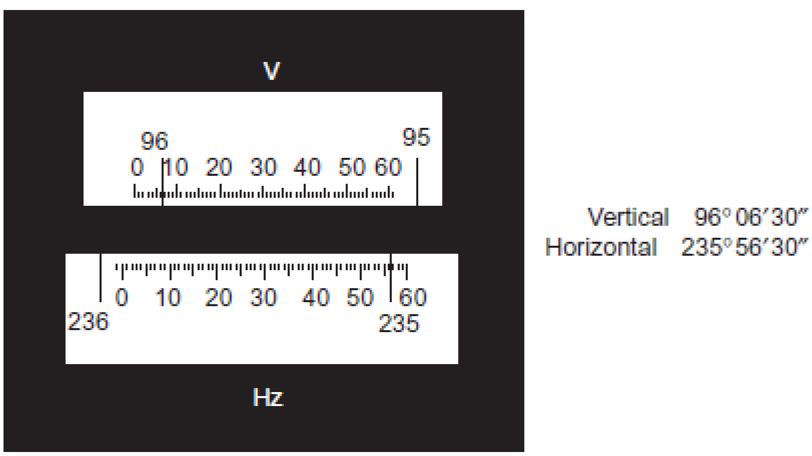

Figure 4 *Wild T16 direct reading theodolite*

(2) The optical micrometer system generally uses a line microscope, combined with an optical micrometer using exactly the same principle as the parallel plate micrometer on a precise level.

Figure 6 illustrates the principle involved. If the observer's line of sight passes at 90° through the parallel plate glass, the circle reading would be 23°20′ + *S*, with the value of *S* unknown. The parallel plate is rotated using the optical micrometer screw (Figure 2) until the line of sight is at an exact reading of 23°20′on the circle. This is as a result of the line of sight being refracted towards the normal and emerging on a parallel path. The distance *S* through which the observer's line of sight was displaced is recorded on the micrometer scale as 11′ 40″.

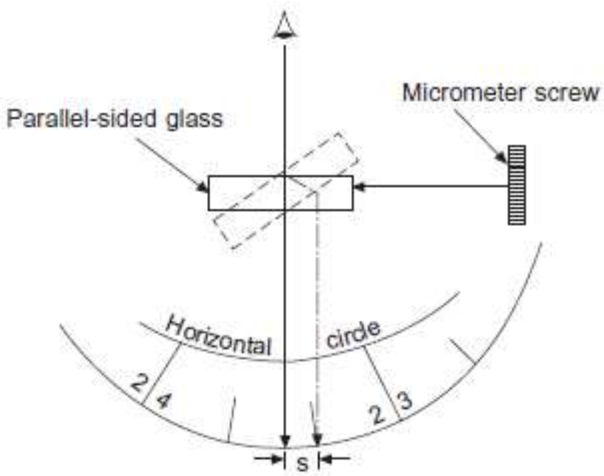

Figure 5

The shift of the image is proportional to the angle of tilt of the parallel plate and is read on the micrometer scale. Before the scale can be read, the micrometer must be set to give an exact reading (23°20′), as shown on Figure 6, and the micrometer scale reading (11′ 40″) added on. Thus the total reading is 23°31′ 40″. In this instance the optical micrometer reads only one side of the horizontal cricle, which is common to 20″ instruments.

On more precise theodolites, reading to 1″ of arc and above, a coincidence microscope is used. This enables diametrically opposite sides of the circle to be combined and a single mean reading taken. This mean reading is therefore free from circle eccentricity error. Figure 7 shows the diametrically opposite scales brought into coincidence by means of the optical micrometer screw. The number of divisions on the main scale between 94° and 95° is three; therefore each division represents 20′. The indicator mark can only take up one of two positions, either mid-division or on a full division. In this case it is mid-division and represents

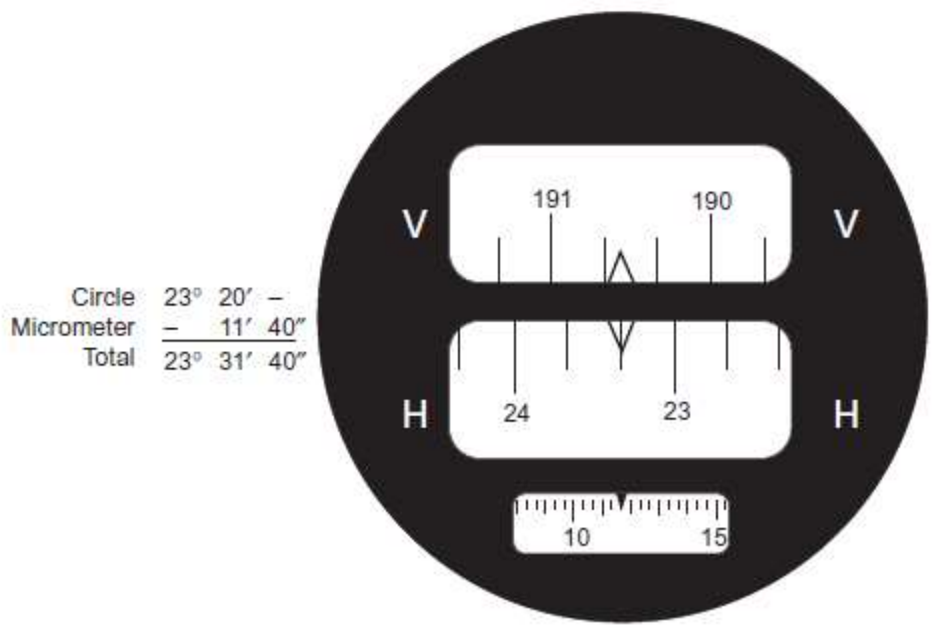

Figure 6 the *reading system of a Watts Microptic No. 1 theodolite*

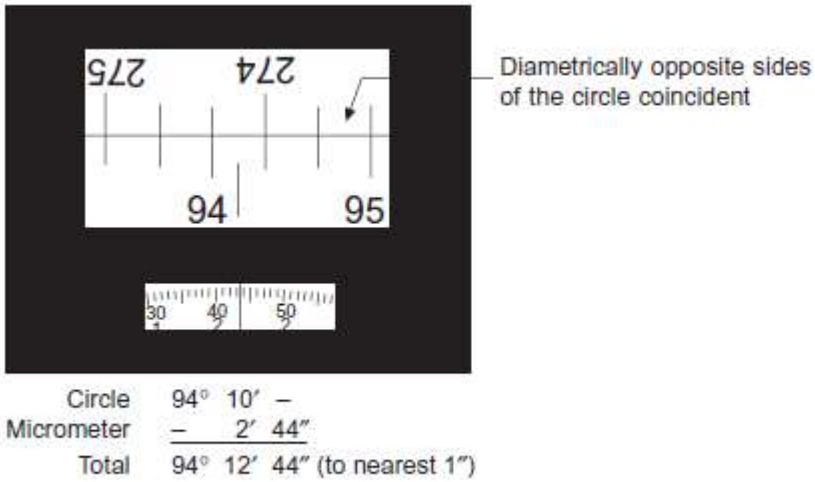

Figure 7 *Wild T2 (old pattern) theodolite reading*

a reading of 94°10′; the micrometer scale reads 2′ 44″ to the nearest second, giving a total reading of 94° 12′ 44″. An improved version of this instrument is shown in Figure 8.

The above process is achieved using two parallel plates rotating in opposite directions, until the diametrically opposite sides of the circle coincide.