General Notice

Digital levels
NA2002/NA3003 V3.3

Reserved for staff manual(s)

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General Notice

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

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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.

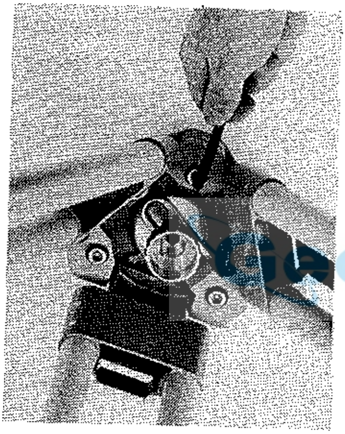

Figure 1 Checking and securing the tripod screws

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

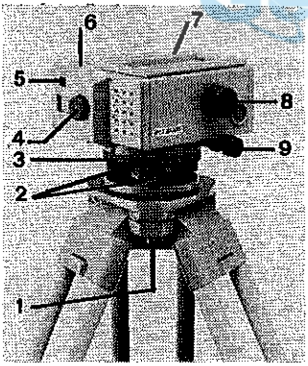

Figure 2 NA2002/NA3000 Front view

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

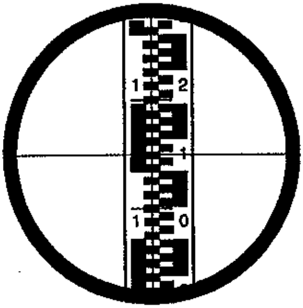

Figure 3 Optically reading the staff

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

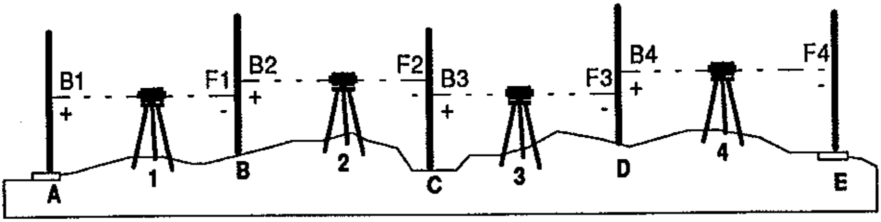

Figure 4 Line levelling between A and E

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.

- By always using the **same aiming distance** for forward- and back-sights you can eliminate most of the collimation errors, earth curvature and atmospheric refraction.
  To keep the aiming distances balance to within a few decimetres it is recommended to determine the instrument and staff positions, using a measuring tape, beforehand.
  From the digital level it is also possible to measure a distance for checking out the other functions.

- If with simple line-levelling two Invar-staffs are simultaneously used (i.e. alternately), then the **difference of the staff zero-point errors** must be taken into consideration. The zero-point difference plays no effect if the surveying is ended by aiming at the same staff it was started with. From this requirement you should always use an even number of stations.

- A systematic error is generated if **the staff or tripod sinks into the ground,** in that a misclosure can be found in the forward- and back-measurements (absolute value of the rises is larger than of the falls).
  This type of error can be minimised by firmly treading the tripod legs and the ground plate into the ground. What is important is that during the changing of positions, the height of the tripod or staff does not change.
  On asphalt surfaces it is better to use a ground plate with a large supporting area.

- **Vertical positioning of the Invar-coded staff**
  It is imperative that the staff also stands exactly vertical. If a staff stands somewhat inclined in the direction of the instrument, even with the digital measurement system a systematic error will result. Make sure that the bull's-eye level has been correctly adjusted.

Measuring at the ends of a staff (with coded staffs):
For the highest accuracy the complete vertical field of view through the telescope should be covered by the staff (image processing with the maximum amount of code information). When aiming at the ends of a staff this requirement can no longer be upheld because the code reaches to half way across the field of view (at least).
The 1% rule can be used as a rule of thumb: reduce the effective staff length on top and on the bottom by 1% of the distance to the staff. In this way the field of view should be 80% full of the coded staff.
Example for a 3m Invar staff:
Distance = 10m: Max. staff reading = 2.90m (3m - 10cm)
Min. staff reading = 0.10m

Distance = 20m: Max. staff reading = 2.80m (3m - 20cm)
Min. staff reading = 0.20m

etc.

Target distance:
Just as with optical levelling, the distance to the target (staff) should not be more than 25-30m. On gradients (greater than 4%) it is recommended not to aim at the lowest 30-50cm of the staff due to the extreme refraction which can be encountered so close to the ground.

Parasol:
The instrument and tripod should never be directly exposed to sunshine. Always use a parasol in such circumstances!

Double measurements:
As previously performed with optical levels, double measurements (BFFB BFFB ...) serve to cover reading errors and the control of staff- and instrument-movements (sinking) during the measurements.
As the 'human' reading error is no longer a problem with digital levels, double measurement could be necessary just because of the problem of sinking. Because the time it takes to perform a measurement using a digital level is so much shorter than with an optical level, the problem of sinking does not carry so much weight, so that when measuring on firm ground it can be negligible and double measurement need not be performed.

5. Safety directions

The following directions should enable the person responsible for the NA2002/3003, and the person who actually uses the instrument, to anticipate and avoid operational hazard.
The person responsible for the instrument (see section 5.3, "Responsibilities") must ensure that all users (see section 5.3, "Responsibilities") understand these directions and adhere to them.

5.1. Intended use of instrument

5.1.1 Permitted uses

The NA2002/3003 digital levels are designed and suitable for the following applications, within the limits of their intended conditions of use:

- Measuring heights and distances on staffs, with or without recording of the results.

5.1.2 Prohibited uses

- Activation of the digital level without instruction.
- Activation outside the range of conditions for which the instrument is intended (see section 5.2 "Limits to use").
- Deactivation of safety systems and removal of hazard notices.
- Opening of the product by using tools (e.g. screwdriver), unless this is specifically permitted for certain functions.
- Modification or conversion of the product.
- Activation after misappropriation.
- Use of accessories from other manufacturers without the express approval of Leica.
- Aiming directly into the sun.
- Inadequate safeguards at the site.

WARNING: Prohibited use can lead to injury, malfunction and damage. It is the task of the person responsible for the instrument to inform the user about hazards and how to counteract them.
The NA2002/3003 digital levels are not to be operated until the user has been instructed how to work with them.

5.2. Limits to use

Refer to the technical data in chapter 2, section 15.

Environment:
Suitable for use in an atmosphere appropriate for permanent human habitation (no protection in an aggressive or explosive environment). Use in rain is permissible for limited periods.

5.3. Responsibilities

- Responsibilities of the manufacturer of the original equipment LEICA AG, CH-9435 Heerbrugg (hereinafter referred to as LEICA): LEICA is responsible for supplying the product, including the user manual and original accessories, in a completely-safe condition.

- Responsibilities of the manufacturers of non-LEICA accessories:
  The manufacturers of non-LEICA accessories for the NA2002/3003 digital levels are responsible for developing, implementing and communicating safety concepts for their products, and are also responsible for the effectiveness of those safety concepts in combination with the LEICA product.

- Responsibilities of the person in charge of the instrument:
  WARNING: The person responsible for the instrument must ensure that it is used in accordance with the instructions. This person is also accountable for the training and deployment of personnel who use the instrument and for the safety of the equipment when in use.

The person in charge of the instrument has the following duties:
- To understand the safety instructions on the product and the instructions in the user manual.
- To be familiar with local regulations relating to accident prevention.
- To inform LEICA immediately if the equipment becomes unsafe.

5.4. Hazards in use

5.4.1 Main hazards in use

WARNING: The absence of instruction, or the inadequate imparting of instruction, can lead to incorrect or prohibited use, and can give rise to accidents with far-reaching human, material, financial and environmental consequences.

Precautions:
All users must follow the safety directions given by the manufacturer and the directions of the person responsible for the instrument.

CAUTION: Watch out for erroneous distance measurements if the instrument is defective or if it has been dropped or has been misused or modified.

Precautions:
Periodically carry out test measurements and perform the field adjustments indicated in the user manual, particularly after the instrument has been subjected to abnormal use and before and after important measurements.

DANGER: Because of the risk of electrocution, it is very dangerous to use staffs in the vicinity of electrical installations such as power cables or electric railways.

Precautions:
Keep at a safe distance from electrical installations. If it is essential to work in this environment, first contact the safety authorities responsible for the electrical installations and follow their instructions.

WARNING: By surveying during a thunderstorm you are at risk from lightning.

Precautions:
Do not carry out field surveys during thunderstorms.

WARNING: Inadequate safeguarding of the survey site can lead to dangerous situations, for example in traffic, on building sites and at industrial installations.

Precautions:
Always ensure that the survey site is adequately safeguarded. Adhere to the regulations governing accident prevention and road traffic.

WARNING: If computers intended for indoors are used in the field, there is a danger of electric shock.

Precautions:
Adhere to the instructions given by the computer manufacturer with regard to field use in conjunction with our instruments.

CAUTION: Be careful when pointing a digital level towards the sun, because the telescope functions as a burning glass and can injure your eyes or damage the internal components of the instrument.

Precautions:
Try to avoid pointing the telescope directly at the sun.

CAUTION: If the accessories attached to the instrument are not properly secured, and the equipment is subjected to mechanical shock (blows, falling etc.), the equipment may be damaged or people may sustain injury.

Precautions:
When setting up the equipment, make sure that the accessories (e.g. tripod, staff, strut, battery, connecting cables) are correctly adapted, fitted, secured and locked in position. Avoid subjecting the equipment to mechanical shock.

CAUTION: During the transport or disposal of charged batteries it is possible for inappropriate mechanical influences to constitute a fire hazard.

Precautions:
Before dispatching or disposing of your equipment, discharge the battery, either by running the instrument in AUTO-OFF mode until it displays "off", or by means of the GKL23 charger.

CAUTION: A strut-supported vertical staff can be blown over by a strong gust of wind, possibly causing injury or damage.

Precautions:
Never leave a strut-supported staff unattended.

WARNING: If the equipment is improperly disposed of, the following can happen:
- If polymer parts are burnt, poisonous gases are produced which may impair health.
- If batteries are damaged or are heated strongly, they can explode and cause poisoning, burning, corrosion or environmental contamination.
- By disposing of the equipment irresponsibly you may enable unauthorized persons to use it in contravention of the regulations, exposing themselves and third parties to the risk of severe injury and rendering the environment liable to contamination.

Precautions:
Dispose of the equipment appropriately in accordance with the regulations in force in your country. Always prevent access to the equipment by unauthorized personnel.

5.4.2 Electromagnetic acceptability

The term "electromagnetic acceptability" is taken to mean the capability of the instrument to function smoothly in an environment where electromagnetic radiation and electrostatic discharges are present, and without causing electromagnetic disturbances to other equipment.

WARNING: Electromagnetic radiation can cause disturbances in other equipment.

Although the digital levels meet the strict regulations and standards which are in force in this respect, LEICA cannot completely exclude the possibility that other equipment may be disturbed.

CAUTION: There is a risk that disturbances may be caused in other equipment if the digital level is used in conjunction with accessories from other manufacturers (field computers, personal computers, walkie-talkies, non-standard cables, external batteries etc.)

Precautions:
Use only the equipment and accessories recommended by LEICA. When combined with digital levels, they meet the strict requirements stipulated by the guidelines and standards. When using computers and walkie-talkies, pay attention to the information about electromagnetic acceptability provided by the manufacturer.

CAUTION: Disturbances caused by electromagnetic radiation can result in the tolerance limits for measurements being exceeded.

Although the digital levels meet the strict regulations and standards which are in force in this connection, LEICA cannot completely exclude the possibility that the digital level may be disturbed by very intense electromagnetic radiation, for instance near radio transmitters, diesel generators, or high-tension power cables. Check the plausibility of results obtained under these conditions.

WARNING: If a digital level is operated with connecting cables attached at only one of their two ends (e.g. external supply cables, interface cables), the permitted level of electromagnetic radiation may be exceeded and the correct functioning of other instruments may be impaired.

Precautions:
While the digital level is in use, connecting cables (e.g. instrument to external battery, instrument to computer) must be connected at both ends.

5.4.3 FCC statement (applicable in U.S.)

WARNING:
This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

WARNING:
Changes or modifications not expressly approved by Leica for compliance could void the user's authority to operate the equipment.

<u>Product labelling:</u>

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

5.5. Important user directions or addenda

Take care when measuring through windows, or if there are several reflecting objects in the field of view. Incorrect readings may result.

If the connecting cable or the REC-module is removed during the measurement procedure, data may be lost.
Do not remove the connecting cable or the REC-module until you have switched off the instrument.

5.5.1 Addendum to section 1.1: "Care and storage"

Respect the temperature limits when storing the instrument, particularly in summer if the instrument is inside a vehicle.

Keep the contacts of the REC-module clean and dry.
If the contacts become dirty, clean them with pure alcohol and leave them to dry.

5.5.2 Addendum to section 1.4: "Transport and shipping"

When transporting the equipment in the field, always make sure that you

- either carry the instrument in its original case
- or carry the tripod with its legs splayed across your shoulder, keeping the attached instrument upright.

NA2002 NA3003

User Manual

SW Version 3.3

Software Version 3.3:
This software version includes improvements to the measurement software. The functions remain unchanged. The enclosed user manual for the version 3.2 is therefore fully valid for the version 3.3 as well.


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

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Contents

Appendix

1 Introduction

1.1 What is new? What is different? A comparison with Version 3.0

You can quickly see here below the differences between the new software and the previous Version 3.0 software, and where to find more information about them in the manual.

SW-Version 3.2	NA3003	NA2002
New or expanded functions		
Additional measuring modes in SET MEASURE: - Mean: The mean is taken as previously. - Mean σm: The mean is taken with automatic termination when the required standard deviation of the mean value is attained, and with an outlier test. - Median: The result is expressed as the median (central) value together with its band width. Description in sections 5.1.3 and 8.2.	 X X X	 X X X
Two levels of system accuracy, standard and enhanced, can be selected with the SET function. The standard accuracy is that already obtainable. The time for measuring with enhanced accuracy is about two seconds longer. Description in section 5.1.1.	X	-
The integration time of a measurement can be lengthened. Times between three and nine seconds can be selected with the SET function. Description in section 5.1.2.	X	-
An additional two-peg test, which covers two methods at the same time: - First station in the middle, the second near to a staff - First station in the middle, the second beyond the staffs Description in section 7.1.	X	X
Individual collimation error can be entered manually (SET function). Description in section 7.1.2.	X	X

Repeated search for point number in REC-module with [REP] (in START LEV and SET OUT). Descriptions in sections 6.5.1 and 6.6.4.	X	X
Direct readout of data from REC-module, using serial interface of computer (data dump). Description in section 7.3.2.	X	X
New data words: Band width WI 521 Integration time WI 57 Description in section 10.	 X X	 X -
Interface commands for new functions. Description in section 6.7.2.	X	X
Recognition of last measurement during multiple measurement in on-line mode. Description in section 6.7.3.	X	X
Changes		
Individual point number entered with [NR] instead of in SET INCREMENT. Description in sections 6.2.1 and 6.2.2.	X	X
Interface command SET/467/... (choice of staff) is also valid for NA2002. (Already present in NA3003.)	-	X
Corrections		
Location of the first point number and height in START LEV. The search stops at the data set which includes a height.	X	X
Choice of staff (SET CONFIG ROD) remains stored after OFF (only relates to NA2002).	-	X

1.2 General

The digital level concept

The Leica digital levels are compensator levels. They are therefore classified as automatic levels (the compensator automatically levels-up the line of sight). In contrast to optomechanical levels, the measurement is processed electronically, and so the operator can work faster and with less stress.

The other advantages of the system are its ease in use, the absence of reading- and writing errors, the automatic height calculation during the measurement, and the data recording.

The applications extend from conventional staff reading measurement, through comfortable line- and area levelling, to on-line operations with a computer connected.

The NA2002

The NA2002 is used for all types of technical levelling, e.g. for line- and area levelling or for recording profiles.

For low to medium accuracies, use a standard staff. For high accuracies, use an invar staff.

The NA3003

The applications of the NA3003 extend from technical surveys to precision levelling , depending on the type of staff used.

Industrial levelling can be performed to a limited extent.

The measurement principles of a digital level

The bar code on the staff is stored in the instrument as a reference signal.

During the measurement procedure, the whole of that part of the bar code visible in the field of view is captured as the measurement signal by an IR-sensitive line detector. This measurement signal is then correlated (compared) with the reference signal. The staff reading and the horizontal distance are displayed as the results.

For more information, please request the technical reports available for the digital levels.

Data recording and external control

The easiest and most usual way to record data is to store it in a recording ("REC") module, the GRM10. Afterwards, the data can be extracted with a GIF10/GIF12 reader or directly across the interface of the instrument (data-dump procedure).

If a cable link is available, a field computer such as the GPC1, or another model of computer with serial interface (desktop, laptop, notebook) can be attached and the data stored in that.

In on-line mode you can configure the instrument and trigger the measurements by remote control.

About this user manual

The NA2002 and the NA3003 are very similar to one another and so this user manual describes both instruments together. Where differences exist, they are indicated.

To get a quick overall idea of the instrument, work your way through the short instructions (separate leaflet) or study section 2: "*Introduction with examples*".

In the appendices you will find a synopsis of the user programs (PROG key) and of the system configuration (SET key).

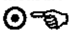
To get the most out of the instrument, we recommend you to study the user manual carefully.

1.3 Keyboard legend

The following two key symbols are frequently used in the user manual:

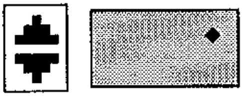
DSP — Screen scroll: Keep DSP▼ or DSP▲ pressed down until the required display appears.

Measure

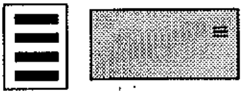


Press the red measuring button.

1.4 User operations legend



Menu prompt (= character used for menu choices):
Stacked in the background is more information.
To access it, roll the display with [DSP].



Measurement prompt (= the device is ready to measure):
The measurement prompt symbol represents the bar code on the staff.
Four different versions of the measurement prompt provide information about:

- The staff position: normal or inverted.
- Earth-curvature correction: with or without.

The four versions are:

a) 

- Staff <u>normal</u>
- <u>Without</u> earth-curvature correction.

b)  flash-ing

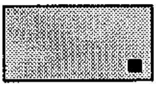
- Staff <u>inverted</u>
- <u>Without</u> earth-curvature correction.

c) 

- Staff <u>normal</u>
- <u>With</u> earth-curvature correction.

d)  flash-ing

- Staff <u>inverted</u>
- <u>With</u> earth-curvature correction.

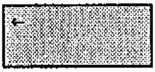


Input prompt (field flashes):
The instrument requests numerical input, e.g. the code number.

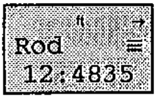
The input prompt flashes over the last digit to be entered:
The digit can be overwritten.

The data recording mode is turned on:
The measurement values are stored automatically.

Battery-low symbol. The battery is very low or not charged. Replace it with a charged battery.



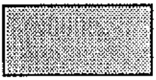
Overflow symbol.



Display in inches.
Imperial units indicated by the symbol "ft →" and by colon used as decimal point,
e.g. 12:4835 = 12.4835 inches

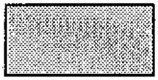
Brief displays

Some displays are faded in for a brief but variable period; the next display follows automatically.



(about 1 sec)

This display appears for between a fraction of a second and one or two seconds.



(DSP-TIME)

This display appears for a time determined by the setting in SET CONFIG DSP-TIME. The setting range is 1 - 9 seconds.

2 Introduction with examples

2.1 Container and exterior of instrument

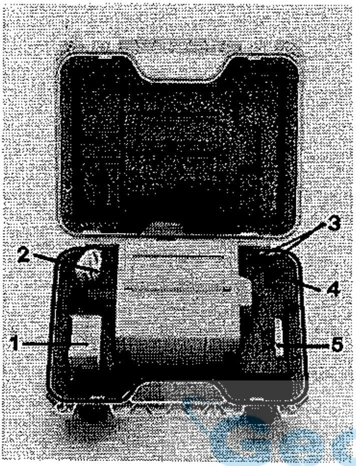


Fig 2-1 NA2002/NA3003 in container

1 Plug-in battery GEB79
2 Protective hood and optional sunshade
3 Adjusting pins
4 Plumb-bob
5 REC module

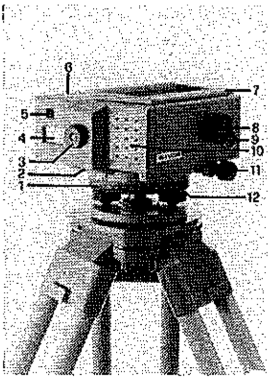


Fig 2-2 NA2002/NA3003, front view

1 Horizontal circle
2 Cover screw for adjusting crosshair
3 Telescope eyepiece
4 Display
5 Bull's-eye bubble: View from operator's side
6 Bull's-eye bubble: Illumination window / view from above
7 Carrying handle
8 Focusing knob
9 Red measuring knob
10 Keyboard
11 Endless horizontal drive
12 REC module

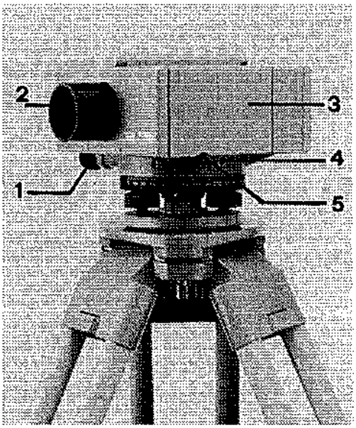


Fig 2-3 NA2002/NA3003, rear view

1 Endless horizontal drive
2 Telescope objective
3 Plug-in battery GEB79
4 Socket for interface- and battery cable
5 Stop lever for plug-in battery

2.2 Preparing to measure

2.2.1 The battery GEB79

When you have received the instrument and unpacked it, the first thing you should do is to charge the battery as directed in section 14.3.

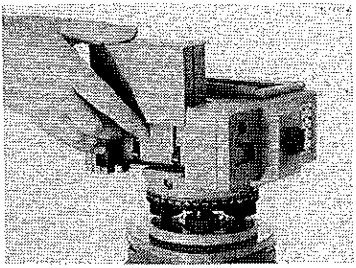


Fig 2-4 Inserting and removing the plug-in battery

Insertion:
Place the battery in the guide rails from above. Push it down until it locks into place.

Removal:
Pull out the clamp on the underside of the battery. Lift and remove the battery.

2.2.2 Setting up the instrument

- Insert the plug-in battery.
- Secure the digital level on the tripod.
- Using the three footscrews, level-up the instrument, observing the bull's-eye bubble from the front.
- Using the eyepiece ring, bring the crosshair into sharp focus.

2.2.3 Setting up the staff

Using the bull's-eye bubble, set the staff vertically.

Caution:
As in conventional levelling, the operator and the assistant must together ensure that the staff is vertical at the time of the measurement.

2.3 Measuring without recording

The digital level can be used for either optical or electronic measurement. The optical method is carried out with the normal staff with centimetre graduations and, being well known, is not further described here. The electronic method is carried out with the bar-code staff and is very simple.

[ON] | MEASURE ONLY | (about 1 second)

Switch on the instrument. The name of the current user program is briefly faded in. If the instrument is new, the message MEAS ONLY is displayed.
If the instrument has already been used, the last user program is displayed.

| Rod ≡ 2.0246 |

If MEAS ONLY has been set, the instrument stops at this display.

Select the user program

Various user programs are available. Inspect the choice offered and then select the measurement program MEAS ONLY (= measure only):

[PROG]

Call the Program menu.

[DSP] | P MEAS ♦ ONLY | [RUN]

Scroll through the menu with [DSP] and finally select MEAS ONLY. Confirm.

| MEASURE ONLY | (about 1 sec)

The measurement program selected is briefly faded in.

Rod ≡
2.0246

The last measurement with MEAS ONLY is displayed, e.g. the staff reading. The instrument is ready for measuring (measurement prompt is displayed).

Measure

Using the vertical crosshair, target the middle of the levelling staff and use the focusing knob to bring the image of the staff into sharp focus.

Measure

Press the red measuring button.

Rod ≡
1.6258

When the measurement is complete, the staff reading is displayed.

DSP

Dist ≡
27.85

The distance to the staff is displayed.

The instrument is now ready for the next measurement.

2.4 Measuring with recording in the REC module

The data are stored in the removable REC module.

There are two options for reading out the data:

- To use the special GIF10 or GIF12 reader to read out the contents of the REC module. This method is used mainly back in the office, where the readers are attached to the computers; its advantage is that the instrument does not need to be brought to the computer.
- To read directly across the serial interface of the instrument. This method is particularly suitable if a portable computer is available. The data can be saved and post-processed on site.

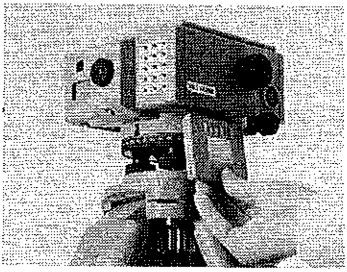


Fig 2-5 Inserting and removing the REC module

Insertion:

The contacts of the REC module, and its label, must face outwards.

Push the REC module into the shaft until it engages.

Removal:
Pull the REC module slightly outwards and then down.

If the instrument is not yet switched on, press [ON] and set the program MEAS ONLY. Proceed as already described in section 2.3. The following display appears:

```
Rod      =
   1.6258
```

The last measurement is displayed, either as a staff reading or as a distance.

Switch on recording mode

If the data are to be stored in the REC module:

[SET], [DSP]

```
SET      ♦
RECORD
```

[RUN]

Scroll through the display until SET RECORD appears. Confirm.

[DSP]

```
RECORD ♦
module
```

[RUN]

In the next menu, confirm the selection of RECORD *module*.

```
ALL
MEAS  No=
        1
```

The display of ALL indicates that the recording mode is switched on. The instrument is ready for measuring (measurement prompt is displayed).

The running point number (No) shown is 1. If your instrument has already been used, a different number may be shown.

Measure

Using the vertical crosshair, target the middle of the levelling staff and use the focusing knob to bring the image of the staff into sharp focus.

Measure

Press the red measuring button.

ALL
Rod ◆
1.8564

(DSP-TIME)

When the measurement is complete, the staff reading is briefly displayed. The data block is automatically stored in the REC module.

ALL
MEAS No=
2

The point number is automatically incremented by 1. The instrument is now ready for the next measurement.

Inspect the remaining data

The remaining data in the current data set can be called up individually with DSP:

DSP

ALL
Rod ◆
1.8564

(DSP-TIME)

The staff reading, ...

DSP

ALL
Dist ◆
20.93

(DSP-TIME)

... the horizontal distance ...

DSP

ALL
PtNo ◆
1

(DSP-TIME)

... and the point number.

ALL
MEAS No=
2

After the elapse of the short time allowed for displaying data, the display jumps to the starting menu.

2.5 Setting the instrument parameters

The SET key is used for setting the instrument parameters.

Example:
Setting the number of decimal places for the display of the staff reading, e.g. the maximum number of places.

[SET]			Call the SET menu
[DSP]	SET ◆ FIX	[RUN]	Scroll through the menu until you reach the SET FIX entry, then confirm.
[DSP]	FIX ◆ all	[RUN]	You can now choose between *standard* and *all*. Choose FIX *all*: NA2002: 0.0001m / 0.001ft, NA3003: 0.00001m / 0.0001ft

3 Operating the instrument

3.1 The keyboard

3.1.1 The colour-coding

The colour-coding is intended to help you find functions and digits.

orange:	PROG and SET , the main functions.
yellow:	All digits.
green:	DSP, scrolling.
blue:	FIND, access to the data in the REC-module.
white:	Other standard functions.

3.1.2 Key descriptions

The keyboard of the NA2002/NA3003 is arranged so that related functions are grouped together, simplifying its use.

ON / OFF and **display lighting**

ON
Switch the instrument on by pressing the key briefly. The display immediately and briefly shows the name of the current user program, e.g. MEAS ONLY, and then automatically returns to the last menu accessed before it was turned off.

ON-key held down for one or two seconds:
The **display lighting** is activated by turning on the instrument.

OFF
Switch the instrument off by pressing the key briefly.

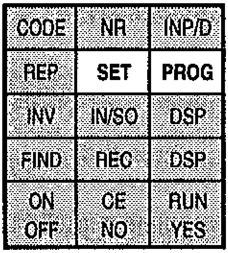


Fig. 3-1

Choosing parameters and user programs

[SET] [PROG]

[SET]
Sets the instrument parameters. The key is only enabled when the measurement prompt is displayed. Consult Appendix B for an overview of the parameters. For more details, see section 9.

[PROG]
Activates the user program menu. The key is only enabled when the measurement prompt is displayed. See section 4.2 and Appendix A.

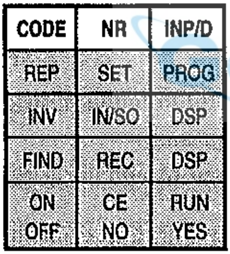


Fig. 3-2

Enter numerical data

[CODE] [NR] [INP/D]

The keys for entering numerical data are all located on the top row of the keyboard.

[CODE]
For recording the code block with four sets of additional information. The key is only enabled if the recording is also enabled. For more details, see section 8.5.

[NR]
For entering a running- or individual point number. The key is only enabled if the recording is also enabled. For more details, see section 6.2.

[INP/D]
This key can be configured as function **INP** (= manual data input) or as **D** (= distance measurement). The key is only enabled when the measurement prompt is displayed. For more details of **INP** and **D**, see section 8.4.

CODE	NR	INP/D
REP	SET	PROG
INV	**IN/SO**	DSP
FIND	REC	DSP
ON OFF	CE NO	RUN YES

Fig. 3-3

Input for special applications

[REP]

[INV] [IN/SO]

[REP]
Repeats the last measurement. The key is only enabled when the measurement prompt is displayed.

[INV]
For levelling with an inverted staff (0-point above). The measurement prompt changes from "≡" to "i" and flashes at a slow rate. The key is only enabled when the measurement prompt is displayed. To change back, press [INV] again.

If the inverted measurement prompt is shown, a measurement cannot be made by mistake to a normally-positioned staff (0-point below). The opposite is also true (normal measurement prompt displayed, no measurement to inverted staff). In both cases Error 51 is displayed.

[IN/SO]
Switches during line levelling to intermediate sight or to setting-out, or back again to line levelling. The key is only enabled when the measurement prompt is displayed. For more details, see sections 6.6.2 to 6.6.4.

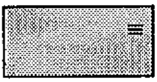
CODE	NR	INP/D
REP	SET	PROG
INV	IN/SO	**DSP**
FIND	REC	**DSP**
ON OFF	CE NO	RUN YES

Fig. 3-4

Display scroll

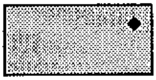
[DSP]▼ Scroll down
[DSP]▲ Scroll up

[DSP]



When the <u>measurement prompt</u> is displayed:
The results of the last measurement are shown in succession.

DSP



When the menu prompt is displayed:
The selectable user programs, SET options and measurement values are shown in succession.

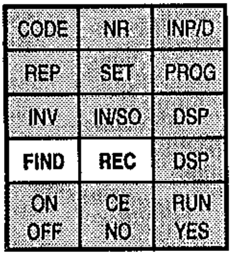


Fig. 3-5

Display and store data

FIND REC

FIND
Retrieves and displays the data stored in the REC-module.

REC
Stores the code block or a measurement within the setting-out program.

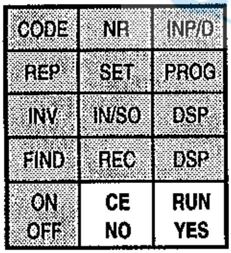


Fig. 3-6

Confirms or corrects user input

CE / NO RUN / YES

CE
- Deletes numerical input values, digit by digit. When all digits have been deleted, the input is terminated and the previously-stored value is retained.
- Quits a wrongly-called function. The instrument returns to its previous state.

RUN
- Ends the numerical input. The new value is saved.
- Starts the chosen function or program.

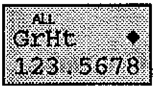
YES / NO

YES / NO

A question ending with "?" is always answered with YES or NO . The function is then either carried out (YES) or not carried out (NO).

3.2 User guidance

3.2.1 The display

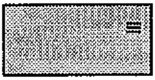


The display for the NA2002/NA3003 contains a status line (e.g. for showing ALL, ft or Bat) and two display lines, each with eight characters, for showing the data.

Overflow symbol: " ← "

One or more digits, and perhaps the negative sign, are positioned to the left of the displayed number, but there is not enough room for them to be displayed unless you reduce the number of decimal places.

3.2.2 The prompts and menu labels



Measurement prompt

- The instrument is waiting to measure.
- Most other functions, e.g. PROG, SET etc, are enabled.
- To call previous stacked measurements, use DSP.

Menu prompt with SET

Use DSP to successively display the options.
Use RUN to confirm the option selected.

```
F PtNo ♦
     100
```

Menu prompt with FIND

Use [DSP] to search forwards or backwards within the file. "F"indicates that the FIND-function is enabled.

```
P MEAS ♦
  ONLY
```

Menu prompt with PROG

Use [DSP] to select a user program. Use [RUN] to confirm the choice.
"P" indicates that entries from the PROG menu are being displayed.

```
Dist    ♦
   25.46
```

(DSP-TIME)

Menu prompt when showing measurement results

After the measurement has been successfully completed, the staff reading (Rod) is displayed.

The other data and ancillary data (e.g. distance to staff, point number, height etc.) are stored in the stack until the next measurement. They can be called up and displayed with [DSP] (scrolling). See the example in section 2.4 ("Inspect the remaining data").

[RUN] or [CE] prematurely terminates the automatically-restricted period of display.

A list of all abbreviations found in the user guidance can be found in Appendix E.

3.3 Measuring

3.3.1 The measuring button

The red measuring button triggers the measurement. To avoid turning the level away from the staff, press the button only lightly. Measuring commences only after you have released the button. This ensures that the instrument has time to stop vibrating.

The measuring button is located next to the focusing screw, so that you can conveniently reach and operate it with one finger after focusing.

3.3.2 The measurement procedure

You can only measure if the measurement prompt is showing.

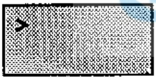
Aiming at the staff

Using the vertical crosshair, target the middle of the levelling staff and use the focusing knob to bring the image of the staff into sharp focus.

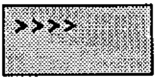
Now inspect the quality of the image to see in particular whether it keeps still or whether it shakes (because of wind or vibration). Take appropriate action: Either wait until it is still, or use another measuring mode, or switch to multiple measurement.

Measure

When the image of the staff is satisfactory, press the red measuring button. As you let it go, you will hear a beep.



The measurement is proceeding.



The measurement is complete after about four seconds (four arrows are displayed). The beep sounds again as the measurement results are displayed.
If for some reason the instrument cannot complete the measurement normally, the message *Error 51* appears, accompanied by a double beep.

If the audio signal facility is switched off, you will not hear a beep.

4 The user programs

The user programs incorporated in the digital level make levelling extremely simple. Because values no longer need to be read off from the staff, less skill and therefore less training are required. However, the basic rules of levelling, such as positioning the instrument in the middle between the backsight and foresight staff positions, or the routine checking of the collimation error (two-peg test) must still be known and respected. This is particularly true for more demanding assignments such as precision levelling.

4.1 PROG = calling up programs

[PROG]	P MEAS ◆ ONLY	The name of the current measurement program is dsplayed.
[DSP]	P CONT ◆ LEVELING [RUN]	Scroll through the list of programs until you find the one you want, then confirm.
	CONT LEVELING (about 1 second)	The name of the program selected is briefly faded in for inspection.

The program selected remains active until another is chosen.

4.2 Program descriptions

The measuring program:

MEAS ONLY	Staff reading and distance measurement only.
START LEV BF	Start line levelling with the **BF BF** technique (Method 1, see description below).
START LEV BFFB	Start line levelling with the **BFFB BFFB** technique (Method 2, see description below).
CONT LEVELLING	Continue line levelling with the option of branching to the subprograms Intermediate sights and Setting out.

Descriptions of the BF and BFFB methods:

BF BF ... (Method 1)

From the station a backsight is measured, then a foresight.

BFFB BFFB ... (Method 2)

This is the procedure for precision levelling from each station, with two backsight measurements (B1, B2) and two foresight measurements (F1, F2) in the sequence **B1-F1-F2-B2**.

After F1 you may change the instrument height, for example by turning the footscrews and carefully recentring the bull's-eye bubble.

The height difference is the mean of the two individual height differences $\Delta H1 = (B1-F1)$ and $\Delta H2 = (B2-F2)$.

The station difference is the difference between the two individual height differences ($\Delta H1 - \Delta H2$). The station difference is compared with the station tolerance.

The difference in sighting distance ($= \Sigma D_B - \Sigma D_F$) can be monitored by means of preset tolerance values.

To change from the BF method to the BFFB method or vice versa you must start again from the beginning.

The service programs:

CHECK 'A x x B'

Two-peg test for the Förstner- and Näbauer procedure (distances in the ratio 1:2).

CHECK 'A x Bx'

Two-peg test for the procedure in which the first station is located equidistant between the two positions of the staff:
- Classical procedure (second station near to a staff)
- Kukkamäki procedure.

CHECK COLLIMTR

Checking the electronic line of sight in front of the collimator. Only for the NA3003.

REC-M. DATA
- **ERASE DATA**
- **SEND DATA**

Erasing data from the REC-module, or reading them from across the serial interface.

5 Recommendations for surveying

5.1 Important instrument settings

Before you start measuring or line-levelling, ask yourself the following questions:

- Measurement with correction for earth curvature, or without?
- What sort of a system accuracy?
- What sort of an integration time?
- Which measuring mode, and how many measurements?

You can set the appropriate parameters by using the SET function.

5.1.1 System accuracy

The system accuracy describes the difference between the measured actual value and the theoretical required value for the staff reading.

In the normal setting, the standard deviation of a measured value is < 0.05mm. If enhanced (= *"extended"*) system accuracy is demanded, the calculation is refined to reduce the standard deviation to < 0.03mm, under which circumstances the measurement takes between two and four seconds longer.

You should opt for the enhanced system accuracy if you measure statically, e.g. for monitoring. You should also select it if you want the highest attainable precision, provided that the longer measurement time is not a great disadvantage.

The standard deviation specified for the double-run levelling continues to be the accuracy to be aimed for in the normal setting.

The system accuracy is indicated by means of the arrowheads as follows:

```
>>>>
```

Setting:
SET CONFIG ACCURACY *standard*

```
*>>>
```

Setting:
SET CONFIG ACCURACY *extended*

The first ">" is replaced by "*".

5.1.2 Integration time

The integration time (SET CONFIG INT_TIME) is analogous to the exposure time as it is known in photography. In the automatic mode, the measurement time (excluding the time for calculation) ranges from four milliseconds to two seconds, depending on the prevailing light.

Under difficult measurement conditions, where the staff image shakes slightly as a result of heat shimmer or vibration, very short integration times are a disadvantage, because the measurement is a momentary event and therefore does not represent the mean value. It is therefore useful to carry out the measurement over a longer period of time, and this is achieved with an integration time which you, the user, can set to between three and nine seconds.

Display of integration time (example):

```
>>>>
I TIME 4
```

The manually-set integration time is faded in during the first measurement:

The integration time is four seconds.

5.1.3 Measuring mode and number of measurements

There are single measurements ($n = 1$) and multiple measurements ($n > 1$). "n" is the number of measurements automatically carried out in succession by the instrument. This is not the same as tracking. The values are averaged or the median value is calculated. The three measuring modes available are described below. The settings in the mode SET MEASURE, and the displays, are listed in section 8.2.

Mean value ($1 \le n \le 99$)
The running mean value of the measurements is displayed along with the standard deviation of the single measurement. This measuring mode is used for normal measuring conditions where all measurements are processed without filtering.

By setting $n = 1$, the single-measurement mode is engaged.

Mean value with input of its standard deviation and with outlier test ($2 \le n \le 20$)
The running mean value of the measurements is displayed along with the standard deviation of the mean value. You can prescribe the standard deviation of the mean value and the minimum ("n min") and maximum ("n max") number of measurements. As from the minimum prescribed number of measurements, the instrument starts to calculate whether the prescribed standard deviation is reached and it stops as soon as this is so. If the prescribed standard deviation is not reached, the instrument stops measuring when the maximum number of measurements is attained.

In addition, an outlier-elimination procedure is carried out, during which "bad" measurements are filtered out. The maximum number of outliers is defined by the difference "n max" - "n min". If you do not want to reject any measurements, set "n max" = "n min".

The measurement proceeds as follows:

1. Carry out "n min" measurements.
2. Is the standard deviation ≤ the prescribed standard deviation? If so, the measurement is finished.

3. If the prescribed standard deviation is not reached, perform one more measurement (provided that "n max" has not been reached).
4. Is the new standard deviation (calculated from all measurements) ≤ the prescribed standard deviation? If so, the measurement is finished.
5. If the prescribed standard deviation is not reached, eliminate one outlier and test the standard deviation calculated from the remainder. Repeat the procedure until you reach the prescribed standard deviation or "n min".
6. The loop recommences at point 3.

Median (1 ≤ n ≤ 20)
The median value is the central entry in a sorted list of values. If there is an even number of values, the median is expressed as the average of the two central values. For example, for three measurements the second one is the median value; for four measurements the median is the average of the second and third values in the sorted list.

Applying the median procedure has the effect of filtering outliers, because one or more outliers become peripheral values in the sorted series of measurements and therefore lapse automatically.

Apply the median procedure if the instrument or the staff is on an unstable foundation (e.g. because of vibration from traffic) or, more generally, if the staff image is seen to tremble slightly. The median procedure can also be combined with longer integration times.

By setting n = 1 , the single-measurement mode is engaged.

5.2 Measuring without recording

Unlike in measuring with recording, here no point numbers are displayed. Otherwise the process unfolds in the same manner.

Please note the following special aspects:

Measuring program MEAS ONLY

Unlike in measuring with recording, the results remain displayed after the measurement, also if you try to display them with [DSP]. You have enough time to study them or to write them down.

Measuring program CONT LEVELLING

During line levelling, the results (e.g. the foresight staff reading) are briefly faded in and then the corresponding prompt is displayed (Backsight).
Choose therefore a somewhat longer display time if you want to look at the results. Set SET CONFIG DSP_TIME to about three seconds.

6 Measuring with recording

Activating the recording mode
SET RECORD *module/serial* (*module* for saving in the REC-module, *serial* for saving via the serial interface). The facility of entering point numbers is now automatically activated.

The recording template is a fixed parameter.

6.1 The recording devices

6.1.1 The REC-module GRM10

The 64Kbyte REC-module can store up to 8000 data words. This is enough to store 800 height differences (backsight minus foresight) or 1330 intermediate sights.

The data can be either transferred to the computer either directly across the serial interface or via the GIF10/GIF12 reader.

To transfer to the REC-module the required heights for setting out, use the GIF10/GIF12 reader.

6.1.2 The field computer GPC1

With the GPC1, an MS-DOS-compatible field computer, you can store data and apply your own programs for controlling the instrument and for post-processing the measurements.

Settings on the digital level:
- SET RECORD *serial*
- SET CONFIG COMM *standard*

Settings on the GPC1:
- Standard data transfer parameters
- Prepare the GPC1 for recording: [ALT] +[ESC] (see GPC1 manual)

6.2 Managing point numbers

Running- and individual point numbers
Set a starting value for the running point number. This value is automatically incremented by a predetermined amount.

Instead the running point number you can enter an individual point number at any time. Afterwards, provided that no further individual point number is entered, the running point numbering is automatically reintroduced.

Running point number counters

The instrument only manages one running point number counter, i.e. the same counter is used for all measuring programs. If, while the line-levelling program is active, the intermediate sight or setting-out subprograms are called, they will use the point number from the line-levelling program.

6.2.1 Entering point numbers

Note: The point number of the backsight cannot be changed.

Key	Display	Input	Description
[NR]	ALL ind. ◆ PtNo		Calls the point-number input. You have a choice between individual ....
[DSP]	ALL running◆ PtNo	[RUN]	... and running point numbers. Choose with [DSP] and confirm with [RUN].
	ALL run. No 345	101 [RUN]	The current number is displayed (345). Enter a new point number (e.g. running point number 101). With SET *enter* INCREMENT the input of the point number is concluded here. With SET *show* INCREMENT the menu for the incremental input is called up. The current increment for each point-number entry is displayed and you can overwrite it if necessary:
	ALL INCREM. 1	2 [RUN]	The current increment (1) is displayed. Confirm the value shown or overwrite it (e.g. with 2). This concludes the point-number input.

6.2.2 Setting increments

Increment for point number

With the function SET INCREMENT you can preset any increment sizes for the running point numbering.
This function is only active if the recording facility is enabled.

[SET], [DSP] — Display: ALL / SET ◆ / INCREMNT — [RUN]

Select the function SET INCREMENT.

You have two options: a), b)

a) …[DSP] — Display: ALL / show ◆ / INCREMNT — [RUN]

This option causes the point-number input with [NR] to be followed by a display of the increment, which can then be altered.

Choose the above option if you frequently need to change the size of the increment or if you need to display the increment for inspection.

b) …[DSP] — Display: ALL / enter ◆ / INCREMNT — [RUN]

This option accesses the incremental input.

It also causes the point-number input with ([NR]) to be followed by no display of the increment.

Choose the above option if you rarely need to change the size of the increment and if you often enter point numbers.

Display: ALL / INCREM. / 1 — -10 [RUN]

Incremental input (e.g. -10).
Positive and negative values, including zero, are permitted.

6.3 Automatically storing data in the REC-module

Measure — Display: ALL / Bl 0033

(about 0.2 sec)

The data block is automatically stored after the measurement. The instrument briefly fades in the block number (0033) and confirms successful storage with a long acoustic signal. With the setting SET CONFIG BEEP *off* there is no acoustic signal.

6.4 MEAS ONLY

[PROG], [DSP] — P MEAS ◆ ONLY — [RUN]

Select the program MEAS ONLY.

ALL MEAS No= 100

The current point number, e.g. No = 100, is displayed. The instrument is ready to measure.

Measure — Rod ◆ 1.294 (DSP-TIME)

After the values have been measured and stored, the staff value is displayed.
After the time permitted for the display has elapsed, the display goes back to showing the measurement prompt.
[CE] or [RUN] prematurely terminates the automatically-restricted period of display of the staff value.

ALL MEAS No= 101

The point number was automatically incremented by +1. You can now carry out the next measurement, or ...

[DSP] — Dist ◆ 27.85 (DSP-TIME)

... you can display the measurement values and the point number.

6.5 START LEV = Start line levelling

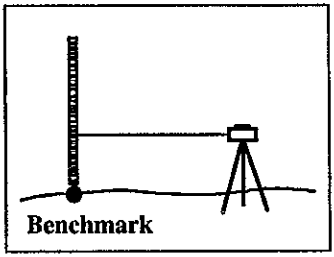


Fig. 6-1 Starting the line levelling

The height and point number of the starting point of a line-levelling procedure are entered. The instrument then goes automatically to the program CONT LEVELLING.
The height of the starting point can be called from the REC-module.

6.5.1 START LEV BF (BFFB)

[PROG]		Call the measuring programs.
[DSP] ALL P START◆ LEV RV	[RUN]	Select the measuring program BF or BFFB.
ALL START L sure?	[YES]	[YES] = continue [NO] = abort
ALL StatTol mm 0.25	[RUN]	*Only appears for BFFB.* Enter the station tolerance (value > 0.0) for permanently monitoring the station difference. The units are: mm / 0.001ft / inch
ALL PtNo 100	[RUN]	Confirm the proposed point number or enter a new number for the starting point.
ALL INCREM. 2	[RUN]	Confirm the proposed increment or enter a new increment for the point numbering. The instrument starts at the beginning of the file and searches for the data set which has the required point number.
ALL F Block◆ 0016 (about 1 second)		The numbers of the blocks containing the point number are briefly faded in. To search for another data set having the same point number, press [REP]. If none exist, the message "no data" appears.
ALL GrHt ? 100.1234	[YES] *oder* [NO] **460.35** [RUN]	[YES] accepts and stores the proposed ground height. [NO] enables a new height (e.g. 460.35) to be entered. Then press [RUN] to store the value.

The height of the instrument above sea level is generally entered here. By entering 0.0m the misclosure at this point is displayed.

After the values have been stored, the menu automatically goes to the measuring program CONT LEVELLING.

6.6 CONT LEVELLING = Continue line levelling

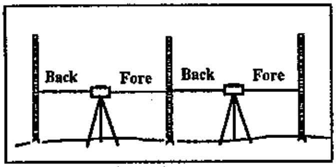


Fig. 6-2 Line levelling

The program continuously calculates the height differences (B - F) and the resulting heights of the points measured in foresight or in intermediate sight. A comparison with known heights can therefore be made at any time.

Also, points with known heights can be set out.

After switching off or quitting, followed by switching on or logging in, the program continues where it left off.

Point number - of backsight

The point number of a backsight is always the same as the point number of the last foresight and therefore cannot be changed (the [NR]-key is blocked).

Point number - of intermediate sight

For the intermediate sights you should use a new point number, different from those used in the line levellings.

6.6.1 Line levelling BF

Sequence of measurements at the station

1. Backsight
2. Foresight / intermediate sight / setting out (in any repeating sequence).

After the station has changed, always measure the backsight first, because all of the other measurements (foresight, intermediate sights and setting-out measurements) relate to the last-measured backsight.

PROG, DSP

ALL
P CONT ◆
LEVELING

RUN

Select program CONT LEVELLING.

ALL
BACK No=
100

The display shows the last-activated display position, with either BACK- or FORE prompt.

Measure

ALL
Rod BK◆
1.7920

(DSP-TIME)

Measure. The staff reading in this example is 1.7920m. (BK = backsight.)

The display time is that already entered in SET CONFIG DSP_TIME (recommended value: one or two seconds).

ALL
FORE No=
101

Request to measure the foresight. (The point number has been incremented.)

In the data stack, the measured values and the absolute instrument height (InstHt) are shown by scrolling (DSP):
462.1420m = 460.35m + 1.7920m.

After START LEV the point number of the first foresight is always set to 1.

Measure

ALL
Rod FR◆
1.4893

(DSP-TIME)

Measure.

The staff reading in this example is 1.4893m. (FR = foresight.)

ALL
BACK No=
101

Request to measure the backsight (from the next station). Now you go with the instrument to the next station.

After the foresight measurement, the measured values, and also the height difference (HDif) and the absolute height of the foresight point (GrHt), are shown in the data stack by scrolling (DSP):
HDif = 0.3027m = 1.7920m - 1.4893m.
GrHt = 460.6527m = 460.35m + 0.3027m.

6.6.2 IN/SO

You can switch to intermediate sights or to setting out without quitting the line-levelling program.

Key	Display	Description
[IN/SO]	ALL INTER- ◆ MEDIATE	Call the menu for the sub-program *intermediate sights* and *setting-out*. Choose intermediate sights, or ...
[DSP]	ALL SET OUT◆	... setting-out, or ...
[DSP]	ALL CONT ◆ LEVELING	... return to the line-levelling menu.

6.6.3 IN = intermediate sights

To correctly calculate the heights of intermediate sights, you must first measure the appropriate backsight. If the intermediate sights were measured before the backsight, this "wrong" measurement data can still be used, but during the evaluation it must be allocated to the appropriate backsight.

Key	Display	Description
[IN/SO], [DSP]	ALL INTER- ◆ MEDIATE [RUN]	Call the program menu for intermediate sight from the line-levelling program.
	ALL IN NO= 101	The instrument is now ready to take the intermediate sight measurement. The point number from the line levelling has been adopted and if necessary it must now be altered.
Measure	ALL Rod IN◆ 1.6085 (DSP-TIME)	Measure. The staff reading in this example is 1.6085m.

```
ALL
IN     No=
       102
```

The instrument is ready for the next measurement. (The point number has been incremented).

The rest of the information, consisting of the measurements, the height differences (HDif) and the ground height (GrHt), is stored in the data stack ([DSP]) in a similar manner to the foresight measurement.

Now measure the next intermediate sight, or ...

[IN/SO]

```
ALL
CONT       ♦
LEVELING
```

[RUN]

...quit intermediate sights and return to line levelling .

6.6.4 SO = setting out point heights

First measure the backsight, and then you can set out either before or after measuring the foresight.

Measuring with the REC-module

The instrument reads required heights from the REC-module provided that they are already stored there.

The point number is used in searching for setting-out heights, starting at the beginning of the file. If in the REC-module there is no height entry for the point number entered, the message "no data" is displayed. The required height can then be entered by hand.

Make sure that the storage on the instrument is set to SET RECORD *module.*

Measuring without the REC-module

You must enter the setting-out heights manually.

[IN/SO], [DSP]

```
ALL
SET OUT♦
```

[RUN]

From the line-levelling program, call the setting-out functions.

```
ALL
PtNo SO
       115
```

The instrument requires the point number. The present point number is suggested. Confirm with [RUN] or enter a different point number.

```
ALL
F Block◆
    0016
```
(about 1 second)

The numbers of the blocks which contain the point numbers are briefly faded in.

```
ALL
SHt  ?
400.0000
```

The required height stored in the REC-module has been found and is displayed for inspection (400.0).

If necessary, press [REP] in order to search for the next height which has the same point number.

[YES]

```
ALL
SO    No≡
     115
```

Confirm the displayed height with [YES] , or press ([NO]) and enter another height.

The instrument is now ready to measure.

Measure

```
ALL
Diff SO◆
  0.0134
```
(DSP-TIME)

After the measurement, the difference (required height minus measured height) is briefly displayed.

The staffperson should now correct the position of the staff by the amount displayed:

+0.013m: Raise the staff by 13mm
- 0.013m: Lower the staff by 13mm.


```
ALL
SO    No≡
     115
```

The instrument is again ready to measure. The point number remains unchanged.

Next steps (four options):

Measure

First option:
Repeat the measurement to the same point, e.g. after correcting the height of the staff.

[REC]

```
ALL
SO    No≡
     115
```

Second option:

Record the measurement and terminate.

[RUN] — ALL PtNo SO 116 — The point number is incremented automatically.

[RUN] — ALL PtNo SO 116 — Third option:
Measure without recording. The point number is incremented automatically.

[IN/SO] — ALL CONT ◆ LEVELING — [RUN] — Fourth option:
Return to the line levelling program.

6.6.5 Line levelling BFFB

After START LEVELLING, the procedure is as follows:

ALL BK1 No= 100 — Measure — Measure the backsight B1

ALL FR1 No= 1 — Measure — Measure the foresight F1.
The point number is set to 1. It can be changed if necessary ([NR]).

After F1 the sighting-distance test is automatically carried out, provided that the appropriate tolerance has been set (SET CONFIG TOLERANCE *enter* DIST_TOL).

ALL d 4.7 Tol 3.0 — Sighting-distance test:
This message appears if the distance tolerance has been exceeded (d = measured difference in sighting distance; Tol = tolerance value entered).
+d : Backsight distances are greater,
- d : Foresight distances are greater

[CE] / [RUN] — Delete message.

ALL
repeat
Station?

[YES] / [NO]

[YES] = Repeat measurements, starting with B1 (after optimizing the sighting distances)

[NO] = Accept and continue measuring.

ALL
FR2 No=
1

Measure

If the difference in sighting distance was in order, or the value was accepted, the next display follows. Measure the foresight F2.

ALL
BK2 No=
100

Measure

Measure the backsight B2.

The station difference is calculated and is compared with the station tolerance.

ALL
S 0.35
Tol 0.30

If the station difference is out of tolerance, a message appears.

S = measured station difference

[CE] / [RUN]

Delete message.

ALL
repeat
Station?

[YES] / [NO]

[YES] = Repeat measurements, starting with B1

[NO] = Accept and continue measuring.

ALL
BK1 No=
1

If the difference in sighting distance was in order, or the value was accepted, measurement of B1 is requested for the next station. The point number is adopted.

Additional notes:

Changing tolerance values

The station- and distance tolerances can be altered with the measurement prompt at any time.

[IN/SO]: **intermediate sights**

Intermediate sights do not appear as double observations in the BFFB procedure. If necessary, press [REP] to repeat the first measurement. Alternatively, enter the point number from the first measurement and then use this to carry out a second measurement.

For the NA3003 in BFFB mode, intermediate sights are only permitted after B1 or B2. After F1/F2 the IN/SO key is rendered inactive. It is an advantage to delay measuring the intermediate sights until immediately after a rapidly-performed BFFB.

The values for the intermediate sights relate to only one of the just-determined backsight measurements, either to B1 or to B2.

6.7 On-line operation

One or several digital levels can be controlled from the computer. Various instrument functions (e.g. the measurement itself) can be triggered externally and also special texts for individual user guidance can be written into the display.

Ask for the *WILD instruments on-line guide*, which gives additional details for on-line operation and lists all interface commands.

6.7.1 The computer link

It is often possible to link the instrument directly to the RS232 interface of the computer via the data-transfer cable. If, because of differing voltage levels, the communication does not function, the GIF2 serial RS232 interface with GIF7 voltage-regulating module for Leica instruments must be interposed.

Settings on the instrument

- SET RECORD *serial*
- SET CONFIG COMM USER (Set the interface parameters in accordance with the computer interface)

6.7.2 Interface commands

The new interface commands are listed below:

Command	Function
SET/470/n/m/σ n (n min.) = 2 to 20 m (n max.) = 2 to 20 σ = 0 to 999 [1/100mm]	SET MEASURE Mean_σm Requirement: n min. ≤ n max. σ = Standard deviation of mean value for sighting distance 20 metres.

Command	Function
SET/471/n n = 1 to 20	SET MEASURE Median
SET/455/n n = 3 to 9 [sec] n = 0 automatic	Integration time (only for NA3003): SET CONFIG INT_TIME
SET/480/n n = 0 standard n = 1 extended	System precision (only for NA3003): SET CONFIG ACCURACY
SET/450/n n = 0 to ±999 [1/10"]	Sets absolute collimation errors

6.7.3 Tagging the last measurement

If multiple measurements are triggered with the red measuring key, the instrument stores only the result.

If however the measurement is triggered via the on-line command (GET/M/11/...) the instrument transmits to the interface every intermediate result (= the contents of the display, updated after each measurement). Therefore "n" measurements are transmitted.

In the measuring mode "Mean σm", it is not evident after how many measurements the procedure was halted. Therefore the last measurement to be sent across the interface is specially tagged with the mark "4" at position 5 in data word 330 (refer also to section 10.1.1).

The special tagging of the last measurement applies generally to all measuring modes from n > 1 upwards. Example of data word: 330148+00012345.

7 The service programs

7.1 CHECK ... = Two-peg test

Correcting collimation error
The collimation error is the vertical angle between the line of sight of the instrument and the ideal horizontal line. In the digital level, there is both an optical and an electronic collimation error, and these are assigned to the appropriate measuring technique (optical or electronic).

The electronically-measured staff reading is automatically corrected with the collimation error stored in the instrument. As with an optical level, the optical collimation error must be precisely compensated by displacing the crosshair.

Two-peg-test methods
The collimation error can be determined on the basis of established procedures. The instrument offers two incorporated procedures: CHECK "A x x B" and "A x Bx" ("A" and "B" represent the staff stations and "x" the instrument stations). These two procedures each cover two methods, so that four different methods are available.

Two collimation errors are determined each time, the optical and the electronic. The electronic collimation error can be optionally stored as an instrument constant. For adjusting the crosshair, the theoretically correct staff reading for the optical sighting is displayed immediately after the determination.

The four individual measurements obtained when checking the line of sight cannot be stored.

The distance ranges are inspected during the measurements, so that an incorrect instrument station is reported immediately (Error 05).

It is also possible to set any collimation error manually. Please refer to section 7.1.2.

Procedure "A x x B" (figs. 7-1 to 7-3)
The distances are in the ratio 1:2. The instrument stations are either between the staffs or outside them.

Distance requirements:
$0.2 \times D <$ shorter run $< 0.4 \times D$. D = sum of both runs from the first station.

a) Instrument stations inside
The staff distance is 45m - 60m. The instrument stations are at a third of this distance.

Fig. 7-1 First station

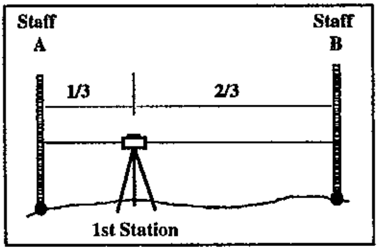
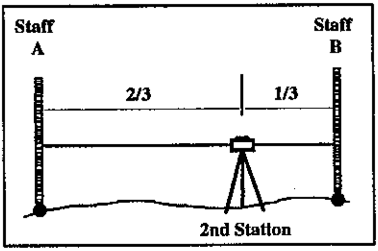


Fig. 7-2 Second station



b) Instrument stations outside
The disadvantage of this procedure compared with a) is that the staffs must be turned when the station is changed.

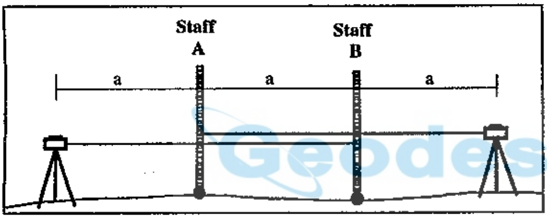


Fig. 7-3 Instrument outside

a = 15m - 20m

Procedure "A x Bx" (fig. 7-4)
The first instrument station is in the middle, between the staffs. The second is either very close to one of the staffs, or is outside at the full staff distance.

Distance requirements:

First station:	The mean must be accurate to ±1m
Second station:	b ≥ 2.5m.

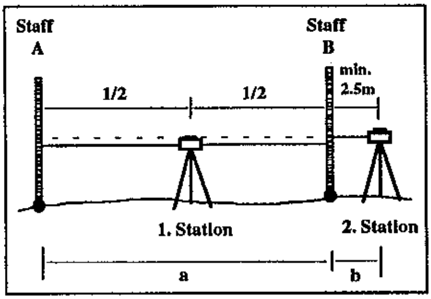


Fig. 7-4

a) Instrument in the middle and near to staff B (inside or outside)
a = 30m - 40m.

b) Instrument in the middle and outside at a distance of b = a
a = approx. 20m.

The measurement sequence
The sequence in which the measurements are made to the staffs must be <u>strictly</u> followed in all four procedures. It is: <u>A1, B1; B2, A2</u>. For stations where the two staff distances differ, the nearer staff must be measured to first.

When measuring from the middle, make sure that you do not first measure to B1 by mistake, as this can lead to an incorrect but substantial collimation error (< 100") not recognized as such by the system, which reports *Error 04* only if the error exceeds 100".

The calculated values
In the NA2002/NA3003 a distinction is made between the <u>absolute collimation error</u> (absColl) with respect to the original factory setting of 0.0", and <u>the change in collimation error</u> (CollDif) with respect to the previous current collimation error. Both values are calculated and displayed after all measurements have been taken.

The formula below enables the change in collimation error α (CollDif) to be calculated on the basis of the measurements displayed when the line of sight is checked (two-peg test):

$\alpha =$ arc tan [(A1-B1+B2-A2) / (d1-d2+d3-d4)]
A1, B1, B2, A2 : Staff readings
d1, d2, d3, d4 : Corresponding distances, e.g. d3 belongs to B2.

The change in collimation error is used only as a control value during the current two-peg test. The value is therefore deleted after the collimation error has been stored. The absolute collimation error is always available for inspection.

The collimation errors (*absColl* and *CollDif*) are shown in seconds of arc ("). The following approximation enables you to quickly convert seconds of arc into arc distances:

1" = 0.1mm / 20m or **2" = 0.001ft / 100ft**

7.1.1 Procedure

The procedure is essentially the same in both programs ("A x x B" / "A x Bx"). Here "A x x B" is taken as an example.

The results of a measurement can always be re-checked afterwards by means of [DSP].

In the two-peg test, use only the multiple-measurement mode, e.g. with n= 4 (median or mean value). Select SET MEASURE ...

[PROG], [DSP]	P CHECK◆ A x x B	[RUN]	Select the program.

	MEAS A1= A x B	The instrument requires the first measurement to staff A to be taken (measurement A1). The instrument station is marked with "x".
DSP	absColl◆ 3.6" (DSP-TIME)	*Optional:* Call up momentary absolute collimation error (absColl)
Measure	Rod A1◆ 1.6541 (DSP-TIME)	Measure and display the staff reading A1.
	MEAS B1= A x B	The instrument requires the first measurement to staff B to be taken (measurement B1). To display values from the previous measurement A1, press DSP.
Measure	Rod B1◆ 1.5012 (DSP-TIME)	Measure and display the staff reading B1.
	move Instr.! (about 1 second)	Move to the second instrument station.
YES	Instr. moved?	Confirm move.
	MEAS B2= A x B	The instrument requires the second measurement to staff B to be taken (measurement B2). The instrument station position "x" has changed.
Measure	Rod B2◆ 1.5625 (DSP-TIME)	Measure and display the staff reading B2.

Key	Display	Response	Description
	MEAS A2= A x B		The instrument requires the second measurement to staff A to be taken (measurement A2).
Measure	Rod A2♦ 1.7158 (DSP-TIME)		Measure and display the staff reading A2.
	compute Coll?	YES / NO	Should the collimation error be calculated? If NO, the existing values remain valid (message: "oldColl retained"). If YES : ...
	CollDif♦ 2.9" (DSP-TIME)		... the change in the collimation error is 2.9".
DSP	absColl♦ 6.5" (DSP-TIME)		Inspect the <u>absolute</u> collimation error. The value is derived from: 3.6" + 2.9" = 6.5" (= old value + difference).
	store newColl?	YES / NO	Store the new collimation error? If NO , the previous value is retained (message: "oldColl retained"). If the new values are acceptable you can save them with YES (message: "newColl stored").
	adjust reticle?	YES / NO	Do you want to adjust the crosshair for optical levelling? If YES: ...
	adjust to 1.716		... the required reading for staff A is here 1.716m. Read off the actual value from the cm scale on the staff and check this actual value against the required value.
PROG			Leave the two-peg-test program and return to the program menu.

Quitting the two-peg test early
If you press [NO] to quit the two-peg test early, e.g. before you have stored the collimation error, the instrument will return to the program menu from where you can choose another program or restart the CHECK ... program.

Computational accuracy of the collimation error
The standard deviation of a collimation error determined once only under normal atmospheric conditions is about 2".

7.1.2 Manual input of collimation error

You can also enter the absolute collimation error manually. This is useful if a mean collimation error is available, derived from several two-peg tests carried out in quick succession.

The value displayed afterwards can differ from the value entered by 0.1" . This is merely due to internal rounding-off.

The manually-entered collimation error replaces the previously-entered value and remains valid until it is itself altered as a result of the two-peg test or of a new manual entry.

Example: Manual entry of collimation error

[SET], ...	CONFIG ◆ COLLIM.	[RUN]	Call the function SET CONFIG COLLIM.
	absColl 2.3"	-3.5 [RUN]	The momentary collimation error is displayed (2.3"). Enter the new value (-3.5").

7.1.3 Adjusting the crosshair

If the instrument has been properly adjusted, the reading required from the two-peg test just described, and the actual reading, should be the same. If there is an appreciable difference, the crosshair should be adjusted, but this decision depends on the accuracy required. As a guideline, the limit of acceptable divergence is about 3mm - 5mm at a distance of 30 metres (100 feet).

If you adjust the crosshair, repeat the two-peg test afterwards and also inspect the adjustment. The new values should differ only slightly.

Two Allen keys for this adjustment have been supplied in the container.

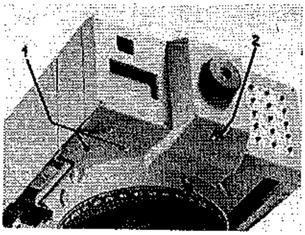


Fig. 7-5 Release the locking screw

Using the larger of the two Allen keys, carefully slacken the locking screw of the crosshair adjustment.

1 Adjusting screws for the bull's-eye bubble
2 Locking screw for the crosshair adjustment

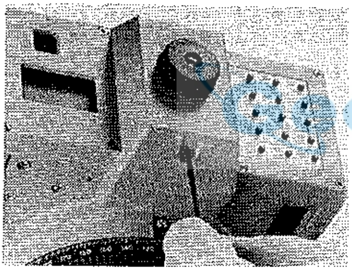


Fig. 7-6 Adjust the crosshair

After removing the locking screw, use the smaller of the two Allen keys to turn the adjusting screw until the crosshair is at the required value.

When the two-peg test gives satisfactory results, retighten the locking screw.

7.2 CHECK with COLLIMATOR

This two-peg test is only used for the NA3003. It involves determining the electronic collimation error. The test does not involve the crosshair adjustment procedure.

The special collimator required for this adjustment is not delivered as part of the normal package. It has a reticle which carries the bar code of the digital level. For more information, please contact our Technical Service Department.

This measuring program has the same menu structure as the others and is therefore very easy to use.

Key	Display	Description
PROG, DSP	P CHECK◆ COLLIMTR — RUN	Choose the program (checking with collimator)
	Co Dist 0.00	The instrument requires the input of the distance calibration value of the collimator.
20.236	RUN	Enter the distance calibration value.
	Co Rod 0.0000	The instrument requires the input of the staff reading calibration value of the collimator.
2.0237	RUN	Enter the staff reading calibration value.
	MEAS ≡ COLLIMTR	The instrument is now ready to measure. Proceed as follows: 1. Aim at the checkerboard pattern on the collimator reticle. 2. Bring the crosshair and the image into sharp focus. 3. Swing the crosshair over so that its image rests on that of the bar-code staff, which appears slightly fuzzy.
Measure	Rod ◆ 2.00229 (DSP-TIME)	Measure. The staff reading is briefly displayed. (Take multiple measurements to improve the accuracy.)
	store newColl?	Store the computed collimation error? Additional information (Rod, Dist, CollDif, absColl) can be briefly displayed by pressing DSP.
YES / NO :		
YES	newColl stored — PROG	The new collimation error is stored. Quit the adjustment program with PROG.

or [NO]	MEAS = COLLIMTR	([PROG])	The new collimation error is not stored. Return to the measuring prompt from where the measurement can be repeated, or quit with [PROG] .

7.3 REC-module DATA

This program includes the functions for <u>erasing</u> and <u>reading</u> the data stored in the REC-module. It is not possible to edit the data stored in the REC-module.

7.3.1 ERASE DATA = erase the data from the module

With this function, only the <u>entire</u> contents of the REC-module can be erased.

[PROG], [DSP]	P REC-M◆ DATA	[RUN]	Choose program and confirm.
[DSP]	P ERASE◆ DATA	[RUN]	Choose sub-program ERASE DATA.
	Passwd ■	951 [RUN]	The password is "951".
	data erased (about 2 sec)		All data in the REC-module are deleted.

7.3.2 SEND DATA = read out data

With this function, the entire contents of the REC-module can be read out across the serial interface. If several files are stored in the REC-module, only the first of them will be completely read out.

You can use the DOS-Programm TRANSINT.EXE to receive data and to store it in the PC. Please consult your local Leica agency.

You can also receive and store data by means of a terminal program (DOS- or WINDOWS). The communications parameters, and the procedure, resemble the description below.

Preparing to transfer data with TRANSINT.EXE:

- Link the digital level to the computer (RS232 interface).
- Prepare the digital level as follows:
  - SET CONFIG COMM *standard* (first sets the standard parameters)
  - SET CONFIG COMM USER: BAUD *9600*, *without* protocol
  - The REC-module is in position.
- Start up the transfer program TRANSINT on the computer and:
  - Configure the interface as follows:
    Baud rate = 9600
    Interface = COM1/COM2
    Stop bit = CR/LF
  - In the main menu, choose "Digital level" (3).
  - Now choose "Data from digital level to computer" (1).
  - After you have then defined the ouput device required, the computer is ready to accept the data.
- Start the data transfer on the digital level:

[PROG], [DSP]	P REC-M◆ DATA	[RUN]	Select the program and confirm.
[DSP]	P SEND ◆ DATA	[RUN]	Select the sub-program SEND DATA.
	ready to send?	[YES]	Do not confirm until the computer is ready to receive data.
	sending data ...		The data are transmitted. Wait until data transfer is completed (signalled by a long and a short audible signal).

Refer to the block number to see whether all data have been transmitted. To do this, press [FIND] and compare the block number of the last data set with that of the last data set to be transmitted.

To abort the data transfer:

Press [CE] during the transmission.

8 General functions

8.1 REP = repeat function

A measurement (foresight, backsight or intermediate sight) can be immediately repeated with [REP]. In line levelling, all of the station measurements can be repeated (B and F, or B1-F1-F2-B2). The last (= repeated) measurement is invariably used for the continuous calculation of the displayed height.

Example: BF measurement:

FORE No=
126

The instrument is ready to measure the foresight to point number 126.

[REP]

You would like to repeat the last backsight.

rep BK?
125

[YES] / [NO]

Should the backsight measurement for point number 125 be repeated?
If [YES], then ...

BACK No=
125

... the measuring prompt of the last backsight measurement (point number 125) is displayed and you can repeat this measurement.

Repeating within the BFFB-levelling procedure

[REP] takes you back step by step to each of the four observations and you can repeat the measurement from there.

You can therefore repeat the measurements for an entire station, even if for example you have accidentally answered the question *"Repeat station?"* with [NO].

Coding the repeated measurement

If the measurement is repeated in recording mode, a special code block is automatically stored and this indicates which measurement was repeated. See sections 10.1.3. und 10.2

8.2 Multiple measurements

Multiple measurements are set in SET MEASURE *Mean/Median* , using **n ≥ 2** .

Perform multiple measurements if the image shakes (because of e.g. heat shimmer, wind, vibrating foundation) and, in general, to improve the accuracy during precise levelling and during the two-peg test.

The instrument stops automatically after n measurements and records the result.

Manual termination

You can also terminate the measurement procedure manually, prematurely if necessary, after assessing the values displayed:

a) [REC] Store the values directly.

b) [CE] Terminate with the question:

ALL
store
meas.?

[YES] / [NO]

[YES] = Store measurements.

[NO] = Do not store, terminate.

8.2.1 Mean value

Setting

SET MEASURE *Mean* (n). n = 1 to 99

Measure

ALL
3 0.12
1.69437

After you trigger the measurement, this sort of display structure appears.

Top left: Counter for the number of measurements i which have been performed (i = 3).

Top right: Standard deviation of the single measurement after i measurements (= 0.12mm)

Below: The constantly-updated mean value after i measurements.

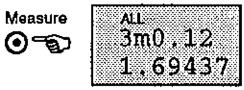
8.2.2 Mean value with standard deviation of mean value

Setting

SET MEASURE *Mean σm* (n min / n max / σm/20m):

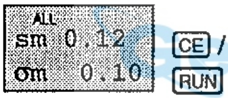
n min = 2 to 20

n max = 2 to 20 <u>and</u> ≥ n min
(if n max = n min, no outliers are cancelled)
σm/20m = standard deviation of mean value for a target distance of 20m (66ft). The input is always in <u>millimetres</u> , whatever units were set.



After you trigger the measurement, this sort of display structure appears.

<u>Top left</u>: Counter for the number of measurements i which have been performed (i = 3).
<u>Top right</u>: Standard deviation of the mean value in relation to the <u>present</u> distance after i measurements (= 0.12mm).
"m" indicates the standard deviation of the mean value.
<u>Below</u>: The constantly-updated mean value after i measurements.



Standard deviation σm not reached

This message is displayed if, after the maximum number of n measurements, the standard deviation entered has not been attained (sm > σm).
sm = measured standard deviation of mean value in relation to present distance.
σm = standard deviation entered, recalculated to present distance.
Finally the measurement can be either stored or rejected.

8.2.3 Median

Setting

SET MEASURE *Median* (n). n = 1 to 99

After you trigger the measurement, this sort of display structure appears.

<u>Top left</u>: Counter for the number of measurements i which have been performed (i = 3).
<u>Top right</u>: Band width = difference between largest and smallest value after i measurements (in this example = 0.12mm)

"B" indicates the band width.
Below: The constantly-updated median value after i measurements.

8.3 Distance summation and distance comparison

Very often in line levelling it is necessary to have the same distances for the foresight and backsight. It is possible to display the total length surveyed, along with a comparison of the backsight distance with the foresight distance.

The values can be called after every measurement ([DSP]):

$d = \Sigma D_R - \Sigma D_V$ Distance comparison = sum of the backsight distances minus the sum of the foresight distances

$\Sigma = \Sigma D_R + \Sigma D_V$ Sum of the distances = total length surveyed.

Example:

[DSP]

```
d   -0.8◆
Σ   407.3
```

(DSP-TIME)

After the foresight has been measured successfully, the results are displayed.

Here, the total length surveyed is 407.3m. The sum of the backsight- and foresight distances is balanced to within 0.8m.

[DSP]

```
d   24.7◆
Σ   432.8
```

(DSP-TIME)

Suppose, for example, that the backsight has been measured. To keep the distances balanced, the next foresight distance measured must be 24.7m. As the staffperson walks past the instrument station, the observer should say "25 metres", the distance to be walked.

You can test the distance value at any time by pressing the [INP/D] key (see section 8.4.2).

8.4 INP/D

8.4.1 INP = manual input of measurement data

There are times when you must enter measurement data manually, e.g.:

- When you have to take an optical measurement using the cm-divisions on the staff because electronic measurement is not possible (bar code too obstructed, distance less than 1.8m, flat battery, etc.)

- When you have to measure to a hanging measurement tape because of large height differences
- When you are using a staff which is longer than 4.05m and which has no bar code.

The configuration required is SET CONFIG KEY *Input*.
Measurement data can be entered manually in all measuring programs with the exception of the two-peg tests.

Example from line levelling:

	FORE No≡ 241		The foresight to a very close profile point must be taken optically, using the cm-divisions on a standard staff.
INP/D	Rod ■	1.588 RUN	Enter the staff reading (1.588m).
	Dist ■	1.45 RUN	Enter the distance (1.45m).

8.4.2 D = Single distance measurement

The single-distance measurement is used to optimize or inspect the distance from level to staff, e.g. in distance levelling or with the two-peg test. It is also possible to use it when you just need a horizontal distance and are not concerned with levelling.
The function can always be called when the instrument is ready to measure, i.e. when the measurement prompt "≡" is displayed. After the measurement, the distance to the staff is displayed briefly, but is not stored.

The configuration required is SET CONFIG KEY *Dist*.

Example:

	FORE ≡	Instrument is ready to measure the foresight.
INP/D	Dist 21.50 (about 2 sec)	The distance is measured and is briefly displayed.

FORE ≡

The instrument is again ready to measure the foresight.

8.5 CODE = input of code and information

In recording mode, a code block can be stored with up to four additional pieces of information. Many different types of data can be stored (e.g. date, observer, instrument number, job number, point coding, horizontal angle measurement etc.) either before or after the measurement.

A code block can be stored when the measurement prompt "≡" is displayed.

The instrument first requests the code number (*Code*) and afterwards the information to be stored (*Info1* bis *Info4*). To quit and to automatically record the data at any time, e.g. directly after Info1, press [REC].

The values entered can be up to eight digits long (without decimal point), and provided with a sign.

Example: Input of code number and Info1

[CODE] | ALL Code No ■ | **12** [RUN] | Call the code entry function and enter the code number (12).

ALL Info1 ■ | **960619** [RUN] | Enter information (960619).

ALL Info2 ■ | [REC] | Conclude the entry and store.

Aborting the code entry
To abort the code entry, press [CE]. Answer the question "clear all?" with [YES] (or with [NO], if the entry is to be retained).

8.6 FIND = display the data stored in the REC-module

Data stored in the REC-module can be displayed by using the [FIND] function.

First check to see that the REC-module is in place. The function call is available only from the measurement programs MEAS ONLY or CONT LEVELLING. The measurement prompt "≡" must be visible in the display.

Key	Display	Description
[FIND]	F GrHt ◆ 402.3568	The last value stored is displayed. "F" indicates that the [FIND] function is active.
[DSP], [DSP],...	F RodFR◆ 1.63582	The data can be scrolled up and down with [DSP].

After the letter "F" the values are tagged with the abbreviations used in the user guidance, e.g. "GrHt" = ground height, "RodFR" = foresight, etc.

"Unknown" data found in the REC-module, e.g. angle measurements from a theodolite, are displayed together with the respective word index (WI) , e.g. *WI=21*. For more information, refer to section 10 (Data format).

Other displays

- `F end of file`
- `F begin of file`
- `F no data` (REC-module is empty)

The data block

Each measurement is stored as a data block . A foresight measurement, for example, consists of:
a block number (F Block); a point number (F PtNo); a distance (F Dist) and a foresight measurement (F RodFR).

The codes and their associated information are also stored as data blocks. The data set consists of:
a block number (F Block); a code number (F Code) and the four information words (F Info1 to FInfo4).

8.6.1 Searching for point- and code numbers

A point- or code number can be searched for directly.

The search commences with the present data block and proceeds towards the first data block. The first matching data set is displayed. The search for a certain point- or code number can be repeated with [REP] , but it is not possible to jump to a chosen block number.

The message *Err. 71* (data block not available) appears when no matching data set, or no additional matching data set, can be found. To delete this message, press [CE].

Example:

Key	Display	Input	Description
[FIND]	F GrHt ◆ 402.3568		The last results stored are displayed.
[NR] / [CODE]	F PtNo ■	52 [RUN]	To search for a point- or code number, press [NR] / [CODE]. Enter the point- or code number required (in this example 52).
	F Block◆ 0035 (about 1 second)		If a data block with this point- or code number is present, the appropriate block number (35) is briefly displayed.
	F PtNo ◆ 52		The point- or code number found in data block 35 is displayed.
[REP]	F Block◆ 0008 (about 1 second)		To repeat the search, press [REP]. If the number is again present, the next block number (8) to contain it is briefly displayed.
	F PtNo ◆ 52		The point- or code number in data block 8 is displayed.

9 SET functions

The digital level can be matched to different requirements by setting various parameters. The settings are summarized in Appendix B. The functions and parameters are arranged in a menu tree and are very easy to locate.

When the measurement prompt "≡" is showing, you can call the SET functions with [SET].

Within the SET tree the options related to the current function are displayed by pressing [DSP].

[RUN] confirms the parameter or function selected and you then move a step lower in the tree if an additional step is available.

If you select a parameter which offers several possibilities, the first value to be displayed is always the one currently valid.

If you quit from a parameter or the SET function with [CE], the old values remain unchanged. The values also remain unchanged if the instrument is turned-off. Note that the protocol for data transfer is always returned to the *with* PROTOCOL mode when switching on.

The parameter displayed at the end of the menu chain is always in small letters. Higher-level concepts are in capitals.

The quickest way to the lower parameters is with the [DSP]▲key. For example, the sequence [SET] [DSP]▲ [RUN] [DSP]▲ [RUN] leads directly to SET CONFIG COMM *standard/USER*.

Example: Disabling the audio signal

Key	Display	Confirm	Description
[SET]	SET ◆ TEST		Call the SET function.
[DSP]	SET ◆ CONFIG	[RUN]	Select the menu SET CONFIG and confirm.
[DSP]	CONFIG ◆ BEEP	[RUN]	Select the menu CONFIG BEEP and confirm.
[DSP]	BEEP ◆ off	[RUN]	Select BEEP *off* and confirm.

9.1 SET main menu

The main menu contains all of the most important parameters.

SET ...

TEST Battery	Battery test: The battery voltage is displayed on a scale from 2 (minimum) to 9 (maximum).
TEST Version	Software version

MEASURE Mean n = 1 to 99	Mean value with automatic stop after n measurements. n = 1 Single measurement n = 2 to 99 Multiple measurements
MEASURE Mean σm n min = 2 to 20 n max = 2 to 20 <u>and</u> ≥ n min σm/20m [mm]	Mean value with automatic stop when the standard deviation of the mean value is reached, or after n measurements (n = n max). Minimum number of measurements Maximum number of measurements Standard deviation of mean value at 20m staff distance
MEASURE Median n = 1 to 99	Median value with automatic stop after n measurements. n = 1 Single measurement n = 2 to 99 Multiple measurements

enter **INCREMENT**	Input of increment. When the point number is entered, the present increment value is <u>not</u> faded in (less keystrokes are needed when entering the point number).
show **INCREMENT**	The increment is displayed for inspection after the point number has been entered. The increment can then be changed.

FIX standard	Reduced number of decimal places in the display NA2002: mm ft/100 NA3003: mm/10 ft/1000 in/1000

FIX all	Full number of decimal places in the display NA2002: mm/10 ft/1000 NA3003: mm/100 ft/10000 in/2000

RECORD off	Recording disabled
RECORD module / serial	Recording in the REC-module or across the interface.

9.2 SET CONFIG ...

Other instrument parameters

DSP TIME 1 to 9 [seconds]	Display time: Relates to the time during which the values are displayed after the measurement or are displayed after scrolling of the stack.
INT TIME 0 3 to 9 [seconds]	Integration time (NA3003): Normal integration time (system value) Longer integration time (user value)

BEEP	Audio signal: off / soft / loud

KEY Dist	INP/D key = distance measurement
KEY Input	INP/D key = input key for optical measurement

ROD 4m/2.7m	End of staff identified at <u>4.05m und 2.7m</u>: This option must be set for all staffs of length 2.7m, 4.00m or 4.05m. The measurement range for the staff reading is from 0m to 4.05m at a range of up to 100m (330ft).
ROD 3m/2m	End of staff identified at <u>3m and 2m</u>: This option must be set for all staffs having lengths 2m or 3m (e.g. invar staffs). The measurement range for the staff reading is from 0m to 3m. The maximum distance is about 60m (200ft).

	Err. 05. is displayed: a) if you target a 4m-long staff from a distance of between 3m and 4m b) or if the staff is more than 60m away. If necessary, change to the setting *4m/2.7m*.

EARTH C. with / without	Earth-curvature correction for all measurements. (In the two-peg test, earth-curvature correction is permanently installed.)

ACCURACY standard / extended	System accuracy (NA3003)

TOLERANCE enter STAT TOL	Input of station tolerance (alteration of present value).
TOLERANCE enter DIST TOL without DIST TOL	Input of distance tolerance, and sighting-distance check [Σ(backsight dist.) - Σ(foresight dist.)]: Input of distance tolerance No sighting-distance check

AUTO-OFF 5 min off	Automatic power-off after the last key is pressed: Instrument switches off after five minutes Instrument remains switched on.

UNIT	Units of measurement: Metre / foot / (inch units only for NA3003)

COLLIM.	Display and input of the absolute collimation error (absColl). Values in ["].

SERVICE	Only for servicing.

9.3 SET CONFIG COMM ...

Parameters for data communication:

standard	Set the standard parameters: 2400 baud, even parity, 7 data bits, CR LF

USER ...	Set the interface parameters individually:
BAUD R	Baud rate: 300 to 9600 baud.
PARITY	Parity: even / odd / none
END CHAR	Termination character: CR / CR LF
PROTOCOL	Transfer protocol: with / without. *with*: Instrument transmits data sets with terminal "w" and waits for a "?". Instrument receives commands, and confirms with a "?". When first switched on, the instrument always sets this parameter to *with*.

MESSAGES	Error reports: standard / extended *standard*: An error report "@4xx" is displayed. "xx" is the error number as listed in section 11. *extended*: For the service department an extended error message is displayed: "@4xx/aa/bb/cc".

ADDRESS	Instrument address: Enter an instrument identification number (0.1 to 99999999) for use with on-line operations.

10 The data concept

10.1 The data format

The data format for the digital level largely conforms with the existing GSI format for Leica instruments:
- Data are recorded in blocks.
- Each data block (= measurement block) is composed of several data words.
- Each data word has a fixed length of 16 characters.

The following section describes the important points. Further details, which are not described here, can be found in the user manual for the GIF10/GIF12 (readers for use with the REC-module) and in the publication "*WILD instruments on-line*".

10.1.1 The data word

The data word consists of 16 characters:

```
Position:   1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6
            . . . . . . ± n n n n n n n n ×
```


Position 1-3: Word identification using WIs. For a list of WIs, see the next section.

Position 4: 1 = Compensator flag

Position 5:
0 = measured; without earth-curvature correction, system accuracy standard
1 = entered manually; without earth-curvature correction
2 = measured; with earth-curvature correction, system accuracy standard
4 = the last of several measurements transmitted (result)
5 = entered manually; with earth-curvature correction
6 = measured; without earth-curvature correction, system accuracy enhanced
7 = measured; with earth-curvature correction, system accuracy enhanced

Position 6: Units and decimal places
6 = metre, last place 0.1mm
1 = foot, last place 0.001ft
0 = metre, last place 1mm
7 = foot, last place 0.0001ft (only NA3003)
8 = metre, last place 0.01mm (only NA3003)
9 = inch, last place 0.0005inch (only NA3003)

Position 7-15: Data (measurement data / entered manually)

Position 16: Space character, ASCII-Code 32 (×)

10.1.2 The word indices

The measurement block consists of between 2 and 6 fixed data words . The individual words cannot be selected. The following word indices (WIs) are used:

WI = 11	Point number
WI = 32	Distance to staff
WI = 330	Staff reading in MEAS ONLY
WI = 331	Staff reading, backsight / B1
WI = 332	Staff reading, foresight / F1
WI = 335	Staff reading, B2
WI = 336	Staff reading, F2
WI = 333	Staff reading, intermediate sight
WI = 334	Staff reading, setting-out
WI = 374	Setting-out difference *Required minus actual* (corresponds to displayed value "Diff SO").
WI = 52	Number of measurements, and standard deviation of the single measurement
WI = 521	Number of measurements, and band width (median measure mode)
WI = 57	Integration time [sec], for values from 3 to 9 seconds
WI = 41	Code number
WI = 42 - 45	Info1 to Info4
WI = 571	Station difference S
WI = 572	Cumulative station difference ΣS
WI = 573	Difference in sighting distance d
WI = 574	Total distance D
WI = 83	Ground height
WI = 95	Internal instrument temperature [°C] (this value can only be obtained over the serial interface; see on-line operation manual).

10.1.3 Special code blocks

The levelling technique and the repeat measurements are tagged by means of special code blocks (WI 41). They are recognizable by the "?" and "!" at the eighth position in the word.

Levelling method 1 (= BF BF ...)	**410010+?......1**
Levelling method 2 (= BFFB BFFB ...)	**410011+?......2**
Repeated measurements of "xxx": xxx = 330 / 331 / 332 / 333 / 335 / 336	**410012+1....xxx**

10.2 Recording

The measured values (e.g. distance, staff reading etc.) and the results (e.g. ground height) are stored in separate blocks according to their type.

Examples of the data blocks in the various measurement programs:

MEAS ONLY

```
110015+00000124 32..00+00024200 330106+00010509
    |          |               |               |
  Block number |           Distance       Staff reading
          Point number
```

START LEV


```
110016+00000035 83..16+04026500
              |          |
        Point number   Ground height
```

Backsight

```
110017+00000035 32..00+00025870 331106+00012554
              |          |               |
        Point number  Distance        Backsight
```

Foresight (first block for measurements, second block for results)

```
110018+00000036 32..00+00023480 332106+00010473
              |          |               |
        Point number  Distance        Foresight

110019+00000036 573..0-00000560 574..0+00151390 83..06+04029024
                         |               |               |
         Diff. in sighting dist.  Total distance  Ground height
```

Backsight (first block for measurements, second block for results)

```
110020+00000101 32..00+00016530 333106+00013286
              |          |               |
```

```
       Point number     Distance      Intermediate sight
110021+00000101 83..06+04020337
                                 | Ground height
```

Setting-out (first block for measurements, second block for results)

```
110022+00005501 32..00+00018500 334106+00012054
                Point number     Distance     Staff reading (setting-out)

110023+00005501 374.06-00000012 83..06+04027030
                                  |             |
                      Setting-out difference Ground height
```

NA2002: Measuring with mean value

```
110024+00000016 32..00+00024760 330106+00012054 52..06+0006+002
              |             |              |             |   |
       Point number     Distance     Staff reading       1)  2)
   1) = number of measurements (6)
   2) = standard deviation of individual measurement (0.2mm)
```

NA3003: Measuring with median value and integration time = 5 seconds

```
110025+00000017 32..00+00024760 330108+00012054 521.08+0004+019 57....+00000005
              |             |              |             |  |               |
       Point number     Distance     Staff reading      1) 2)    Integr. time
   1) = number of measurements (4)
   2) = band width of measurements (0.19mm)
```

Repeat of a backsight with REP

```
110032+00000002 32..00+00025630 331106+00008111 52..06+0003+021
410033+!....331
110034+00000002 32..00+00025630 331106+00008111 52..06+0003+003
```

Code block

```
410022+00000099 42....+00020692 43....+00001122 44....+00000015 45....+00000788
              |             |              |             |              |
            Code          Info1          Info2         Info3          Info4
```

Illustration of the data set- and WI sequences in the two methods:

Methode:	1 = BF BF BF ...	2 = BFFB BFFB ....
START LEV Method Starting height	WI: 41 (410001+?......1) 11, 83	WI: 41 (410001+?......2) 11, 83
CONT LEVELLING Measurements, additional information and height	WI: 11, 32, 331, (52) 11, 32, 332, (52) 11, 573, 574, 83 11, 32, 331, (52) 11, 32, 332, (52) 11, 573, 574, 83 etc.	WI: 11, 32, 331, (521) 11, 32, 332, (521) 11, 32, 336, (521) 11, 32, 335, (521) 11, 571, 572, 573, 574, 83 11, 32, 331, (57) 11, 32, 332, (57) 11, 32, 336, (57) 11, 32, 335, (57) 11, 571, 572, 573, 574, 83 etc.

Calculation accuracy

The NA2002 stores the staff readings and ground heights with an accuracy of 0.1mm. The ground heights are not calculated with these staff readings, but from transient staff readings within the instrument and which have a higher calculation accuracy. Consequently, small height differences amounting to a few tenths of a millimetre can arise between the displayed or stored values and the results of calculations from measured staff readings [B]-[F]. A comparable situation exists in the NA3003.

The definitive values for analysis in the office are those of foresight and backsight.

10.3 Setting out planned heights

The data set which contains the setting-out heights can include any number of data words, e.g. point number, X- and Y-coordinates, and the height H. You can therefore use for the digital level the setting-out coordinates which were originally intended for the total station. The digital level will, of course, select and display only the heights.

Any unit of measurement may be used, e.g mm / 0.1mm / 0.01mm. The last character at the end of each data set must be the space (ASCII-code 32).

Examples:

```
110019+00000025 83..16+04001234
```

(point number = 25 and height = 400.1234m)

or

```
110019+00000025 81..10+15370807 82..10+09521164 83..10+00400123
          PtNo.          E                  N                 H
```

To read the data out of a computer and into the REC-module you need a GIF10 or GIF12 reader.

To convert setting-out data from an ASCII- or text file into a file with Leica data format, and to transfer it by means of the GIF10, you need the DOS program CONVTRAN.EXE, which is obtainable from your Leica dealer.

For transferring data to the REC-module by means of the GIF12 this PC software is supplied along with the GIF12. Note that the data must be loaded in GRE format and not in ASCII format.

You should position the setting-out data at the beginning of the file in the REC-module. If the required point number is missing, or if no height has been stored in the recognized data set, the search procedure stops and the message "no data" is displayed.

11 Error reports

Message	Cause	Action to be taken
BAT	Early warning of a flat battery	You can still take a few more measurements, but insert a fully-charged battery as soon as possible.
03	Values entered are outside permitted range	[CE], enter value properly.
04	Collimation error >100"	[CE], repeat two-peg test. First measure A1, not B1. If the error message keeps on appearing, contact your local Leica service workshop.
05	Distance to staff is outside permitted range (1.8m to 100m) or is not in accordance with procedure for two-peg test	[CE], Shorten or lengthen the distance, as appropriate.
09	Early warning: next point number is 0 or 99999999	[CE], continue.
12	Battery is too weak	[CE], change the battery.
21, 23-26	Interface error	[CE], inspect the interface parameters.
22	No connection to external recording device	[CE], inspect cable, inspect external device or select SET RECORD *module* .
24	More than 80 characters, including CR LF, were transmitted	[CE], no more than 80 characters are allowed.
51	Measurement is not possible because: Poor light; too much staff coverage; no coverage at all allowed for distances <5m; unsharp focusing; outside permitted measuring range; function [INV] activated or staff inverted	[CE], rectify cause and continue measuring
58	Digital level not horizontal	[CE], level-up instrument.

Message	Cause	Action to be taken
71	Data set being searched for is not stored in REC-module	CE
72	REC-module is almost full	CE, 20 blocks are still available.
74	REC-module is full. The block has not been stored	CE, insert a new REC-module and remeasure the last point
75	Internal battery in REC-module is weak	CE, save the data. The data will be lost after two months. Contact your Leica service workshop.
76	Functional fault in REC-module	CE, save the data. Contact your Leica service workshop if this fault arises again.
77	Wrong data format in REC-module	CE, inspect the data format.
79	REC-module is not in position	CE, insert the REC-module correctly or select SET RECORD *serial*.
89	Internal instrument temperature too high (60°C)	Let the instrument cool down in the shade. Use a parasol.
8C	Backup battery of digital level is weak	CE, if this error report keeps on appearing, contact your Leica service workshop.
8F	System error	CE, if this error report keeps on appearing, contact your Leica service workshop.
91	Division by 0	CE, check the measurement sequence.
92 - 9F	System error	CE, if this error report keeps on appearing, contact your Leica service workshop.

12 Important notes

To get the best out of your digital level, and to ensure that it always functions correctly, please study the following notes .

12.1 Lighting

Stray light reflected from the staff to the objective can make measurement impossible (Error 51). Get the staffperson to turn the staff slightly so that the reflection is directed elsewhere.

If the instrument can no longer measure because the staff is not bright enough, you can try to improve the situation by engaging the enhanced system accuracy (SET CONFIG ACCURACY *extended*). Increasing the integration time will not help in these circumstances.

12.2 Measurement times

The time for a single measurement depends on the lighting. With the setting SET CONFIG ACCURACY *standard* , and under normal lighting conditions, the time is about four seconds, but in low-light conditions it is about seven seconds.

12.3 Working in artificial light

To work where it is dark you need to use a source of artificial light which provides adequate infrared. A halogen bulb, or even a normal light bulb, is ideal.

The part of the staff that you can see in the field of view must be illuminated uniformly and there must be no brighter patches. If the lamp is held above the staff, the centre of the cone of light should be directed at the foot of the staff and not at the area of measurement.

If the source of artificial light is too weak, or if the range is too great, it may help to measure with enhanced system accuracy (SET CONFIG ACCURACY *extended*).

12.4 Measuring into the sun

The objective tube of the NA2002/NA3003 has been specially lengthened to protect the instrument against stray light impinging at an angle, but this will not protect it against direct stray light. In this event you can try holding your hand over the front, taking care not to obstruct the field of view seen on the staff.

If you have a lot of problems with stray light, construct from a thin metal sheet a tube about seven centimetres long which you can slide over the objective.

12.5 Measuring with the sun behind you

If you are measuring when the sun is low in the sky, stray light can enter through the eyepiece, disturbing the detector and making measurement impossible. To stop this happening, shade the eyepiece with your head or body, or place a finger over the eyepiece during the measurement.

12.6 Maximum range

The furthest you can measure is 100 metres (330 feet) with a standard staff and 60 metres (200 feet) with an invar staff and depends on the setting in SET CONFIG ROD. The ranges quoted assume ideal atmospheric conditions and bright lighting. If there is heat shimmer, or if you are measuring against the light, or at dawn or dusk, you may not be able to measure (*Err. 51*). Under these circumstances you should shorten the distance between level and staff.

12.7 Parasol as protection against the sun

In bright sunlight you should protect the instrument with a parasol. This is important if the level is being left in one place for a long time, for example during precision area levelling being conducted from a central point.

12.8 Coverage of the staff

For distances above five metres (about 17 feet), the analysis software of the digital level tolerates a 20% - 30% coverage of the staff in the field of view. Between 1.8 metres (six feet) and five metres (about 17 feet), the coverage tolerance is a minimum or zero.

12.9 Shadows cast on the staff image

A heavy shadow cast on the part of the staff seen in the field of view can make measurement impossible (*Err. 51*). Try to cast a shadow on the brightly-illuminated part of the staff so that the staff illumination is uniform.

Shadows cast by twigs and branches are not generally of critical importance provided that they do not cover too great an area. If the instrument can still measure at all, then the result will be correct. If the conditions are unfavourable, the message *Err. 51* will be displayed.

12.10 Usable section of staff

Normally the bar code extends over the entire field of view and gaps are interpreted as being due to coverage of the staff. The instrument recognizes the ends of the staff and is aware that the bar code does not continue below 0.0m and (depending on the setting in SET CONFIG ROD) above 2m/3m/2.7m/4.05m. Consequently it does not interpret such gaps as being staff coverage. It is therefore possible to measure right to the end of the staff, and even a little beyond.

You should not apply the above techniques to highest-precision levelling, because they reduce the accuracy. Instead, make sure that at least 80% of the code information is available in the field of view. This is particularly important if you are using the industrial staffs GWCL92/GWCL182, because the system cannot recognize the ends of these staffs (at 92cm and 182cm respectively) as such.

12.11 Aiming at a skewed staff

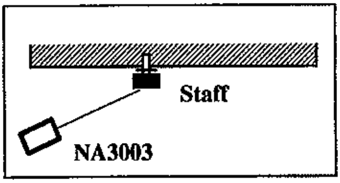


Fig. 12-1 Aiming at a skewed staff

As the digital level needs only a thin strip of the staff bar code in order to analyze the image and to take a measurement, it will also function when the staff is held askew to the line of sight.

12.12 System-related effects at 15m

At a range of between 14.95m and 15.05m (49ft and 49ft 4in) the spread of the height measurements is greater than at the other ranges (band width < 0.3mm in the enhanced accuracy mode).

For highest precision, and particularly for static applications such as monitoring, you should therefore avoid this range (15m ±5cm) and instead measure using the setting "extended system accuracy".

13 Checking and adjusting

13.1 Bull's-eye bubble

If the instrument has been levelled-up properly, the bubble will lie exactly at the mid-point, i.e. it will remain in the same position regardless of the orientation of the instrument (0° bis 360°). Ideally, the mid-point should coincide with the centre of the setting circle.

The mid-point may drift in the course of time, as a result of direct solar radiation or because of temperature changes, for example. The bull's-eye bubble will then be out of adjustment.

Inspecting

- Bring the bubble to the centre of the setting circle.
- Turn the telescope 180°.

If the bubble remains centred, the bull's-eye bubble is properly adjusted (fig. 13-1).

Conversely, if the bubble wanders outside the setting circle, the bull's-eye bubble requires readjustment (fig. 13-2).

Fig. 13-1 Bull's-eye bubble is adjusted

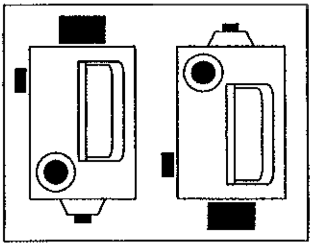
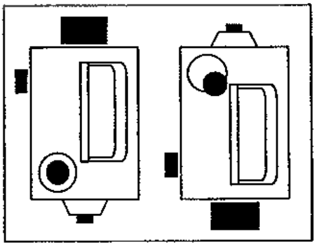


Fig. 13-2 Bull's-eye bubble is out of adjustment



Adjusting

The bubble offset is now corrected halfway with the footscrews, and the rest of the way with the adjusting screws.

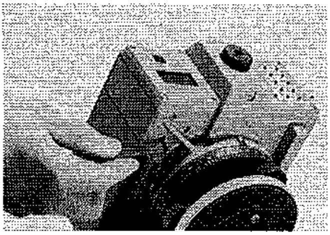


Fig. 13-3 Bull's-eye bubble adjustment screws

These are located beneath the instrument. The adjustment tool is in the carrying case.

Adjust in small steps. Do not turn too much at one time.

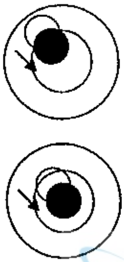


Fig. 13-4 Eliminating the bubble offset

1. Correct the bubble offset halfway with the footscrews.
2. Correct the remaining bubble offset with the adjusting screws, first turning the adjusting screw which is nearest to the continuation of an imaginary straight line connecting the centre of the bubble to the centre of the circle.

Repeat the inspection procedure and, if necessary, readjust until the bubble remains in the centre whatever the telescope orientation.

To obtain the best results from the compensator, you should keep the bull's-eye bubble properly adjusted at all times.

14 Electrical equipment

The digital level requires a 12V DC power supply. The instrument requires the same amount of power when measuring (signal reading and subsequent image analysis) as when standing idle and so, once switched on, its consumption is constant.

The most suitable battery to use for line-levelling surveys, where the instrument is being continually moved, is the GEB79 internal battery or the GEB70 small battery. When the instrument is stationary, e.g. during area-levelling surveys, the GEB71 universal battery can also be used. All three types of battery are rechargeable NiCd units.

The capacity of a battery decreases with age, and at low temperatures.

14.1 Internal battery GEB79

The capacity of the GEB79 battery at normal temperatures (above 20°C) is enough for a full day of surveying.

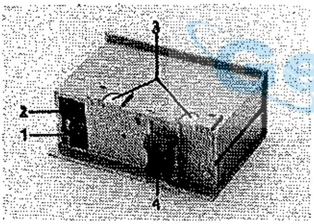


Fig. 14-1 Internal battery GEB79

1 Connector socket:
- 2-pole for charger GKL12
- 5-pole for charger GKL22/23

2 Fuse
3 Contacts
4 Clips

14.2 Connecting the small battery GEB70

The GEB70 is a small, light and handy external battery which can be hung from the top of a tripod leg. Connect the battery via the cable to the socket at the side of the instrument (socket for data transfer and battery connection) and make sure that the cable and instrument can still turn without being obstructed.

If both an external and the internal battery are connected, the instrument is powered from the battery having the higher output. The battery test therefore shows the capacity of the more powerful battery. The internal battery cannot be recharged from the external battery.

14.3 Charging the batteries

Use the GKL12 charger, or one of the newer chargers (GKL22 or GKL23).

Warning:
Use the chargers only indoors, in dry rooms.
Charge the batteries only at ambient temperatures of between +10°C and +30°C (50°F to 86°F).
Store the batteries at 0°C to 20°C (32°F to 68°F).

New batteries, and batteries which have not been used for some months, should be recharged over a period of between 20 and 24 hours. After two or three normal charge/discharge cycles (14 hours charging followed by complete discharge), the NiCd battery should reach its full capacity. Empty batteries, and batteries of unknown charge status, should be charged for 14 hours.

If the performance of the battery deteriorates noticeably, subject it to one or two complete charge/discharge cycles (charge for 14 hours and then discharge each time until completely flat).

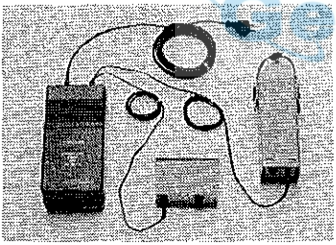


Fig. 14-2 **Charging the battery with the GKL12**

The GKL12 is routinely supplied with a 14-hour overload protection timer. If the power supply is interrupted. the timer automatically restarts at the beginning.

Prepare the GKL12 battery charger for use:
- Set the switch to the supply voltage available.
- Plug the power cable into the AC power socket. The green pilot lamp should shine. If it fails to do so, either there is no power or the charger is defective.

Connect the battery to the GKL12 and start charging:
- Connect the battery cable from the charger to the battery or batteries.
- Press the red charge button (Timer). The red pilot lamp must shine. The 14-hour charge phase commences. If the red pilot lamp does not shine, either the fuse, or the connection to the battery, is defective and no charging current is flowing.
- After 14 hours the charging stops automatically and the red pilot lamp goes out.

GKL22 normal charger
This charger supplies a steady current which completely recharges a flat NiCd battery in 14 hours.

The charging procedure starts automatically when a battery is connected to the charger. A red pilot lamp shows that the battery is being charged.

To load batteries with two-pole plugs an adapter cable is required.

GKL23 rapid charger
Quick charging is only possible for the new Leica NiCd batteries with five-pole charger plugs. Depending on the condition and capacity of the battery, the charging time is between 1.5 hours and five hours.

Leica batteries with two-pole charger plugs can be connected to the GKL23 only through an adapter cable. The charger time for such batteries is always 14 hours.

For further details regarding the use, function and display, please refer to the GKL23 user manual.

14.4 Discharging a 12V NiCd battery

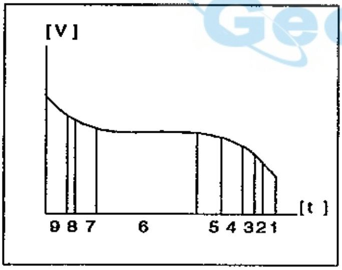


Fig. 14-3 Discharge curve for a NiCd battery

This diagram shows the relationship between the battery-charge indicator and the battery output voltage .

Level 6 means that between 40% and 80% of the full battery capacity is available.

Level 1 means that no more than 10% of the full battery capacity is left. The actual amount depends on the battery temperature.

When in use, the voltage of a freshly-charged battery falls rapidly from level 9 to level 7, and then much more slowly and over a long period from level 7 to level 3. The decrease in voltage from level 3 to level 1 is again rapid. When level 1 is reached, the message "Bat" appears in the display. When *Err. 12* is displayed, the instrument switches off after a few seconds.

15 Technical data

Standard deviation		
(1km double-run levelling)		
Electronic measurement	**NA2002**	**NA3003**
with invar staff	0.9mm	0.4mm
with standard staff	1.5mm	1.2mm
Optical measurement (only with the standard staff)	2.0mm	2.0mm
Measurement range		
Electronic measurement		
SET CONFIG ROD 3m/2m	1.8m to 60m	
SET CONFIG ROD 4m/2.7m	1.8m to 100m	
Optical measurement (only with the standard staff)	from 0.6m upwards	
Distance-measurement accuracy		
Electronic measurement	1cm - 5cm	
Optical measurement	0.2m - 0.5m (with standard staff)	
Measurement units	m / ft / inch (NA3003)	
Conversion m to ft	1m = 3937/1200ft	
Conversion m to inch	1m = 39.3700inch	
Display	LCD matrix display, illuminated, 2 lines, 8 characters per line	
Resolution	**NA2002**	**NA3003**
Decimal places selectable	1mm/0.1mm 0.01ft/0.001ft	0.1mm/0.01mm 0.001ft/0.0001ft 0.001in/0.0005in
BFFB levelling method	in NA3003	
Station difference S		
Tolerance test	incorporated	
Formula	S = (B1-F1) - (B2-F2)	
Sighting-distance difference d		
Tolerance test	selectable	
Formula for d after B2	$d = \frac{1}{2} [\Sigma(D_{B1} + D_{B2}) - \Sigma(D_{F1} + D_{F2})]$	
Total distance D	$D = \frac{1}{2} \Sigma(D_{B1} + D_{B2} + D_{F1} + D_{F2})$	
Magnetic screening	**NA2002** yes	**NA3003** yes

Keyboard	Weatherproof, 15 keys, colour-coded functions, 1 red measuring button
Electronic measurement	
Values measured	Staff reading, horizontal distance
Typical time for a single measurement	SET CONFIG ACCURACY *standard*: 4 seconds SET CONFIG ACCURACY *extended*: 6 - 8 seconds
Manual data entry	
Point numbers	Numerical values
Values measured	Staff reading, horizontal distance
Coding	Code block with up to four information words (all numerical values)
Earth-curvature correction	
Formula	$E = x^2/2R_{(earth)}$ x = distance measured $R_{(earth)}$ = 6'378'000m
optional	in all measurement programs
permanent	in the two-peg test
Measurement programs	
MEAS ONLY	Staff reading and distance
START LEV BF	Start the line-levelling survey BF
START LEV BFFB (NA3003)	Start the line-levelling survey BFFB
CONT LEVELLING	Line-levelling with the possibility of intermediate sight (area levelling) and setting-out
Service programs	
CHECK "A x x B"	Two-peg test, first method
CHECK "A x Bx"	Two-peg test, second method
CHECK W. COLLIMATOR (NA3003)	Adjusting the electronic line of sight in front of the collimator
REC-M DATA:	REC-module data:
ERASE DATA	Erase data
SEND DATA	Read out data across interface
Measurement modes	
Mean value	n = 1 - 99
Mean value σ	Mean value with standard deviation of mean value: n = 2 - 20
Median value	n = 1 - 20
Integration time	NA3003
Settings	Without extension (automatic) or 3 - 9 seconds

Recording		
Internal	REC-module GRM10	
External	GPC1, on-line operation	
REC-module		
Memory	CMOS	
Capacity	64Kbyte (about 8000 data words)	
Dimensions	74mm x 60mm x 10mm	
Weight	70g	
Temperature range		
Working	-20°C to +50°C	
Storage	-40°C to +70°C	
Power supply		
Internal battery GEB79	NiCd, rechargeable, 12V/500mAh, capacity for 8 hours use	
External power	z.B. GEB70, 12V/2Ah	
Telescope		
Magnification	24x	
Clear objective aperture	36mm	
Angular aperture	2°	
Field of view at 100m/100ft	3.5m / 3.5ft	
Multiplication constant	100	
Additive constant	0	
Compensator	Pendulum compensator with electronic range control. Pneumatic or magnetic damping.	
Tilt range		
Pneumatic damping	~ ±12'	
Magnetic damping	~ ±10'	
Setting acuracy	**NA2002**	**NA3003**
Standard deviation	0.8"	0.4"
Bull's-eye bubble		
Sensitivity	8'/2mm	
Horizontal circle	rotatable	
Angle unit	400gon	360°
Divisions	1gon	1°
Estimation accuracy	~ 0.2 interval	
Diameter	108mm	
Weight		
NA2002/NA3003	2.5kg including GEB79 battery	
Carrying case	1.6kg	

Sunshade (accessory)	plug-on
Material	polymer
Application	for pointing against the light and for bright diffused light from in front.
Battery charger GKL12	
Use for	2 GEB70 or GEB79
Input voltage	115/230V +10% -15%, 50/60Hz
Power consumption	approximately 15W
Charging current	2x 0.2A ±15%
Charging time	14 hours
Charging temperature	+10 to +30°C
Fuse	Thermal fuse in transformer

Notes

PROG functions: Measurement and service programs

[PROG] ...

P MEAS ◆ ONLY	Staff reading and distance
P START◆ LEV BF	Start line-levelling survey BF
P START◆ LEV BFFB	Start line-levelling survey BFFB (only NA3003)
P CONT ◆ LEVELING	Continue line-levelling survey
P CHECK◆ A x x B	Two-peg test on site (1)
P CHECK◆ A x Bx	Two-peg test on site (2)
P CHECK◆ COLLIMTR	Two-peg test in front of collimator (only NA3003)
P REC-M◆ DATA	Delete / send all data stored in REC-module

SET functions

[SET] ...

TEST	→	Battery | Version
MESSMODE	→	Mean | Mean σm | Median
INCREM. [1]	→	show incr. | enter increment
FIX	→	standard | all
RECORD	→	off | module | serial

<u>CONFIG</u> ⇒

DSP TIME	→	1 to 9 seconds
INT TIME [2]	→	0 | 3 to 9 seconds.
BEEP	→	high | low | off
KEY	→	Dist | Input
ROD	→	3m/2m | 4m/2.7m
EARTH C.	→	with | without
ACCURACY [2]	→	standard | extended
TOLERANCE [2]	→	enter STAT TOL | without DIST TOL | enter DIST TOL
AUTO-OFF	→	5 min | off
UNIT	→	m | ft | inch [2]
COLLIM.	→	enter collimation error
SERVICE		

<u>COMM</u> ⇒ **standard** (2400, even, cr lf)

<u>USER</u> ⇒

BAUD R	→	9600 to 300
PARITY	→	even | odd | none
END CHAR	→	cr | cr lf
PROTOCOL	→	with | without
MESSAGES	→	standard | extended
ADDRESS	→	No. 1 to 99999999

1) inactive at RECORD *off*
2) only NA3003

Stack register for BFFB

Example: Ground height for backsight = 409.0000m (starting point)

after B1		after F1	
Rod B1♦ 2.12345		Rod F1♦ 1.12345	
n 4♦ s 0.25	n = number of measurements s = standard deviation of single measurement	n 4♦ s 0.25	
Dist B1♦ 24.56	n = number of measurements s = standard deviation of single measurement	Dist F1♦ 25.34	
d 23.4♦ D 1234.5	$d = \Sigma D_B - \Sigma D_F$ $D = \Sigma D_B + \Sigma D_F$	d -1.9♦ D 1259.8	$d = \Sigma D_B - \Sigma D_F$ $D = \Sigma D_B + \Sigma D_F$
PtNo B1♦ 1000		PtNo F1♦ 1001	
InstHt ♦ 411.1235	First instrument height	HDif F1♦ 1.00000	First height difference = B1-F1
		← GrHt F1♦ 10.00000	Height of foresight point after B1 and F1 GrHt = 410.00000m

Stack register for BFFB (continued)

after B2		after F2	
Rod F2◆ 1.12361		Rod B2◆ 2.12369	
n 4◆ s 0.25		n 4◆ s 0.25	
Dist F2◆ 24.36		Dist B2◆ 25.58	
PtNo F2◆ 1000		S -0.08◆ ΣS -1.68	S = station difference. ΣS = cumulative station difference
InstHt ◆ 411.1236	2. (new) instrument height	d -1.9◆ D 1259.8	Final result (mean value)
		PtNo B2◆ 1000	
		HDif FR◆ 1.00004	Final result: Mean of two height differences
		← GrHt FR◆ 10.00004	Final result (mean value): GrHt = 410.00004m

Number of decimal places in display of NA3003 (NA2002)

	SET FIX standard			SET FIX all		
	m	ft	inch	m	ft	inch
Rod	4 (3)	3 (2)	3	5 (4)	4 (3)	4
Dist	2 (2)	2 (2)	1	2 (2)	2 (2)	1
GrHt (START LEV)	4 (3)	3 (2)	3	4 (4)	3 (3)	3
GrHt (CONT LEV.)	4 (3)	3 (2)	3	5 (4)	4 (3)	4
SHt	4 (3)	3 (2)	3	4 (4)	3 (3)	3
InstHt	4 (3)	3 (2)	3	4 (4)	3 (3)	3
HDif	4 (3)	3 (2)	3	5 (4)	4 (3)	4
Diff SO	4 (3)	3 (2)	3	5 (4)	4 (3)	4
Standard dev. s, Band width B	NA3003 *1)* NA2002 *4)*	NA3003 *2)* NA2002 *2)*	*3)*	NA3003 *1)* NA2002 *4)*	NA3003 *2)* NA2002 *2)*	*3)*
Mean value, median value	5 (4)	4 (3)	4	5 (4)	4 (3)	4
Station diff S, Σ S	*1)*	*2)*	3	*1)*	*2)*	3
Sighting-distance difference d, total distance D	1 (1)	1 (1)	0	1 (1)	1 (1)	0

1) 0.01mm *2)* 0.1 [1/1000ft] *3)* 0.01 [1/10inch]
4) 0.1mm

Storage formats: Number of digits in column 6 of data word

	NA3003			NA2002	
	m	**ft**	**inch**	**m**	**ft**
Rod	8	7	9	6	1
Dist	0	1	9 *1)*	0	1
GrHt (START LEV)	6	1	9	6	1
GrHt (CONT LEV.)	6	1	9	6	1
SHt	6	1	9	6	1
Diff SO	8	7	9	6	1
Standard dev. s, Band width B	8	7	9	6	7
Mean value, median value	8	7	9	6	1
Station difference S, Σ S	8	7	9	-	-
Sighting-distance difference d, total distance D	0	1	9 *1)*	0	1

1) Rounding-off to the first decimal place; the last three places are zeros.

Main abbreviations used in displays

Rod / Dist	Staff reading / distance
BACK / BK / B	Backsight
FORE / FR / F	Foresight
INTERMEDIATE / IN	Intermediate sights
SET OUT / SO	Setting-out
PtNo	Point number
ind. No / run. No	Individual point no. / running point no.
InstHt / GrHt	Instrument height /ground height
HDif	Height difference
SHt / Diff SO	Setting-out height / setting-out difference
n / s	Number of measurements / standard deviation of single measurement
d / D	Sighting-distance difference / total distance
S / ΣS	Station difference / cumulative station difference
σm / sm	required / actual standard deviation of mean value
m / B	Reference to: standard deviation of: Mean value in "Mean σm" measuring mode / Band width in median measuring mode
Coll	Collimation error (line-of-sight error)
absColl / CollDif	Absolute collimation error / collimation-error difference
Tol	Tolerance value
STAT TOL / StatTol	Station tolerance
DIST TOL / DistTol	Distance tolerance