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B100

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ELECTRONIC TOTAL STATION

SET4A

OPERATOR'S MANUAL

SOKKISHA

Battery charging precautions

To charge the battery, use only the recommended charger.

1) Charge the battery at least once a month if it is not used for a long time.
2) Charge the battery at a temperature between 10°C and 40°C.
3) Before using EDC2 or CDC15, set the voltage selector to the proper voltage.
4) EDC14 has a breaker switch. Normally the red mark appears on the breaker. If not, set the red mark in place.
5) When using a car battery, make sure that the polarity is correct.
6) Make sure that the cigar lighter has 12V output and that the negative terminal is grounded.
7) When charging the battery, first connect it to the battery charger and then connect the charger to the power supply. Check that the battery charger light is on. If not switch power supply off and on again until the light comes on.
8) The battery charger may become warm while charging. This is normal.
9) Do not charge the battery for any longer than specified.
10) Store the battery in a place where the temperature is between 0°C and 40°C.
11) Battery operating life is shortened at extreme temperatures.

6. REFLECTING PRISMS AND ACCESSORIES

All Sokkisha reflecting prisms and their accessories have standardized screws (5/8" x 11 thread) for easy compatibility.

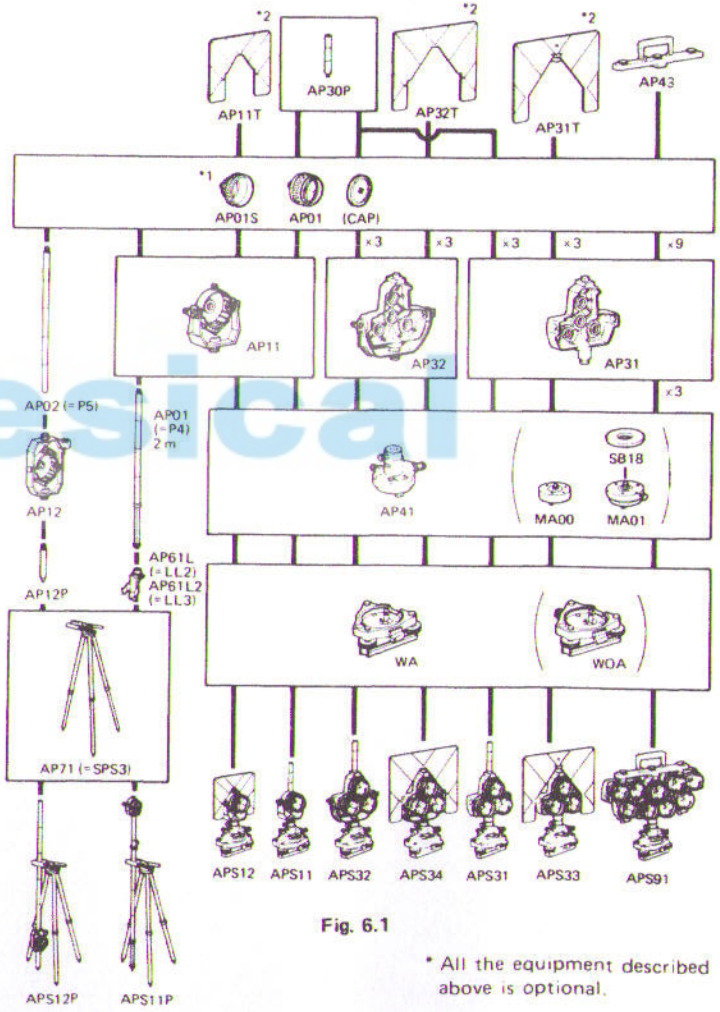


Fig. 6.1

* All the equipment described above is optional.

*1: See 10.3.1 Prism constant correction.
*2: Fluorescent paint finishing allows clearer sighting in adverse observing conditions.

Precautions

1) Carefully face the reflecting prism towards the instrument; sight the target centre accurately.
2) To use the triple prism assembly AP31 or AP32 as a single prism (e.g. for short distances), mount the single prism AP01 in the centre hole of the triple prism holder.
3) Check that "236" (the height of the SET4A) is displayed in the window of the instrument height adaptor AP41.
   The height of the AP41 can be adjusted as follows:
   ① Loosen the two fixing screws.
   ② Turn the centre part counterclockwise to unlock it.
   ③ Move it up or down until "236" appears in the window.
   ④ Turn the centre part clockwise to re-lock it.
   ⑤ Tighten the fixing screws.

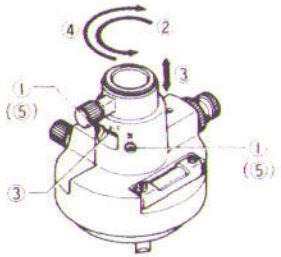


Fig. 6.2

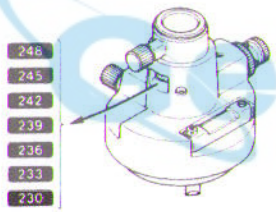


Fig. 6.3

4) Use the plate level on the AP41 to adjust the tribrach circular level as in 13.1.2.
5) Check the optical plummet of the AP41 as in 13.1.6.
   After all checks and adjustments have been completed, make sure that the AP41 optical plummet sights the same point as the optical plummet of the SET4A.

7. DISPLAY SYMBOLS

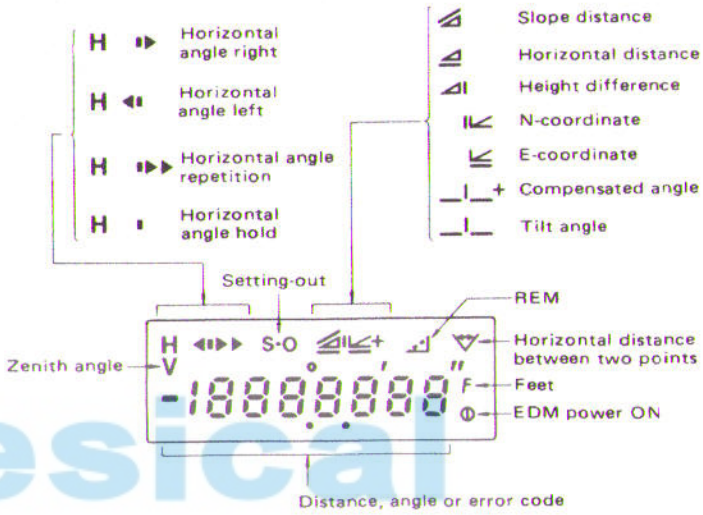


Fig. 7.1

8. KEY FUNCTIONS

SET4A has three measurement modes.
When it is switched on and the vertical circle is indexed by rotating the telescope, it is automatically in the theodolite mode.

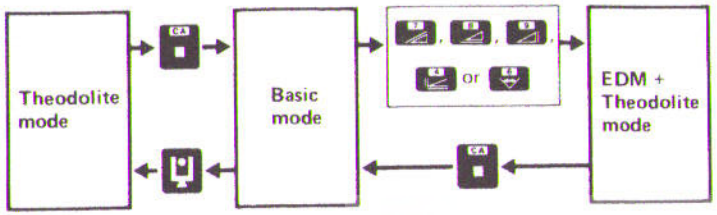


Fig. 8.1

Theodolite mode

Angle measurement.

SET4A accepts [CA], [0], [7], [8], [9], [ENT] or [0 SET] keys.

Basic mode

Prism sighting and recall.

SET4A accepts all keys except [CA], [5], [ENT], [0 SET] keys.

EDM + Theodolite mode

Angle and distance measurement.

SET4A accepts [CA] or [ENT] keys only.

- When entering setting-out values, keys [0] ~ [9], [S-O], [+/- RCL], [CE], [ENT] and [CA] can be used.

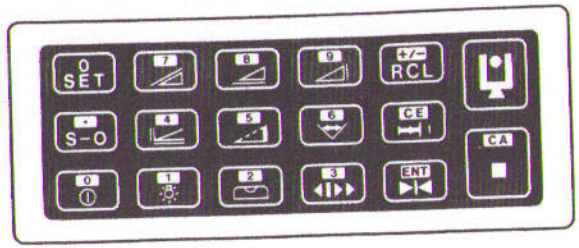


Fig. 8.2

- [⏻] • Select theodolite mode.
- [CA] • Stop data entry before [ENT] has been pressed.
  • Stop measurement and transfer to basic mode.
- [0 SET] • Set horizontal angle to zero. To confirm zero setting, press [ENT].
- [7] • Enter "7".
  • Measure slope distance.
- [8] • Enter "8".
  • Measure horizontal distance.
- [9] • Enter "9".
  • Measure height difference.
- [+/- RCL] • Change the sign of data before entry.
  • Recall data from memory.
- [S-O] • Enter decimal point.
  • Measure setting out (stake-out) distance.
- [4] • Enter "4".
  • Measure N- and E-coordinates.
- [5] • Enter "5".
  • Measure remote elevation.

- Enter "6".
- Measure horizontal distance between two prism points.

- Clear entry.
- Enter setting out (stake-out) distance.

- Enter "0".
- EDM power ON/OFF for locating prism.

- Enter "1".
- Illuminate display and reticle of telescope for 30 seconds.

- Enter "2".
- Display vertical axis tilt angle ON/OFF.

- Enter "3".
- Select horizontal angle to left, right or by repetition (accumulation).

- Transfer entered data to memory.
- Confirm input of SET (setting horizontal angle to zero).
- Hold/release horizontal angle.

9. INTERNAL SWITCHES

Switches are located under internal switch cover ❹.

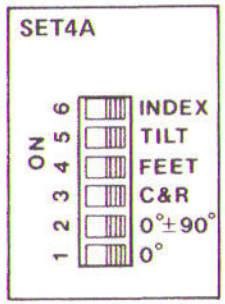


Fig. 9.1

Switch		Function
6	ON	Manually index vertical circle by V1, V2
	* OFF	Automatically index vertical circle by transitting telescope
5	ON	Vertical circle compensator off
	* OFF	Vertical circle compensator on
4	ON	Display distance in feet
	* OFF	Display distance in meters
3	ON	Distance corrected for earth-curvature and refraction
	* OFF	Distance not corrected for earth-curvature and refraction
2	ON	Display vertical angle with 0° (0 gon) horizontal ±90° (100 gon)
	* OFF	Vertical angle display controlled by switch 1
1	ON	Display vertical angle with 0° (0 gon) horizontal on face V1
	* OFF	Display zenith angle

(The asterisk indicates the position of each switch at the time of shipping from factory.)

- Before changing switch settings, turn power switch OFF.

10. OPERATION

10.1 PREPARATION FOR ANGLE MEASUREMENT

10.1.1 Battery, BDC18: Mounting and check

1) Confirm that the power switch ㉓ is OFF.
2) Mount the battery BDC18 in the SET4A.
   Hold the left standard when inserting the battery. Push it until a click is heard to indicate correct location. Confirm that the battery is fixed securely.

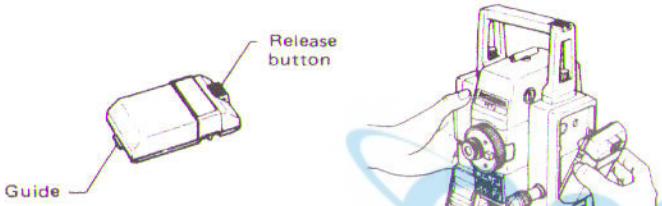


Fig. 10.1

(To remove the battery, turn the power switch OFF and push down the release button of the battery.)

3) Two short audio signals are heard when the power is switched ON. The display shown in ① and then ② indicate the instrument is in normal condition.

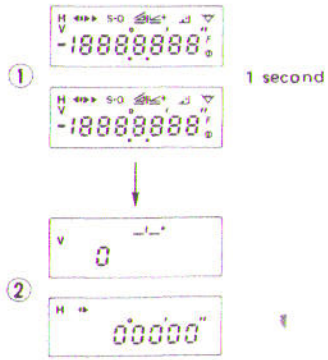


Fig. 10.2

If the battery voltage is too low, the display will appear as shown below. Set the power switch OFF and replace the battery with a charged one, or charge the battery.

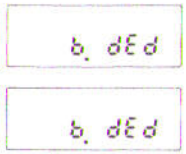


Fig. 10.3

10.1.2 Compensation of zenith angle

1) Remove the switch cover ❹.
2) To use zenith angle with compensation, set switch 5 to OFF with a screw driver. (The factory setting is OFF.)
3) Replace the cover.

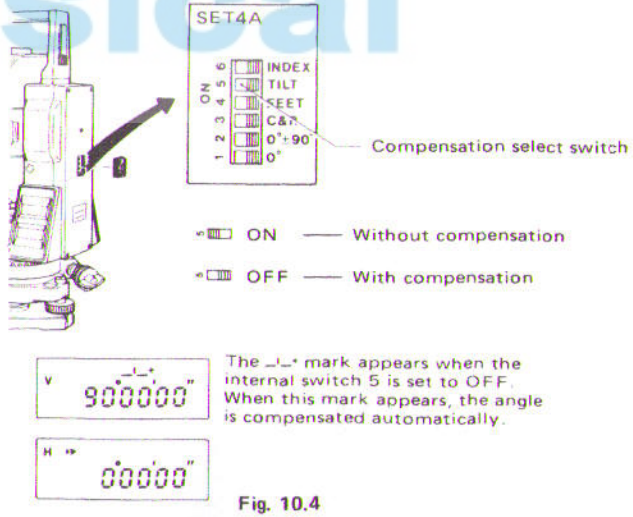


Fig. 10.4

The internal tilt sensor has a range of ±3′ and a resolution of 5″. Read the automatically compensated zenith angle when the display is steady. When the display is not steady due to vibration or strong wind, set switch 5 to ON to use the SET4A without compensation.

10.1.3 Centring the SET4A by adjusting tripod leg length

1) Make sure that:
   a. The tripod head is approximately level.
   b. The tripod shoes are firmly fixed in the ground.
2) Set the SET4A on the tripod head. Tighten the centring screw.
3) Focus on the surveying point:
   a. Turn the optical plummet eyepiece ㉒ to focus on the reticle.
   b. Turn the optical plummet focussing ring ㉑ to focus on the surveying point.
4) Turn the levelling foot screws ⑫ to centre the surveying point in the reticle.
5) Observe the off-centre direction of the bubble in the circular level ⑩. Shorten the leg nearest that direction, or extend the leg farthest from that direction.
   Generally, two legs must be adjusted to centre the bubble.
6) When centring of the circular level is completed, turn the levelling screws to centre the plate level ㉓ bubble.
7) Look through the optical plummet again. If the surveying point is off-centre, loosen the centring screw to centre the surveying point on the reticle. Tighten the centring screw.
8) Repeat 6), 7) if the plate level bubble is off-centre.

10.1.4 Focussing

1) Looking through the telescope, turn the eyepiece fully clockwise, then anticlockwise until just before the reticle image becomes blurred. In this way, frequent refocussing can be dispensed with, since your eye is focussed at infinity.
2) Loosen the vertical ㉚ and horizontal clamp ㉙.
   Bring the target into the field of view with the peep sight ㉜.
   Tighten both clamps.
3) Turn the focussing ring ㉛ and focus on the target.
   Sight the target with the vertical ㉛ and horizontal fine motion screws ㉕. Focus on the target until there is no parallax between the target and the reticle.

Parallax:
Relative displacement of target image in respect to the reticle when observer's head is moved slightly before the eyepiece.
If sighting is carried out before parallax is eliminated, this will introduce errors in reading and will impair your observations.

10.2 ANGLE MEASUREMENT

Make sure that:
a. The SET4A is set up correctly over the surveying point.
b. Battery voltage is adequate.

10.2.1 Automatically indexing vertical circle

1) Turn the power switch ㉓ ON.
   Make sure that the display appears as shown below.

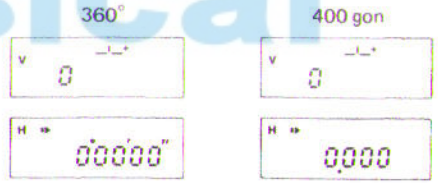


Fig. 10.5

2) Loosen the vertical clamp ㉚, and use the telescope plunging knob ㉝ to rotate the telescope completely.
   (Indexing occurs when the objective lens crosses the horizontal plane in position V1.)
   When the vertical circle is indexed, an audio signal is given and the display appears as below.

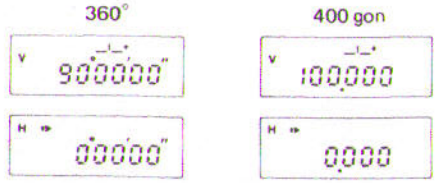


Fig. 10.6

Angle measurement can now begin.

Note: When the power switch is turned off for any reason, the vertical index is lost. When the power switch is turned back on, the vertical index must be redetermined.

10.2.2 Angle measurement

Before this procedure, index the vertical circle.

1) Select the horizontal angle right or left with [HOLD] according to measuring method.

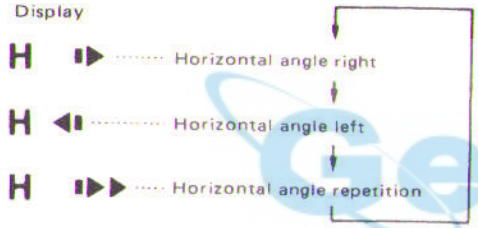


Fig. 10.7

When [HOLD] is pressed, the display changes alternately as shown in Fig. 10.7

2) Sight the first target A.
3) Press [SET] then [0 SET] to set the horizontal angle display to 0° (0 gon).

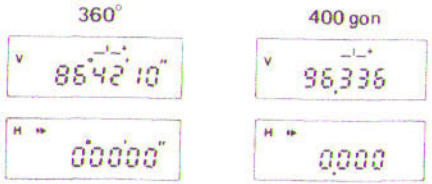


Fig. 10.8

4) Use the horizontal clamp ㉔ and the vertical clamp ㉚ to sight the second target B.

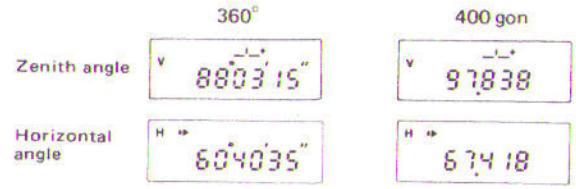


Fig. 10.9

The displayed horizontal angle is the angle between targets A and B.

10.2.3 Setting the horizontal circle to a required value

To set the horizontal circle to the reference target, for example 90°10'20" (100.191 gon):

1) Loosen the horizontal clamp ㉔ and the lower clamp ❻ and hold the upper alidade lightly. Turn the circle positioning ring ⓮ until the display becomes about 90° (100 gon) and tighten both clamps. Turn the horizontal fine motion screw ㉕ until the desired angle is displayed.

Note: When using the lower clamp ❻, push in the cover ❼.

2) Press [HOLD].

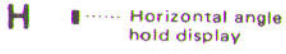


Fig. 10.10

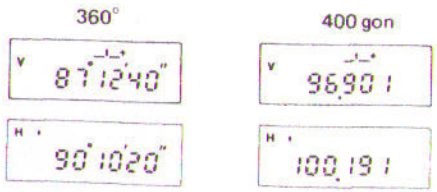


Fig. 10.11

3) Turn the instrument and sight the target.
4) Press [CNT] to release the display hold.
The required horizontal circle value is now set to the reference target.

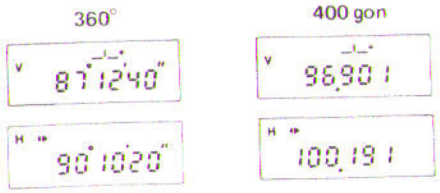


Fig. 10.12

10.2.4 Repetition of angles

Repetition of angles from -1,999°59'55" to 1,999°59'55" (-1,999.999 gon to 1,999.999 gon) is displayed by using [HOLD].

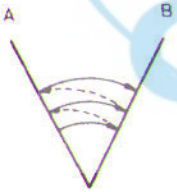


Fig. 10.13

1) Press [HOLD] to select repetition of angle.

H ▮▶▶ ..... Repetition of angle display

Fig. 10.14

2) Sight target A, and press [0 SET] then [CNT].

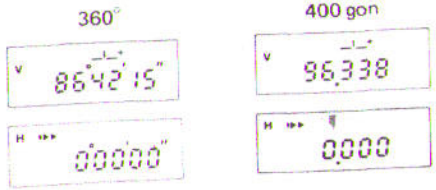


Fig. 10.15

3) Use the horizontal clamp ㉔ and the horizontal fine motion screw ㉕ to sight target B.

Fig. 10.16

4) Press [CNT] to hold the horizontal angle display.
5) Use the lower clamp ❻ and the horizontal fine motion screw ㉕ to turn back to target A.

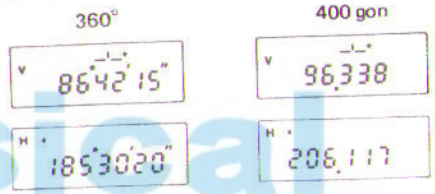


Fig. 10.17

6) Press [CNT] to release the display hold.
7) Use the horizontal clamp and the horizontal fine motion screw to sight target B.

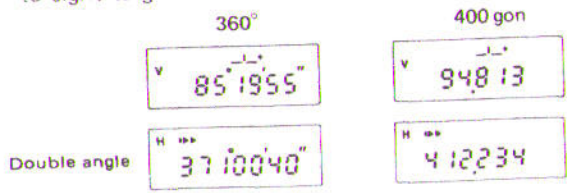


Fig. 10.18

8) Repeat 4) to 7) steps to measure repetition of angles.
9) To release the repetition of angle display, press [HOLD].

10.3 PREPARATION FOR DISTANCE MEASUREMENT

10.3.1 Prism constant correction

1) Remove the prism constant switch cover ⑮ with a coin.
2) Use the screwdriver to turn the prism constant setter to match the prism constant value of the reflecting prism.
   i.e. For a prism constant correction value of -3 cm, set the index to 3 (-3 cm).

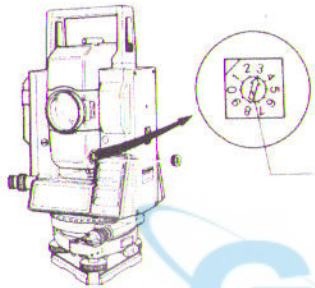


Fig. 10.19A

3) Replace the cover.

Prism constant values of Sokkisha reflecting prisms.

The prism constant of the AP series prisms is 30 mm (the same value as the previous Sokkisha prism) using the prism spacer AP01S (standard accessory). The constant can be changed to 40 mm by removing the prism spacer.

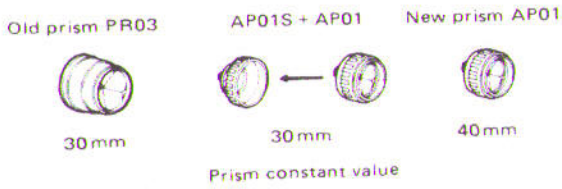


Fig. 10.19B

When using reflecting prisms with constant values other than the above, a prism constant correction of 0 cm to -9 cm can be set in steps of 1 cm using the prism constant setter.

10.3.2 Atmospheric correction

The SET4A is designed so that the correction factor is 0 for a temperature of +15°C and an atmospheric pressure of 760 mmHg. The correction factor is obtained from the pressure and temperature as follows.

1) Measure the temperature and atmospheric pressure with a thermometer and a barometer.
   Pressure can be obtained from weather station sea level data by correcting for altitude. For altitude correction see 15.2.
   To convert millibars to mmHg multiply by 0.75.
   Example: 959 millibars
   0.75 x 959 = 719 mmHg

2) Read the correction factor from the atmospheric correction table on pages 63 and 64.
   Example: Temperature +25°C
   Atmospheric pressure 750 mmHg
   Correction factor is +13 ppm.

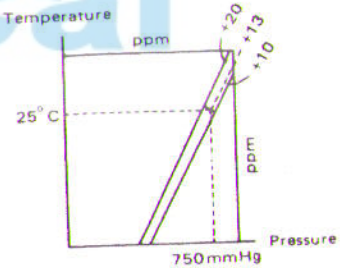


Fig. 10.20

3) Set the ppm switch ㉗ to +13.

Fig. 10.21

4) To obtain the atmospheric correction factor by computation.
Example A: Using pressure in mmHg.

$$\text{Atmospheric correction factor } X = 278.96 - \frac{0.3872 \times P}{1 + 0.003661 \times t}$$

P: Atmospheric pressure in mmHg
t: Temperature in centigrade

Ex.: P = 912 mmHg, t = +20°C

$$ppm = 278.96 - \frac{0.3872 \times 912}{1 + 0.003661 \times 20}$$
$$= -50.07 \fallingdotseq -50$$

Therefore, set the ppm switch ㊲ to -50.

Example B: Using pressure in mbars.

$$\text{Atmospheric correction factor } X = 278.96 - \frac{0.2904 \times P}{1 + 0.003661 \times t}$$

P: Atmospheric pressure in mbars
t: Temperature in centigrade

Ex.: P = 1020 mbars, t = +50°C

$$ppm = 278.96 - \frac{0.2904 \times 1020}{1 + 0.003661 \times 50}$$
$$= 28.58 \fallingdotseq 29$$

Therefore, set the ppm switch ㊲ to 29.

5) For slope distances equal to or more than **2,000.000 m (6,561.68 ft)** (exceeding the maximum display **1,999.999 m (6,561.67 ft)**), the ppm switch should be set to 0 and the corrected slope distance calculated by the formula:

$$D = (2{,}000 + d) \times \left(1 + \frac{X}{1{,}000{,}000}\right)$$

D: Corrected slope distance
d: The displayed slope distance when ppm is set to 0
X: Correction factor in ppm

Example: Slope distance 2,010.000 m (displayed as 10.000 m)
X = +5 ppm

$$D = (2{,}000 + 10.000) \times \left(1 + \frac{5}{1{,}000{,}000}\right)$$
$$= 2{,}010.010\ m$$

10.3.3 Earth-curvature and refraction correction

1) Remove the internal switch cover ❹.
2) To correct horizontal distance and height difference for earth-curvature and refraction, set switch 3 to ON with a screwdriver.
3) Replace the cover.

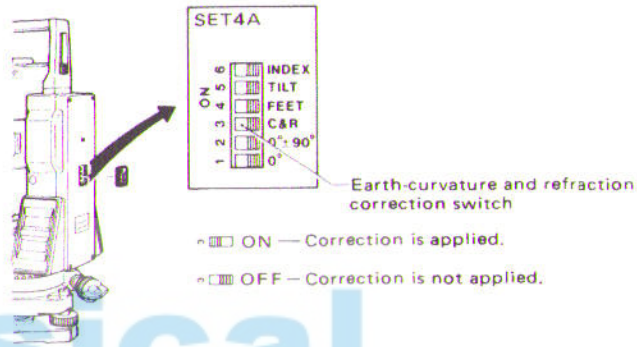


Fig. 10.22

- This correction is performed in the measurement of horizontal distance and height difference.
The value displayed by the SET4A is computed by the following formula:

When the switch is ON

Horizontal distance after correction

$$H' = S \times \sin Z - \frac{1 - \frac{K}{2}}{R} \times S^2 \times \sin Z \times \cos Z$$

Height difference after correction

$$V' = S \times \cos Z + \frac{1 - K}{2R} \times S^2 \times \sin^2 Z$$

When the switch is OFF

Horizontal distance $H = S \times \sin Z$
Height difference $V = S \times \cos Z$

S: Slope distance (value after atmospheric correction)
Z: Zenith angle
K: Atmospheric refraction constant (0.142)
R: Radius of the earth (6.372×10^6 m)

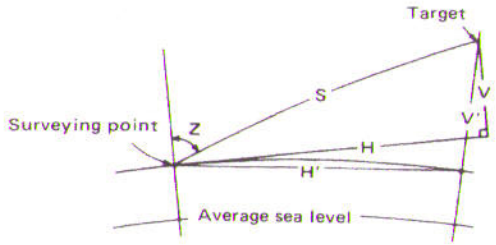


Fig. 10.23

Example: Amount of correction for a zenith angle of 70°

S (m)	200	500	1000	1500
H' - H (m)	-0.002	-0.012	-0.047	-0.105
V' - V (m)	0.002	0.015	0.059	0.134

Note that the horizontal distance is a distance measured at the height of the surveying point above the sea level. If necessary, reduce this distance to the average sea level and apply the local projection correction.
Further, since the SET4A does not apply the earth-curvature and refraction and atmospheric corrections when a slope distance is more than 2 km, such corrections should be performed by computation.

10.3.4 Prism sighting

1) Sight the centre of the reflecting prism with the telescope.
2) Set the return signal audio switch ㉝ to ♪.
3) Set the power switch ㉙ to ON and press [EDM].
   [EDM] turns the power supplied to the EDM unit ON or OFF. Usually the power of the EDM unit turns OFF automatically after 1 second of inactivity and the power source mark disappears.
   But when [EDM] is pressed, power is supplied to the EDM unit for about 2 minutes to permit prism sighting.
   a. When power is supplied to the distance measurement unit (EDM unit), the power source mark ⓫ is displayed.

   b. When the reflected light is received by the telescope, an audio signal is heard and the return signal lamp ㉝ lights up.

> **When the light intensity coming back from the prism is very high, the return signal lamp may light up, even for a slight mis-sighting. Make sure that the target centre is sighted correctly.**

4) Switch off the audio target acquisition.

10.3.5 Mode selection

1) Select the mode switch ㉟ to MEAS. for fine measurement, or TRACK. for tracking.

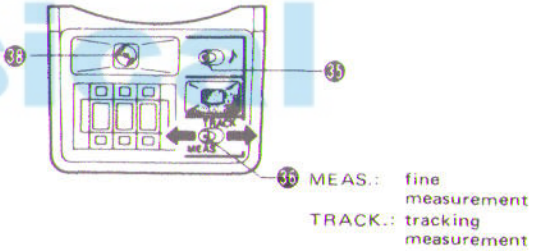


Fig. 10.24

MEAS.: Measures in mm units at first after 6 to 8 seconds and then every 4 seconds.
TRACK.: Measures in cm units at first after 6 to 8 seconds and then every 0.4 to 1 second.

10.4 DISTANCE MEASUREMENT

Make sure that:
a. The SET4A is set up correctly on the surveying point.
b. The prism constant switch, the earth-curvature refraction switch, and ppm switch are set correctly.
c. Battery voltage is adequate.
d. Indexing the vertical circle is complete.

10.4.1 Angle, distance and coordinates measurement

1) Press [ESC] to change from angle measurement mode to basic mode.

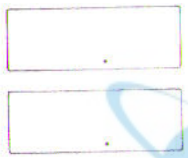


Fig. 10.25

2) Press [SHIFT] and sight the centre of the reflecting prism. (See 10.3.4)
3) Press [▲] to measure slope distance.
The following display appears showing that the slope distance measurement is being performed.

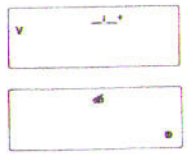


Fig. 10.26

4) The slope distance and the zenith angle will be displayed after about 6 seconds.

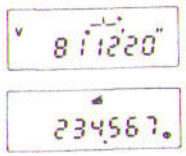


Fig. 10.27

Slope distance will continue to be measured every 4 seconds.

- Maximum display for slope distance is 1,999.999 m (6,561.67 ft). For longer slope distances, see 10.3.2.
- When the following keys are pressed instead of [▲] in step 3), the measurement corresponding to each key is performed.

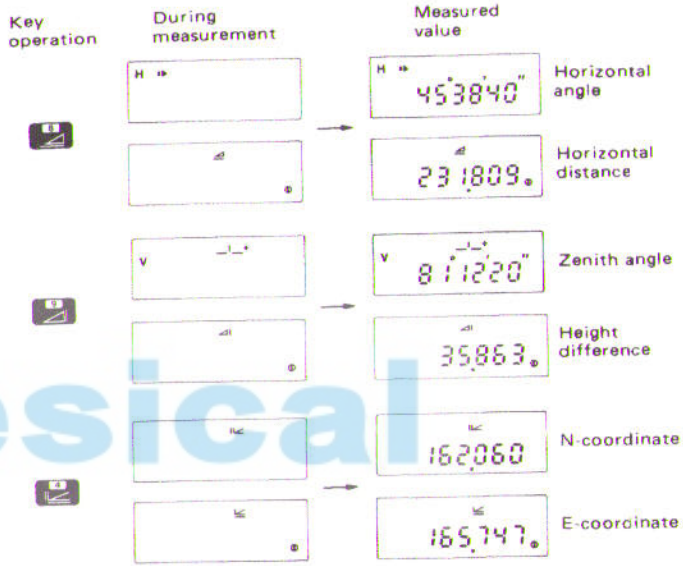


Fig. 10.28

5) Press [ESC] to stop measurement and return to basic mode.

Note: The SET4A computes the coordinates using the following formulas:

$$\text{N-coordinate} = H \cos \theta_H$$
$$\text{E-coordinate} = H \sin \theta_H$$

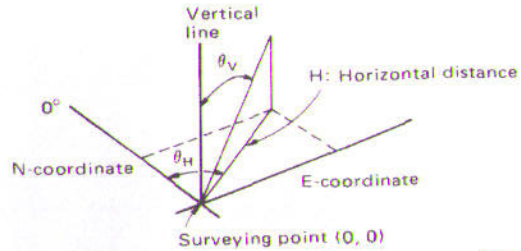


Fig. 10.29

6) After stopping the measurement, you can recall the following observational data, which are stored in the instrument, by pressing the appropriate keys.

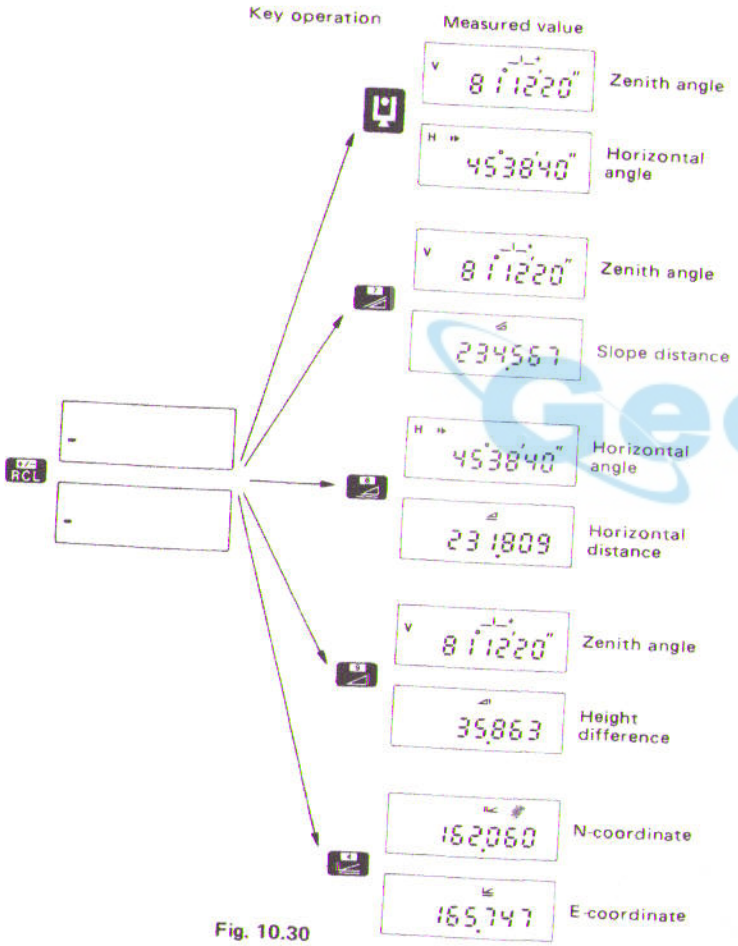


Fig. 10.30

- Each measured value displayed is the result obtained in the latest measurement.

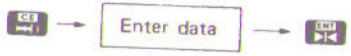
7) To use as a theodolite after distance measurement, press .

10.4.2 Setting-out measurement

1) Setting-out data is a given distance where a stake is supposed to be driven into the ground.
The SET4A displays the measured distance minus the given distance (setting-out data).

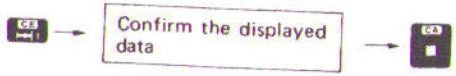
Displayed value = Measured value – setting-out data

2) Entry of setting-out data
The setting-out data need to be entered once for the slope distance, horizontal distance, height difference or remote elevation measurement.
The SET4A should be in the basic mode for data entry.



- To clear the entry halfway, press .
- To stop the entry halfway, press .
- The range of setting-out data is between -9,999.999 and 9,999.999 m.
- The data once entered is stored until the power switch is turned OFF, then becomes 0.

3) Confirmation of setting-out data



- To correct the stored data, re-enter it.

4) Measurement
The following measurements can be performed with .

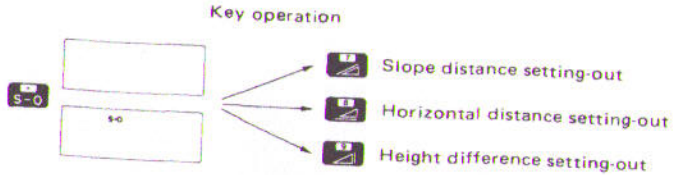


Fig. 10.31

Example: Horizontal distance setting-out measurement when setting-out data is 90.5 m

a. Entry of setting-out data

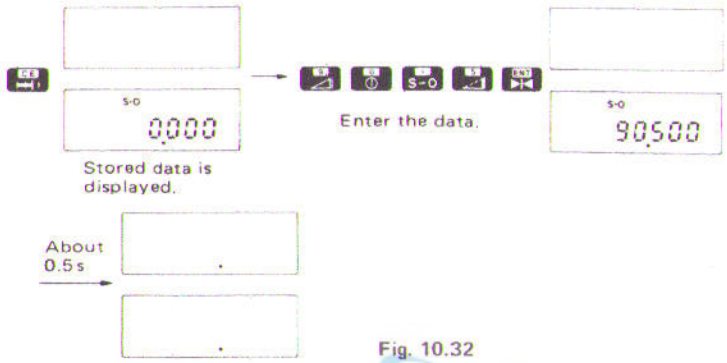


Fig. 10.32

b. Measurement

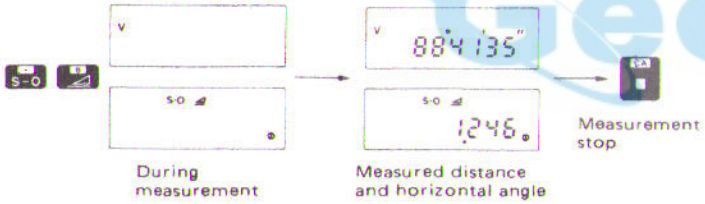


Fig. 10.33

The measured horizontal distance is 1.246 m longer than the setting-out data (90.5 m).

10.4.3 Remote elevation measurement

At certain surveying points e.g. power transmission lines or cables supporting bridges, etc., a reflecting prism cannot usually be positioned. In such cases the remote elevation measurement makes height differences easy to measure.

$$h = h_1 + h_2$$

$$h_2 = S\,(\sin\theta_{Z1} \times \cot\theta_{Z2} - \cos\theta_{Z1})$$

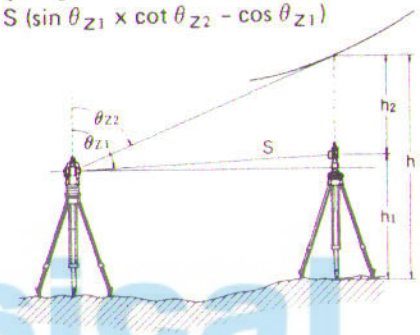


Fig. 10.34

1) Between the ground and the object

a. Set up a reflecting prism under the object and measure the prism centre height from the ground with a tape measure.
- Use an optical plummet to set the prism accurately.

b. Enter the height, h_1 measured in step a., as a positive value, as stake-out data.
Example: The prism centre height from the ground is 1.523 m

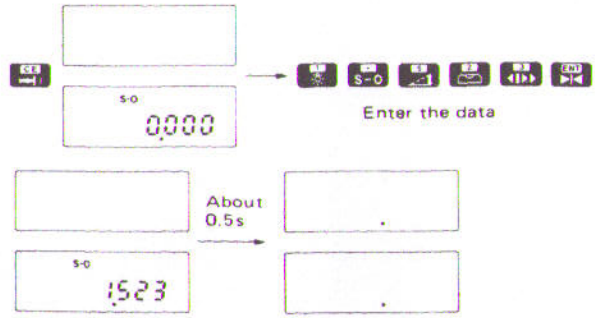


Fig. 10.35

c. Sight the reflecting prism and press [MEA].
Press [CA] after the distance measurement data is displayed.

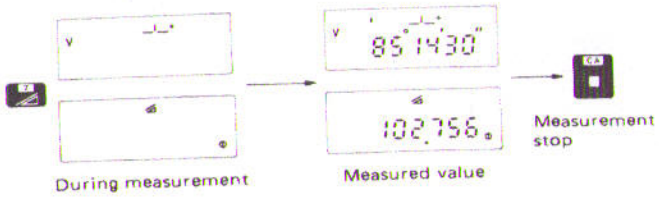


Fig. 10.36

- The measured value is stored in the SET4A.

d. Press [S-O], then [MEA].

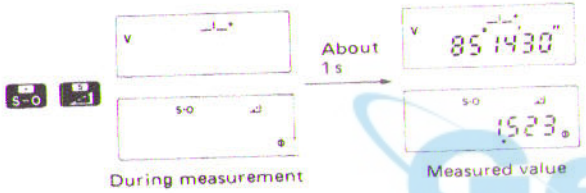


Fig. 10.37

- When the SET4A is sighted on the prism, the height, h_1, measured with a tape measure (the prism height from the ground) will be displayed.

e. Sight the object. The object height from the ground, h, will be displayed in the lower display.

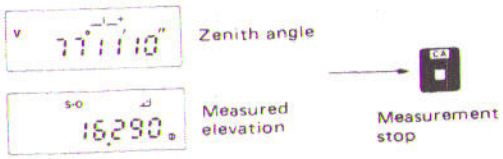


Fig. 10.38

- The range of measurement is between vertical angles of -89° (-98 gon) and 89° (98 gon).

10.4.4 Measurement of horizontal distance between two target points

Horizontal distance L and height difference H between two points can be measured.

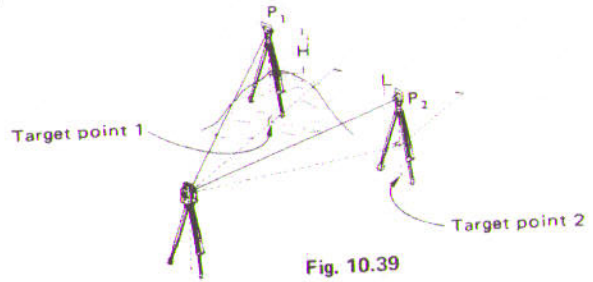


Fig. 10.39

1) Set up the reflecting prisms P_1, P_2, on target points 1, 2.
2) Sight the prism P_1 and press [MEA].
Press [CA] after the distance measurement data is displayed.

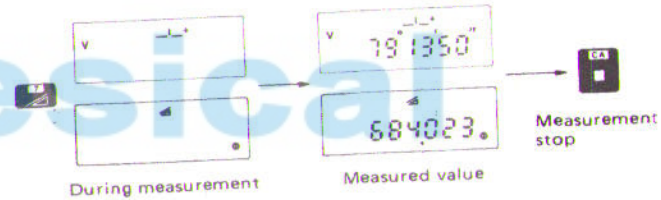


Fig. 10.40

- The measured value is stored in the SET4.

3) Sight the prism P_2 and press [MEA].

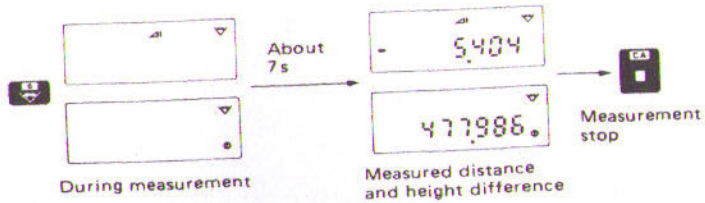


Fig. 10.41

11. SELF DIAGNOSIS

If there is any fault in the measuring function, the error codes shown in the following table will be displayed.

Display	Meaning	Action
b. dEd	Battery voltage is too low.	Replace the battery with a charged one, or charge the battery.
E 100	*Error when measuring a horizontal angle.	Reset the horizontal angle to 0° (0 gon).
E 101	*Error when measuring a zenith angle.	Index the vertical circle again.
E 115	Compensator range error. Tilt angle exceeds -3'.	Level the SET4A again.
E 117	Compensator range error. Tilt angle exceeds +3'.	
E 200	Incoming reflected light decreased during measurement. Incoming reflection was disturbed.	Sight the reflecting prism again. Increase the number of reflecting prisms for long distances.
S. OFF E 201	Incoming reflection is totally absent when the instrument is ready for distance measuring.	Measure the distance again confirming the condition with the return signal lamp or sound.

Display	Meaning	Action
E 206	Error when measuring the initial slope distance during either remote elevation or horizontal distance between two points measurement.	Sight the reflecting prism and perform slope distance measurement again.
E 207	During remote elevation measurement, the vertical angle is more than ±89° (±98 gon) or the measured distance is more than ±9,999.999 m.	Press [CE] to stop measuring.
E 208	The measured distance is more than ±19,999.999 m (±19,999.99 ft).	Press [CE] to stop measuring.

* If the SET4A is rotated faster than four revolutions per second, the error indication "**E100**" or "**E101**" is displayed.

When the error indication "**E**" appears with any number other than the ones above, please contact our agent.

13. CHECKS AND ADJUSTMENTS

It is important that the SET4A is periodically checked and adjusted. In addition, the instrument should be checked after transportation, long storage or when damage to the instrument is suspected to have occurred. The checks should be performed as follows:

13.1 ANGLE MEASURING FUNCTION

13.1.1 Plate level
13.1.2 Circular level
13.1.3 Index error of the tilt angle sensor
13.1.4 Reticle adjustments
  a) Perpendicularity of the reticle to the horizontal axis
  b) Vertical and horizontal reticle line positions
13.1.5 Coincidence of the distance measuring axis with the reticle
13.1.6 Optical plummet

13.1.1 Plate level

The glass tube of the plate level is sensitive to temperature change or shock. Be sure to check the plate level ㉘ before use.

1) See Figs. 13.1 and 13.2 for relation between bubble movement and rotation of the levelling foot screws.

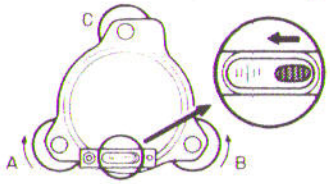


Fig. 13.1

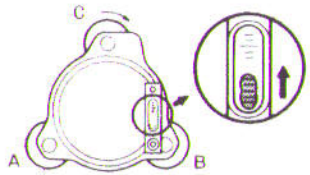


Fig. 13.2

2) Turn the upper part of the SET4A until the plate level is parallel to a line between levelling screws A and B. Then centre the bubble using levelling screws A and B.

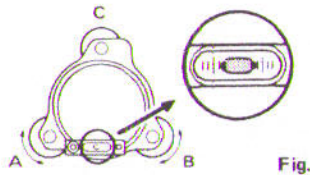


Fig. 13.3

3) Turn the upper part 90° (100 gon) until the plate level is perpendicular to a line between levelling screws A and B. Then centre the bubble by turning levelling screw C.

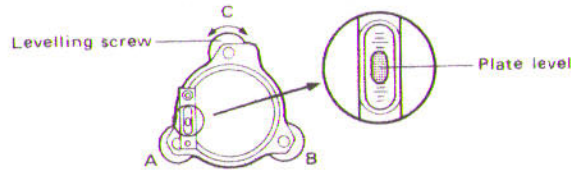


Fig. 13.4

4) Turn the upper part 180° (200 gon). Correct any bubble deviation by half the amount with levelling screw C.

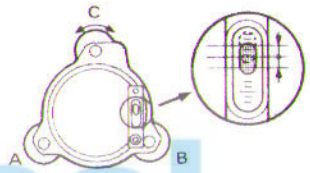


Fig. 13.5

5) Correct the remaining half deviation by turning the plate level adjusting screw ㉙ with the adjusting pin.

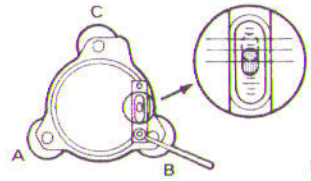


Fig. 13.6

6) Repeat 2) to 5) above until the bubble remains centred for any position of the upper part.

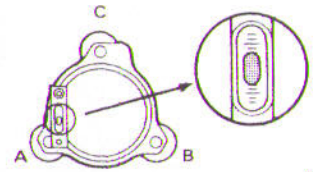


Fig. 13.7

13.1.2 Circular level

When the plate level adjustment is complete, the circular level ⑩ should be checked. Note the direction off-centre of the bubble. Loosen the adjusting screw ⑨ farthest from that direction and tighten the other adjusting screws to centre the bubble. Ensure that the tension of the each screw tightening is the same after adjustment.

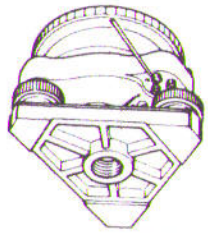
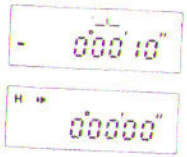


Fig. 13.8

13.1.3 Index error of the tilt angle sensor

When the circular level adjustment is complete, the index error should be checked.

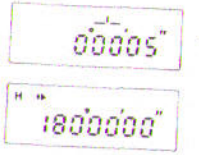
1) After indexing the vertical circle, tighten the vertical clamp ㉚.
2) Press SET then HOLD to set the horizontal circle to zero, then press V/% to display the tilt angle.



Tilt angle a = -10"

Fig. 13.9

3) Loosen the horizontal clamp and turn the upper part through 180°±5' (200 gon±0,1 gon).



Tilt angle b = 5"

Fig. 13.10

4) Calculate $\frac{a+b}{2}$ = index error c

Example: $\frac{-10" + 5"}{2} = -2.5"$

5) If the index error is less than 5", no adjustment is necessary.

For adjustment, remove the sensor index adjustment cover ⑳.
Return to 0° horizontal angle position.
Using a suitable flat screwdriver, adjust the internal screw until the upper display $d_{0°} = a - c$.
Turn the upper part through 180°.
Adjust the internal screw until the upper display $d_{180°} = b - c$.

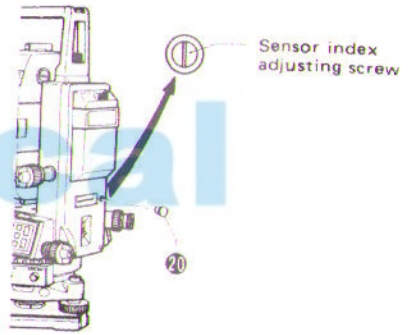


Fig. 13.11

Example:

If a = -20", b = -10", index error $c = \frac{-20" + (-10")}{2} = -15"$

$d_{0°} = a - c = -5"$
$d_{180°} = b - c = +5"$

Replace the sensor index cover.
Press V/% again to return to theodolite mode.

13.1.5 Coincidence of the distance measuring axis with the reticle

After the reticle has been checked, check the distance measuring axis relative to the reticle as follows.

1) Level the SET4A. Set up the reflecting prism at a horizontal distance of 50 to 100 m.

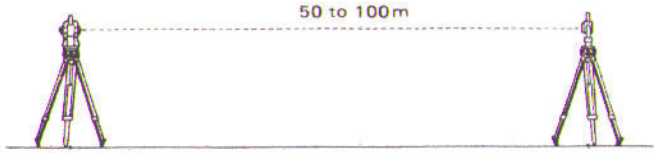


Fig. 13.20

2) Sight the reflecting prism centre and take the horizontal and zenith angle readings. (H and Z respectively)

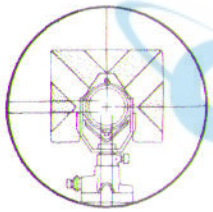


Fig. 13.21

3) Press [SHV] on the keyboard and make sure the return signal lamp ⑬ lights up.
4) Four more readings are necessary.
   Turn the horizontal or vertical fine motion screw slowly until the return signal lamp goes off. Then take readings.
   Readings H_l, H_r: when the telescope is directed to the left (right) of the sighted direction in 2) above.
   Readings Z_a, Z_b: when the telescope is directed above (below) the sighted direction in 2) above.
5) Check the differences of H_l (H_r) against H, and Z_a (Z_b) against Z.
   When the four differences obtained are larger than 3' (0.056 gon), the coincidence is normal. If any of the differences obtained are less than 3' (0.056 gon), please contact an authorized service facility for repair.

13.1.6 Optical plummet

1) Level the SET4A. Centre a surveying point in the reticle of the optical plummet. Loosen the horizontal clamp and turn the upper part through 180° (200 gon). If the surveying point is still centred, no adjustment is necessary.
2) If the surveying point is off-centre, correct half the deviation with the levelling screws, and correct the remaining half with the four adjusting screws. The screw adjusting procedure is the same as the reticle adjustment 9) on page 51.

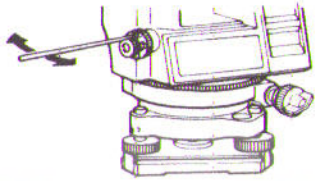


Fig. 13.22

3) Repeat the adjustment if necessary.

13.2 DISTANCE MEASURING FUNCTION

13.2.1 Check flow chart

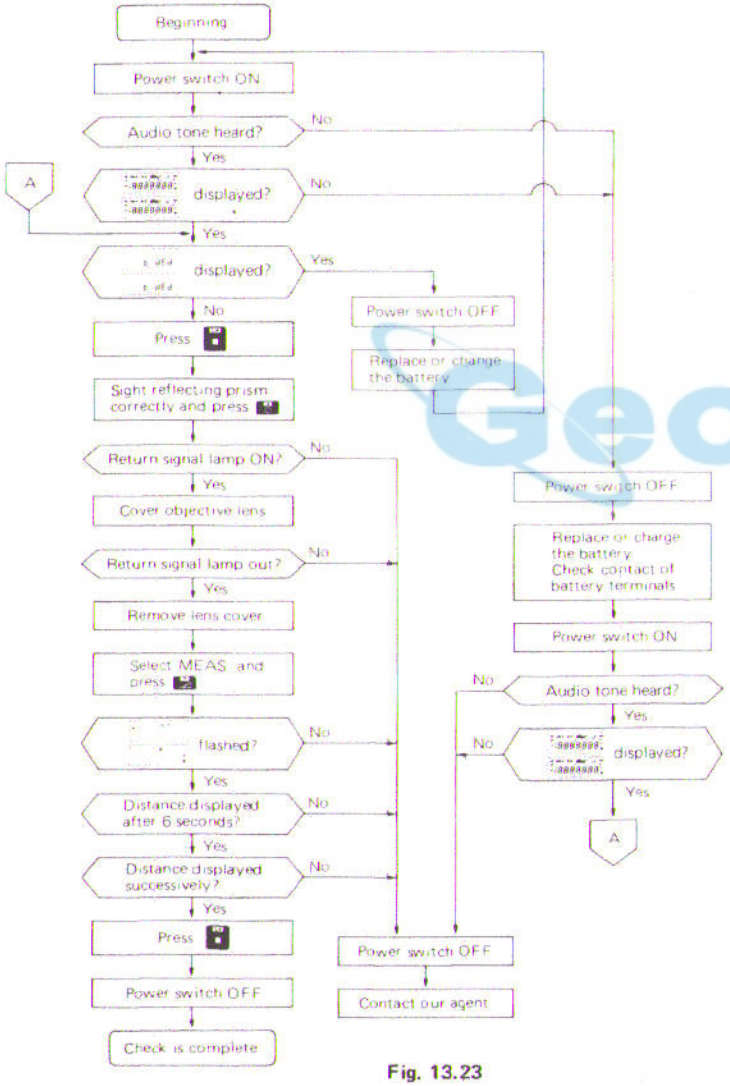


Fig. 13.23

13.2.2 Additive distance constant

The additive distance constant of the SET4A is adjusted to 0 before delivery. However, the additive constant can change with time and so should be determined periodically and then used to correct distances measured.

1) Determining the additive distance constant.
   The most reliable method of determining the additive distance constant is to test the SET4A on an established base line with a maximum range of approximately 1,000 m, and with 6 to 8 intermediate stations spaced at multiples of the instrument unit length, which is 10 m. Measurements should be taken in all combinations of the 6 to 8 stations.
   If an additive distance constant of greater than 5 mm is found please contact our agent.
2) Confirmation of the additive distance constant K if a base line is not available.
   a. Select points A and B on flat ground about 100 m apart, and C in the middle.
   b. Set up the SET4A at A, and measure the distance AB.
   Note: Be sure prism height is the same as the height of the SET4A objective lens centre. If ground is not level, use an automatic level to set correct instrument heights of all points.

Fig. 13.24

c. Shift the SET4A to C, and measure the distance CA and CB.

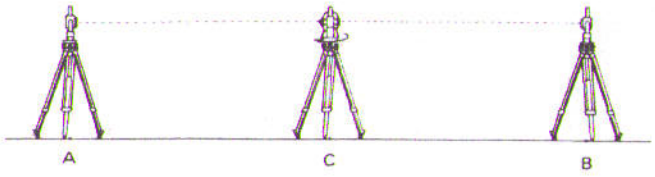


Fig. 13.25

d. Compute the additive distance error K using the formula:

$$K = \overline{AB} - (\overline{CA} + \overline{CB})$$

$\overline{AB}$, $\overline{CA}$, $\overline{CB}$: Average of ten measurements.

e. Obtain K value three times. If all K are greater than 5 mm, contact our agent.

14. FOR ANGLE MEASUREMENT OF THE HIGHEST ACCURACY

14.1 MANUALLY INDEXING VERTICAL CIRCLE BY V1, V2

Like every theodolite, the SET4A will have a vertical index error. A vertical index error can be removed as follows.

1) Turn the power OFF, remove the internal switch cover ❹ and set switch 6 to ON.
   (When switch 6 is ON, the automatic indexing of the vertical circle by transitting the telescope is inactive.)
2) After levelling the SET4A, turn the power ON and make sure that the display appears as shown below.

Fig. 14.1

3) In position V1, accurately sight a clear target at a horizontal distance of about 30 m.

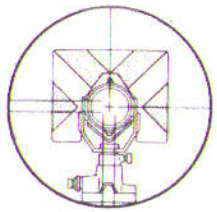


Fig. 14.2

4) Press SET then HOLD.

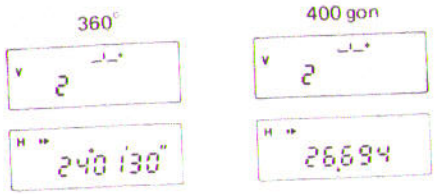


Fig. 14.3

5) Next in position V2, accurately sight the same target.

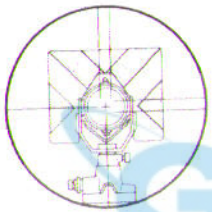


Fig. 14.4

6) Press SET then HOLD. When the vertical circle is indexed, the display appears as below.

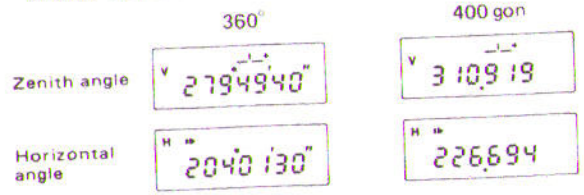


Fig. 14.5

- If the power switch has been turned OFF, the vertical circle must be indexed again.
  When moving the SET4A after measurement, turn the power OFF.

15. FOR DISTANCE MEASUREMENT OF THE HIGHEST ACCURACY

15.1 ACCURACY OF MEASUREMENT OF ATMOSPHERIC CONDITIONS

The relation between measured distance and the velocity of light is given by

$$D = \frac{T}{2} C = \frac{T}{2} \frac{C_o}{n}$$

T: The period between light emission and reception.
C: The velocity of light in the air.
C_o: The velocity of light in a vacuum.
n: Refractive index of the air.

The measured distance is affected by variation in the refractive index

$$\frac{dD}{D} = -\frac{dn}{n} \fallingdotseq dn \quad (\text{or } dD \fallingdotseq D \cdot dn)$$

Therefore, the accuracy of measurement of the refractive index must be the same as that of the measured distance.
To calculate refractive index to an accuracy of 2 ppm, temperature must be measured to within 1°C and pressure to within 5 mmHg.

15.2 TO OBTAIN THE ATMOSPHERIC PRESSURE

To obtain the average refractive index of the air throughout the measured light path, you should use the average atmospheric pressure.
If flat terrain there is little variation in the atmospheric pressure. In mountains, the following calculation should be used.

Example:

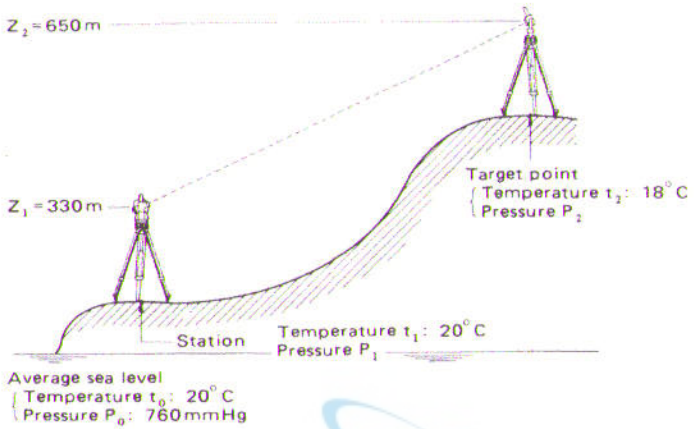


Fig. 15.1

By the Laplace formula

$$Z_n - Z_0 = 18{,}400\left(1 + 0.00367\,\frac{t_n + t_0}{2}\right)\mathrm{Log}\,(P_0/P_n)$$

t: Temperature (°C)
Z: Height above sea level (m)
P: Pressure (mmHg)

$$P_n = 10^{\left\{\mathrm{Log}\,P_0 - \frac{Z_n - Z_0}{18{,}400\left[1 + 0.00367\left(\frac{t_n + t_0}{2}\right)\right]}\right\}}$$

P_0 = 760 mmHg Z_1 = 330 m Z_2 = 650 m
t_0 = 20°C t_1 = 20°C t_2 = 18°C

$$P_1 = 10^{\left\{\mathrm{Log}\,760 - \frac{330}{18{,}400\,(1 + 0.00367 \times 20)}\right\}} \fallingdotseq 731$$

$$P_2 = 10^{\left\{\mathrm{Log}\,760 - \frac{650}{18{,}400\,(1 + 0.00367 \times 19)}\right\}} \fallingdotseq 704$$

Average pressure: 717.5 mmHg

16. PRECAUTIONS AND MAINTENANCE

16.1 PRECAUTIONS

1) When the SET4A is not used for a long time, check it at least once every three months.
2) Handle the SET4A with care. Avoid heavy shocks or vibration.
3) If any trouble is found on the rotatable portion, screws or optical parts (e.g. lens), contact our agent.
4) When removing the SET4A from the carrying case, never pull it out by force. The empty carrying case should then be closed to exclude dust.
5) Never place the SET4A directly on the ground.
6) Never carry the SET4A on the tripod another site.
7) Protect the SET4A with an umbrella against direct sunlight, rain and humidity.
8) When the operator leaves the SET4A, the vinyl cover should be placed on the instrument.
9) Do not aim the telescope at the sun.
10) Always switch the power off before removing the internal battery.
11) Always remove the battery from the SET4A when returning it to the case.
12) Do not wipe the display ❺, keyboard ⓯ or the carrying case with an organic solvent.
13) When the SET4A is placed in the carrying case, follow the layout plan.
14) Make sure that the SET4A and the protective lining of the carrying case are dry before closing the case.
The case is hermetically sealed and if moisture is trapped inside, damage to the instrument could occur.

16.2 MAINTENANCE

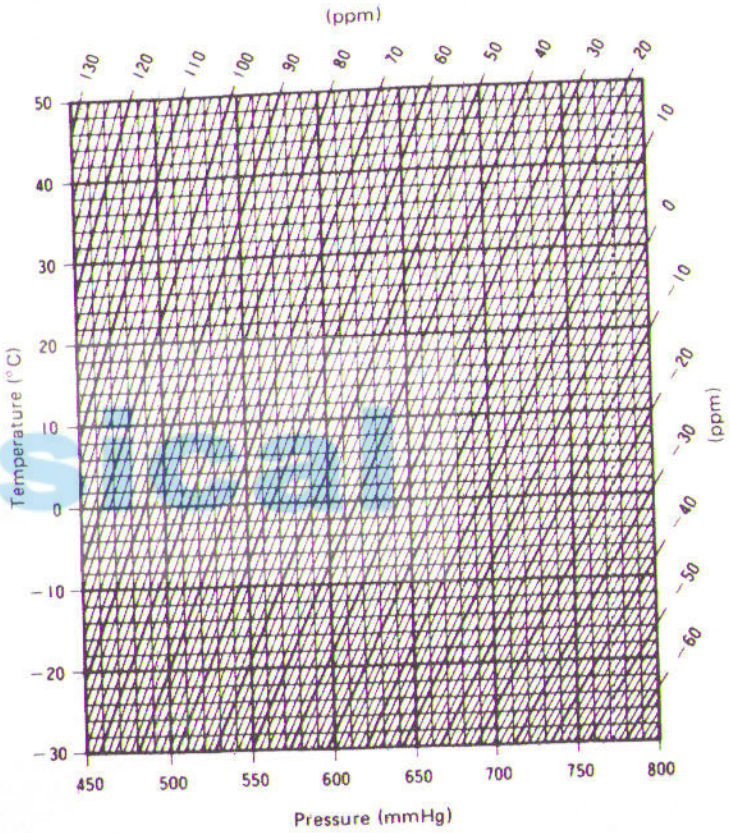
1) Wipe off moisture completely if the instrument gets wet during survey work.
2) Always clean the instrument before returning it to the case.

> The lens requires special care. Dust it off with the lens brush first, to remove minute particles. Then, after providing a little condensation by breathing on the lens, wipe it with soft clean cloth or lens tissue.

3) Store the SET4A in a dry room where the temperature remains fairly constant.
4) If the battery is discharged excessively, its life may be shortened. Store it in a charged state.
5) Check the tripod for loose fit and loose screws.

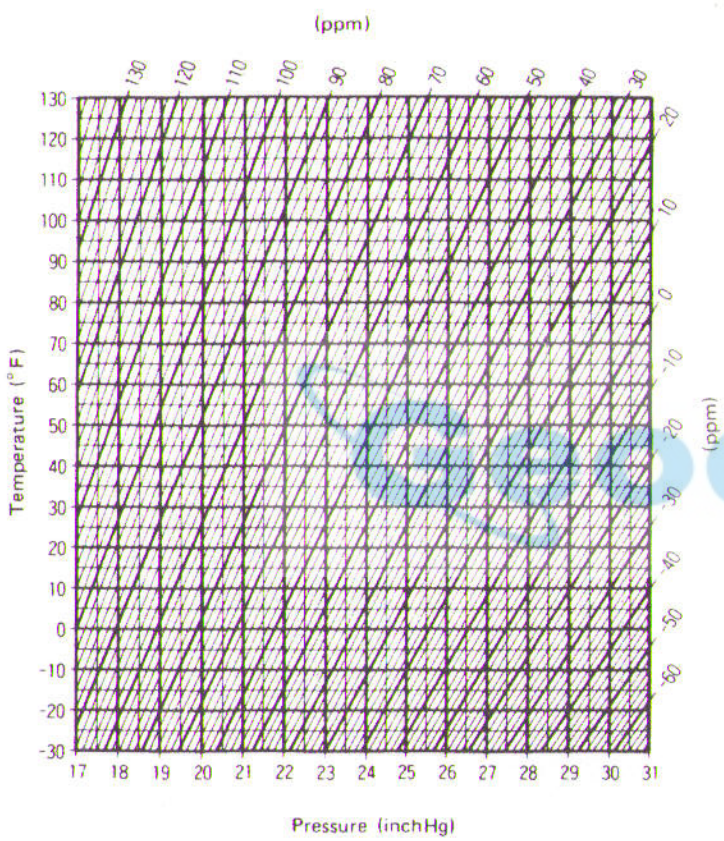
17. ATMOSPHERIC CORRECTION CHARTS

(Metric)



The chart shows the correction every two ppm, while the atmospheric correction can be applied to the SET4A for every ppm.

(English)



The chart shows the correction every two ppm, while the atmospheric correction can be applied to the SET4A for every ppm.

The specifications and general appearance of the instrument may be altered at any time and may differ from those appearing in catalogues and the operator's manual.

18. INDEX