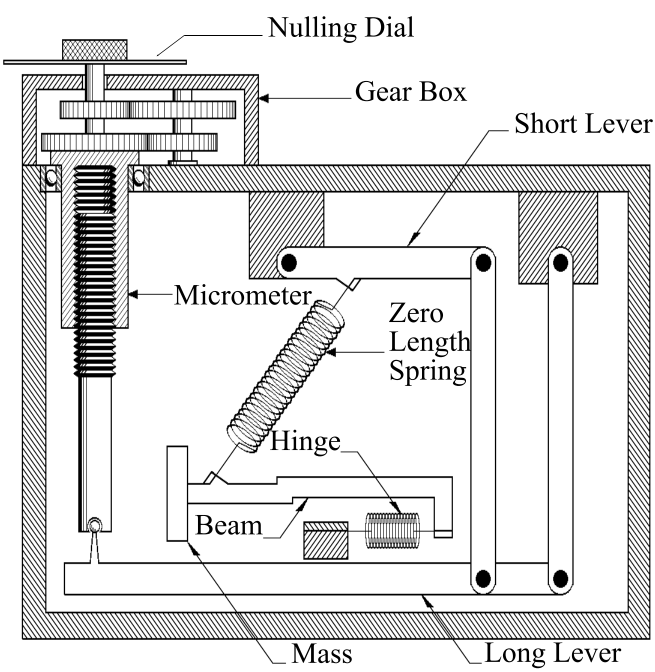
PRIMARY INFORMATION

INTRODUCTION

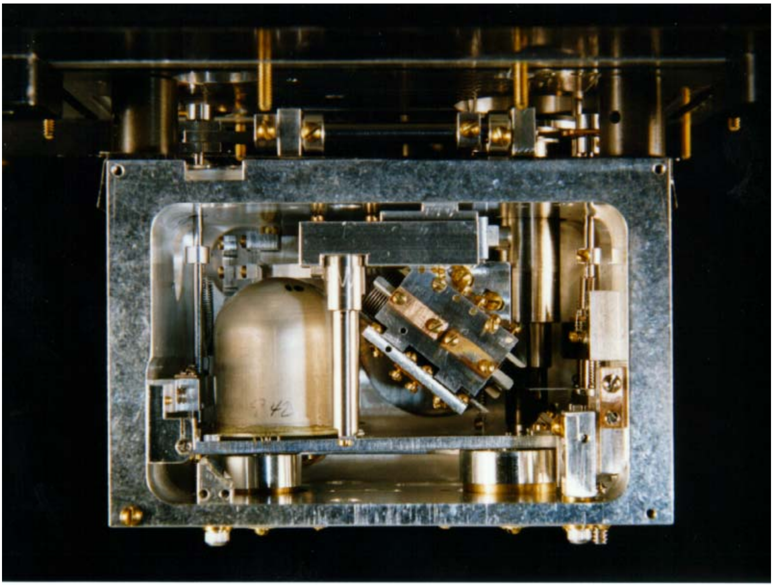
DESIGN

The *LaCoste and Romberg* gravity meter is made of metal parts. It is far more rugged than meters made of fused quartz glass. Because the thermal expansion and contraction of metals are generally greater than quartz, the *L and R* meters must be accurately thermostated. Since metals creep when thermally expanded or contracted, it is best to maintain the *L and R* meters at their constant thermostated temperature whenever practical.

The Model G meters have a worldwide range without resetting. The Model D meters normally have a range of 200 milligals and a reset that allows them to operate any place on earth.



The design of the meter allows it to be very sensitive to small changes in gravity. The simplified diagram of the meter shows a mass at one end of a horizontal beam. At the other end of the beam are a pair of fine wires and springs that act as a frictionless hinge for the beam. One purpose of the hinge springs is to help eliminate damage to the meter from all but the most severe impact.



The beam is supported from a point just behind the mass by a "zero length" spring. The spring is at an angle of approximately 45 degrees from horizontal. The meter is read by nulling the mass position, that is, adding or subtracting a small amount of force to the mass to restore it to the same "reading" position. This is accomplished by lifting up on the top end of the zero length spring. This must be done with great accuracy and is accomplished with a series of levers. In turn, the levers are moved by a high-precision screw which in turn is rotated by a gear box with considerable reduction.

The lever system and screw are accurately calibrated over their entire range. Calibration factors depend only on the quality of the lever system and measuring screw, not upon a weak auxiliary nulling spring as are used in other meters. For this reason the calibration factors of the *L and R* meters do not change perceptibly with time. This eliminates any need for frequent checks of the calibration.

The moving elements of the meter are restricted from movement of more than a few thousands of an inch (less than a tenth of a millimeter). Thus, if the meter sustains a severe impact it would be difficult for the movable parts to attain enough momentum to damage themselves. For further security and to minimize irregular instrumental drift, the beam can be clamped when not in use.

When the beam is clamped, it is pushed down against the bottom movement limiters or "stops". This would elongate the main spring and induce creep in the springs metal. To eliminate this creep, the beam also is pushed backwards upon clamping. Thus the length of the main spring in the clamped position is exactly the same length as it is when unclamped and at the reading line.

Few ferrous metal parts are used in the meter. The meter is demagnetized or compensated, then installed in a double μ-metal shielding to isolate it from magnetic fields.

Changes in air pressure could cause a small apparent change in gravity because of the buoyancy of the mass and beam. This is prevented by sealing the interior of the meter from the outside air. As an additional precaution, should the seals fail, there is a buoyancy compensator on the beam.

When the meters are new, their average drift is less than one milligal per month. With a few years of aging, their average drift is usually less than half a milligal per month. This small drift is true drift, not a large drift compensated to a small value by a clock and microprocessor.

BASIC OPERATING INSTRUCTIONS

STARTING

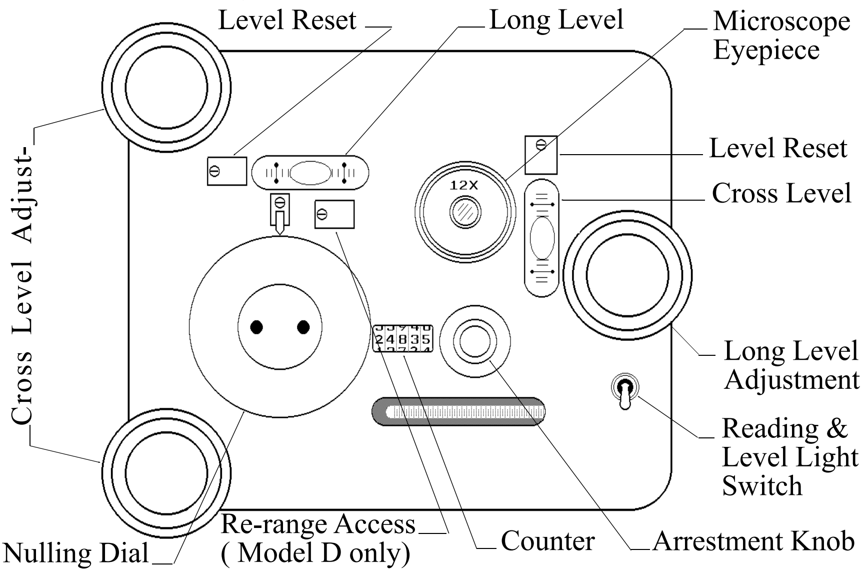
Before unpacking the meter and its accessories, inspect the shipping carton for signs of damage during transit. Promptly report any damage to the transporting company.

To bring the meter up to operating temperature, you must connect the meter to the battery. Begin by connecting the charger to a suitable AC power source, the charger will automatically accept 115 to 230 VAC. Next plug the charger's DC power connector to the small plug located on the side of the battery's plexiglass terminal block. Both LEDs on the charger should now be illuminated. The gravity meter can now be connected to the battery using the round Cannon connector on top of the plexiglass battery terminal block. With the meter connected in this manner, the charger will power the meter and also charge the battery. A red LED on the top of the meter should be illuminated once successfully connected, the LED will then cycle on and off after the meter has reached it's operating temperature, approximately two to five hours, depending on how cold the meter is. The internal heater will continue to cycle on and off to maintain a constant temperature. (In the field, the meter will be connected only to a fully charged battery.) An adapter is available that will allow the meter to be powered directly from the charger as well as charge another battery.

When the meter is at operating temperature, a series of tests may be performed to be certain the meter is in good condition. Each meter has its own operating temperature. It is recorded in the manual or on the meters' calibration table.

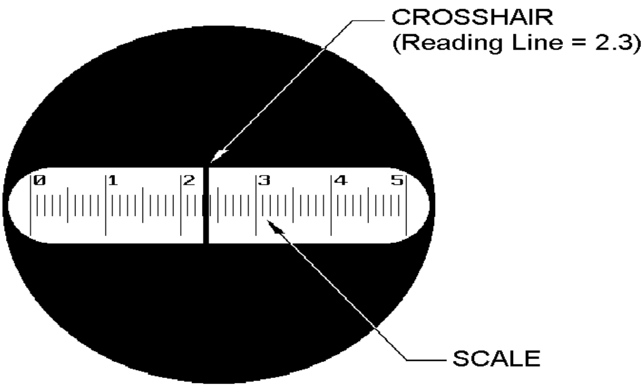
TAKING THE FIRST READING

- Place the meter on the aluminum base plate.
- Turn on the reading light and the spirit level lights. The switch is located on the near right side of the black lid. Do not leave the light turned on for a prolonged time, especially in hot weather, if accurate readings are desired. If the meter is equipped with electronic levels, the lights may not be necessary.



- Gently slide the meter in the concave base plate until the meter levels indicate the meter is approximately level. Finish the leveling with the three leveling screws of the meter. For efficiency, you may wish to level the cross level first then the long level. On the meter in the standard white box, there are three knobs atop the meter that turn the leveling screws. On some early meters in the miniature white box, these screws and their knurled turning flanges are under the white box.
- Release the internal beam of the gravity meter by turning the knurled arrestment knob counterclockwise to its limit. The knob is located on the near side of the microscope eyepiece.

- The position of the beam is determined by the image of the crosshair in the microscope. The crosshair is a very fine wire attached to the beam. A reticle or scale is placed in the optical path for a reading reference. The total motion of the beam is 14 small scale divisions. The downscale or left side of the crosshair is used as the reading edge.



- Each meter has its characteristic reading line. There is a small placard on the meter lid indicating the reading line for the meter. In the example above, the reading line is 2.3.

- Bring the left side of the crosshair to the reading line by turning the nulling dial. If the crosshair needs to move to the right, turn clockwise. If it needs to move to the left, turn counterclockwise.

- Always approach the reading line from the same direction. For uniformity, we suggest approaching from left to right, (turning clockwise). If coming from the right side (counterclockwise), turn the dial about a quarter turn past the null and approach clockwise. The play or slack in the gears and universal joint would cause an error if the null is not approached always from the same direction.

- The number of turns of the nulling dial is limited by the counter. The counter is located under a window in the middle of the black lid and just to the right of the nulling dial. The maximum reading of the model G is 7000, on the model D it is

2000 and on the extended range model D it is 3000. If there is a large difference between the gravity at your location and the location where the meter was last read, it will require many turns of the nulling dial to balance the meter's beam. Because of the limited range of the model D, it may be necessary to re-range the meter.

Model G: If the meter was last read at a much different latitude, a rough estimate of the counter reading necessary to null a Model G may be obtained from this table:

Latitude	Approx. Gravity	Approx. Reading
0	978.046	1430
10	978.203	1600
20	978.652	2050
30	979.337	2750
40	980.178	3600
50	981.078	4530
60	981.930	5400
70	982.623	6100
80	983.073	6560
90	983.223	6700

Model D: To re-range a Model D meter, set the counter to mid-range, 1000.0, and range the meter until it is roughly balanced. This is done by turning the coarse or re-ranging screw located beneath a small cover plate near the center of the black lid (see diagram pg. 1-7). Each turn of the ranging screw is about 74 milligals. If the crosshair is on the left side of the scale, turn clockwise. If it is on the right side, turn counter-clockwise. If the meter is tapped with the finger, the crosshair will bounce at the end of its range of travel. The closer the meter is to balance, the slower the crosshair will return to the end of travel. When the meter is in approximate balance, close the cover plate and finish balancing with the nulling dial. For more details on re-ranging the Model D, see the Field Procedures section (pg. 3-8).

- Obtain the reading from the counter and nulling dial. The last digit on the counter should correspond with the number on the nulling dial. This number is considered tenths of units. The dial is further divided so that hundredths of units can be read.

- It is good practice to double check the levels, the reading and the field notes after each reading.

- Clamp the meter by turning the arrestment knob clockwise to the end of travel (about 3 full turns).

After the meter has been shipped or received a hard impact, it is good practice to check the setting of the levels and sensitivity. See the paragraphs in this section for more details.

CONVERTING THE COUNTER READING TO MILLIGALS

Let us illustrate conversion of meter readings to milliGals with some examples.

MODEL G

If the counter reading is ***2654.32***, look at the calibration table for your meter. Remember that each meter has its own unique table.

Portion of calibration table

Counter Reading	Interval Factor	Cumulative Value
2500	1.00794	2519.42
2600	1.00799	2620.21
2700	1.00805	2721.01
2800	1.00811	2821.82

Divide the reading into two parts.

2600.00	2620.21
+ ***54.32***	+ 54.75
2654.32	2674.96

Interval factor x reading within interval

1.00799 x 54.32 = 54.75

MODEL G SURVEY OVER SMALL CHANGE IN GRAVITY

If all the readings are within an interval, you may use a single calibration factor, the interval factor.

Reading x Interval Factor = milligals

2654.32 x 1.00799 = 2675.53

MODEL D WITH SINGLE CALIBRATION FACTOR

Many model D meters have a calibration curve that is adequately straight so that a single calibration factor can be used for the meter. The calculation is almost like the example above except for an important difference: one turn of the D meter's nulling dial is equal to about 0.1 milligal (100 microgals) instead of 1 milligal (1000 microgals) on the G meter's nulling dial. Thus, the decimal must be moved one place to the left in the reading or one place to the left in the calibration factor. If the meter counter reading is 0943.21 and the calibration factor is 0.10123, then the converted reading is 0943.21 x 0.101234 = 95.485 . The same setting could be read 094.321 and the calibration factor 1.01234. The converted reading would then be 094.321 x 1.01234 = 95.485.

MODEL D WITH CALIBRATED WORLDWIDE RANGE

The standard Model D meter has two micrometer screws and lever systems for balancing the force of gravity. The “coarse” side has a worldwide range of at least 7,000 milligals. Normally this is not calibrated and is only used to place the meter into the operating range of the “fine side”. The "coarse" side (re-range) micrometer screw is normally turned by placing a small screwdriver through the re-range access port in the middle of the black lid (see diagram pg. 1-5).

If the coarse side is calibrated, a gearbox, counter and nulling dial are mounted above the "coarse" micrometer screw. There are 100 turns of the coarse nulling dial for each turn of the micrometer screw. Each turn of the screw is about 70 milligals. Thus, each turn of the of the nulling dial is about 0.7 milligals.

During surveys over a gravity span of less than the range of the fine screw, the coarse side would be locked and unused. The meter would be used in the same manner as the regular Model D meter. Be sure to use the fine side calibration table.

Where the range of the gravity observations is greater than the range of the of the fine side screw, the fine side can be locked and the meter used in the same way as a Model G geodetic meter. Be sure to use the coarse side calibration table.

A better method of reading the meter over a large range of gravity is to turn the coarse screw integral numbers of turns and complete the balancing of gravity with the fine side. If there is periodic or circular error on the coarse side, full turns of the screw should minimize this possible source of error. Because of the design of the Model D meter, periodic error of the fine side should be insignificant.

Here is an example of calculating the gravity difference between two sets of readings.

	Coarse Side	Fine Side
First Reading	4565.00	1234.56
Second Reading	4865.00	1567.89

From the coarse side calibration table:

From the fine side calibration table:

First Reading

Coarse Side 3351.446 + 65.00 x 0.74682 = 3399.989
Fine Side 84.633 + 34.56 x 0.07021 = 87.059
3487.048

Counter Reading		Factor	Counter Reading		Factor
4500	3351.446	0.74682	1200	84.633	0.070210
4600	3426.128	0.74691	1300	91.654	0.070175
4700	3500.819	0.74699	1400	98.672	0.070134
4800	3575.518	0.74706	1500	105.685	0.070120

Second Reading

Coarse Side 3575.518 + 65.00 x 0.74706 = 3624.077
Fine Side 105.685 + 67.89 x 0.07012 = 110.445
3734.522

Gravity is 247.474 milligals greater at the second reading than at the first. 3734.522 - 3487.048 = 247.474 milliGals

RELATIVE INSTRUMENT

Remember that the meter is a relative gravity meter. A single reading does not determine gravity. The meter only measures the difference in gravity between two observation locations or over a time interval at one site. If the converted reading is 2789.12 milligals at Station A and 2889.12 milligals at Station B, then gravity at Station B is 100.00 milligals greater than Station A. If gravity at Station A is 980,234.56 milligals, then you have determined gravity at Station B to be 980,234.56 plus 100.00 milligals or 980,334.56 milligals.

CHECKING LEVELS AND SENSITIVITY

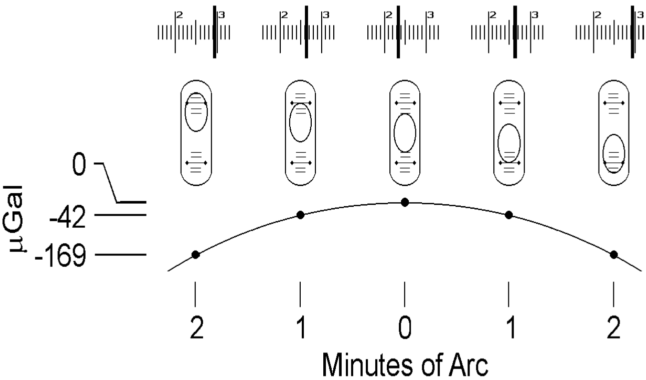
Whenever the meter has been shipped or has received a sharp blow or has been in the hands of a person not experienced with the meter (such as a customs inspector), it is good practice to be certain the levels and sensitivity setting are in proper adjustment. All good operators should know how to perform these checks and adjustments. They should not be delegated to a technician. The technician is not in the field when you bump or drop the meter. They are easy to learn and fundamental to a good understanding of the meter.

CHECKING THE TRANSVERSE LEVEL

The transverse level is also called the cross level. It is at 90 degrees from the direction of the meter's beam. With most meters, the spirit level is on the right side of the meter's lid. The galvanometer for most electronic cross levels is on the left side of the meter's lid.

The purpose of this level is to position the gravity meter, in the transverse plane, so the meter measures maximum gravity. If the meter is tipped to one side or the other (away from or toward the operator) it will not measure the full force of gravity.

If the cross level setting is correct, the gravity should decrease if the meter is tipped away from or toward the observer. That is indicated by the crosshair (and galvo on CPI meters) moving to the right when the meter is tipped off level.



If the meter is nulled to the reading line when the meter is out of level, the gravity reading will be less and less the more the meter is out of level. Be sure the other level, the long or longitudinal level, is in the level position each time the meter is read.

If the meter does not indicate a maximum gravity reading when the cross level is centered, the cross level is out of adjustment. Tilt the meter until the maximum reading is obtained. Remember to always keep the long level centered.

Now while being careful not to move the meter, use the level adjusting tool to center the level bubble. There is a small coverplate on the black lid. It is located on the far side of the cross level window. With a very small screw driver or the blade of a knife, loosen the screw that secures the coverplate. Rotate the coverplate and expose the access hole. The hexagonal level adjusting tool will fit through this hole and into the head of the level's small adjusting screw.

Repeat the testing of the cross level to be certain your adjustment was done accurately. If it was, you should obtain a maximum gravity reading when the cross bubble is in the center.

If the cross level is far out of adjustment, the meter's beam or spring may drag along the side or the other. Tilt meter considerably to one side and the other to determine at what angle the beam becomes free. If the beam moves but is unstable and can not be nulled to the reading line, check the meter's sensitivity (next section).

Some older meters do not have levels that can be adjusted through a small port in the black lid. These older meters must have their black lids removed to reach the level adjustments. See the METER DETAILS section for more information. A special aluminum tube is required to hold the eyepiece while adjusting these older levels with the black lid removed.

CHECKING THE SENSITIVITY

The longitudinal or long level is parallel to the meter's beam. It is used to set the mechanical sensitivity of the meter.

Raising the right side of the meter makes the beam less sensitive to a given change in gravity or spring tension. As the sensitivity becomes greater, the period of the beam becomes longer. If the period becomes too long, it is no longer practical to read the meter by the nulling method. Still more lowering of the meter's right side causes the beam to have an infinite period, and still more lowering of the right side and the beam becomes unstable with the beam accelerating as it moves toward the upper or lower limit of its movement.

The beam is limited in movement by "stops". They are factory adjusted to limit the beam movement to 14 small optical lines. The reading line is usually close to the center of the range of movement. *L and R* places a small label on the black lid indicating the reading line when the meter was last tested at *L and R*. When the beam is clamped, it is pushed down onto the bottom stop. Because of the optical system, the bottom appears toward the left side of the optical scale and the top toward the right.

To check the sensitivity:

- Level the meter.
- Turn on the reading lamp.
- Observe the position of the beam. It will be close to the bottom stop.
- Unclamp the beam.
- Turn the nulling dial to locate the lower and upper stops.
- Position the crosshair about one small optical division above the bottom stop. Be sure to approach from the left (clockwise turn of the nulling dial).
- Turn the nulling dial approximately one milligal clockwise. This would be one full revolution for the Model G and ten full revolutions for the standard Model D.
- Observe the number of small optical divisions the crosshair moves in the eyepiece.
- If the beam moves approximately 9 to 11 small optical divisions, then a long level adjustment is not necessary. (9 to 10 optical divisions if the electrostatic nulling system is used)

If the sensitivity is out of the above range, the long level and sensitivity should be adjusted in small increments, usually about a fourth or a half of a bubble division.

If the sensitivity is too low (less than 9 small optical divisions), lower the right side of the meter a small amount so the level bubble moves away from the eyepiece stalk. Recheck the sensitivity of the meter. If the sensitivity is now within the acceptable range, reset the long level as follows:

- Be careful not to move the meter.
- Open the small level adjusting access hole at the left end of the long level.

- Insert the hexagonal adjusting tool through the access hole into the level adjusting screw.
- Gently turn until the level bubble is centered.

If the sensitivity is too high (greater than 11 small optical divisions), raise the right side of the meter a small amount so the long level bubble moves toward the eyepiece stalk (to the right). Recheck the sensitivity. If the sensitivity is now within the acceptable range, reset the long level with the level adjusting tool as described above.

During all of the above adjustments, be sure the cross level remains with its bubble in the center.

CHECKING THE READING LINE

- Level the meter.
- Turn on the reading lamp.
- Unclamp the meter.
- Use the nulling dial to adjust the crosshair to the reading line as specified on the meter. If the reading line is not known, choose the optical line midway between the beam stops.
- Keeping the cross level in the level position, tilt the long level one division in one direction and record the eyepiece reading.
- Tilt the long level one division to the other side of the level positions and record the eyepiece reading.
- If the crosshair moves upscale approximately the same amount for each tilt, then the chosen reading line is correct.
- If the crosshair moves downscale when the meter is lowered on its right, the assumed reading line is too low.
- If the crosshair moves upscale appreciably more when the meter is lowered on the right (the long level bubble is one division farther away from the eyepiece stalk) than when the meter is raised on its right side, the assumed reading line is too high.
- If the correct reading line was not chosen in the above test, relevel the meter, reposition the crosshair with the nulling dial to a new trial reading line and repeat the above procedures.

The reading line should be checked whenever the long level has been adjusted.

STANDARD ACCESSORIES

BATTERIES

Two 12-volt gel-type rechargeable lead-acid batteries are provided with each new meter. They have a capacity of 9 amp-hours. An electrical connector is securely mounted on the battery. Beginning in 1997 an additional plug was added to the batteries to accommodate the new battery charger. Since 1984, a 2-pin Cannon KPT02A-8-2S connector has been used as the primary power connector. Prior to 1984, a 3-pin Bendix JT06A-8-3S fitting was used. To prolong the life of the batteries, it is important not to deep discharge the batteries and always to recharge them as soon as possible after use.

The batteries are fully charged when shipped but should be recharged before using. Recharge only with the *LaCoste and Romberg* charger. Other chargers may reduce battery life.

Though the acid electrolyte is stabilized in gelatin, the batteries can discharge damaging acid if they become hot and are not upright. Left on their side in a hot vehicle is a likely way to damage the battery and surrounding property!

Do not ship batteries inside the meter carrying case. There is considerable energy and value in close proximity if an accident should occur.

Batteries should be stored in the fully charged state. Preferred storage temperature is 20° C (70° F) or below. The batteries should be recharged every two or three months while in storage. If the temperature is above 20° C more frequent recharging is required to prolong the life of the batteries. Storage at temperatures above 40° C (100° F) should be avoided.

A charging period of 12 to 20 hours is usually sufficient to bring a fully discharged battery to a full charge. A fully charged battery should provide enough energy to maintain the meter for a long field day in all but the coldest weather.

Eventually batteries gradually lose their capacity to fully recharge. When operating time after a full charge is no longer satisfactory, it is time to replace the battery.

NEW BATTERY CHARGER

Beginning in 1997 LaCoste & Romberg began shipping a new battery charger and batteries with a new style connector block that can be used with the new battery charger, replacing the previous charger/battery eliminator. The new battery charger is much more reliable and easier to use. The new batteries have an additional socket to accept the DC plug of the charger. An adapter is available to allow the charger to power the gravity meter without a battery. This new charger is not compatible with the older batteries.

OLD CHARGER/BATTERY ELIMINATOR

This charger/eliminator is no longer sold by LaCoste & Romberg. We recommend upgrading to our new charger and batteries.

The charger/eliminator serves two purposes: to charge the batteries and to provide a regulated 12-volt DC power for the meter when it is not in the field.

The charger/eliminator is powered by 115 or 230 volts ± 10% at 47 to 420 Hertz: AC power only!

FIRST set the input voltage switch to 115 or 230 volts. Chargers shipped before 1989 have the switch on the face of the charger. From 1989 onward, the switch is located inside the charger. AFTER setting the switch, connect the power source. The charger may be damaged if the switch is set to 115 volts and the charger connected to 230 volts power.

ALUMINUM CARRYING CASE

The carrying case is made of anodized aluminum and is divided into two padded compartments. On the left is the meter compartment and on the right the battery compartment. The case should be dried as soon as possible if it becomes damp. This will minimize corrosion to the gravity meter's leveling legs. Good field practice dictates periodic cleaning of the pads and removal of debris accumulated beneath the bottom pads.

Spare fuses and reading lamps are stored in a small box taped to the inside of the carrying case lid. Remove the cushion to expose the fuse and lamp box.

The most common malfunction of the case is a failure of the latches. If prolonged field work in a remote location is anticipated, a spare pair of latches is advisable.

The case is modified for use with meters that are equipped with the analog electrostatic nulling option. The meter side of the case is about 15mm (5⁄8-inch) wider.

ALUMINUM BASEPLATE

A standard aluminum base plate is supplied with each meter. It has three legs about 50mm (2 inches) long and a bullseye bubble at its center. The low temperature functional limit of the bubble is -54°C (-65°F) and the bubbles can tolerate -62°C (-80°F).

There are several optional baseplates available for special purposes (see options).

CABLES

Each new meter is provided with a power extension cable for use with a 12-volt power source other than the standard batteries or eliminator. The cable attaches to the end of the standard meter power cable and has two color coded battery lugs at the other end. Red is positive and black is negative.

Meters with the CPI option are equipped with a recording cable. It is a short two-conductor cable with a miniature phone plug at the meter end and lugs at the recorder end.

ALLEN ADJUSTING TOOL

For adjusting the levels, an Allen driver is provided with each new instrument. It has a screw driver handle and a hexagonal shaft and tip. The tool is stored in the carrying case. The tool comes in two lengths: a short one for meters that only have spirit bubble levels and a long one for meters with electronic levels.

SPARE FUSES

Spare ATO-3 fuses are stored in a small box taped to the inside of the carrying case lid. Remove the pad from the inside of the lid and the box is apparent.

SPARE LAMPS

Meters that have incandesant reading lamps have spare lamps stored in a small box taped to the inside of the carring case lid. New meters have LED reading lamps and no spares are necessary

MANUAL

Each meter is provided with a manual. *L and R* is endeavoring to improve the manual. Suggestions for improvement or adding additional information would be appreciated.

CALIBRATION TABLE

Each meter has its own unique calibration table. Some Model D meters have a single calibration factor. If the table is lost, *L and R* maintains the original, together with the raw data from which the table was generated.

SPECIAL METER SHIPPING CONTAINER

The shipping container in which the instrument is shipped from *L and R* is a reusable container. It is important to retain it in good condition for use when the meter is next shipped.

SERVICE

There are three basic types of service:

- Repair a specific part
- General testing, cleaning and adjusting
- Long term servicing

Repairing a specific part is usually charged on a time and material basis. There is a fixed rate for some of the more common repairs.

General testing, cleaning and adjusting is a fixed price. It includes:

- Testing the meter
- Opening
- Cleaning the beam stops
- Adjusting the hysteresis compensator
- Making other internal adjustments
- A 16 hour check of the meter seals
- Flushing meter with dry inert gas
- Sealing meter
- Retesting to verify adjustments were made properly
- Field testing
- Cursory check of calibration (17 milligal range)

The time required for the above is usually one to two weeks.

Long term servicing includes all of the above plus:

- Replacing all seals
- Removing the micrometer screw (two for Model D), cleaning, inspecting and relubricating

- Removing the gear box, cleaning, replacing any questionable micro-bearings or gears and relubricating.

The time required for long term servicing is usually two to three weeks. There is a fixed price for the work. Any significant updates are an additional charge. Long term servicing should be performed every EIGHT TO TEN YEARS. Seals will start failing after that many years due to hardening. The lubrication on the micrometer screw ages and should be cleaned and replaced, regardless of the amount of use.

L and R is proud to service and maintain its instruments, regardless of their age. Almost every Model G and Model D meter is still in service, G-1 looks and works like a new meter.

Our service policy is to charge a reasonable price for service and to perform it promptly.

WARNING!

DO NOT OPEN THE SENSOR. It is sealed with dry inert gas. There is nothing in the sensor that can be repaired outside the *L & R* laboratory. Only SEVERE AND COSTLY damage can result from opening the sensor.

WARRANTY

All *LaCoste and Romberg* gravity meters are guaranteed for a period of 1 year after delivery. At the Purchaser's request, *LaCoste and Romberg* will make all necessary adjustments, repairs and parts replacements. All parts will become the property of *LaCoste and Romberg* on an exchange basis. This guarantee will not apply if such adjustments, repair or parts replacement are required because of accident, neglect, misuse, operation on improper power, transportation or causes other than ordinary use. All necessary adjustments, repair or parts replacement will be made at no charge to the Purchaser provided that the Purchaser pays all transportation cost to and from the *LaCoste & Romberg LLC.* laboratory in Austin, Texas. The period of the guarantee is extended by the length of time that the gravity meter is in transit and in the laboratory for repairs. The guarantee is void if the internal sensing element is opened by an unauthorized person.

The foregoing guarantee is in lieu of all other guarantees expressed or implied, and all obligations or liabilities on the part of *LaCoste & Romberg LLC.* for damages, including but not limited to consequential damages arising out of or in connection with the use or performance of the meter.

This page left blank intentionally