General Notice

Digital levels
NA2002/NA3003 V3.2

Staff Overview

Standard Staffs
GNLE4C/GBNL4C

Invar-Coded Staffs
GPCL2/GPCL3

Leica AG, Heerbrugg, Switzerland, has been certified as being equipped with a quality system which meets the International Standard of Quality Management and Quality System (ISO standard 9001)

Total Quality Management- Our commitment to total customer satisfaction

Ask your local Leica agent for more information about our TQM program

G2-555-0en - VIII.96 - Printed in Switzerland - © Leica AG, Heerbrugg, Switzerland, 1996

General Notice

This user manual contains important safety directions (chapter 1) as well as instructions for setting up the instrument and operating it. Read carefully through the user manual before you switch on the instrumets.

Leica AG, CH-9435 Heerbrugg (Switzerland)
Telephone +41 71 70 31 31, Fax +41 71 72 15 06

Leica

Product identification

The instrument model is indicated on the housing of your unit, and the serial number on the underside. Enter this information in your user manual, and always refer to it when you need to contact your agency or service workshop.

Type:_____ Serial number:_____

Meaning of symbols

The symbols used in this user manual have the following meanings:

DANGER:
Indicates an imminently-hazardous situation which, if not avoided, will result in death or serious injury.

WARNING:
Indicates a potentially-hazardous situation which, if not avoided, could result in death or serious injury

CAUTION:
Indicates a potentially-hazardous situation which, if not avoided, may result in minor or moderate injury and/or appreciable material, financial and environmental damage. The symbol is also used to alert against unsafe practices.

Important paragraphs which must be adhered to in practice as they enable the product to be used in a technically-correct and efficient manner.

Table of Contents

1. Using the instrument and staff

Surveying instruments are only fully productive if they are carefully handled, kept clean, and used such that the chosen surveying method is matched to the attributes of the instrument concerned. The instruction manual belongs with the instrument: please read it to obtain full benefit of the instrumentation.

1.1. Care and storage

Cleaning and drying: The telescope lens and ocular should be handled with extreme care. Before cleaning the glass, blow away any dust. Never touch the glass with your fingers. To clean, use a clean, soft cloth. Breathing on the lens before cleaning is allowed. If necessary, damp the cloth using pure alcohol.

Storage: Always unpack damp of wet instruments as soon as you get back from the field. Dry out and clean the instrument, the transport case, foam inserts and accessories. Only pack the instrument when fully dry.
If working in extremely cold temperatures never bring the instrument into the warm, but instead store it in a protected area at outside temperature. In this way you will hinder the build-up of condensation on the lens and inside the instrument which would have otherwise occurred when you took the instrument from warm quarters into the cold outside temperatures when work resumed.

Cable and connectors: Connectors should not be allowed to become dirty or wet. Dirty cable connectors should always be rinsed with pure alcohol and left to dry.

1.2. Test before use

Before beginning any fieldwork the instrument should be tested and adjusted according to the user manual (two-peg test and bull's-eye level). It is also recommended to do this after use, after long pauses and after lengthy travelling.

Also test the correct adjustment of the staff bull's-eye level. The staff can be positioned in the vertical by using an previously adjusted level.

1.3. Temperature adjustment

When there is a large temperature difference between the instrument and the surrounding air, leave the instrument to stand until it has reached the

temperature of the air. As a rule of thumb it takes roughly one minute to change 1°C, i.e. for a 20°C temperature difference you should leave the instrument to stand for 20 minutes. For high-precision levelling it is nevertheless highly recommended to leave the instrument to stand for double this time.

1.4. Transport and shipping

When transporting the instrument via land, sea or air, it is necessary to pack the instrument in such a way as to be shook-proof. Whenever possible, use the correct Leica transport case.

Whenever sending the instrument as freight (e.g. post, rail or air freight), pack the instrument in the Leica transport case and pack that in the original freight carton in which the instrument was delivered. Only empty (discharged) batteries should be included in the instrument or case on safety grounds. Charged batteries should always be taken in personal hand baggage.

1.5. Dangers when working with a staff in the vicinity of electrical installations

For you own safety read and follow the following instructions:

Whenever working with a staff in the vicinity of electrical installations (e.g. electric railways, high-tension cables, transmitters, etc.) there is always a danger of deadly electric shock. This danger is independent of what material the staff is made from: conductive (e.g. aluminium or steel) or non-conductive (e.g. wood or plastic).

If the work in or near such installations is necessary, every precaution must be taken, the permission from the responsible safety officer received, and any instruction strictly adhered to.

2. The equipment

2.1. The tripod

For simple levelling you should use either the standard tripod GST20, or the lighter GST05/GST05L, all having adjustable legs. For high-precision levelling in level terrain, the tripod GST40 can increase the stability of the instrument due to its rigid legs.

The tripods GST20/GST40 have a protective cap, in whose underside is stored the Allen key used to tighten the tripod screws.

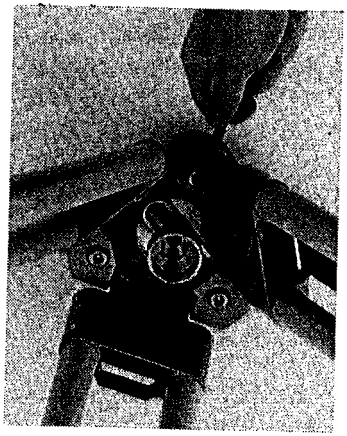

Figure 1 Checking and securing the tripod screws

The individual tripods legs should never be loose in their sockets but should always be held tight. If necessary, tighten the Allen screw above and between each pair of supports.

The clamping force of each joint of the tripod head can also be regulated (see figure). If the tripod, with its legs open, is lifted from the ground by the tripod head, the legs should all remain just open at their original positions. All three legs should slide uniformly.

You should control the firm seating of the leg tips once on a while. If the tips wobble, tighten the fixing screw slightly.

2.2. The level

2.2.1. Setting-up the instrument

When setting up the tripod, the legs should be firmly trodden down onto the ground. At the same time you should make sure that the top of the tripod remains reasonably level and that the eyepiece will be at the observer's eye-level.

The instrument is then placed on to the tripod and tightly fixed using the central fixing screw.

The instrument must never be left loose on top of the tripod.

Therefore:
- if you place the instrument on the tripod you should **immediately** screw it into place;
- whenever you unscrew the instrument from the tripod you should **immediately** remove it from the same.

2.2.2. Levelling and centring

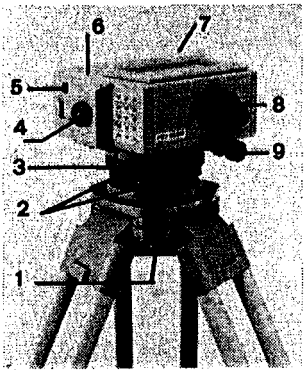

Figure 2 NA2002/NA3000 Front view

1 Central fixing screw
2 Tripod screws
3 Horizontal circle
4 Telescope eyepiece
5 Bull's-eye level, viewed from user's side
6 Bull's-eye level, viewed from above
7 Aiming sight
8 Focusing drive
9 Endless horizontal drive

Levelling the instrument
By adjusting the tripod screws (2), place the bubble of the bull's-eye level (5) in the middle of the centring circle. The tripod screws should no longer be adjusted. The bull's-eye level should be checked throughout the surveying process (to control if the instrument has been inadvertently moved).

Centring over a point in the ground
If you ever have to centre the instrument over a point, e.g. if you need to take horizontal angle measurements, use the plumb bob found in the tripod pocket. Insert the plumb bob socket into the central fixing screw (1) from underneath and fully tighten to the right. Set-out the tripod such that the top remains approximately level and the plumb bob hangs down vertically over the ground. Now tread the leg tips into the ground in such a way that the centring remains within 1 to 2cm of the point. Now release the central fixing screw and shift the instrument until the plumb bob is once again directly above the point, and tighten the fixing screw again.

2.2.3. Focusing the reticule

The observer should make sure that the cross-hair reticule is correctly and sharply focused. For each person, this is different.
To focus the reticule you must first aim the telescope towards an evenly lit, bright surface. Turn the eyepiece ring ((4), page 5) until the reticule appears very dark. By slightly turning the ring first in one direction, then the other, find the average position for the optimal sharpness. The respective number on the diopta scale is your personal adjustment figure to which other instruments may be correctly adjusted before commencing work.
To check, look through the telescope and move your head slightly from side to side, top to bottom: the reticule should no longer appear to move relative to the staff, i.e. it is free from parallax.

2.2.4. Targeting and focusing

Aiming at the staff
Looking through the aiming sight ((7) page 5), turn the instrument by hand around its vertical axis until the staff if coarsely lined-up. Next, by looking through the telescope, focus on the staff and perform the fine aiming at the staff centre using the endless horizontal drive ((9) page 5).

Focusing
The view through the telescope, i.e. the aimed-at staff, is focused sharply using the focusing drive ((8) page 5).

3. Taking the measurement

3.1. Reading the staff and distance measurement by eye

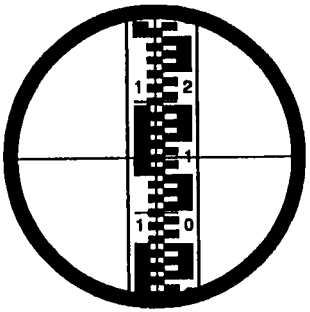

Figure 3 Optically reading the staff

Aim the reticule at the cm-divisions of the staff. Before taking a measurement, make sure that the instrument is levelled-up by glancing at the bull's-eye level. The reading is taken from where the horizontal hair of the reticule crosses the scale. The metre and decimetre values are taken directly from the figures, and the centimetres from the number of complete red and white fields above the next-lowest decimetre line. The millimetres are judged by eye from the bisected centimetre field. Because the staff image is upright, the values increase from bottom to top.

Example in figure 3.

Height reading = 112.6cm
Distance:

Reading above = 120.5cm
Reading below = 105.6cm
Distance = 14.9m

Optical distance measurement

The *horizontal* distance between instrument and staff can be found using the two *stadia hairs* found on the vertical crosshair (see figure above). The part of the staff found between these two stadia hairs is equal to 1/100 of the distance (accuracy 1:500). The staff should be read at the upper and lower marks (in cm) - the difference, when multiplied by 100, gives the horizontal distance in metres.

The reading can be simplified by turning the foot-screw nearest to the telescope axis until the lower distance mark coincides with a decimetre line. You can now read the difference in cm directly from the upper mark. You save time by not having to read two unrounded values and having to calculate the difference.

3.2. Measuring against the light

When measuring against the light (also by electronic measurement) you can shield the telescope objective with a hand.

3.3. Wind / Vibration

Strong winds or ground vibrations can start the compensator of automatic levels oscillating, and the picture through the telescope begins to tremble. You can stop the vibration by firmly holding the top of the tripod legs. The aiming is not influenced because the compensator automatic levels again.

3.4. Angle measurement

The horizontal circle ((3) page 5) can be turned to any direction by hand to read 0.0 or any other value when reading horizontal angles or setting-out.

If you are using the staff as the signal pole for your horizontal angle measurements, it is most accurate to aim the vertical cross-hair at the centre of the centimetre divisions.

4. The levelling

4.1. Line levelling

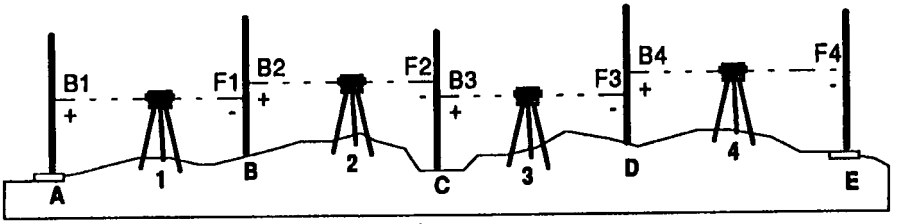

Figure 4 Line levelling between A and E

To measure the height difference between two points, e.g. A and E, you must choose intermediate points placed between 40m and 50m apart (20-25m with precise levelling).
From the first instrument position the measurement B_1 is taken to the staff at position A (B_1 = Backsight from position 1). After a successful measurement has been taken, the staff is carried passed the instrument. As the staffman is doing this he counts how many paces it took him to reach the level. He uses this figure again to position the staff at roughly the same distance from the level on the other side. The observer now aims the telescope at the staff at position B and measures the foresight, B_1. The observer now carries the level past position B to station 2. He chooses his position such that the next pair of back- and fore- sights can be made at roughly the same distance. The staffman now turns the staff carefully around so that the staff divisions face once more toward the instrument. The measurements B_2 and F_2 now follow. The measurements all the way to E are performed in much the same way.
By choosing the same distances for each pair of back- and fore- sights it is possible to eliminate certain instrument adjustment errors. For more precise measurements, the rule described should be used.
The height difference between A and B is obtained from the difference $(B_1 - F_1)$, from B to C from $(B_2 - F_2)$, etc., and all with a positive sign so long as the height increases. The total height difference between A and E (ΔH) is the same as all of the differences $(B_i - F_i)$. It is also the same as the difference between the sum of all B minus the sum of all F. Therefore, $\Delta H = \Sigma(B_i - F_i) = \Sigma(B_i) - \Sigma(F_i)$. The second equation is used to test the arithmetic.

To protect from coarse errors (or blunders) take care to measure in both directions when line levelling (double levelling), i.e. in our example from A to E (fore) and then from E back to A (back).

In sunny weather you should protect the instrument and staff with a parasol if you wish to obtain more accurate results.

The ground under the staff should be firm enough such that during the measurement the staff does not sink or move. After the instrument has been moved the staff must be turned towards it again. It is necessary to watch carefully that the ground plate does not slip nor lean away.

If a line levelling has to be performed across a wide river or valley with over-dimensioned aiming distances the requirement for equal aiming distances cannot be easily upheld. Apart from this, the reading of the staff over great distances is made difficult, if not impossible.

In these cases you should use a theodolite instead of a level. By reciprocal and simultaneous measurements of small vertical angles to special targets, it is possible to perform the surveying more quickly and accurately.

4.2. Area levelling

This term should be interpreted as the measurement of many points in the terrain, from just one, central station. The instrument horizon is so chosen that the highest point can still be surveyed.
If you are surveying a large area it is perhaps easier to use a regular grid. In this way the X/Y-position of terrain points can be easily reconstructed.

If you are making a local height map then the instrument horizon can be given any figure, e.g. 10m. The height of each surveyed point is thus found by subtracting the staff reading from the instrument height (10m).
In other circumstances, when the surveyed points have to be tied into a fixed point network, the heights (above mean sea level) must be first obtained by line levelling from a fixed point in the surrounding area, or by direct backsights to such a point.

Unlike line-levelling, where the aiming points are roughly the same distance from the instrument, in area levelling the individual distances can be very different. Because of this, and in view of the required accuracy and use to which

the survey results are put, any instrument-collimation error, or the influence of the earth's curvature, must be taken into account.
The instrument-collimation error can be controlled by taking control measurements to a fixed reference point before, (during,) and after the surveying. The readings must remain constant.

When surveying in bright sunlight it is recommended to place the tripod and instrument under the shadow of a parasol, especially if they are to remain stationary for a considerable amount of time.

4.3. Precision levelling

The following section covers only general rules and notes. They are by no means complete. Country-specific regulations must also be followed.

A general note:

- When turning a staff on a change point towards the level it must be turned whilst still on the ground plate. Lifting and lowering again to the ground plate should be avoided.
- At midday under intense sunshine the problem of **refraction** is particularly noticeable, whereby the measurements can be falsified. Avoid taking measurements at this time of day. Care should also be taken when aiming over asphalt surfaces or car roofs due to the refraction generated.
- Temperature affects the staff scale. For precise measurements the **temperature of the staff** should be taken and used for corrections. For more information consult section 5 concerning the Invar-coded staff.

Particular attention should be paid to the **avoidance of systematic errors:**

- To compensate for possible **residual errors in the automatic compensation** you should centre the bubble within the bull's-eye level alternately in one direction then the other (fore- and back- sight), etc.. If you are working simultaneously with two staffs you get the correct sequence if you always aim the instrument for levelling-up towards the same staffman.