FLM4 DIFlux

User manual

07/2021 Rev.1

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Overview

The FLM4 DIFlux is a precision instrument used for determining the orientation of the geomagnetic field vector. Operated with care, this DIFlux is able to determine the geomagnetic field declination and inclination with an accuracy of a few arcseconds.

The FLM4 DIFlux mainly comprises a TDJ6E-NM non magnetic theodolite, manufactured by BOIF company, a fluxgate magnetometer, and the associated electronics.. It can be installed on a tripod equipped with a flat top and 5/8" securing bolt. Alternatively, it can be installed on a pillar equipped with 120° V-grooves by mounting a special tribrach underplate (optional).

The FLM4 embeds a GPS receiver for UTC timing and WGS84 geopositioning. Additionally, in order to ease sun shots, the onboard software is able to calculate the Sun's azimuth to the nearest arcsecond for any epoch and from any position on Earth.

A digital data logger, able to record the fluxgate output at a 1 sample/minute rate is included. Therefore, the DIFlux can work as a temporary recording magnetic station. A typical use is on-site recording for correction of the diurnal variation.

Figure 1 FLM4 DIFlux Overview

Description

1. Theodolite TDJ6E-NM (Operating Manual in Annex 1)

This theodolite includes:

a) Foot screws
b) Lock knob of tribrach
c) Optical plumb
d) Wheel for circle changing
e) Vertical axis clamp
f) Fine tuning of the vertical axis
g) Horizontal axis clamp
h) Fine tuning of the horizontal axis
i) Locking knob for compensator
j) Telescope lens
k) Telescope sharpness adjustment
l) Sharpness adjustement
m) Circle reading optics
n) Circle readings sharpness adjustement
o) Light mirror for reading
p) 1 axis level
q) Bull eye level
r) Diagonal eyepieces
s) Tools

2. FLM4 Electronics

1. Power switch (On/OFF)
2. Select button up
3. Select button down
4. Select button OK
5. Screen
6. Battery charger socket PJ1
7. Green led
8. Blue led
9. Fluxgate connector
10. Data transfer connector
11. Sunshot add-on connector

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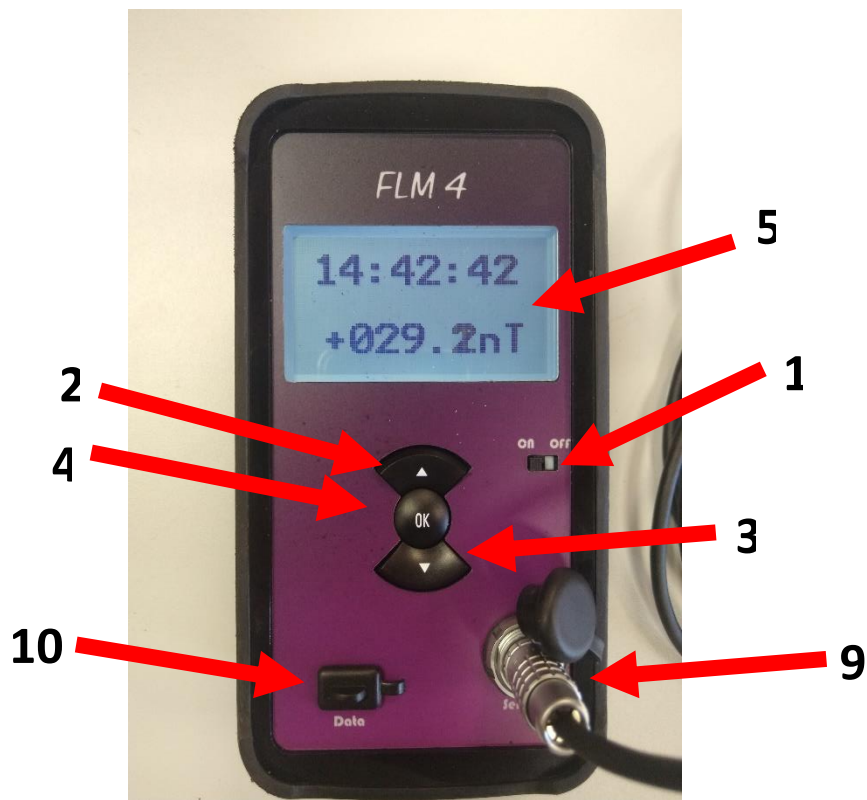
Figure 2: FLM4 electronics. A convenient foot is foreseen (operate according to markings 1 & 2)

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Standard equipment and optional accessories

Figure 3 FLM4 DIFlux in its carrying case

Non-magnetic theodolite TDJ6E-NM 1 pc
Instrument carrying case 1 pc
Dust Cover 1 pc
Objective Cover 1 pc
Plummet 1 pc
Adjustment Pins 2 pcs
Soft Hair Brush 1 pc
Lens Cloth 1 pc
Desiccant 1 pc
Connector sensor 1 set
Non-magnetic steep angle prism 1 set
Non-magnetic reading diagonal eyepiece 1 pc
Non-magnetic telescopic diagonal eyepiece 1 pc
Non-magnetic tool bag 1 set
Electronics, including Pandect fluxgate sensor 1 pc
Battery charger 1 pc
Underplate (optional)
Non magnetic tripod (optional)
Sunshot add-on (optional)
User manual 1pc
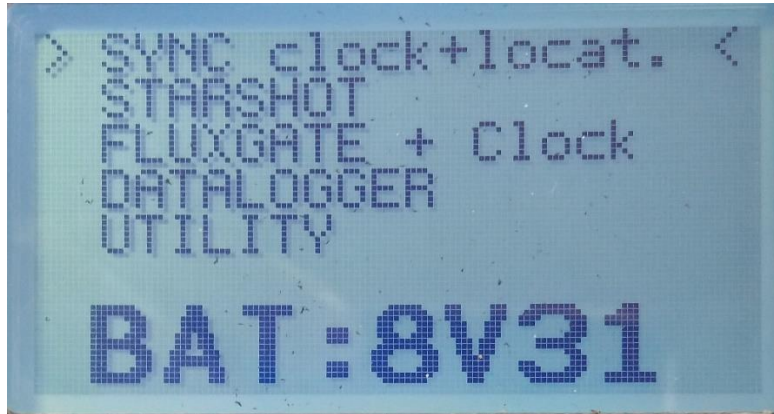
Display Menu: overview (software 2 v 6)

Figure 4: FLM4 Data logger main menu

Use power switch to power the FLM4.

Upon switching on the magnetometer console, the battery level in Volts is displayed, prompting adequate action if charging is needed (see below "Battery charging").

Navigate through the menu (and submenus) using the up/down button, and confirm your selection by pushing on the select button. The main menu and submenus are:

1. SYNC clock+locat.
2. STARSHOT
    1. MANUAL SHOT
        1. SUN
        2. POLARIS
    2. AUTOMATIC SHOT (only for the sun, with sunshot add-on)
3. FLUXGATE + Clock
4. DATALOGGER
    1. WRITE DATALOGGER
    2. READ DATALOGGER
    3. ERASE DATALOGGER
    4. SEND DATA TO PC
5. UTILITY
    1. BACKLIGHT ON
    2. BACKLIGHT OFF
    3. BKL INTENSITY

To go back in the menu, keep pressing on the select button OK

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Synchronization of clock and positioning by GPS

After switching ON, before the start of a measurement, the console clock must be synchronized to UTC by running the "SYNC clock+locat." utility. This is done by GPS satellites and needs a clear view to the sky. It may be necessary to do it first slightly remotely, for instance if buildings are present.

After selecting the menu "SYNC clock + locat", acquisition of satellites will start and the message "GSA valid wait…" appears on the screen. Then, "GSA data ok" announces successful GPS data transmission. "Sync.OK" then confirms succesful clock synchronization. The RTC as well as the GPS time from the receiver are displayed. If this does not happen, your satellite coverage is probably bad and another open location should be considered.
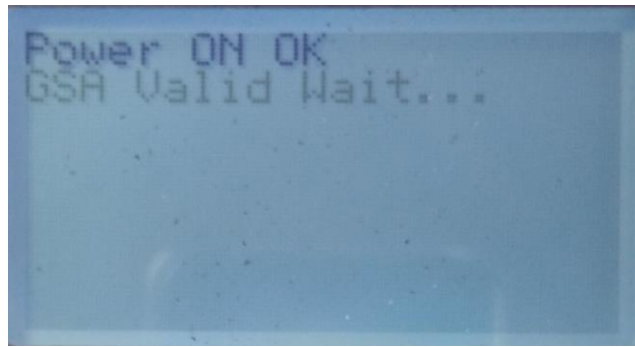

Figure 5: Satellites acquisition in progress (power ON ok confirms the GPS is ON)

If the number of available satellites is lower than 7, or if the RTC and GPS time differ, it is recommended to wait for more satellites and then perform another synchronization by a short press on "Select button OK".

After sync, the display also gives the local WGS84 latitude and longitude and the number of observed satellites.

If # Valid Sats remains lower than 7, try to find a better reception location. For precise timing, ensure that at least 8 satellites are considered.

The console clock has a typical timing drift better or equal than 2s/day.

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Starshot

Before performing a star shot, ensure that the console clock has been synchronized as previously explained. Remember a rule of thumb: "1 second in time is 10 arcseconds in azimuth".
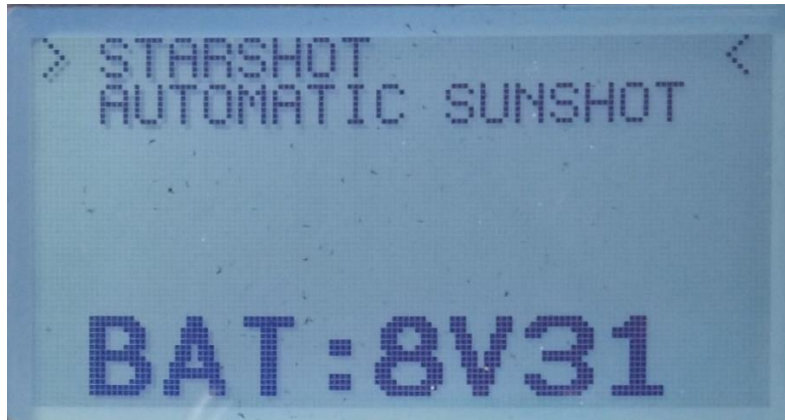

Figure 6: Starshot menu (automatic sunshot needs sunshot add-on, not yet available)

1. Manual shot

Manual shot can refer to the SUN or to POLARIS

Figure 7: manual shot menui

The manual method requires the observer to point the telescope to the center of the star and to record the UTC time.

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!!!WARNING!!!

CAUTION FOR SUNSHOT: never point to the Sun with the naked eye! This will cause eye injury.

Two different procedures are recommended:

1. Mount a solar filter onto the telescope ocular and use this set-up to point to the sun.
2. Project the sun image through the telescope onto a white paper sheet 20cm or so behind the ocular and normal to the sunrays. The focus and reticule should be adjusted to have a sharp image of both the Sun and the reticule.

!!!WARNING!!!

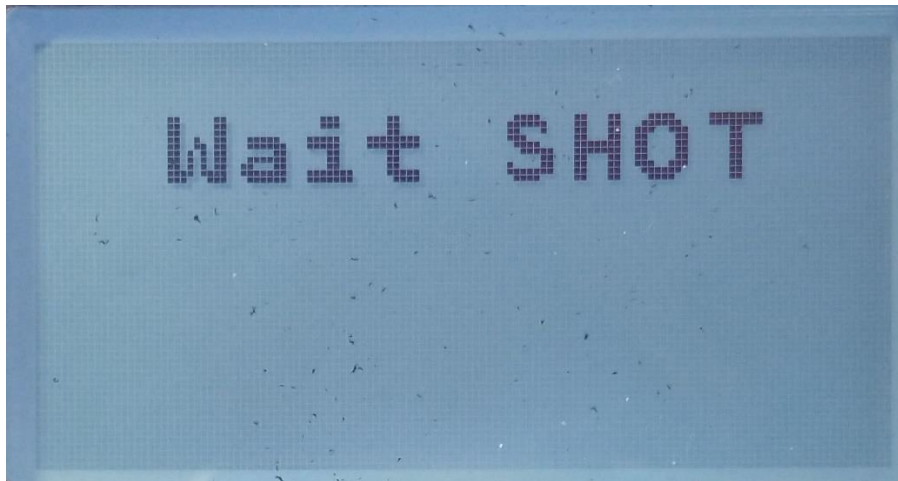When you have selected the Sun or Polaris, the message "Wait SHOT" appears and blinks.

Figure 8: the FLM4 is ready for a Sun or Polaris shot

When the optical axis of the telescope is oriented to the sun/star, press the selection button. This latches the UTC time and brings into view on the display (Figure 8):

- o The star you have chosen
- o Azimuth of the sun/star (+/-180°) in degrees, minutes, seconds to 0.1" at this time and location
- o UTC date
- o UTC time to 0.01s
- o WGS84 local latitude in degrees, minutes, seconds to 0.001"
- o WGS84 local longitude in degrees, minutes, seconds to 0.001"
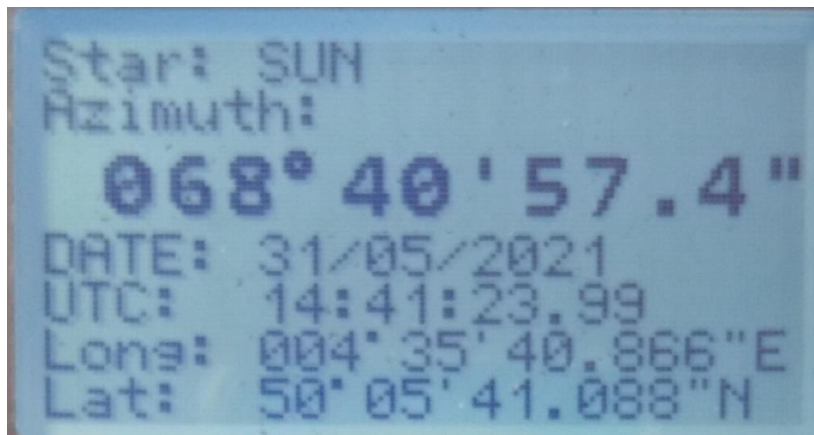
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Figure 9: After a sun shot, the time and date of the shot as well as the latitude and longitude are displayed. The azimuth of the sun for this time and location is shown at the bottom of the screen.

The Sun / Polaris is now a target whose precise azimuth is known and the azimuth of whatever fixed target in view can easily be measured and computed.Another shot can now be initiated by a short press on the select button, which will bring the blinking "Wait SHOT" back into view.

2. **Automatic**

This requires the optional sunshot add-on to be available and mounted on the theodolite eyepiece ocular. The add-on cable should also be connected to the console to power the add-on and allow data transfer. To know more about this option, please refer to the paper[1] "Semiautomatic sun shots with the WIDIF DIflux" .

Figure 10: Sunshot add-on is required for automatic sunshot (please contact us if interested)

[1] Rasson, J. L., Hendrickx, O., and Marin, J.-L.: Semiautomatic sun shots with the WIDIF DIflux, Geosci. Instrum. Method. Data Syst., 6, 257-261, https://doi.org/10.5194/gi-6-257-2017, 2017.

Fluxgate magnetometer and Clock

Select the menu "FLUXGATE + Clock", the fluxgate electronics displays the magnetometer output value on the LCD display along with the UTC time in 24h format to the nearest second.

The magnetometer output "*L*" can be expressed as the scalar product of the measured magnetic field vector "*F*" and a unit vector "*E*" along the fluxgate sensor axis, multiplied by the scale factor K:

$$\text{Magnetometer output [nT]} = L = K(\boldsymbol{F}\bullet\boldsymbol{E})$$

The scale factor K has been designed to 1 nT per display unit.

The noise level of the fluxgate magnetometer is about 0.1nT pk-pk in the ½ Hz-DC bandwidth, making geomagnetic field orientation measurements meaningful at the 1 arcsecond level. Indeed, when performing the standard DIflux measurement protocol, the fluxgate sensor output changes dD[nT] and dI[nT] can be related to angular units for the magnetic declination D and inclination I by the formulas:

$$\delta D[°] = atan(dD/H) \quad \delta I[°] = atan(dI/F),$$

where H and F are the horizontal component and modulus of the geomagnetic field respectively. For instance a 0.1nT output change during the D measurement step will reflect a 1.03 arcsecond rotation in a horizontal field of 20000 nT.

Data logger

The FLM4 can work as a temporary recording single axis magnetic station. A typical use is on-site recording for correction of the diurnal variation.

The digital data logger is able to record 660 fluxgate outputs at a 1 sample/minute rate, which corresponds to 11 hours of record. Minute samples are taken at the round minute with timestamp hh:mm:00 with no averaging taking place.

To start, select menu item DATALOGGER and press OK. The following menu appears:
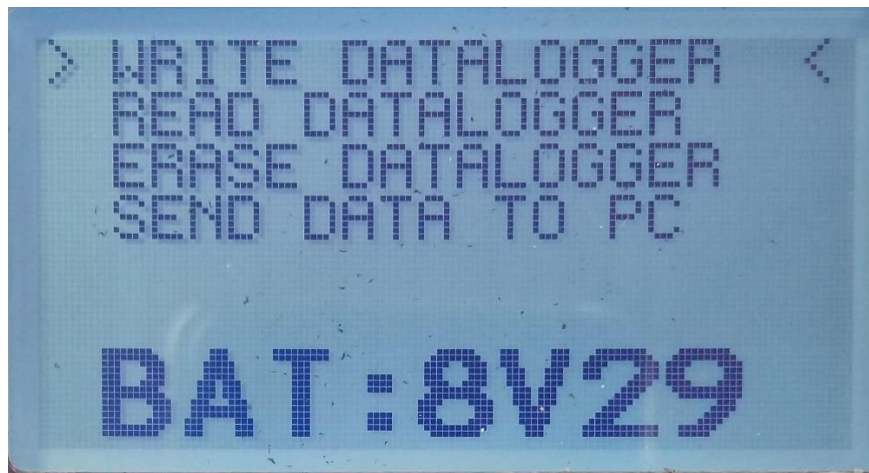
Figure 11: Data logger menu

- WRITE DATALOGGER
- READ DATALOGGER
- ERASE DATALOGGER
- SEND DATA TO PC

WRITE DATALOGGER

The data logging will start at once after selecting this command. The blinking message "WRITE DATA" informs that the recording is ongoing. The current 1Hz data is displayed along with the UTC time. The battery voltage is displayed and the remaining free memory is shown by the fraction nnn/660. If the memory contains previous data, the new data will be appended. Please note the date is not recorded by the logger. When 660 data have been recorded, the acquisition will stop and a "memory full" message will be displayed.
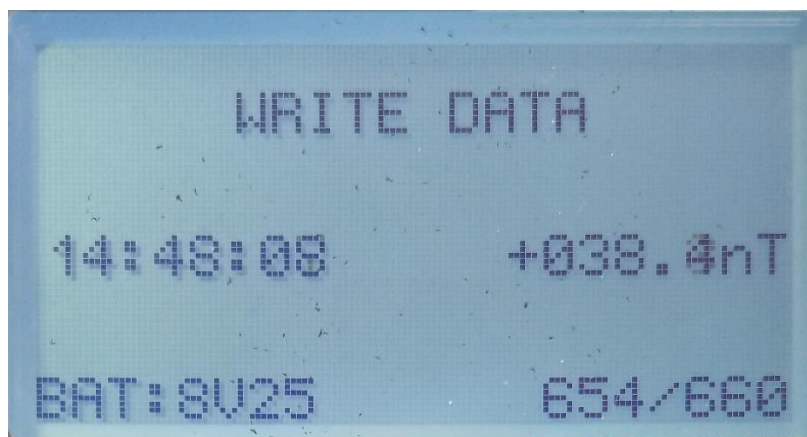

Figure 12:Write Data Logger shows UTC Time, 1Hz data, battery voltage and memory status

The recording can be paused at any time by a long press on OK. The command WRITE DATALOGGER must be issued again to continue the recording.

The data are stored in flash memory and will not be erased when the console is switched off.

READ DATALOGGER

When this command is selected, the logged minute data is displayed with its UTC timestamp. This is useful to inspect some of the acquired data. For accessing and processing a larger amount of data, use the command SEND DATA TO PC.
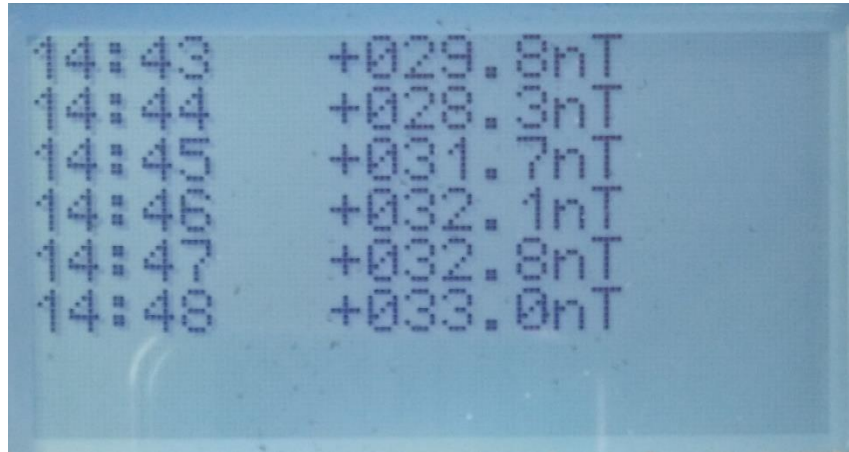

Figure 13: Read data logger displays minute data in UTC time

The screen displays up to 8 data. Previous or later data can be accessed by pressing the up or down arrow keys to display the previous or later data respectively.

Exit the data inspection at any time by a long press on OK. Data will remain in memory.

ERASE DATALOGGER

When selected, this command will flash the message: "ERASE DATA", and propose the answer "NO". Using the up arrow key, you can change the answer to "YES". If you really want to erase, press the "OK" key, and this will erase all logged data.
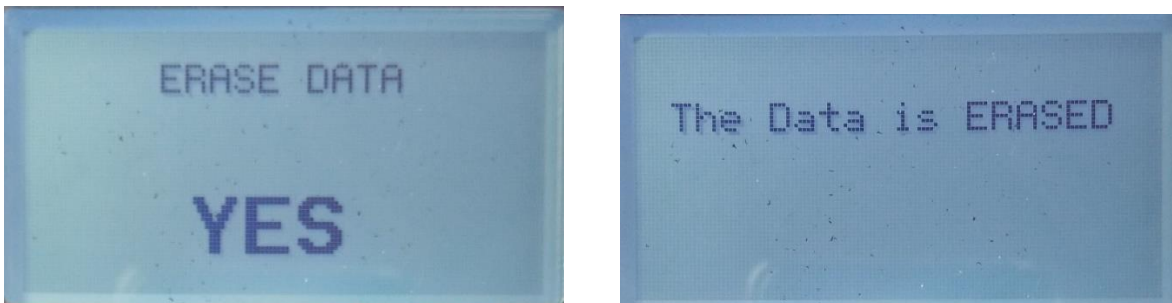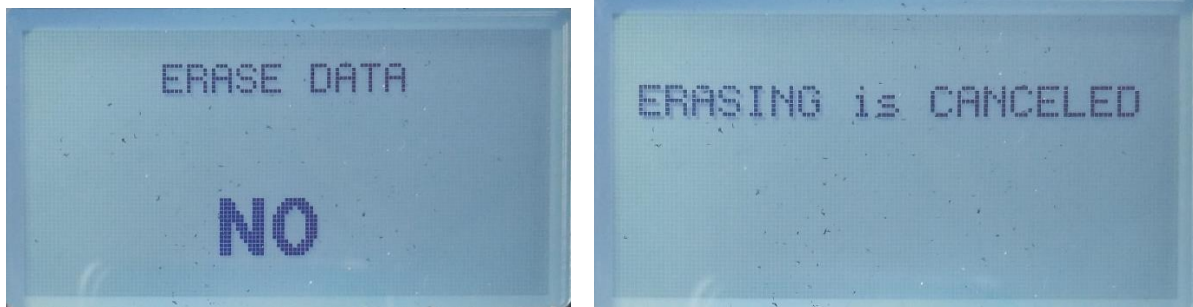

Figure 14: Erase data

Figure 15: Cancel Erase data

Exit the Erase Datalogger menu by a long press on OK.

<u>SEND DATA TO PC</u>

Use the dedicated cable (included) to connect the console to the Windows PC (USB is for PC connection).

1. *Installing the driver*

In a Windows 10 environment, tconnecting the console to the computer will trigger automatic installation of the driver. Nothing must be done except leave enough time for the PC to complete the installation.

With older computers or if the automatic installation does not proceed, the Windows driver for the *microchip* UART in the console is available at the website:
http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=adm00559 where you must select the download: "`MCP2200/MCP2221 Windows Driver & Installer`". Copy and unzip your download to a known located folder. Do **not** run the installer. Upon connecting the console to the USB port of your computer, a wizard will start and possibly ask for the location of the driver. Indicate the subfolder of the above folder as `x64` or `x86` for a 64 bit or 32 bit PC OS respectively.

2. *Transferring the file*

Use a terminal program such as Tera-Term, available for free at: http://download.cnet.com/Tera-Term/3055-2094_4-75766675.html?tag=pdl-redir . Select the serial mode and configure the serial setup as 57600 baud, 8 bits, no parity, 1 stop bit, no flow control. In the Port combo box you may have a choice between several COM ports; usually the port with the highest value should be selected; some experimentation may be necessary including inspection of the Windows Device Manager at the line "Ports". Experiment by manually connecting and disconnecting the console to the USB port and look at which line is added/removed in the Device Manager.

Once a connection is established, the `SEND DATA TO PC` command can be utilized and the complete data memory content will be sent and appear in the Tera-Term window. This data can then be manipulated (copy/paste) for further processing.

Figure 16: Data transfer completion is announced

Utility

In order to ease reading, the screen backlight intensity can be adjusted.
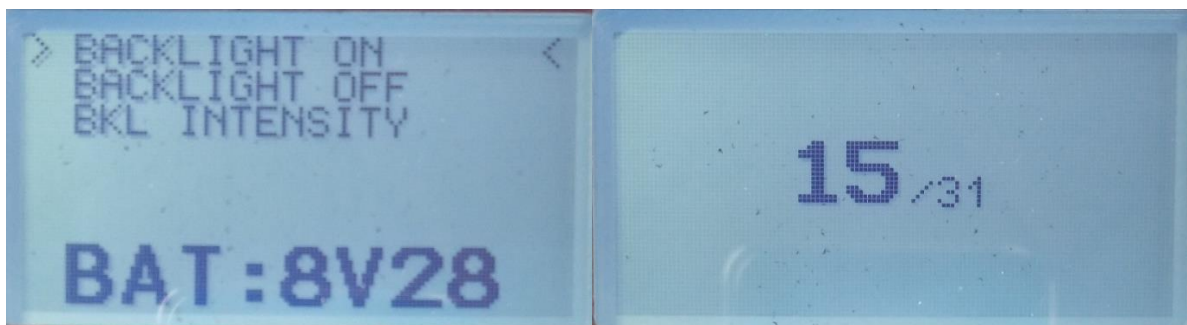

Figure 17: The screen backlight intensity can be adjusted from 0 to 31

We recommend to keep it off when performing measurements under sunny conditions and / or to maximize power autonomy.

In order to keep your backlight intensity preference in memory, keep pushing on "OK" until you reach the main menu.

Battery charging

Figure 18: The FLM4 Battery charger

The FLM4 is equipped with a liPo battery with internal security charger. The tension of the battery is indicated on the screen when the main menu is displayed.

When the tension drops down to 7V2, "LOW "is displayed and the FLM4 needs to be charged. The full capacity is reached at 8V4

To charge the battery: first plug the connector P1J (see figure 2, plug into 6), and then plug into the power network. About 5 to 6 hours is needed to fully charge the battery.

In order to control the battery, the FLM4 is equipped with a charging interface. This one is composed by 2 leds, one blue and one green (see figure 2, 7 & 8).

- The green led indicates that the 5V power supply unit is connected, and correctly working.
- The blue led indicates the status of the charger. This led will only light up if the green led is already on.

1. If the blue led is Off: the battery is fully charged.

   Note: this does not necessarily mean that the battery is still good. If after a full charge, the user can only operate the device for a short time compared to the original time (14h), changing the battery should be considered.

2. If the blue led is On: the battery is charging .

3. The blue led flashes at 1Hz: problem with the battery (excessive imbalance between the two cells, short circuit on one or more cells, one or two cells out of service, temperature too high in the battery pack, battery not present,...)

To solve the problem, we recommend to:

1. Check the presence of the battery
2. Unplug the 5V charger, wait 1 minute and start again (if this solve the problem, it means the charger previously failed to detect the battery).
3. If the led is still flashing, disconnect everything and wait for 1 hour with the instrument in a cool and shady place
4. If the blue led keeps flashing, you probably have to change the battery (and recycle the old one). Please contact us.

NOTE

To keep the battery in the best conditions, we recommend:

- to put the battery in storage mode if the theodolite will not be used during more than one week. The storage mode corresponds to 7V6. If voltage is higher, simply leave the instrument ON in the "Fluxgate + Clock" menu until it reaches the desired voltage.

- to store the FLM4 DIFlux in convenient conditions. Iin particular, temperature should be between 5 ° C and 25 ° C (between 41°F and 77°F)

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Annex 1: TDJ6E-NM Operating Manual
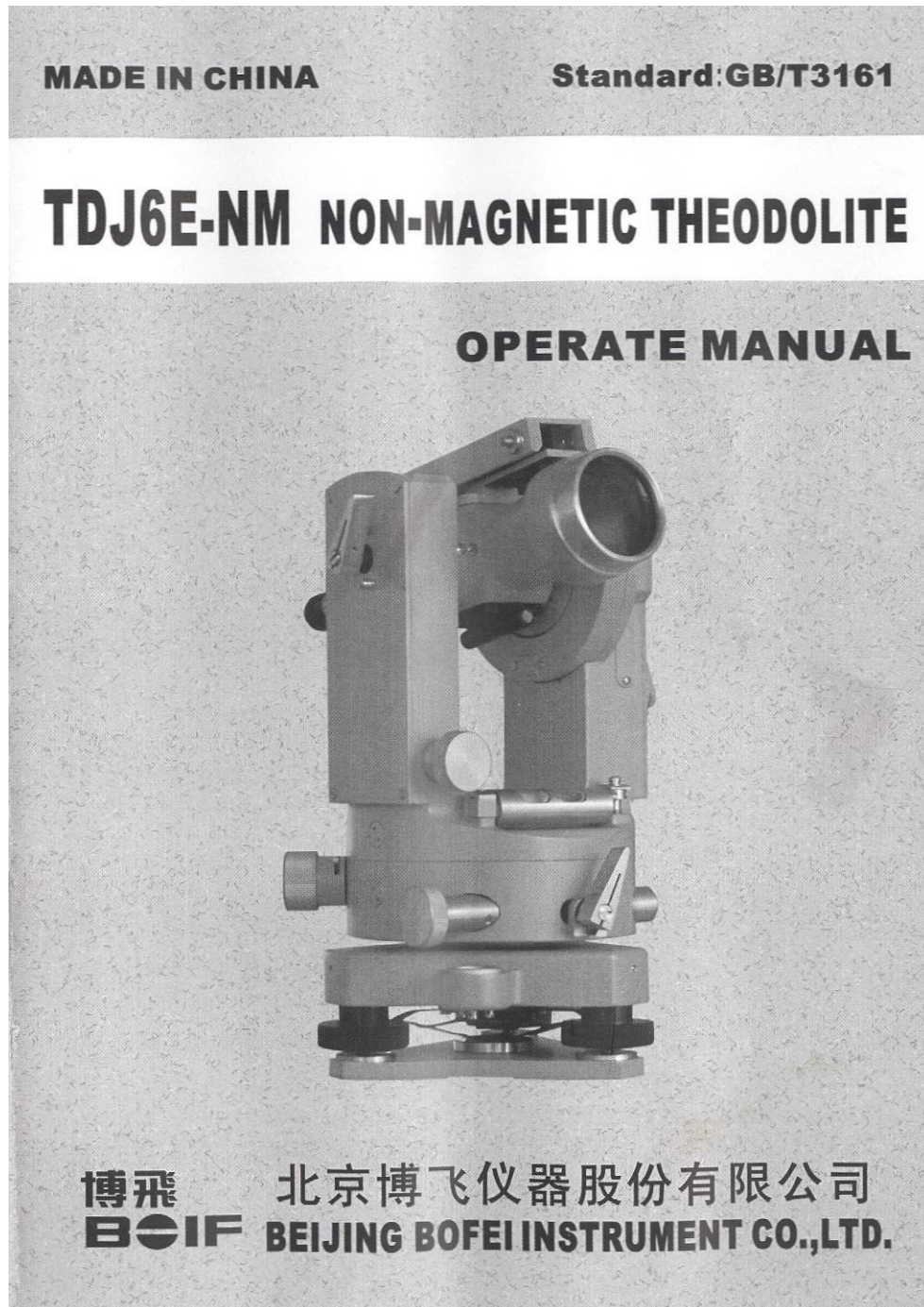
Foreword

    Thank you for choosing our products! TDJ6E-NM non-magnetic theodolites are special instruments developed by our company for geomagnetism, geology and national defense fields.

If you have any question while reading this manual or any problem while operating the instrument, you can dial the number +86 10 67816696 of our customer service department for technical support and service.

Thank you for your cooperation!

Date: 2013.5

Contents

1. General care and handling precautions

The theodolite is a precise optical instrument. Improper storage and maintenance will lower its precision, shorten its service life and even affect its normal use in surveying work. Although a damaged instrument can be repaired its performance cannot be fully restored. Therefore, every surveying and instrument handling personnel should make proper use of the instrument and take good care of it in all seriousness.

1.1 The instrument has a plastic box, when take it out, be gentle to hold the alidade part with one hand and the tribrach with the other, and do not grasp the telescope.

1.2 When mounting or dismounting the instrument on or from the tripod, one hand should hold the alidade while the other turns the central screw of the tripod so as to prevent it from slipping off and dropping on the ground.

1.3 When making observations please hold the alidade as the instrument is being turned. Do not use the telescope for this purpose.

1.4 When high precision surveying is undertaken an umbrella should be held over the instrument and the tripod to prevent strong sunlight from striking them directly and affecting their performance.

1.5 In cold winters, the difference in temperature of interior and outdoor is very large, so wait a few minutes before opening the carrying box , in order to prevent the form of air condensate on the telescope of the instrument.

1.6 When it is necessary to clean the lens use the soft hair brush in the box to whisk off the dust and dirt on the surface and then use absorbent cotton or lens cleaning paper to clean it. Do not use the handkerchief or any part of one's clothes to do the cleaning.

1.7 For storage, the instrument should be kept in a dry, clean and well-ventilated storeroom. The ideal temperature is from -20°C to +45°C.

1.8 The drying agency in the carrying box should be kept at a humidity of less than 20%.

1.9 After using the instrument, remove all dust and dirt on its surface and then put it into the clean and dry carrying box.

1.10 When transporting the instrument over long distances, it is wise to place it in the carrying box to avoid vigorous shaking on the way.

1.11 On outdoor surveying, when there is need to move from one station to another close by, the instrument can be moved together with the tripod, with the instrument in front of you, and hold it with one hand. For long distance, it is better take down and put the instrument in its box.

1.12 A regular check and adjustment is very important, also keep its record. When the instrument fails to be of service it should be sent to a specialized serviceman or to the factory for repairing.

2. Fields of application

TDJ6E-NM non-magnetic theodolites are developed specially for fields like geomagnetism, geology and national defense. The instrument and fluxgate testing system constitute a DI magnetometer which can be used to observe magnetic declination and magnetic inclination in fields and stations by relative departments like geomagnetic station, earthquake and national defense. TDJ6E-NM non-magnetic theodolite is proven to reach the technical requirement after testing. TDJ6E-NM non-magnetic theodolite can be used as compass theodolite, along with tubular compass. TDJ6E-NM, beside its non-magnetic feature, can perform the duties performed by ordinary optical theodolite. It can measure horizontal angle, vertical angle, and distance. Therefore, it can by applied to many fields like fourth class triangulation, traverse survey, various mines, railway, bridge, fairway, urban construction, hydrogeological investigation, farmland, water conservation and transportation.

3. Main specifications

Magnetic Influence ≤1nT
Measurement Range: 0°-360°

Zenith/nadir mark： Zenith (↑) - 0°/ Nadir (↓) -180°

Accuracy 6″

Telescope TDJ6E-NM

Length 172mm

Image: Erect

Magnification: 30×

Aperture: 40mm

Field of view: 1º30′

Shortest distance: 2m

Stadia multiplication constant 100

Stadia addition constant 0

Spirit level

Tubular level accuracy 30″/2mm

Circular level accuracy 8'/2mm

Graduated circle and tape measure

Graduation diameter of horizontal circle 94mm

Graduation interval 1° Graduation

Diameter of vertical circle 76mm

Graduation interval 1° (g)

Graduation interval of tape measure 1″(c)

Estimation reading to 0.1″ (0.2°)

Reading microscope

Magnification of the horizontal system 68X

Magnification of the vertical system 65.4X

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Compensator for vertical circle index

Working range ±2'

Optical plummet

Magnification 2.5X

Angle of visual field 5°

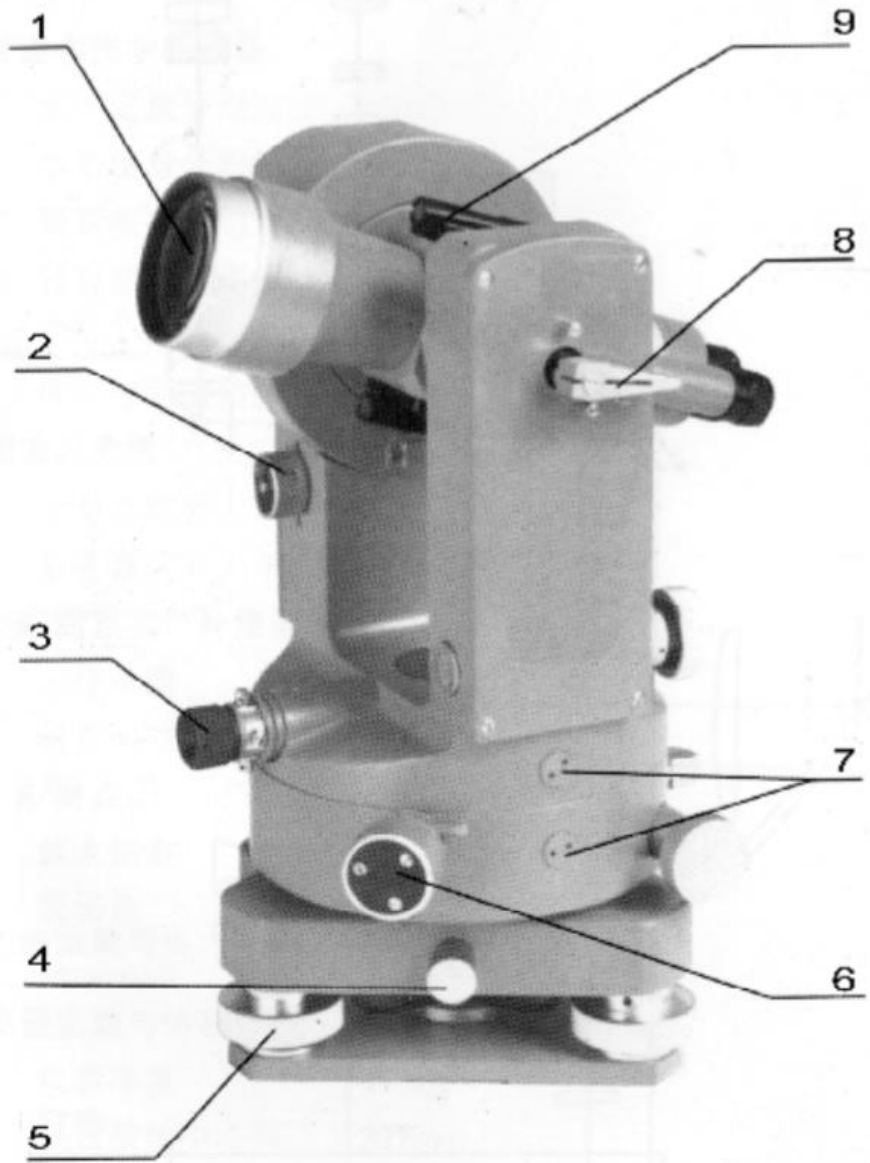Range of focusing 0.7-∞

Weights and dimensions of instrument

Net weight 4.3kg

Height of horizontal axis 207mm

Dimension 136mm×130mm×286mm

Optical system picture (Fig. 1)

Instrument structure picture (Fig. 2, Fig3)

1. Telescope lens, 2. Locking knob of compensator,

3. Optical plummet eyepiece, 4. Lock knob of tribrach, 5. Foot screw,

6. Wheel for circle changing, 7. Access cover, 8. Vertical clamp,

9. Optical sighting device

Fig.2 Instrument structure

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4. Construction features

The construction of the instrument is compact and light. It affords easy portability and direct, rapid reading. The form of construction is stable and reliable. The design of the V-shape long pendulum type of automatic compensator for the vertical circle index gives it a good performance in resisting high-frequency vibrations. This not only promotes surveying precision, but also, makes the operation easy. It simplifies manipulation procedures, and raises working efficiency. The color visual field makes reading soft and smoothing to the eye. TDJ6E-NM has an erect telescope. The large aperture and the high magnifying power of the telescope lens ensure the possibility of getting a sharp image quality even under relatively poor lighting conditions. Loosen the screw that fastens the tribrach, and the upper part of the instrument can be dismounted from it to allow the mounting of accessories like the collimator, the sighting target, etc. for surveying (Zeiss accessories are universal) . A dischargeable tubular compass can be installed on the compass support.
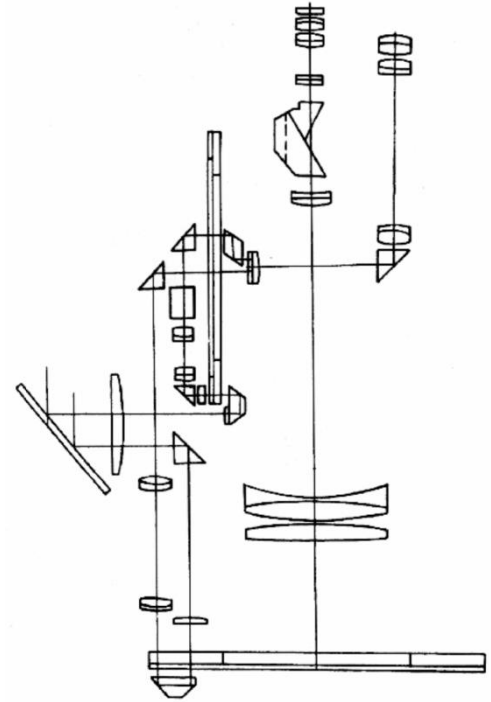
Fig.1 optical system diagram

5. Instructions for use

To measure the horizontal angle, vertical angel or distance between the measuring point and the known point, you can follow the following steps:

5.1 Positioning the tripod

Place the tripod over the measuring point and set the three legs almost equidistant to it. At the same time, take note that the angle of divergence of the legs and the height of the tripod are appropriate. The place of mounting should be as level as possible. Turn the wing clamps on the legs clockwise will enable them to be properly extended. If the instrument is to be used on a tower, it necessitates a pillar plate placed on the head of the inner tower, on which the instrument is fixed.

5.2 Mounting the instrument on the tripod

Place the instrument carefully on the tripod then tighten the central screw properly.

5.3 Leveling the instrument

Adjust the circular level of the instrument for rough leveling, and then adjust the tubular level for precision leveling.

5.3.1 Adjust the circular level

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Turn the foot screws 1 and 2, as shown in figure 4.1, so that the bubble moves to the central line of the circular level, and then turn foot screw 3, as shown in figure 4.2, so that the bubble is exactly at the center of the level.

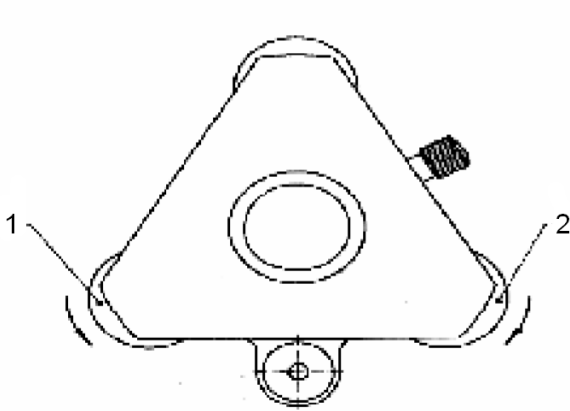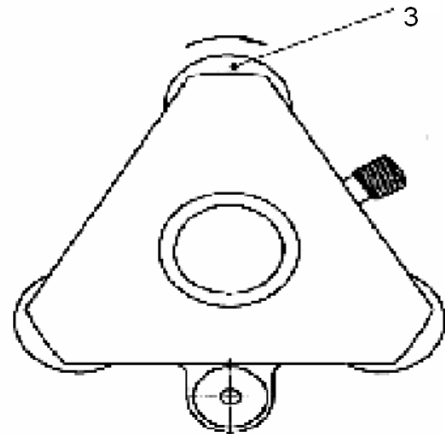
Fig. 4.1   Fig. 4.2

The regular pattern the bubble move: When use left hand to turn the foot screw, the bubble will move to the direction of the thumb of your left hand. And we call it the "left hand way".

5.3.2 Adjust the tubular level

Turn the alidade (bracket) part of the theodolite first in order to make the tubular level parallel to the line connecting the centers of any two foot screws (fig.5.1), and at the same time, turn the two foot screws to enable the bubble to position itself in the middle of the tubular level. Then turn the alidade 90 degrees (Fig.5.2) and also the foot screw 3 to make the bubble move to the middle of the level. Repeat the above described procedure several times so that the offset of the bubble does not exceed the allowance for whatever position the alidade is turned.
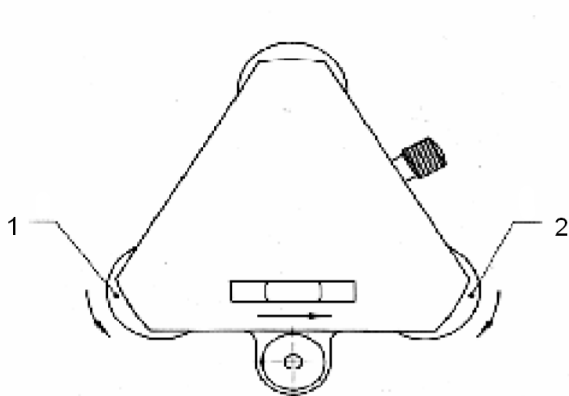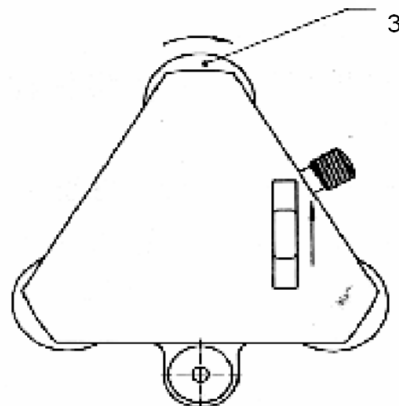

Fig. 5.1   Fig. 5.2

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5.4 Set the instrument over measuring point.

Use a plumb bob or optical plummet to enable the centre of the vertical axis of the theodolite to be directly over the plummet line of the measuring point .When the optical plummet is used, pull out its visual lens and turn it so that the measuring point is distinctly imaged on the graduated tubular. If the centre of the measuring point is not in the centre of the graduated tubular, loosen the central screw of the tripod. Then tighten the central screw of the tripod, and check the leveling of the instrument.

5.5 Illumination

Turning the position of the light reflection mirror properly will result in a bright illumination of the graduated circle.

5.6 Aiming at the target

5.6.1 Loosen the vertical binding handle

(fig.2), turn the telescope to a bright place. Rotate its eyepiece tubular in counter-clockwise. At this moment, the graduated tubular will become blue. Then rotate the lens in clockwise until the graduation marks on the tubular are distinctly visible.

5.6.2 Let the instrument in erect position (i.e. vertical circle at the left of the operator) Aim the object through the optical sighting device. Lock both the vertical and the horizontal clamps, and turn the focusing sleeve of the telescope so that the object will clearly be imaged on the reticule. At this moment, move the eye left and right, and then up and down. In doing so, no relative displacement should be detected between the target image and the graduation marks on the reticule. This means that no parallax exists.

5.6.3 Turn both the vertical and the horizontal micro-motion knobs so that the telescope is precisely aimed at the target to be measured.

5.7. Graduated circle reading

After illuminating the graduated circle, adjust the reading eyepiece (fig.3) so that the reading visual field (as shown in Fig.6) can be seen distinctly. The symbols H and V on both the upper and lower parts of the visual field indicate the readings of the horizontal and the vertical circles respectively. There are 60 graduations to every division (1′) on the tape and so estimation readings up to 0.1' can be made easily. Before reading the vertical circle, it is necessary to turn the locking knob (fig.2) of the compensator in anticlockwise to make the mark "ON" at the vertical position. In this condition, if the alidade is turned at this moment, very distinct sounds are audible. It is then and only then that the reading of the vertical value may be taken. After finishing the vertical angle measurement, do make the mark "OFF" on the locking knob at the vertical position by turning the knob clockwise. In this case, the compensator is locked safely.
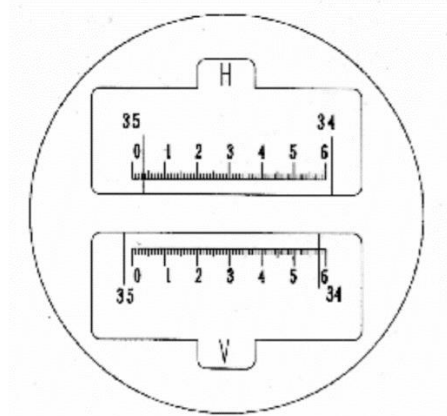
Horizontal graduated reading (H window)
Vertical graduated reading (V window)
Fig.6

5.8 Distance measurement

There are two pairs of short hairs (the upper and lower, and the right and left, see fig. 7) on the reticule of the telescope, i.e. the stadia hairs. They are used to measure the distance between the measuring point and the known point. Assume the distance between the two points is D, the length cut by a pairs of the stadia hairs on the scale is L, and the multiplication and addition constants of the stadia are K and C which are 100 and 0 respectively. Then the distance measurement formula will be as follows:
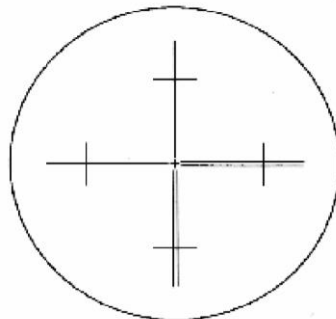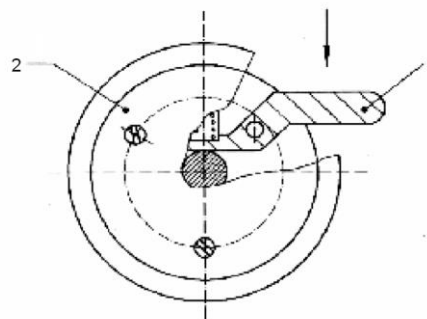
$$D=KL+C=100L$$

Fig.7   Fig.8

5.9 How to use the rotary circle mechanism

The theodolite is equipped with a rotary circle knob 2. It enables the reading value of the horizontal graduated circle required to be placed in the direction of the target to be measured. For to its use, it is necessary to depress the horizontal rod 1 of the rotary knob 2. At this moment, knob 2 can be pushed in to effect the mutual

meshing of gears inside the instrument. Turn knob 2, and the purpose of varying the reading on the graduated circle (Fig.8) is achieved. After changing the reading, press the horizontal rod 1 again and knob 2 will be self-ejected. Operation may then be conducted

6. Performance checks and adjustment

All instruments turned out of factory are all strictly adjusted and checked, and then transported to user units after careful packing. Nonetheless, prior to their use, adjustments ought to be strictly made again at all positions where adjusting is permissible, especially so as various factors and conditions may tend to engender the possibility of deviation from correct positions originally adjusted. Such adjustments should be done as follows:

6.1 Adjusting the tubular level

The foot screw to which the bubble deviates should be turned so as to eliminate the half of the offset value. The other half can be corrected by turning the screw 1 and nut 3 on the tubular level (Fig 9). Repeat the above procedure until the air bubble at any position the alidade may be turned is in the middle of the level.
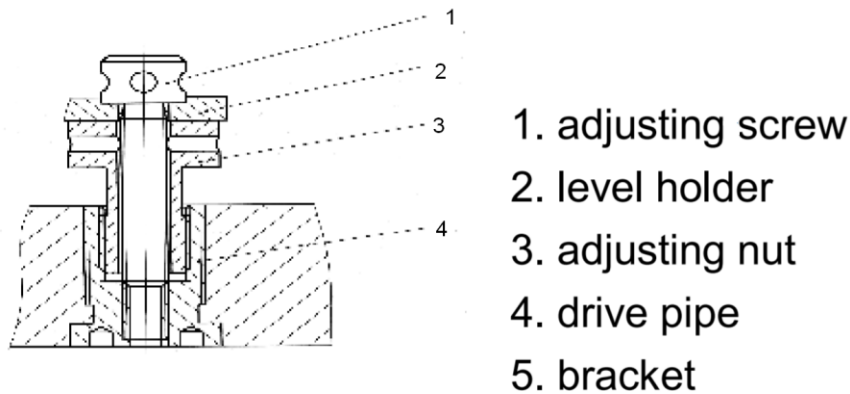

1. adjusting screw
2. level holder
3. adjusting nut
4. drive pipe
5. bracket

Fig. 9 for tubular level

Detailed operation of the adjusting device ： Assume after rotating the alidade 180°, the bubble deviates one grid towards the adjusting device, first revise half grid by foot screw, the left half should be revised by the following method: screw the adjusting nut 3 downwards to such an extent that when adjusting screw 1 is tightened up, the bubble is in the center. If the bubble deviates in the other direction, do the opposite: turn adjusting screw 1 upwards first and then tighten up adjusting nut 3 to center the bubble. Repeat the above procedure to achieve a required accuracy.

6.2. Adjusting the circular level

After adjusting the tubular level, the circular level should be checked immediately. If the bubble of the circular level deviates from the center, adjust the three bleed screws beneath it so that the bubble is centered.
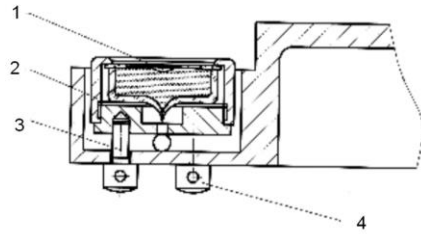
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Fig. 10　for circular level
1. circular level
2. level holder
3.adjusting screw Ⅰ
4.adjusting screw Ⅱ,Ⅲ

The adjusting device of circular level (Fig. 10) can be adjusted by 3 adjusting screws. See Fig. 11. In the case of deviation of the bubble as in Fig.11.1 eliminate the component of the deviation as follows: in the direction of adjusting screw 2 and 3 with the two screws.

6.2.1 Screw the adjusting screw 3 in clockwise, 2 in anticlockwise, to make the bubble move to 1 (see Fig.11.2).

6.2.2 Screw the adjusting screw 1 in anticlockwise to make the bubble center (see Fig. 11.3). Finally, all the adjusting screws should be firmly tightened.
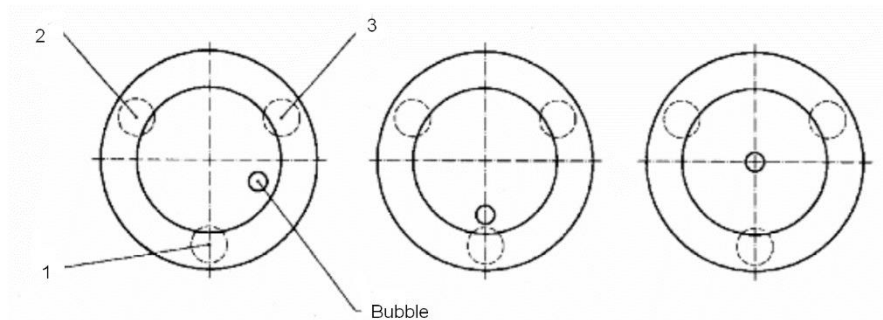
Fit. 11.1　　　Fit. 11.2　　　Fig. 11.3

Fig. 11

6.3 Adjusting the vertical hair on the reticule of the telescope

After leveling the instrument, focus the vertical hair precisely at a target about 50 meters away. Turn the vertical micro-motion knob and watch whether the vertical hair at the intersection deviates from the target or not. If so, adjustment is necessary.

6.3.1 Screw the protective cap of the reticule of the telescope in the counter-clockwise direction, and take it off, It is now possible to see the four adjusting screws.

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6.3.2 Loosen the four adjusting screws a little, knock the adjusting screw on the reticule frame gently to make it move to Fig. 11 obtain the perpendicular of the vertical hair.

6.3.3 Check in accord with the above, until qualified. Then tighten the fastening screws.

6.4. Adjustment to the sight axis error（2c）

The horizontal collimation is adjusted in our factory as closely as possible. If observations are taken on both faces, its residual error is cancelled out in the mean reading. Therefore this adjustment is not recommended when it is not absolutely necessary. To check and adjust the horizontal collimation error: Set up two staffs (A ,B) about 100m apart in a flat stretch of ground and the instrument to be checked adjusted in between.

6.4.1 Sight a point, "a", on staff A with the vertical hair on Face Left and fix the horizontal clamp of the theodolite.

6.4.2 Plunge the telescope without disturbing horizontal position and sight the staff B with the vertical hair on Face Right. Assume the reading b1 is taken.

6.4.3 Release the horizontal clamp and turn the alidade through 180°. Sight the point "a" on staff A with the vertical hair again, but on Face Right.

6.4.4 Plunge the telescope once more. Sight the staff B with the vertical hair and reading b2 is assumed to be taken and b1≠b2. This means that the sight axis is not perpendicular to the horizontal axis and the collimation error (2C) should be adjusted as follows: Remove the reticule guard. Unscrew one of the two horizontal adjusting screws and screw in the other by a small amount with an adjusting pin. This process continues until the movement of the vertical hair on staff B is equal to (b2-b1)/4 within the acceptable limit. Repeat the above procedure until a satisfactory result is obtained.

6.5 Adjusting the index error

After leveling, release the vertical index by turning the vertical index clamp clockwise. Sight a target twice with the horizontal hair in both telescope positions and take vertical readings, L and R. The vertical index error I is then: I = (L+R-360)/2. When the value of I goes beyond the specified limit, it is necessary to carry out an adjustment: Alternately unscrew the adjusting screw 1 (or 2) and screw in the adjusting screw 2 (or 1). These screws are located on an adjusting device that becomes visible as shown in Fig. 12. Therefore, the small access cover 20 on Figure 3 must be removed by unscrewing its holding screw. Replace the access cover when the adjustment is completed. The adjusting range is ±2'.

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Besides, the adjustment can also be done by adjusting the upper and lower adjusting screws of the telescope reticule (method 2 – not suitable for sensor site alignment ESI).
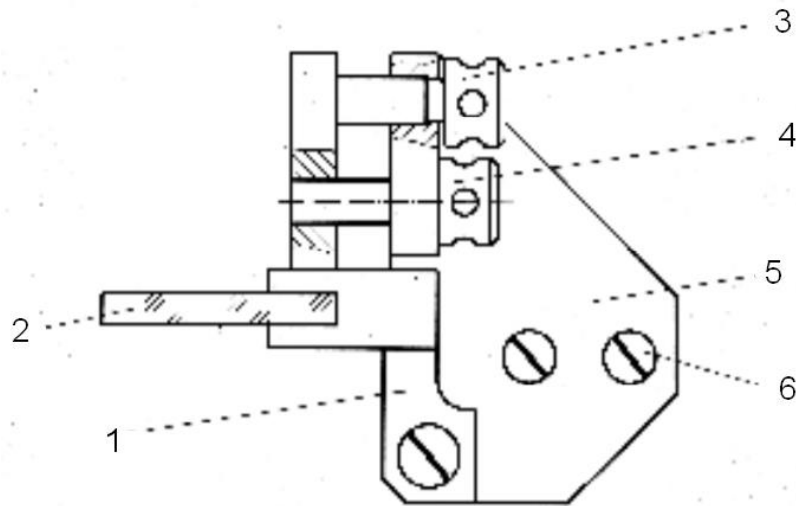

Fig.12. 1) Plate glass holder, 2) Plate glass for index error adjusting, 3) Adjusting screw 1, 4) Adjusting screw 2, 5) Base plate, 6) Spindle

6.6 Test and adjustment of the optical plummet

In centering with the optical plummet, the centering error should not exceed 1mm for all positions of the alidade. Otherwise, or in some cases where even more accurate centering is needed, the plummet should be adjusted by means of the adjusting four screws on the optical plummet. Loosen or tighten up four screws until a satisfactory result is obtained.
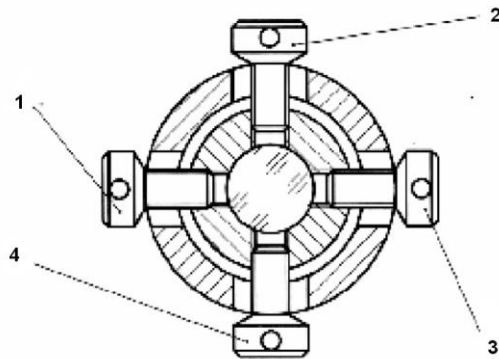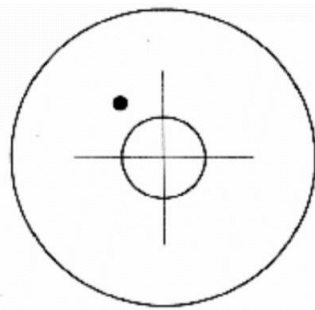

Fig. 13

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6.6.1 Aim at the measuring point with the cross hair on the reticule of the optical plummet. Then turn the alidade 180°, assume the point off center as fig.14.1.
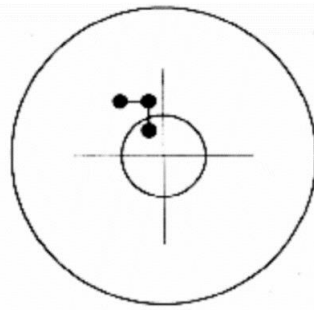
6.6.2 In this case, loose screw 1 and tighten screw 3 to make the measuring point move to vertical hair with 1/2 of the distance. See fig.14.2

6.6.3 Loose screw 4 and tighten 2 to make the point move to the horizontal hair with 1/2 of the distance. See Fig. 14.2.

6.6.4 Move the instrument and let the measuring point center with the reticule cross hair. Repeat the above procedure to obtain the better centering. This adjustment should be made at two heights: 1.5 meters and 0.8 meters. After finishing the adjustment, tighten the four screws.

14.1   14.2

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