APPENDIX C: INITIAL CONSTANTS SHEET FOR AUTOGRAV

SERIAL # 8810110 AUSTRALIA

GCAL1	6748.19
GCAL2	-43.171
TEMPCO	-0.1249
TILTXS	180.6
TILTYS	183.8
DRIFT	0.67 (AT TIME OF SHIPPING)

CG-3 OPERATOR'S MANUAL

DRAFT

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MARCH 1989

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Instrument Overview

The Autograv is a microprocessor-based automated gravity meter that has a measurement range of over 7000 mGals without resetting and a reading resolution of 0.01 mGals. This enables the Autograv to be used for both detailed field investigations and large scale regional or geodetic surveys.

Accurate measurements are taken by simply pressing a key and under most conditions takes under one minute to complete the reading. A series of readings of gravity measurements at a fixed site can be performed by setting the Autograv in the cycling mode. The Autograv obtains a reading by continuously averaging a series of one second samples. The reading is displayed on the LCD directly in mGals. The data is stored in the solid state memory which can be sent to a printer modem, recorder or microcomputer.

The gravity sensor, solid-state control system and battery are integrated into a single instrument housing which doubles as a carrying case. This eliminates the need for packing and unpacking the sensor between readings. Stability is increased and the risk of an accident is reduced by the absence of an external cable between the battery and sensor. The kinetic mounting system which indexes the Autograv onto the tripod further increases instrument stability.

When setting the Autograv up for a reading, the electronic tilt sensors provide greater accuracy and are easier to operate than the conventional bubble levels. The gravity meter displays the outputs from the sensors on high resolution meters on the front panel and also on the 32 character liquid crystal display.

Excellent protection from changes in ambient temperature and atmospheric pressure is achieved by sealing the Autograv sensing element in a temperature-stabilized vacuum chamber.The wide operating temperature of -40°C to +45°C (optional +55°C) enables the operator to use the Autograv in many environments. Since the sensor is made from non-magnetic fused quartz, the Autograv is not affected by magnetic field variations.

Low drift is a result of the extremely stable operating environment of the quartz elastic system. It allows the long term drift of the sensor to be accurately predicted and a real time software correction reduces it to less than 0.02 mGals per day.

Internal tilt sensors constantly supply the Autograv with information when an operator selects the continuous tilt correction feature. If measurements are taken on unstable ground, errors due to the movement of the Autograv are automatically eliminated.

An automatic tidal correction can also be selected via the keyboard. The operator enters in the geographical location and time zone information

and the Autograv automatically calculates and applies a real time tidal correction to each reading.

The internal 12 volt rechargeable battery provides sufficient power to operate the Autograv throughout a normal survey day. An operator can check the battery voltage at any time by pressing a key and viewing the display. When the battery voltage is approaching the discharge level, the Autograv emits an audible alarm. An optional cable enables the instrument to operate from any external 12 volt DC power supply or battery which can supply 2 amperes. In the event of a main battery failure, a set of built-in miniature batteries keeps the memory safe for several days.

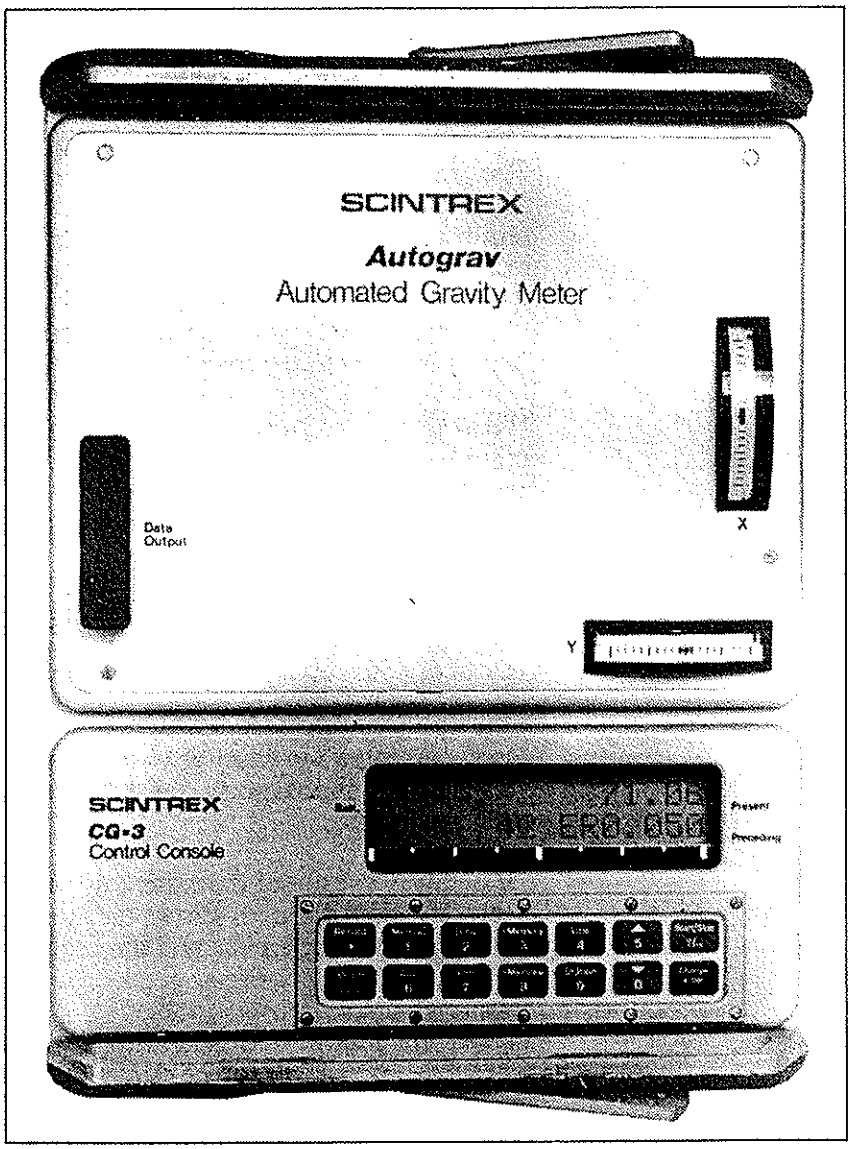

Figure 1: Autograv - The Automated Gravity Meter

How to Unpack the Instrument

The Autograv is packed in an insulated case to protect the instrument during shipment.

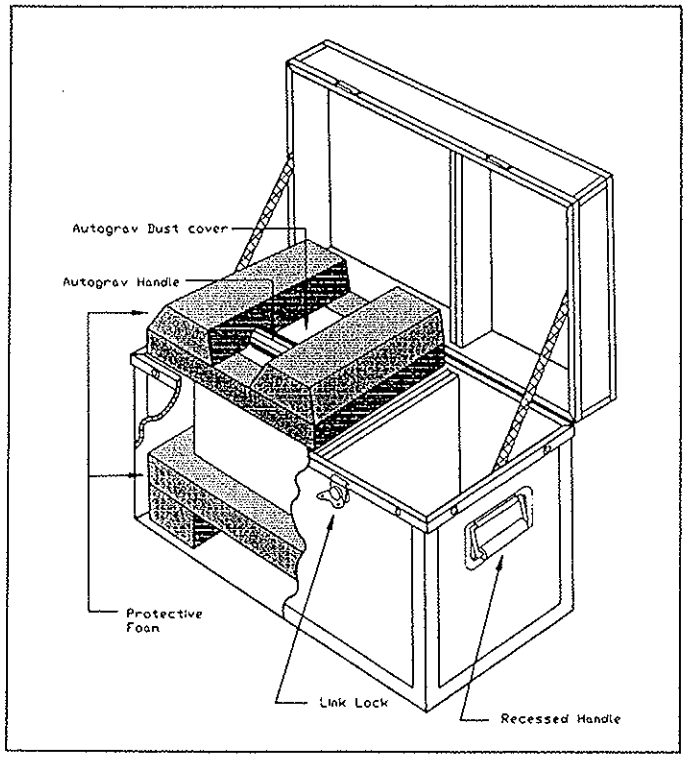

Figure 2: Autograv Transportation Case

To Unpack

1. Pull up the tab of the link lock and turn the tab counter clockwise to unfasten the lock from the keeper plate.
2. Repeat step 1 for the other link lock.
3. Open the Autograv transportation case by lifting the cover.
4. Remove the protective foam from the left hand side of the transportation case to view the top of the Autograv dust cover plate.
5. Remove the Autograv from the transportation case and visually inspect for any physical damage that may have occurred during transportation.

   If there is any evidence of physical damage, immediately call Scintrex Limited.
6. From the right hand side of the transportation case, remove the Autograv accessories.

To Remove the Dust Cover

1. Remove the dust cover plate on the Autograv by pressing down on the two latches and sliding the cover away from the instrument.

2. Place the dust cover back inside of the transportation case for safe keeping.

   Note: If you are shipping the Autograv, insert the dust cover to protect the instrument.

How to Start-Up the Autograv

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3. After you have set the charger voltage and checked the fuse, plug the power cord of the charger into an AC outlet. The green light on the charger turns on to indicate that the charger is working.

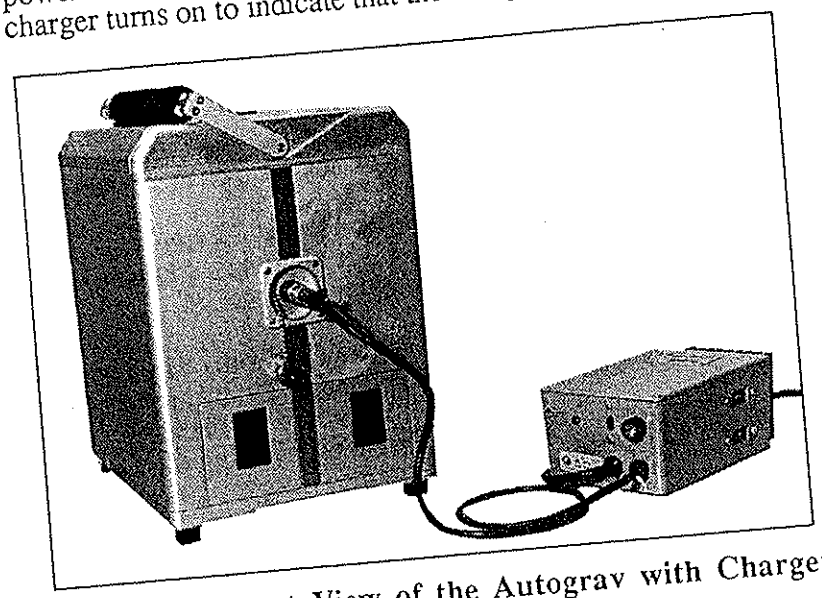

Figure 3: Front View of the Autograv with Charger

4. Remove the dust cap from the charger plug on the Autograv.

5. While holding the top of the instrument, insert the charger connector to the charger plug on the Autograv.

6. Open the battery compartment by pressing down on the two latches and lifting the cover away from the instrument.

7. Remove the battery by pushing on the left side of the battery and then pulling the black tab towards you so the battery can slide out of the compartment.

8. Insert the connector of the battery into either socket on the left side of the compartment. The Autograv has two sockets so that you can change batteries without powering down the instrument (see figure 4).

9. Before you re-install the battery, place your hand inside and flatten the black tab against the bottom, side and top of the compartment. If the black tab is not pressed against the walls of the compartment, the battery will not fit and the foam padding will be damaged.

10. Place the battery inside of the compartment with the top of the battery facing outwards and the battery cable to the left as shown in figure 4.

11. Re-install the battery compartment cover.

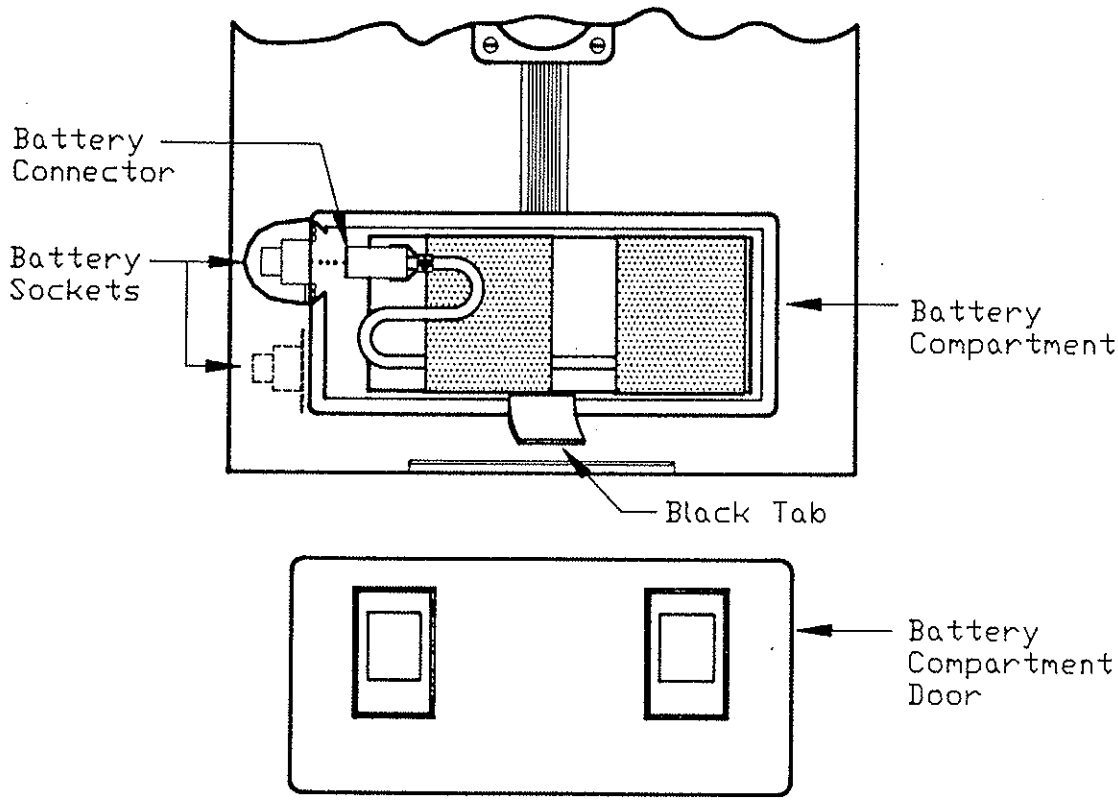

Figure 4: Position Of Battery Inside Compartment

How to Use the Keypad

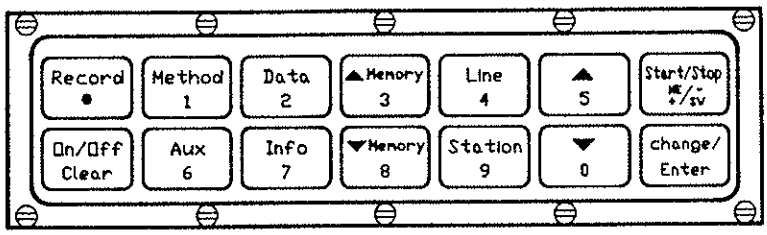

Figure 5: The Autograv Keypad

The Keypad

You can use the Autograv keypad to do the following:

- Select menu options
- Set system parameters
- Take a reading
- Record data
- Recall stored data
- Dump data

Each key has two functions. The mode of operation determines which function the Autograv responds to. The two modes of operation are:

- Operation mode
- Enter mode

If you are in the Operation mode, the key press initiates the function that is displayed on the top of each key.

If you are in the Enter mode, the key press initiates the function that is displayed on the bottom of each key.

Note: If the keypad is not responding to a key press, refer to the Troubleshooting section on how to reset the keypad.

Top Functions

On/Off - Turns the instrument on and off. When you turn on the instrument, the previous menu option appears on the display. The status of the instrument is saved when the Autograv is turned off.

Record - Enters measurements into memory.

Method - Displays the method/mode in which the instrument is currently operating.

Data - Shows on the display the set of measurement parameters being measured or just completed.

▲Memory, ▼Memory - Recalls and displays data that is stored in memory by scrolling.

Line - Shows the present line number and/or a line number recalled from memory (if applicable). The current line appears on the top line while the line number from memory is on the bottom line. It enables you to change the current line number.

▲ ▼ - Perform two functions:

- Scroll through lists of selected data, actions or the menu options
- Goes to the next line or station if line or station number is displayed

Aux - Displays the Auxiliary mode menu options. Use the Aux key to exit from a submenu and to return to the previous menu level. If you press the Aux key twice, the software takes you from your immediate menu to the first level of menu (the main menu).

Info - Provides remaining memory capacity, battery voltage, time and date, grid number and ancillary information.

Station - Displays the current station number and/or a station number for a measurement in memory. The current station appears on the top line while the station number in memory is on the bottom line. It enables you to change the current station number.

Change - Enables you to select the Enter mode so you can modify parameters using the bottom functions of each key.

Start/Stop - Enables you to do the following:

- Start or stop a measurement
- Start or stop the ouput of data to communication or recording devices
- Start erasing and testing memory
- Start the Edit mode

Bottom Functions

Clear - Erases the current number.

0-9 - Inputs numerical data

. - Enters a decimal point

NE/+ -/SW - Toggles between north, south, east, west and +/- for station and line numbers.

Enter - Enables you to access the menu option shown on the display and also to enter a selected value into memory.

How to Read the Display

The Autograv display is a 32 character liquid crystal display which can be divided into four areas.

MENU SELECTION	CURRENT DATA
PROMPT	PREVIOUS DATA

However, not all areas of the display will have information. If you are in the first level of menu, there is no current or previous data so these areas will be blank. If you select a menu option that does not have previous data, this area will be blank.

Menu Structure

The Autograv has three levels of menus. Refer to the Software section for a detailed description of the Autograv software.

Moving Between Menus

When you press a function key in the operation mode, a menu option appears.

Example:

Press: **Aux**
Display: **AUTOGRAV SETUP**
ENTER?

If you want to go to the next menu option in the same level do the following:

Press: ▲ or ▼

If you want to go to the submenu of the displayed menu, press the key shown in the prompt.

To go back to the previous level of menu, press the Aux key.

Selecting a Menu

When the display shows the menu option that you want to select, press the key that is shown on the bottom line.

Example:

Display: **AUTOGRAV SETUP**
ENTER?
Press: **Enter**
Display: **MODE: FLD GRAV**
CHANGE?

Modifying Parameters

The prompt that is on the bottom line shows you how to change the parameter that is displayed. There are three types of prompts:

PROMPT	KEYS	TYPE
SELECT/ENTER	▲ or ▼	limited to selection
xxxx> nnn ENTER?	0-9, ., clear +/-	numerical values, N,S,E,W, +/-
xxxx CHG? >xxxx<	Change	limited to 2 selections

If you change the parameter by using the ▲ or ▼ keys, or change a numerical value, you must press the Enter key to load the change into memory. If you are enabling or disabling a parameter, you do not have to press the Enter key.

Example: To change the read time from 65 secs to 120 secs:

Display: **READ TIME 65**
CHANGE?
Press: **Change/Enter**
Display: **READ TIME> 65**
ENTER
Type: **120**
Display: **READ TIME> 120**
ENTER
Press: **Change/Enter**
Display: **READ TIME 120**
CHANGE?

How To Initialize Software

To Initialize

To prepare the instrument to take a reading, you must first initialize the software by doing the following:

- Reset time and date
- Erase memory
- Set-up the Autograv parameters

Note: If a key is not pressed within approximately one minute, the display automatically turns off. However, the Autograv brings you back to the same place in the menu where you left off when you press the On key.

To Reset Time and Date

1. Press the Aux key twice and then the ▲ or ▼ key until the following prompt appears:

   INITIALISE
   ENTER?

2. Press the Enter key.

3. Press the ▲ or ▼ key until the following menu appears:

   TIME xx:xx:xx
   CHANGE? xx/xx/xx

4. Press the Change key.

   The letters HH appear in the hour position.

5. Type in the hour (the Autograv runs on a 24 hour clock).

6. Press the Enter key.

   The letters MM appear in the minutes position.

7. Type in the minutes.

8. Press the Enter key.

   The letters SS appear in the seconds position.

9. Type in the seconds.

10. Press the Enter key.

    The Date parameters appear. Repeat the steps shown above to set the current date. After you type the day and press the Enter key, the clock starts to run.

To Erase Memory

1. Press the Aux key twice and then the ▲ or ▼ key until the following prompt appears:

   INITIALISE
   ENTER?

2. Press the Enter key.

3. Press the ▲ or ▼ key until the following prompt appears:

   ERASE MEMORY
   ENTER?

4. Press the Enter key.

5. If you want to erase the memory, press the Start key.

   The instrument begins to erase the memory. After the memory is erased, the following prompt appears:

   MEMORY FREE 100%
   TESTED XXK

   XXK is the size of the memory installed in the Autograv.
   For example: 16K

Autograv Set-Up

1. Press the Aux key twice and then the ▲ or ▼ key until the following prompt appears:

   CG-3 SETUP
   ENTER?

2. Press the Enter key.

3. Press the ▲ or ▼ key until the following menu appears:

   MODE: XXXX
   CHANGE?

   If XXXX = CYCLE, go to step 7.

4. Press the Change key.

5. Press the ▼ key and the following prompt appears.

   MODE: > CYCLING
   SELECT/ENTER

6. Press the Enter key.

7. Press the ▼ key and the following prompt appears:

   READ/CYCLE TIME
   ENTER?

8. Press the Enter key.

   READ TIME XXX
   CHANGE?

9. Press the Change key.

10. Type: 120

    READ TIME > 120
    ENTER

11. Press the Enter key.

12. Press the ▼ key and the following prompt appears:

    CYCLE TIME XXX
    CHANGE?

13. Press the Change key.

14. Type: 600

    CYCLE TIM > 600
    ENTER

15. Press the Enter key and then the Aux key.

16. Press the ▼ key and the following prompt appears:

    CHG. START TIME
    ENTER?

17. Press the Change key twice. The drift correction start time is now set to the current time and date on the clock.

18. Press the ▼ key and the following prompt appears:

    CAL AFTER XX
    CHANGE?

19. Press the Change key.

20. Type: 4

    CAL AFTER > 4
    ENTER

21. Press the Enter key.

22. Press the ▼ key and the following prompt appears:

    INIT. CONSTANTS
    ENTER?

23. Review the Instrument Constant sheet that is in the Appendix section. Every instrument has its own set of initial constants and the constants shown on the sheet must match the parameters set up in the initial constants mode.

    Example:

Gravity Reference:	0. mGals	Tilt x sensit.:	200.3
Gravity const. #1:	6439.132	Tilt y sensit.:	174.6
Gravity const. #2:	-58.972	Deg. Latitude:	43.7
Temperature const.:	- 0.143 mGal/mK	Deg. Longitude:	79.6
Drift constant:	- 0.14	GMT Difference:	* 5.hr
Drift Correction Start	Time: 19:09:52	Cal after x samples:	4
	Date: 89:01:	On-line Tilt Corrected = *	

24. Press the Enter key and then the ▲ or ▼ key and set the following initial constants to the values shown on the Instrument Constants sheet.

    - **GCAL.1**
    - **GCAL.2**
    - **TEMP.**
    - **DRIFT**
    - **TILTX S**
    - **TILTY S**
    - **GREF.**

25. Press the Aux key, the▼key and the following prompt appears:

    TILT COMPENSAT.
    CHG? >XXXX<

26. Press the Change key until the following prompt appears:

    TILT COMPENSAT
    CHG? >DISABLED<

28. Press the ▼ key and the following prompt appears:

    TIDE COMPENSAT
    CHG? >XXXX<

29. Press the Change key until the following prompt appears:

    TIDE COMPENSAT
    CHG? >SELECTED<

30. Press the ▼ key and the following prompt appears:

    DEG. LAT XX
    CHANGE?

31. Press the Change key.

32. Type: Decimal degrees to reading site: N is +ve, S is -ve.

33. Press the Enter key.

34. Press the ▼ key until the following prompt appears:

    DEG. LONG XX
    CHANGE?

35. Press the Change key.

36. Type: Decimal degrees to reading site: W is +ve, E is -ve.

37. Press the Enter key.

38. Press the ▼ key and the following prompt appears:

    GMT DIFF XX
    CHANGE?

39. Press the Change key.

40. Type: (GMT - Clock time) in hours.

    Example: If clock is set to local time in Toronto:

    GMT DIFF = 5
    DEG LAT = 43.8
    DEG LONG = 79.8

41. Press the Enter key.

42. Press the ▼ key and the following prompt appears:

    CHART SEL: XX
    CHANGE?

43. Press the Change key.

44. Press the ▼ key until the following prompt appears:

    CHART SEL: > 1
    SELECT/ENTER

45. Press the Enter key.

46. Press the ▼ key and the following prompt appears:

    STOP: ERR. < LIM
    CHG? > XXXX<

47. Press the Change key until the following prompt appears:

    STOP: ERR. < LIM
    CHG? >DISABLED<

48. Press the ▼ key and the following prompt appears:

    AUTO REJECTION
    CHG? >XXX<

49. Press the Change key until the following prompt appears:

    AUTO REJECTION
    CHG? >SELECTED<

50. Press the ▼ key and the following prompt appears:

    AUTO-RECORD
    CHG? >XXX<

51. Press the Change key until the following prompt appears:

    AUTO-RECORD
    CHG? >DISABLED<

52. Press the ▼ key and the following prompt appears:

    MODE: CYCLING
    CHANGE?

    You are now back to the top of the AUTOGRAV SETUP submenu.

How To Set-Up The Tripod

To Set-Up

The tripod enables you to level the Autograv before taking a reading. The three leveling screws on the bottom of the tripod can be adjusted until the X and Y meters on the front panel of the Autograv and the display show that the Autograv is level.

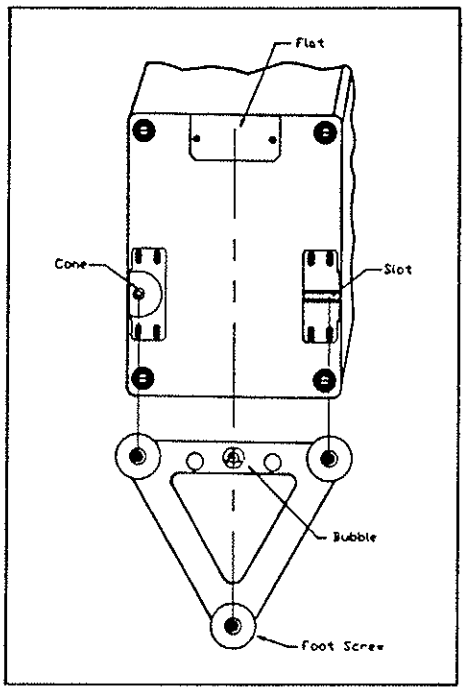

Figure 6: Set-up of the Tripod

1. Set the tripod on stable ground in a quiet location with the bubble level away from you as shown in the diagram above.
2. Place the cone on the bottom of the instrument (left side) down onto the left rear tripod foot.
3. Place the slot on the bottom of the instrument (right side) down onto the right rear tripod foot.
4. Lower the instrument onto the front tripod foot.
5. Press the Start key. The following prompts appear one after the other:

   AUTOGRAV
   ADJUST

   TILTS X: XXX
   ADJUST: XXX

6. View the X and Y meters on the front panel and the display to level the instrument.

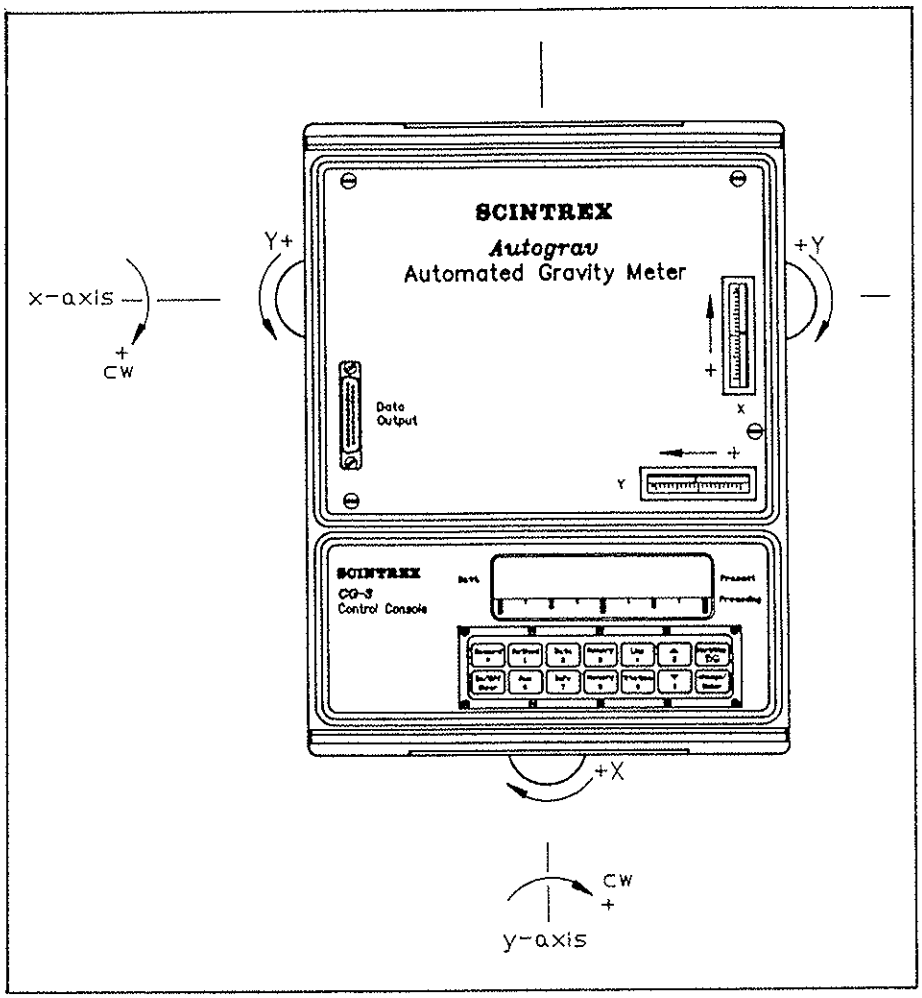

Figure 7: Adjusting the Tripod

7. Adjust the y-axis first by turning the two rear screws on the tripod and viewing the display and bubble meters.

   If you need to level the y-axis in the positive direction, turn the rear screws towards the front of the instrument. See the diagram above. This procedure of rotating both screws in opposite directions at the same time is the most efficient way to level about the y axis.

8. After the y-axis is level, adjust the x-axis by turning the front screw on the tripod and viewing the display and bubble meters.

   If you need to level the x-axis in the positive direction, turn the front screw clockwise. See the diagram above.

How to Set-up the Tripod Extender Legs

The tripod comes with three extender legs which may be used under soft soil conditions.

To Set-up

1. Place one extender leg over one of the pointed bottom legs of the tripod with the tab of the extender leg facing the outside of the tripod. This tab is available so that you can step on the tab to dig the shaft of the leg into the soil.
2. Insert the 8-32 hex bolt through the openings of the legs. Ensure that the head of the nut fits into the recessed slot on the extender leg as this enables you to securely tighten the bolt.
3. Place the washer and the black wing nut onto the bolt and slightly tighten the wing nut.
4. Adjust the angle of the extender leg and tighten the wing nut.
5. Repeat steps 1 through 4 for the other two extender legs.

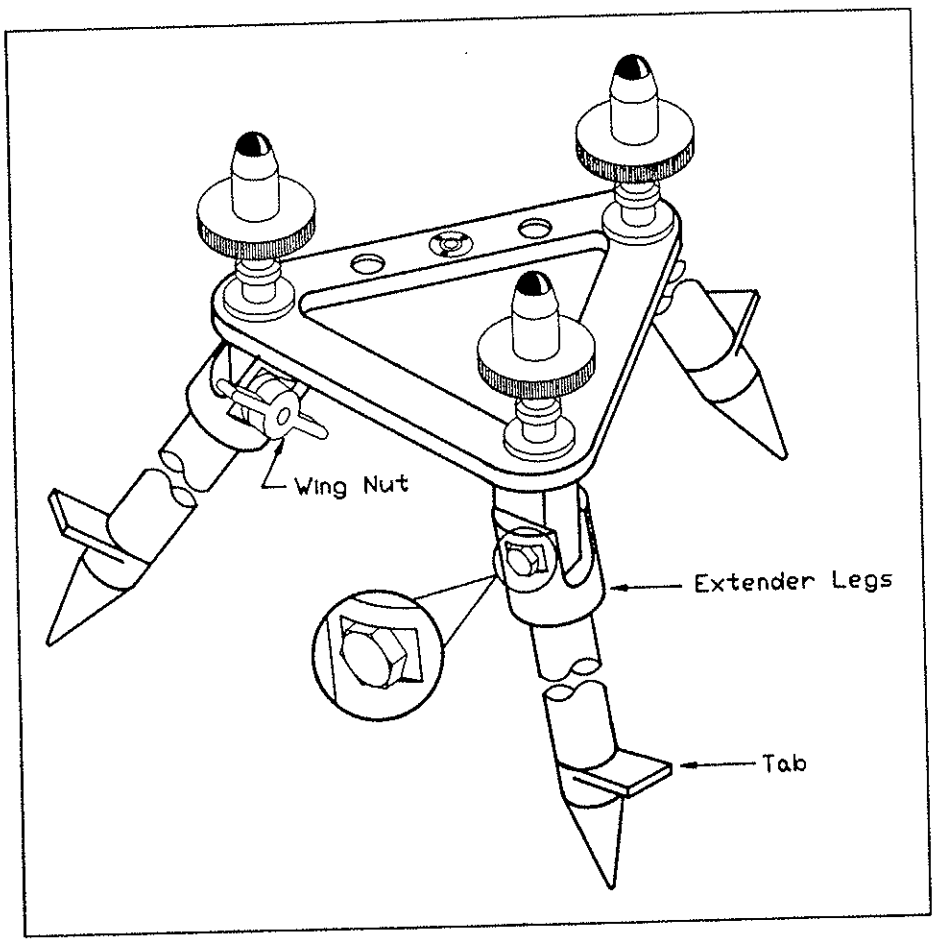

Figure 8: Tripod with Extender Legs

How To Check and Adjust Temperature Compensation

Do not adjust the temperature compensation until the Autograv has gone through the complete stabilization time of 48 hours.

To Check

1. Select a stable base for the Autograv in a quiet location and place the instrument on the tripod.

2. Level the Autograv by following the Tripod Set-up.

3. When the following prompt appears,

   TILTS ADJUST X: XXX Y: XXX

   press the ▼ key. The following prompt appears:

   TEMP. ADJUST X.XX

   If the number on the top line of the display is between +2.0 and -2.0 then the temperature of the gravity sensor is within range. Proceed to the section, Check and Adjust Drift Correction.

   If the temperature value is outside of the acceptable range, you must adjust the temperature compensation offset.

To Adjust Temp. Compensation Offset

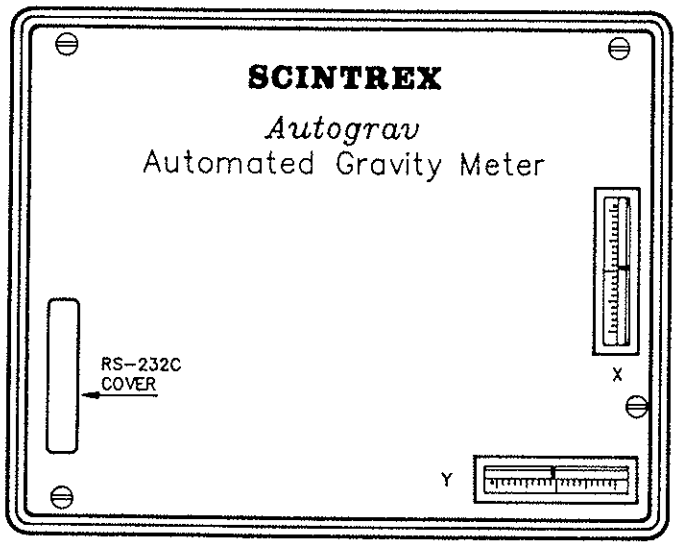

Figure 9: Faceplate of Autograv

To Adjust

1. Using a slot head screwdriver, remove the four 4-40 oval screws from the faceplate of the Autograv.

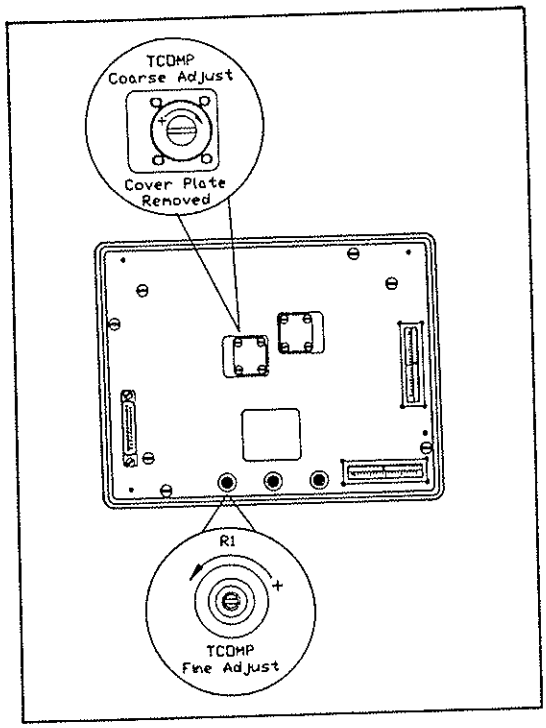

Figure 10: Autograv Faceplate Removed

1. Adjust the Temperature Compensation Fine Adjustment Potentiometer (R1) until the display is within the range of +2.0 to -2.0.

   Counter clockwise = positive

   If the temperature value is adjusted to this range, proceed to step 9.

   If the temperature value cannot be adjusted to be within the specified range, proceed to step 2.

2. Centre R1 by turning the potentiometer clockwise 25 turns followed by 10 turns counter clockwise.

3. Using a slot head screwdriver, remove the four M2.5 x 5mm flat head screws from the temperature coarse adjustment cover. Underneath the cover is an O'ring seal. This ensures that no moisture or dust can enter into the adjustment pot. When you remove the O'ring seal, place it in a dry, clean place. See diagram above.

4. View the position of the Coarse Adjustment screw. You only need to slightly move the screw to make an adjustment. Before turning the screw, carefully note its position.

Clockwise = positive
Counter clockwise = negative

After making a very small adjustment of a few degrees, wait several seconds for the system to stabilize before reading the temperature value.

Note: Do not push down on the coarse adjust screw as this could damage the adjustment potentiometer.

5. Adjust the coarse adjustment screw to bring the temperature reading to as close to zero as possible.

6. Adjust the Fine Adjustment potentiometer until the reading is within the range of -0.1 to +0.1.

7. Wait 30 minutes and then check the reading.

8. Re-adjust the Fine Adjustment potentiometer if necessary.

   Note: If the reading does not come within the range with a coarse adjustment of 1 turn in either direction, contact Scintrex Limited.

9. Replace the cover(s).

How To Adjust Drift Correction

You must first check the temperature compensation before you can adjust the drift correction.

To Adjust

1. After you adjust the temperature compensation, press the ▼ key to display the X and Y Tilts.
2. Level the instrument (using the tripod set-up procedures) to within -10 to +10 arcseconds about both axis. Level the y-axis, rear footscrews, first.
3. Press the Start key. The instrument starts a reading.

   If the reading appears to be out of range (top line of display) refer to the section on Unlatching the Sensor in the Troubleshooting section.
4. The Autograv now automatically takes and records a reading once every 600 seconds.
5. After approximately 24 hours, press the Stop key. This stops the reading cycle.

   If another key is pushed before the Stop key, the software might latch and the keypad will not respond. Refer to the Troubleshooting section on how to reset the keypad.
6. Output the data to a printer or computer.

To Output Data

1. Press the Aux key and then the ▲ or ▼ key until the following prompt appears:

   OUTPUT
   ENTER?

   Note: You must setup the baud rate, data bits and carriage return of the printer before you dump data. Refer to the Software Section on how to set these parameters.
2. Press the Enter key. The following prompt appears:

   AUTOGRAV
   START DUMP
3. Press the Start key.

Reading The Data

1. From the listing, take one reading (R1) at time T1 from near the start of the recording period and another reading (R2) at time T2 from near the end of the period.

   Reject readings which are obviously noisy or disturbed. Refer to the appendix for an example of a listing.

2. From these values, calculate a new Drift Correction.

   DRIFT' = DRIFT + [(R2-R1)/(T2 - T1)]

   where: DRIFT is the Drift constant in the instrument during the readings and (T2-T1) is in units of days.

Adjusting The Drift Correction

1. Press the Aux key twice and then the ▲ or ▼ key until the following prompt appears:

   AUTOGRAV SETUP
   ENTER?

2. Press the Enter key.

3. Press the▲or ▼ key until the following prompt appears:

   INIT. CONSTANTS
   ENTER?

4. Press the Enter key.

5. Press the ▲ or ▼ key until the following prompt appears:

   DRIFT XX
   CHANGE?

6. Press the Change key.

7. Type: New calculated Drift value.

8. Press the Enter key.

   With a new instrument, check the Drift Correction once a week for 4 weeks. After this period, check approximately once a month.

How To Setup For Field Measurements

1. Press the Aux key and then the ▼ key until the following prompt appears.

   MODE: CYCLE
   CHANGE?

2. Press the Change key.

3. Press the ▼ key until the following prompt appears.

   MODE: > FLD GRAV
   SELECT/ENTER

4. Press the Enter key.

5. The reading time (120 seconds) may be too long for normal field operation, however it can be shortened or the Stop Err Lim can be enabled with an Err. Lim of 0.01 (see the Software and Field Operation sections).

6. Take a reading by pressing the Start key once to get into the Adjust mode, wait a few seconds and push the Start key again.

INTRODUCTION

The sensing element of the Autograv is based on a fused quartz elastic system. The gravitational force on the proof mass is balanced by a spring and a relatively small electrostatic restoring force. The position of the mass, which is sensed by a capacitative displacement transducer, is altered by a change in gravity. An automatic feedback circuit applies DC voltage to the capacitor plates producing an electrostatic force on the mass which brings it back to a null position. The feedback voltage, which is a measure of the relative value of gravity at the reading site, is converted to a digital signal and then transmitted to the instrument's data acquisition system for processing, display and storage.

The inherent strength and excellent elastic properites of fused quartz together with limit stops around the proof mass permit the instrument to be operated without clamping. Further protection is provided by a durable shock mount system which attaches the sensor to the housing.

The parameters of the gravity sensor and its electronic circuits are chosen so that the feedback voltage covers a range of over 7000 mGals without resetting. The use of a low-noise electronic design, together with a highly accurate auto-calibrating analog to digital converter, results in a resolution of 0.01 mGal, equipping the gravity meter for both detailed field investigations and large scale regional or geodetic surveys.

The instrument's tilt sensors are also electronic, with a resolution of 1 arc second. The outputs from the sensors are displayed on high resolution meters on the instrument's front panel and also transmitted to the data acquistion system where they are displayed and stored. If the instrument is operated on an unstable base, realtime corrections for tilt errors can be automatically made over a range of $\pm$ 200 arc seconds.

Protection from ambient temperature changes is provided by locating the quartz elastic system, the analog to digital converter, sensitive electronic components and the tilt sensors inside a high-stability, two stage, thermostatically controlled environment. There is no mechanical temperature compensation. External temperature changes are reduced by a factor of 10^5 and small residual effects are corrected in software using the output of a sensor located in close thermal contact with the main spring. The operating range of the thermostat in the standard instrument is -40°C to +45°C. However, since there is no critical operating point for the sensor, the upper operating temperature can be set at a higher or lower value.

The entire gravity sensing mechanism is enclosed in a vacuum chamber. Since there are no mechancial feedthroughs, excellent isolation from variations in atmospheric pressure is obtained. This extremely stable operating environment for the quartz elastic system allows the long-term drift of the sensor to be accurately predicted, and realtime software correction reduces it to less than 0.02 mGals/day.

The sensor design is mechanically very simple. The fine balancing required to obtain astatisation is not needed, as the displacement transducer has sufficient resolution (0.2nm) to detect the beam position of a non-astatised system, and electronic filtering reduces the effect of seismic noise. The mechanisms, micrometer screws, gearboxes and mechanical feedthroughs associated with mechanical feedback systems have been replaced by a voltage applied to the same plates which form the displacement transducer. The temperature control is also accurate enough for the sensor to operate without mechanical compensation.

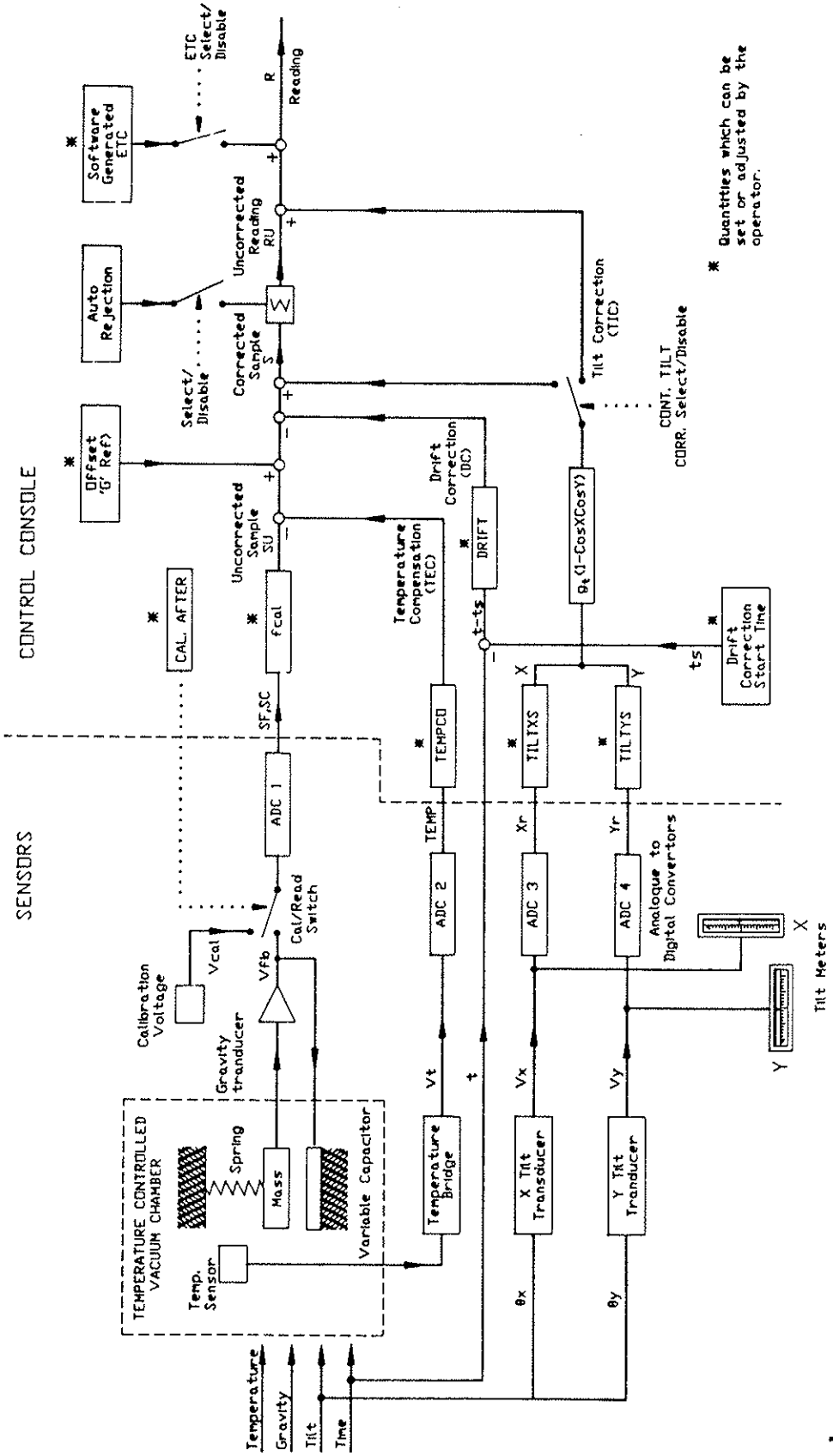

Figure 11: Autograv Block Diagram of Signal Flow

Control Console and Software

The control console includes:

- 14-key dual function keypad
- 32 character LCD
- microprocessor
- solid state memory

It processes and applies corrections to the signals from the sensor, stores data, formats it for outputting and performs instrument control functions. A menu format with prompts is used to operate the instrument.

The gravity meter has two modes of operation:

- field mode
- cycling mode

In field mode, readings are initiated by the operator. In cycling mode, a series of readings are made automatically with an operator selected preset cycle time between each reading. The software function is essentially the same in both modes.

The control console operation is based on a one second gating time. Once every second, analog signals are sampled, the display is updated, keypad commands are responded to and necessary control functions performed.

During a reading, the gravity signal Vfb is sampled once every second by ADC1 (see figure 11). The individual samples are averaged to filter out seismic noise. A running mean of the samples is displayed together with its standard deviation. In the course of a reading, the input of ADC1 is periodically switched to the calibration voltage (Vcal). The frequency of calibration depends on the operating conditions and is determined by the operator before the reading starts. A reading is stopped either by the operator or when a preset time or standard deviation of the mean is reached. Corrections for tilts, sensor temperature and long-term drift are made every second during the reading. A statistical rejection criterion is used to discard any noise spikes. A tide correction is applied at the end of the reading. The tilt and tide correction features can be disabled via the keypad.

When a measurement is completed, the gravity reading is stored in the memory along with the following nine other variables.

- station number
- standard deviation of the mean
- tilt X
- tilt Y
- sensor temperature

- tide correction
- reading duration
- number of rejected samples
- time of start of reading

All current and stored data can be viewed on the LCD by using the scroll feature on the keypad.

Additional information can be entered at the time of measurement for recording in memory. Eight blocks of data, each containing up to a five-digit signed number can be stored with each reading.

The standard memory stores up to 390 readings and can be expanded to a maximum of 1170 readings. The memory is protected for several days in the event of a battery failure.

Other information is also generated and is accessible through the display, including time, date, battery voltage and available memory space.

The instrument is equipped with an RS-232 interface. This enables data from the memory to be accessed through a connector on the instrument front panel. Output of selected portions or of the entire contents of the memory can be obtained in the form of a data listing or as a plot, which can be printed out directly on to a line printer, transferred to a portable computer or tape recorder or transmitted over a telephone line to a modem.

Processing of Gravity Signal

While reading this section, refer to the Signal Flow diagram in Figure 11.

The input to the gravity analog to digital converter (ADC1) is switched between Vfb, the gravity transducer output and Vcal, the stable calibration voltage. When the instrument is in the ADJUST mode (after the Start key is pressed once), the calibration voltage is connected to ADC1. In this mode, the value of Vcal can be viewed on the display under the heading GRAV.

In the READ mode, (after the Start key is pressed a second time) the input to ADC1 is held at Vcal for one second (during PAUSE) then switched to Vfb for x one second samples. It is then switched back to Vcal for one sample then to Vfb for x samples and so on until the reading is terminated. The value of x is entered under the Autograv setup at the CAL AFTER prompt. The output of ADC1 is termed SC when Vcal is applied and SF when the Vfb is applied.

The calibration voltage and other calibration factors are then applied to the gravity signal by the function fcal in order to give an uncorrected sample

$$SU = fcal(SC,SF) = GCAL1\left(\frac{SF}{SC}\right) + GCAL2\left(\frac{SF}{SC}\right)^2 \qquad (3.1)$$

SF is divided by the most recent value of SC to correct for any drift in the scale factor of ADC1. The factors GCAL1 and GCAL2 are the instrument calibration factors which are entered via the keypad. They take into account a small quadratic non linearity inherent in the ADC and in the conversion from electrostatic feedback voltage to force.

The uncorrected sample has the temperature compensation, drift correction and GREF applied and if selected, the tilt correction to give a corrected sample

$$S = SU - TEC - DC + GREF + TIC = SU + C \qquad (3.2)$$

A running average of corrected samples (the function Σ in figure 11) gives the uncorrected reading

$$RUij = \frac{\sum_{J=1}^{y}\sum_{I=1}^{x} GCAL1\left(\frac{SFiJ}{SCJ}\right) + GCAL2\left(\frac{SFiJ}{SCJ}\right)^2 + CiJ}{(j-1)x + i - NR} \qquad (3.3)$$

$$= \frac{\sum_{J=1}^{y}\sum_{I=1}^{x} (Sij + Cij)}{DUR}$$

Where SCj is the value of the jth voltage calibration and SFij and Cij are the ith gravity sample and correction after the jth voltage calibration.

The standard deviation (SD) of the corrected samples is calculated every second and samples which are more than four standard deviations from RUij are rejected. This AUTO REJECT feature can be disabled via the keypad. Details of the statistical calculations are given in the Appendices. The current value of RUij is shown on the top line of the display during the reading period and the current sample number

$$DUR = (j-1)x + i - NR \qquad (3.4)$$

where NR, the number of rejections is displayed on the left hand side of the bottom line. On the right hand side of the bottom line the display alternates between the latest value of the SD during calibration sampling and the standard deviation of the mean

$$ERR = SD/\sqrt{DUR-1} \tag{3.5}$$

during gravity sampling.

Further details of the statistical calculations are given in the Appendices. See the section on Field Operation for application of the AUTO REJECT.

Sampling of the gravity signal stops when either DUR reaches the preset READ TIME, when ERR < ERR LIM or when the start/stop key is pressed. Up to two further corrections: the tilt correction (TIC) and the earth tide correction (ETC) are then added to RU to give the reading R which is displayed.

$$R = RU + TIC + ETC \tag{3.6}$$

Compensation and Corrections

Drift Correction

Long term instrument drift is largely due to stress relaxation in the elastic system. After an initial stabilization period, it can be considered a linear function of time. The effect of long term drift will be to produce a uniform change in reading with time. If two uncorrected readings are taken at times t_1 and t_2[1] at a point where there has been no change in gravity, then the difference between them will depend on the long term drift rate, d, of the instrument and is:

$$RU(\bar{t}_2) - RU(\bar{t}_1) = d(\bar{t}_2 - \bar{t}_1) \qquad (3.7)$$

To eliminate the effects of instrument drift a drift correction

$$DC(t) = (t - t_s)DRIFT \qquad (3.8)$$

is subtracted from each uncorrected sample SU. DRIFT is the drift constant with units of mGal/24hrs, ts is the drift correction start time and t is the time at which the samples are taken. Both DRIFT and ts are entered via the keypad. With the drift correction applied, equation 3.7 becomes:

$$\begin{aligned} R(\bar{t}_2) - R(\bar{t}_1) &= RU(\bar{t}_2) - DC(\bar{t}_2) - RU(\bar{t}_1) + DC(\bar{t}_1) \\ &= d(\bar{t}_2 - \bar{t}_1) - DRIFT(\bar{t}_2 - \bar{t}_1) \end{aligned} \qquad (3.9)$$

If the drift correction is properly adjusted:

$$DRIFT = d \text{ and } R(\bar{t}_2) - R(\bar{t}_1) = 0 \qquad (3.10)$$

The procedure for adjusting the drift correction is given in the Getting Started section.

[1] t_n is the midpoint between the start and finish of a reading

Tilt Correction - TIC

The uncompensated gravity reading changes in response to tilt according to the following expression:

$$RU(\theta x,\theta y) = RU(0,0) - g(1-\cos\theta x\cos\theta y) \quad (3.11)$$

g is the value of gravity at the reading site and θx and θy are the tilts of the gravity sensor about two perpendicular horizontal axes (x and y) as shown in figure 7 with $\theta x = \theta y = 0$ being defined as the orientation in which the uncompensated gravity meter reading is maximized.

The tilt correction operates over a range of ±200 arcsec and is

$$TIC = gt(1-\cos X\cos Y) \quad (3.12)$$

where gt is an average sea level gravity value of 980.6 Gal and X and Y are the indicated gravity meter tilts. Assuming gt = g [2], the corrected reading will be:

$$R(\theta x,\theta y) = RU(0,0) + gt(\cos\theta x\cos\theta y - \cos X\cos Y) \quad (3.13)$$

If

$$X = \theta x \text{ and } Y = \theta y \quad (3.14)$$

then

$$R(\theta x,\theta y) = RU(0,0) = R(0,0) \quad (3.15)$$

and errors due to instrument tilt are eliminated. The method used to adjust X and Y so that condition 3.14 is satisfied, is given in the Maintenance section.

2 This assumption leads to an error of approximately 0.02 mGal in the worst case.

There are two software selectable modes of operating the tilt correction. In the first (CONT TILT CORR - SELECTED), a correction is applied to each one second sample. In the second (CONT. TILT CORR - DISABLED), a correction is only applied at the end of the reading based on the X and Y values of the last one second sample of the reading. The reason for two modes of operation is that the tilt sensors have a relatively fast response (typically a few seconds) up to within approximately 5 arcsec of the final value and then it takes more than a minute to come to within one arcsec of the final value. If the Autograv is on a solid base and it does not move during the reading, then the DISABLE mode will give the most accurate result as the tilt sensors will have more time to settle before a compensation is applied. If the instrument is on a soft base and moves during a reading, it is preferable to select the continuous correction mode.

Temperature Compensation - TEC

The fused quartz mainspring is the most temperature sensitive component in the gravity meter with a coefficient of approximately - 130 mGal/°C (spring becomes stronger as the temperature increases). This spring is protected from ambient temperature changes by a two stage thermostat which maintains the spring temperature Ts constant to within 0.5mK under normal operating conditions. The changes in Ts are measured using a temperature sensor in good thermal contact with the mainspring. The output of the temperature bridge is converted to a digital signal, TEMP, shown in Figure11 and this is converted to the temperature compensation signal.

$$TEC = TEMPCO \times TEMP \qquad (3.16)$$

TEMPCO is the instrument temperature co-efficient in mGal/mK. It is measured during the production of each instrument and is entered through the keypad. A new value of TEC is computed and applied after each one second sample.

The spring temperature TEMP in units of mK can be displayed on the liquid crystal display. The last TEMP value for each reading is also stored in memory together with other measurement variables. The range of TEMP is $\pm$3.0 mK, and it is adjusted with a zero offset to within $\pm$2.0 mK for normal operation (See Getting Started section). This ensures that there is at least a 1.0 mK useful range to compensate for severe ambient temperature fluctuations.

Earth Tide Correction - ETC

The ETC is generated in the software via the Longman formula by entering in the latitude, longitude and difference between the gravimeter clock time and GMT from the keypad. It is applied after the last sample has been taken and it may also be disabled via the keypad. The time used in the tidal calculation is the midpoint between the start and the end of a reading.

Gravity Offset - GREF

This value is in mGal and entered from the keypad. It is added to each reading sample.

Autograv Software

The Autograv software is accessed via the keys on the keypad. The Auxiliary mode is the main menu of the Autograv.

Auxiliary Mode

You can access the main menu by pressing the Aux key and then by pressing the ▲ or ▼ key to scroll through the first level of menus. In the Auxiliary mode there are three levels of menus and to enter a submenu, you follow the prompt that is shown on the bottom line of the display. To return to the previous menu level, you press the Aux key. See the software diagram (figure 11) to view the levels of menus. A description of each parameter is given in the pages following the Auxiliary mode software flowchart.

Notes:

- If you do not use the Autograv for one minute, the display automatically turns off. Press the On key to return to the menu selection where you had previously left the instrument.
- If you have selected a submenu by pressing the key shown in the prompt on the bottom of the display but have not entered in new data, you must press the Enter key to leave the data as it is, or enter in new data and then press the Enter key. To return to the previous menu, press the Aux key.

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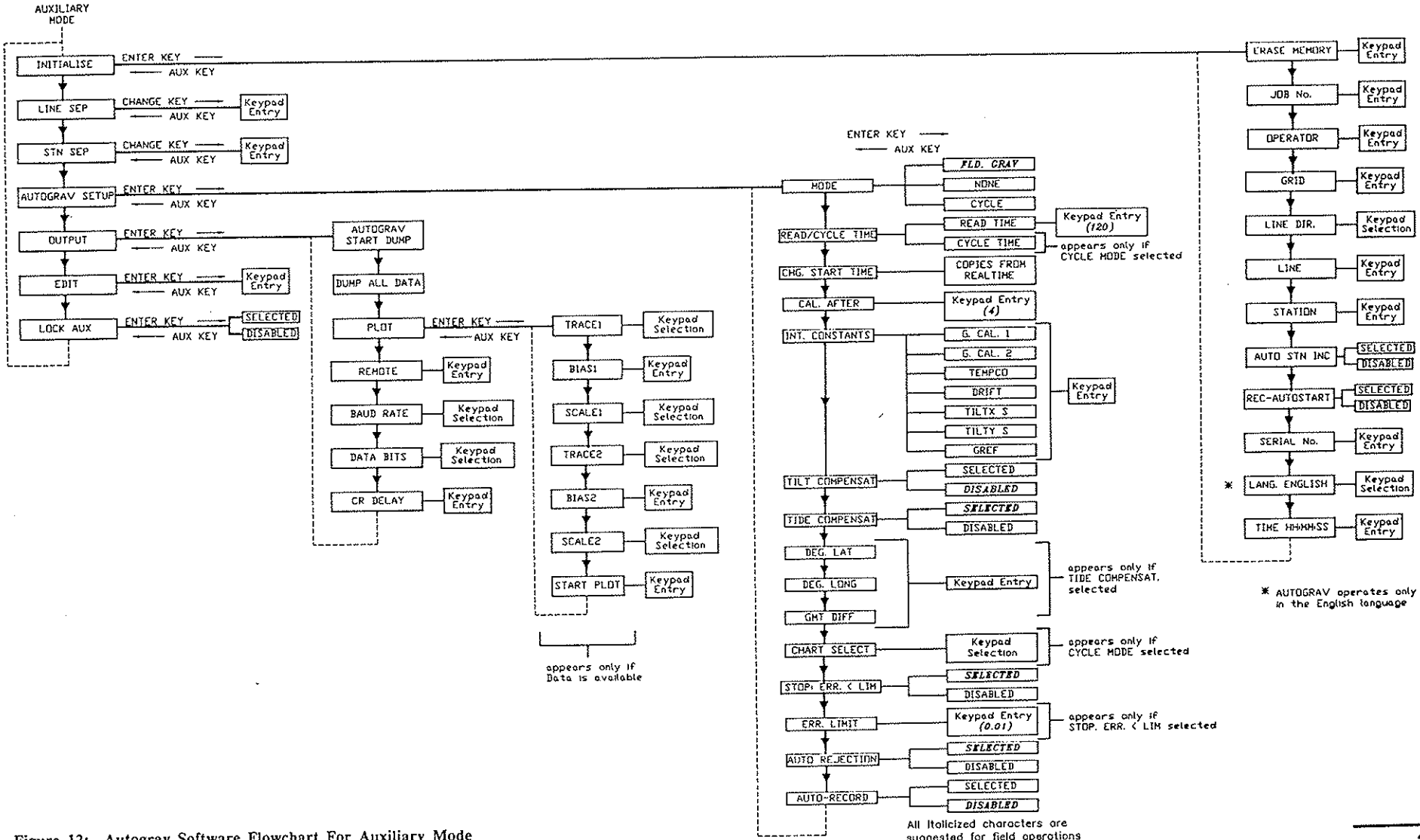

Figure 12: Autograv Software Flowchart For Auxiliary Mode

Auxiliary Mode

There are seven main menu options in the Auxiliary mode:

- Initialise
- Lin Sep
- Stn Sep
- Autograv Setup
- Output
- Edit
- Lock Aux

INITIALISE

There are twelve submenus in the Initialise mode. These menus if selected, require you to input specific data. To enter into the Initialise submenus, press the Enter key and a submenu appears:

Example:

Display:	INITIALISE ENTER?
Press:	Enter key
Display:	ERASE MEMORY ENTER?

To enter into the submenu level, follow the prompt that is shown on the bottom line of the display. To return to the previous level of menu, press the Aux key.

Note: If you have selected a submenu by pressing the key shown in the prompt on the bottom of the display but have not entered in new data, you must press the Enter key to leave the data as it is or enter in new data and then press the Enter key. You may then press the Aux key to return to the previous menu.

Initialise Submenus

The steps involved to enter a submenu is shown from the Initialise menu. If you are already in the submenu level follow the steps from step 2.

ERASE MEMORY - You must erase the memory of the Autograv at the start of each survey day so that there is adequate storage space for the day's data. Erasing the memory does not erase initialization, setup or position parameters.

To erase the memory do the following:

1. Display the Initialise prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   ERASE MEMORY
   ENTER?

3. Press Enter. The following prompt appears:

   ERASE MEMORY
   START?

4. Press the Start key. The prompt - TESTING - appears.

5. When the memory is erased the following message appears:

   MEMORY FREE 100%
   TESTED XXK

   The XXK represents the size of memory installed in the Autograv. If the value in the display does not agree with the installed value, there has been a partial memory failure. The Autograv can still function however, the memory capacity is reduced.

JOB NO. - You can set a job number by selecting this submenu.

To set a job number do the following:

1. Display the Initialise prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   JOB NO. X
   CHANGE?

3. Press the Change key.

4. Type in the new job number

5. Press the Enter key.

OPERATOR - You can enter in an operator number by selecting this submenu.

To enter an operator number do the following:

1. Display the Initialise prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   OPERATOR CHANGE? **X**

3. Press the Change key.

4. Type in the new operator number.

5. Press the Enter key.

GRID - You can set a grid number by selecting this submenu.

Note: You can also set this parameter by pressing the Info key on the keypad and scrolling through the menu to the GRID prompt. Follow the same steps as outlined below in steps 3 to 5.

To set a grid number do the following:

1. Display the Initialise prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   GRID CHANGE? **X**

3. Press the Change key

4. Type in the new grid number

5. Press the Enter key.

LINE DIR - This submenu enables you to set the direction in which the lines are running on the grid. You can choose from the following selections:

- E/W
- N/S
- +/-

Example: If you select E/W, a line is indentified as north or south of zero and a station as east or west of zero along a specific line.

To select a line direction do the following:

1. Display the Initialise prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   LINE DIR X X
   CHANGE?

3. Press the Change key.

4. Press the ▲ or ▼ key until the desired direction appears on the display.

5. Press the Enter key.

LINE - You can enter the line number that is to be surveyed first on the survey day.

Note: You can also set this parameter by pressing the line key on the keypad and following the same steps as outlined below in steps 3 to 5.

To set the first line number do the following:

1. Display the Initialise prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   LINE X
   CHANGE?

3. Press the Change key

4. Type in the first line number.

5. Press the Enter key.

STATION - At the start of a survey day you should enter in the first station number before taking a measurement.

Note: You can also set this parameter by pressing the Station key on the keypad and following the same steps as outlined below in steps 3 to 5.

To set the first station number do the following:

1. Display the Initialise prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   STATION X
   CHANGE?

3. Press the Change key.

4. Type in the first station number.

5. Press the Enter key.

AUTO STN INC - You can set the Autograv so that it automatically increments to the next station after a cycle of survey measurements is recorded. Refer to the first level menu of STN SEP.

To set the Autostation increment feature do the following:

1. Display the Initialise prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   AUTO STN INC
   CHG?>NNNN<

3. Press the Change key to alternately choose either DISABLED or SELECTED.

4. Press the ▲ or ▼ key to scroll to the next submenu.

When all the measurements for a station have been recorded, the station number is displayed along with the prompt - Change?. In the lower line of the display, the number of the station where the measurements were just taken is shown. Depending on whether the Auto Station Increment was selected or disabled, the upper line displays either the next station number or the one just measured, respectively.

Automatic Station Increment - Selected

If you select the Automatic Station Increment feature, after you press the Record key, the station number automatically increments to the next station number after a set of measurements is recorded. However, you must ensure that the station separation parameter (STN SEP) reflects the direction of travel. During a survey, you might walk up one line and down the next. To accomodate this change of direction, the station separation must be changed also.

Example: When walking north (or east, or +), a station separation of 100N (or E, or +)will increment the station number by 100 with each recorded measurement. Walking down the next line, you will be traveling south (or west, or -). For the automatic incrementation to work properly, the station separation must be set to 100S (or W, or -) so that the station numbers will now decrement.

Automatic Station Increment - Disabled

If you disable the Automatic Station Increment feature, you must manually increment the Autograv to the next station by using one of the scroll keys (▲ or ▼). Refer to the chart below to see how the station numbers increment or decrement according to the key press.

Line Direction	Press	Press
N/S	Stations:	Stations:
	• north of zero increments • south of zero decrements	• north of zero decrements • south of zero increments
E/W	• east of zero increments • west of zero decrements	• east of zero decrements • west of zero increments
+/-	• + zero increments • - zero decrements	• + zero decrements • - zero increments

Note: If you select +/- for the line direction, pressing ▼ decreases the station number, possibly to a negative value.

- + indicates north or east
- - indicates south or west

The display only shows the - sign as the + sign is assumed.

REC → AUTOSTART - If you select the Autostart - record feature so that after you press the Record key to record just measured data, the Autograv automatically starts the measurement of the next selected method after recording the current data. If you disable the REC AUTOSTART feature, you must press the Start key to initiate the measurement of the next selected method.

To set the Rec → Autostart feature do the following:

1. Display the Initialise prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   REC → AUTOSTART
   CHG?>NNNN<

3. Press the Change key to alternately choose either DISABLED or SELECTED.

4. Press the ▲ or ▼ key to scroll to the next submenu.

SERIAL # - You can enter in the serial number of the Autograv which can quickly identify the instrument if a malfunction is suspected.

To enter the serial number do the following:

1. Display the Initialise prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

SERIAL #	**X**
CHANGE?	

3. Press the Change key.

4. Type in the serial number.

5. Press the Enter key.

LANG. ENGLISH - The Autograv only offers English as the operating language.

TIME HH:MM:SS - You can set both the time and date from this prompt.

To set the time and/or date do the following:

1. Display the Initialise prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

TIME:	**XX:XX:XX**
CHANGE?	**XX:XX:XX**

3. Press the Change key.

TIME:	**HH:MM:SS**
ENTER?	**XX:XX:XX**

4. Type in the hours and press the Enter key to go to the next parameter in the time field.

5. Press the Enter key after you have typed in the seconds.

TIME:	**HH:MM:SS**
ENTER?	**YY/MM/DD**

6. Type in the year and press the Enter key to go to the next parameter in the date field.

7. Press the Enter key after you have typed in the day. When you enter in the day, the clock starts to run.

LINE SEP

There are no submenus in the Line Separation mode. This mode requires the entry of the regular distance between survey lines in metres or feet. During the survey, when you change to the next line, the instrument advances its records to the next line number. If the direction of travel has changed and Automatic Station Incrementation is selected, the sign (or direction) of the separation parameter has to be changed.

To set the line separation value do the following:

1. Display the LIN SEP prompt and press the Change key. The following prompt appears:

   LIN SEP X
   ENTER?

2. Type in the new line separation value.

3. Press the Enter key.

STN SEP

There are no submenus in the station separation mode. This mode requires the entry of the distance between stations in metres or feet. During the survey, when you change to the next station, the instrument advances its records to the next station number. If the direction of travel has changed and Automatic Station Incrementation is selected, the sign (or direction) of the separation parameter has to be changed.

To set the station separation value do the following:

1. Display the STN SEP prompt and press the Change key. The following prompt appears:

   STN SEP X
   ENTER?

2. Type in the new station separation value.

3. Press the Enter key.

AUTOGRAV SETUP

There are fifteen submenus in the Autograv Setup mode. Four of the submenus appear only if specific parameters are selected. A second level of submenus is available however not all of the first level submenus have a secondary level. To enter into the first level submenu of the Autograv Setup, press the Enter key and a submenu appears:

Example:

Display:	AUTOGRAV SETUP ENTER?	
Press:	Enter key	
Display:	MODE CHANGE?	NNNN

Tp enter into the second level of submenus, follow the prompt that is shown on the bottom line of the display. To return to the previous level of menu, press the Aux key.

Autograv Submenus

The steps involved to enter a submenu is shown from the Autograv Setup. If you are already in the submenu level follow the step from step 2.

Note: You can also set the following parameters by pressing the Method key on the keypad and following the same steps as outlined below.

MODE - You can select from three modes of operation:

- FLD GRAV
- CYCLING
- MODE

Fld Grav mode - This mode is for controlled field operations.

Cycling - This mode is for continuous measurements over a specified cycling time.

None mode - Disables the Autograv.

To select a mode of operation do the following:

1. Display the Autograv Setup prompt and press the Enter key.
2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   MODE: NNNN
   CHANGE?

3. Press the Change key.
4. Press the ▲ or ▼ key until the desired mode appears on the display.

5. Press the Enter key.

READ/CYCLE TIME - You can set the read time and if you have selected the cycling mode, the cycle time. A numerical value must be entered in seconds.

To set the read time do the following:

1. Display the Autograv Setup prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   READ/CYCLE TIME
   ENTER?

3. Press the Enter key and the following prompt appears:

   READ TIME XX
   CHANGE?

4. Press the Change key.

5. Type in a new read time.

6. Press the Enter key.

   If you have selected the FLD GRAV or NONE mode, go to step 11 as the cycle time prompt will not appear in the display.

   If you have selected the CYCLING mode, go to step 7.

7. Press the ▼ key and the following prompt appears:

   CYCLE TIME XXXX
   CHANGE?

8. Press the Change key.

9. Type in the new cycling time.

10. Press the Enter key.

11. Press the Aux key to return to the previous submenu.

CHG. START TIME - This feature enables you to change the start time to the time that is set on the realtime clock.

To change the start time do the following:

1. Display the Autograv Setup prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   CHG. START TIME
   ENTER?

3. Press the Enter key and the prompt shown at the top of the display shows you the current start time.

4. Press the change key.

   The prompt at the top of the display changes to the current realtime clock setting.

CAL. AFTER - You can set the internal calibration by setting this value.

To set the calibration after function do the following:

1. Display the Autograv Setup prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   CAL. AFTER X
   CHANGE?

3. Press the Change key.

4. Type in the new calibration after value (seconds).

5. Press the Enter key.

INITIAL CONSTANTS - Each instrument has its own individual constants. The constants for an instrument is provided in the appendix section of the manual. Refer to the Getting Started section for an example.

To set your Autograv to its initial constants do the following:

1. Display the Autograv Setup prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   INIT. CONSTANTS
   CHANGE?

3. Press the Change key.

4. Set the initial constants to the values shown on the instrument constants sheet. Use the following example to enter in each constant.

   G. CAL 1 XXX
   CHANGE?

5. Press the Change key.

6. Type in the G. CAL initial constant value.

7. Press the Enter key.

8. Press the ▼ key to go to the next initial constant.

9. Follow steps 4 to 8 until you have entered all of the initial constant values.

10. Press the Aux key to return to the previous submenu.

TILT COMPENSAT - You can set the tilt compensation feature so that the instrument will compensate for any movement of the instrument during a reading.

To set the tilt compensation do the following:

1. Display the Autograv Setup prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   TILT COMPENSAT.
   CHG? >NNNN<

3. Press the Change key to alternately choose either DISABLED or SELECTED.

4. Press the ▲ or ▼ key to scroll to the next submenu.

TIDE COMPENSAT. - You can set the tide compensation feature via this function.

To set the tide compensation do the following:

1. Display the Autograv Setup prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   TIDE COMPENSAT.
   CHG? >NNNN<

3. Press the Change key to alternately choose either DISABLED or SELECTED.

4. Press the ▲ or ▼ key to scroll to the next submenu.

   If you select the tide compensation feature the following three submenus appear:

   • DEG. LAT
   • DEG. LONG
   • GMT DIFF

DEG. LAT - This submenu appears only if you select the tide compensation feature.

To set the degrees latitude do the following:

1. Display the Autograv Setup prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   DEG. LAT XX
   CHANGE?

3. Press the Change key.

4. Type in the value

5. Press the Enter key.

DEG. LONG - This submenu appears only if you select the tide compensation feature.

To set the degrees latitude do the following:

1. Display the Autograv Setup prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   DEG. LONG X
   CHANGE?

3. Press the Change key.

4. Type in the value

5. Press the Enter key.

GMT. DIFF - This submenu only appears if you select the tide compensation feature.

To set the GMT. difference do the following:

1. Display the Autograv Setup prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   GMT. DIFF X
   CHANGE?

3. Press the Change key.

4. Type in the value.

5. Press the Enter key.

CHART SEL: - This submenu appears only if you select the Cycling mode. You can choose from the following selections:

- 0.1
- 1.0
- 10
- 100

To set the chart select do the following:

1. Display the Autograv Setup prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   CHART SEL: XX
   CHANGE?

3. Press the Change key.

4. Press the ▲ or ▼ key until the desired chart selection appears on the display.

5. Press the Enter key.

STOP: ERR. < LIM - You can set the Autograv to stop a reading if the error value < the specified limit. If you select the error< limit feature, the error limit value must be entered in the next submenu.

To set the Stop: err< limit do the following:

1. Display the Autograv Setup prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   STOP: ERR. < LIM
   CHG? >NNNN<

3. Press the Change key to alternately choose either DISABLED or SELECTED.

4. Press the ▲ or ▼ key to scroll to the next submenu.

ERR. LIMIT - This submenu appears only if you select the STOP: ERR < LIM feature.

To set the error limit value do the following:

1. Display the Autograv Setup prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   ERR. LIMIT XXX
   CHANGE?

3. Press the Change key.

4. Type in the error limit value.

5. Press the Enter key.

AUTO REJECTION - You can set the Autograv to automatically reject inaccurate readings.

To set the Auto rejection feature do the following:

1. Display the Autograv Setup prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   AUTO REJECTION
   CHG? >NNNN<

3. Press the Change key to alternately choose either DISABLED or SELECTED.

4. Press the ▲ or ▼ key to scroll to the next submenu.

AUTO-RECORD - You can set the instrument so that it automatically records the results of a reading.

To set the Auto-record feature do the following:

1. Display the Autograv Setup prompt and press the Enter key.
2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   AUTO-RECORD
   CHG? >NNNN<

3. Press the Change key to alternately choose either DISABLED or SELECTED.
4. Press the ▲ or ▼ key to scroll to the next submenu.

OUTPUT

There are seven submenus in the Output mode and the Plot submenu has a second level submenu. To enter into the Output mode, press the Enter key and a submenu appears:

Example:

Display:	OUTPUT ENTER?
Press:	Enter key
Display:	AUTOGRAV START DUMP?

To enter into the second level of submenus, follow the prompt that is shown on the bottom line of the display. To return to the previous level of menu, press the Aux key.

Output Submenus

The steps involved to enter a submenu is shown from the Output mode. If you are already in the submenu level follow the steps from step 2.

AUTOGRAV START DUMP - This feature starts the dumping of data that is in memory.

To start the dumping of data do the following:

1. Display the Output prompt and press the Enter key.
2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   AUTOGRAV
   START DUMP?

3. Press the Start key.

   The display shows the prompt - PRINTING

   When the printing is complete, the prompt - FINISHED appears.

DUMP ALL DATA - You can request that all of the data that pertains to the Autograv be dumped.

To dump all data do the following:

1. Display the Output prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   DUMP ALL DATA
   START?

3. Press the Start key.

   The display shows the prompt - PRINTING.

   When the printing complete, the prompt - FINISHED appears.

PLOT - This submenu enables you to set the characteristics of the plot by setting six of the seven second level submenu parameters. Two different sets of data can be traced at one time. The Plot submenus are as follows:

- TRACE1
- BIAS1
- SCALE1
- TRACE2
- BIAS2
- SCALE2
- START PLOT

To set the plot characteristics do the following:

1. Display the Output prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   PLOT
   ENTER?

3. Press the Enter key and the following prompt appears:

   TRACE1 NNNN
   SELECT/ENTER

You can select from one of the following parameters for your first trace:

- INFO A
- INFO B
- INFO C
- INFO D
- INFO E
- INFO F
- INFO G
- INFO H
- GRAV
- TILT X
- TILT Y
- TEMP
- SD.G
- # REJ
- CAL AFTER

4. Press the Enter key.

5. Press the ▲ or ▼ key until the desired characteristic appears on the display.

6. Press the Enter key.

7. Press the ▼ key and the following prompt appears:

BIAS1: XXXX
CHANGE?

The Bias value is a parameter that can be entered which establishes a predetermined threshold for the plotting of data. It is useful in that the lower limits of a plot can be eliminated, thus enhancing areas of a plot that are of interest.

8. Press the Change key.

9. Type in the BIAS1 value.

10. Press the Enter key.

11. Press the ▼ key and the following prompt appears:

SCALE1: XXXX < E X
CHANGE?

12. Press the Change key and the following prompt appears:

SCALE1> XXXX < E X
SELECT/ENTER

There are two sets of parameters that can change in this prompt:

Mulitplier		Exponential Value
XXXX	<E	X

There are six multiplier settings:

- +/-1
- 1
- +/-2
- 2
- +/-5
- 5

There are six exponential selections: 0 - 5

13. Select the multiplier by pressing the ▲ or ▼ key until the desired value appears.

14. Press the Enter key.

15. Select the exponential value by pressing the ▲ or ▼ key until the desired value appears.

16. Press the Enter key.

17. Press the ▼ key and the following prompt appears:

TRACE2: NNNN
CHANGE?

18. Set the second trace characteristics as outlined in steps 3 to 6.

19. Press the ▼ key and the following prompt appears:

BIAS2: XXXX
CHANGE?

20. Set the second Bias value as outlined in steps 8 to 10.

21. Press the ▼ key and the following prompt appears:

SCALE2: XXXX < E X
CHANGE?

22. Set the second scale as outlined in steps 12 to 16.

23. Press the ▼ key and the following prompt appears:

AUTOGRAV
START PLOT?

24. Press the Start key.

The display shows the prompt - PRINTING

When the printing is complete, the prompt - FINISHED appears.

REMOTE - This function permits the transfer of stored data to a peripheral device in a packed format.

To send data to a remote location do the following:

1. Display the Output prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   REMOTE
   ENTER?

3. Press the Enter key and the prompt - WAITING appears until the data is requested.

BAUD RATE - you must set the baud rate that the instrument sends data. There are five different baud rates available:

- 2400
- 1200
- 600
- 300
- 110

To set the baud rate do the following:

1. Display the Output prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   BAUD RATE XXX
   CHANGE?

3. Press the change key.

4. Select the baud rate by pressing the ▲ or ▼ key until the desired value appears.

5. Press the Enter key.

DATA BITS - A choice of 7 or 8 data bits is available.

To set the data bits do the following:

1. Display the Output prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   DATA BITS X
   CHANGE?

3. Press the Change key.

4. Press the ▲ or ▼ key until the desired value appears.

5. Press the Enter key.

CR DELAY - You set the carriage return delay according to the speed of the printer (0-999).

Notes:

• A loss of data may require a higher setting

• The printer supplied by Scintrex requires a CR delay of 0.

To set the carriage return delay do the following:

1. Display the Output prompt and press the Enter key.

2. Scroll through the submenus by pressing the ▲ or ▼ key until the following prompt appears:

   CR DELAY X
   CHANGE?

3. Press the Change key.

4. Type in the carriage delay value

5. Press the Enter key.

EDIT

You can do three types of changes to the data in memory via the Edit mode:

• Erase a measurement
• Change a station, line or grid number, or ancillary information
• Repeat a measurement for a particular station or line

Base station measurements cannot be edited.

Note: Once you enter the Edit mode, filed data can be permanently changed or accidently lost. Scintrex Limited recommends that you use the Edit mode only when you are very familiar with the procedures. To prevent data from accidently being changed or lost, print the day's data and then use the Edit mode as errors can easily be seen on a printout and

can then be changed. Once you have mastered the Edit mode, you can use it to produce an error free notebook while surveying.

To enter the Edit mode do the following:

1. Display the Edit prompt and press the Enter key.

2. When you complete an edit, the following prompt appears:

REC'D AFTER EDIT OR DATA LOST

LOCK AUX

The Lock Aux mode enables you to lock the Auxiliary mode in order to prevent unintentional change of system parameters during surveys.

When the battery is connected or if the Reset button is pressed, the Lock Aux function is automatically disabled and all of the system menu options appear in the display.

To lock the Auxiliary mode do the following:

1. Scroll through the main menu by pressing the ▲ or ▼ key until the following prompt appears:

   LOCK AUX
   CHG? >DISABLED<

2. Press the Change key to choose SELECTED

3. Press the Aux key twice. All of the Auxiliary menu options disappear from the display except Station Separation (STN SEP) and if you use the scroll keys, the following message appears:

   TO UNLOCK AUX. PUSH RESET

   Refer to the Troubleshooting section on how to reset the Autograv to unlock the Auxiliary mode.

FIELD OPERATION

Several features of the Autograv such as the integrated housing with the built-in shock mounts and the absence of an internal clamping system make it easy to safely transport the instrument and to obtain accurate readings.

The following pages describe the field operating procedures for the Autograv.

Software Setup and Keypad Operation

The Getting Started section describes the basic procedure for taking a reading. The following briefly describes the steps that are involved:

1. Initialize the software with the instrument in the Field mode.
2. Place the Autograv on the tripod.
3. Push the Start key once to get into the Adjust mode.
4. Level the instrument via the tripod footscrews.
5. Push the Start key again to start the reading.
6. Push the Record key to store the data.

The Software and the Theory of Operation sections give a full description of the Autograv software function while this section describes how to select setup parameters and software settings for field operation.

Reading Time - Terminating a Reading

A reading can be terminated automatically or manually. How the Autograv automatically terminates a reading depends on the setup of the following options in the AUTOGRAV SETUP.

If you disable the STOP ERR LIM feature, the Autograv terminates the reading when the reading duration (DUR) reaches the preset READ TIME.

If you select the STOP ERR LIM feature, the Autograv terminates the reading when either ERR < ERR LIM or DUR = READ TIME whichever occurs first. The value of ERR LIM is set by the operator.

In either case, you can manually terminate a reading at any time by pressing the Stop key.

The recommended software setting for most applications is to select the STOP ERR LIM feature. With this setting, reading time is automatically adjusted to obtain the desired accuracy under varying external noise conditions. The choice of ERR LIM depends on the expected accuracy of the survey governed by factors such as height control and accuracy at topographic corrections.

An ERR LIM setting of 0.005 mGal ensures that the resolution of 0.01 mGal is reached. However, in most operating conditions there will be little loss of accuracy and reading time will be reduced by a factor of 4 if an ERR LIM of 0.01 mGal is selected.

Cal After

As described in the Theory of Operation section, the CAL AFTER parameter adjusts the ratio of internal calibration samples to gravity samples. Reducing the ratio (reducing the frequency of internal calibration) increases the efficiency of the reading process as more gravity samples are being accumulated in a given time. However, for the instrument to function properly, a minimum of 5 to 10 calibration samples must be taken during a reading.

For most applications, a CAL AFTER setting of 4 is recommended. For longer reading times such as when there is high external noise, CAL AFTER could be increased to 10 or 20.

Leveling Requirements and Continous Tilt Compensation

The Autograv compensates for levelling error by two different methods depending on whether you select or disable the continuous tilt correction feature (CONT TILT CORR).

If you disable the CONT TILT CORR feature, a correction is made based on the last one second samples of X and Y before the reading is terminated. This gives the tilt sensors the maximum time to stabilize before their outputs are used for a correction (refer to the Theory of Operation section). This setting should be used when the tripod is on a relatively hard surface and the instrument does not move during the reading. If the instrument is initially levelled to within $\pm$10 arcsec about both axes, then rapid readings can be made without stabilization drift in the tilt sensors reducing reading accuracy.

If you select the CONT TILT CORR feature, a tilt correction is applied to each one second sample based on the tilt sensor outputs at the time the sample is made. This setting should be used when the tripod is on a soft surface and it is possible that the instrument could move during a reading. The tilt sensors must be allowed to stabilize for approximately 1 minute after you level the instrument and before you take a reading. This ensures that accurate corrections are made if the instrument moves. It is also recommended to try to initially level the instrument within a $\pm$10 arcsec, reducing the size of the corrections which have to be made and making it less likely that the instrument tilts beyond the $\pm$200 arcsec range of the tilt compensation.

Recording Data

The way data is recorded depends on whether you select or disable the AUTO-RECORD option in the AUTOGRAV SETUP.

If you disable the AUTO-RECORD feature, you must press the Record key when a reading is terminated.

If you select the AUTO-RECORD feature, the instrument automatically records the data when the reading is terminated.

If you select the AUTO STN INC option in the Initialise menu, the station number is automatically changed by an amount equal to the STN SEP entry in the Auxiliary mode menu.

If you disable the AUTO STN INC option, you can change the station number by a keyboard entry or by using the scroll keys to change the station setting by an amount equal to the STN SEP entry.

Auto Rejection

This feature eliminates noise spikes from a reading and should be selected during field surveys. Samples which are more than 4 standard deviations away from the average are rejected. No rejections are made from the first five samples which are used to build up an average and standard deviation. Therefore, if you can identify sources of noise spikes, start the reading in a quiet time so that a realistic average and standard deviation can be built up to serve as a basis for rejections. For example, if you want to take a reading beside a road, wait until there are no cars going past before you start the reading.

Transporting and Handling

The Autograv case is waterproof and the instrument has been designed to be transported between stations without the dust cover. The dust cover only needs to be installed when the instrument is being shipped or when there is a danger of the front panel or control console being damaged.

To get the best results from your Autograv and to ensure a long working life, treat your instrument carefully:

- Avoid shocks and jolts especially when walking through doorways and taking the instrument in and out of vehicles.
- When you transport the instrument in a vehicle, place it on a compliant surface, either a padded seat or a pad made from foam or some other shock absorbing material.
- Place the instrument gently onto the tripod.

Operation Hints

The following are some hints for better instrument results:

- Follow the same setup and reading routine at each station. For example, if you are transporting the Autograv by vehicle, take each station reading at approximately the same time interval after the vehicle has stopped.
- Where it is possible, select station locations which are on solid ground, away from trees, poles and other potential sources of vibration.

INTRODUCTION

The instrument must be powered at all times (**even during storage**) by either the internal 12V battery or the battery charger. If a loss of power to the instrument occurs, several things happen:

- After a few seconds of power loss, the clock setting is erased and must be reset to the current time after power is resumed.
- The thermostat loses power and the instrument begins to cool down. The consequences of the power loss depends on the length of time that the instrument is powered down.

Powered-Down Time	Stabilization Time after Power Up
a few minutes	30 minutes (approx.)
12 hours	24 hours (approx.)
48 hours	48 hours (approx.)

Check the temperature output in the ADJUST mode to see when the thermostat is stable. The stabilization time increases as the powered-down time increases.

- If the instrument is powered down for more than 48 hours, the contents of the memory including the Autograv initialization constants will be lost. If this occurs, you will have to go through the Initialization procedures outlined in the Getting Started section.

Battery

The standard internal rechargeable battery for the Autograv is the Sonnenschein 12V/6Ah. When this battery is fully charged, it provides enough power to operate the instrument throughout a normal survey day. However, battery discharge time increases as ambient temperature increases. At 25°C, the battery lasts for 11 to 12 hours but at -10°C, the battery lasts for only 4 hours. Refer to the Appendices for the Battery specification sheets.

If the battery voltage drops below 10.5 volts, the Autograv emits an audible low battery level alarm. The battery has approximately 30 minutes left of operating time after the alarm sounds. The battery should then either be recharged by connecting the instrument to the charger or replaced with a charged battery.

You can check the battery voltage at any time by pressing the Info key on the keypad and scrolling to BATT XXX. Divide the value shown on the display by a factor of 10 to obtain the actual battery voltage.

If you press the Info key quickly several times, you will notice a variation in the displayed battery voltage. This is due to the thermostat

heater switching on and off. When the battery is fully charged, the maximum value that is displayed is 138 which is 13.8 volts. The minimum value that is displayed is 105 which is 10.5 volts.

The life expectancy of the battery is approximately 200 cycles (each cycle being a complete dicharge and recharge). In standby operation, the life expectancy is 4 to 5 years. Two batteries are supplied with each Autograv.

Charger

The charger serves three functions:

- powering up the Autograv via an AC outlet
- charging the internal rechargeable 12V battery
- charging spare batteries via the two external output connectors

When the charger is connected to the Autograv it provides current to charge the internal battery and to maintain its charge. It also enables the internal battery to be removed without affecting the performance of the instrument.

Batteries are charged by applying a constant voltage. The charging current is self limiting. The required charging voltage varies with temperature. To accomodate this the Autograv charger has a temperature sensor in the end of the output cable which is used to automatically adjust the charging voltage to the correct value.

When the Autograv is connected to the charger, the battery in the instrument (if connected inside the battery compartment) is automatically charged. Up to two spare batteries can be recharged by plugging them into the sockets on the side of the charger. Charging time for batteries is approximately 8 hours.

The charger can be used with either of these line voltages:

- 115V
- 230V

When you are selecting a line voltage you must set the charger voltage switch to the correct line voltage. To select an alternate voltage do the following:

1. Ensure that the charger is unplugged from the AC outlet.
2. Using a small flathead screwdriver, flip the recessed voltage switch that is on the front of the charger to the appropriate setting.

3. Change the charger fuse to the appropriate rating as shown below.

Voltage	Fuse
115V	.75A
230V	.375A

When you plug the charger into an AC outlet, the green light turns on to indicate that the charger is working.

Notes:

- To operate the Autograv with the 230V setting, you need the optional 230V adaptor plug.
- If you use the .75A fuse with the 230V setting, the battery and the charger will not be protected against potentially dangerous fluctuations in the line voltage.
- If you use the .375A fuse with the 115V setting, you will blow the fuse when you plug the charger into an AC outlet.
- The battery charger gets hot when in use. This is normal and the charger has an automatic thermal limiting circuit to reduce power dissipation before overheating occurs. To reduce heating, ensure that the charger is uncovered in an open place and that air flow over the case and fins is not restricted.
- If the instrument has a discharged battery in it when the charger is connected, wait for 1 to 2 hours before plugging in another discharged battery into a side socket.
- If the Autograv is plugged into the charger for an extended period of time, remove the battery compartment door.

Battery Compartment Fuse

There is a 3Amp fuse located inside of the battery compartment. This fuse protects the instrument from dangerous voltages. If this fuse is blown the Autograv will not operate.

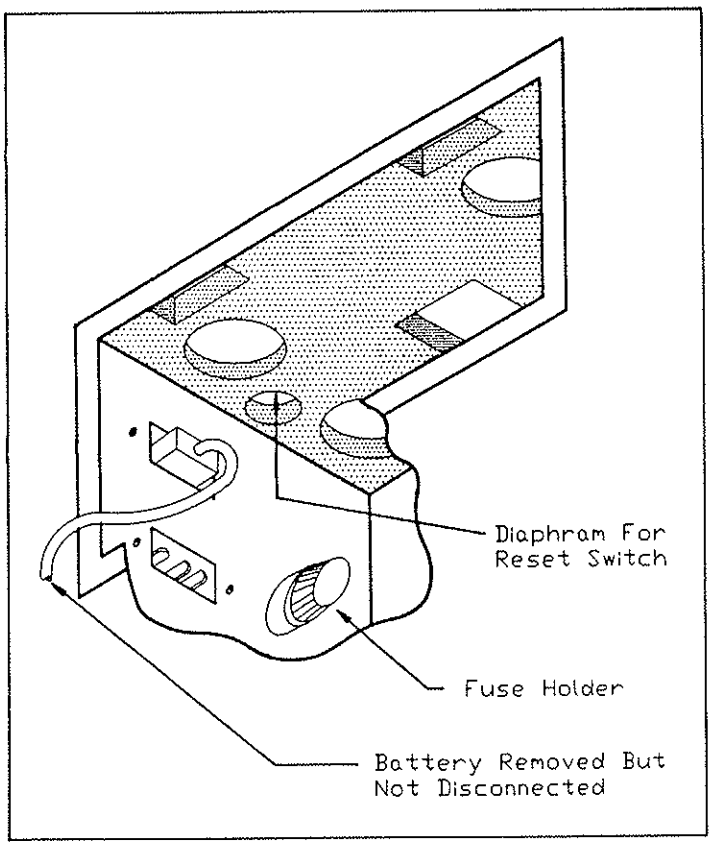

Figure 13: Inside of Battery Compartment

To Change a Battery

To change a battery do the following:

1. Open the battery compartment door by pressing down on the two latches and lifting the cover away from the instrument (see Getting Started section - figure 3).

2. Without unplugging the discharged battery, remove the battery from the battery compartment by pushing on the left side of the battery and then pulling the black tab towards you so the battery can slide out (see Getting Started section - figure 3).

3. Insert the connector of the new battery into the spare socket on the left hand side of the battery compartment wall (See Getting Started section - figure 3).

4. Unplug the discharged battery.

5. Before you re-install the new battery, place your hand inside and flatten the black tab against the bottom, side and top of the compartment. If the black tab is not pressed against the walls of the compartment, the battery will not fit and the foam padding will be damaged.

6. Re-install the battery compartment cover.

External Supplies

The Autograv can operate from any external power supply or battery which can supply between 11V to 15 V at 3 amperes. To connect the Autograv to an external supply you require the optional external 12V cable.

MAINTENANCE

There are several instrument parameters that you need to periodically check and adjust if required. You can adjust some of these parameters by using the keypad while other parameters must be physically adjusted via the sensor front panel. As the instrument gets older you will not have to check these parameters as often.

Check and Adjust Temperature Compensation

The temperature compensation must be checked and adjusted (if required) before the drift correction. Check the temperature compensation under the following conditions.

- Instrument has been turned off for more than two hours.
- Periodically during field operations

The temperature reading must be within the range of:
-2.0 mK < TEMP < +2.0 mK

Refer to the Getting Started section on how to check and adjust the temperature compensation.

Check and Adjust Drift Correction

During the first month of operation for a new instrument, check the drift correction once a week. After this four week period, check the drift correction once every month or longer depending on the individual characteristics of the instrument. However, if an instrument has been turned off for several weeks or more, the setup procedure outlined in section 2 must be followed as if the instrument was new. Read the following notes to obtain accurate Drift correction results.

- The drift correction feature corrects for relatively constant long term instrument drift due to stress relaxation in the elastic system. There may be a small amount of additional drift induced by transportation and handling. The drift correction is not intended to eliminate drift due to transportation as it is generally not constant and depends on the conditions of transportation. Therefore, the drift correction should not be adjusted on the basis of repeat measurements at base stations during a field survey, but only with drift measurements obtained from a stationary instrument.

- Ensure that the tide correction is selected and properly adjusted while measuring the drift correction.

- To obtain the most accurate estimate of instrument drift, connect a chart recorder to the instrument during the measurement period. This enables you to visually filter out any noise from the chart data. The drift is then calculated from the slope of a straight line drawn through the noise free data. The most convenient chart speed for this measurement is 0.5 or 1cm/hr, with a sensitivity of 1mGal full scale. See the following page for details.

To Use a Chart Recorder

When the instrument is in cycling mode, you can obtain an analog output of the reading by connecting the optional chart recorder cable to the instrument front panel. The analog signal is always in the range of 0-1V with the scale being selected in the software through the CHART SELECT submenu of the AUTOGRAV SETUP. The preset ranges available to you are: 0.1, 1, 10 and 100 mGal full scale. The most useful selection for drift measurment is 1mGal full scale.

Before connecting the chart recorder cable to the recorder, check that it is switched to 1V full scale deflection and that it is correctly calibrated and zeroed. Chart speed depends on the cycle time and the application.

Tilt Compensation Adjustment

The perfect tilt compensation condition is the coincidence of instrument tilt as defined by the level bubbles and tilts referred to the horizontal as defined by the maximum sensor output.

To achieve these conditions, you can adjust the tilt sensor zero position and the tilt sensor sensitivity. The sensor zero setting is a hardware adjustment while the tilt sensor sensitivity is adjusted via the keypad.

The tilt sensors are adjusted before the instrument leaves Scintrex Ltd. since the tilt sensors are very stable under normal operating conditions, they only need to be checked approximately every two months.

Tilt Sensor Zero Adjustments

The zero errors X_E and Y_E are measured and adjusted one axis at a time starting with the X axis.

Measuring X_E

1. Initialize the software by setting the following parameters.

   MODE = FIELD
   READ TIME = 120
   TILT COMPENSAT = SELECTED
   TIDE COMPENSAT = SELECTED
   AUTO REJECTION = SELECTED
   STOP ERR < LIM = DISABLED

2. Place the Autograv on the tripod in a quiet location with a solid floor (concrete is preferable). A wooden floor or carpet is not suitable.

3. Press the Start key. The TILTS value appears on the display.

4. Adjust the tripod until X = 150 $\pm$10 and Y = 0 $\pm$5.

5. Wait for 5 minutes and then note the exact value (X1) as shown on the display.

6. Take a reading and record the reading as R1.

7. Rotate the front footscrew counter clockwise until X = -150 $\pm$10 and if necessary adjust the rear footscrews so that Y = 0 $\pm$5.

8. Wait for 5 minutes and then note the exact X value (X2) as shown on the display.

9. Take a reading and record the reading as R2.

10. Calculate the zero error by using the following formula.

$$X_E = \frac{R2 - R1}{X1 - X2} \times 4.3 \times 10^4$$

Where X1, X2 and X_E are in units of arc sec and R1, R2 are in mGal. Refer to the Appendices for the derivation.

Example: X1 = +156 R1 = 4236.58
X2 = -149 R2 = 4236.54

$$X_E = \frac{4236.54 - 4236.58}{156 - (-149)} \times 4.3 \times 10^4$$

$$X_E = \frac{-0.04 \times 4.3 \times 10^4}{305}$$

$$X_E = -5.6 \text{ arc sec}$$

Fine Adjustment of X_E

If $X_E \neq 0$, the Autograv must be adjusted so that the non-level readings are correctly compensated.

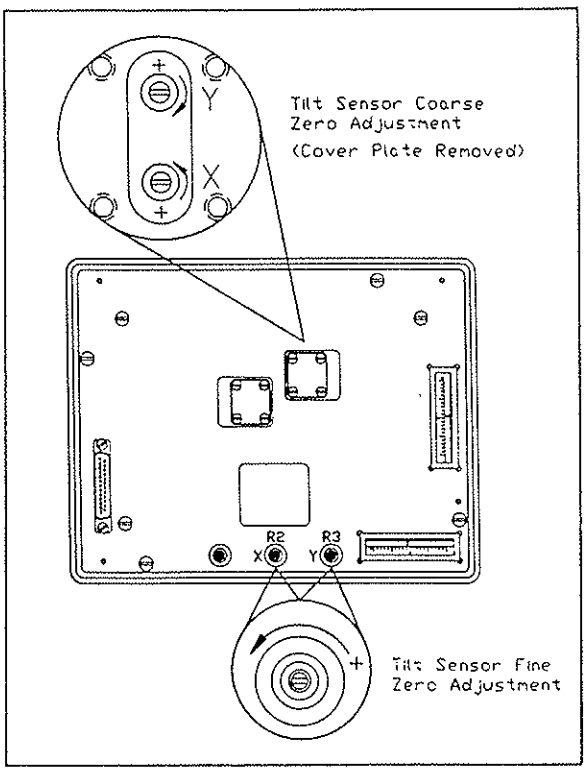

Figure 14: Autograv Faceplate Removed with R2, R3 and Tilt Sensor Coarse Zero Adjustment Shown

1. Leave the instrument in the X = X2, Y = 0 orientation.

2. Remove the Autograv faceplate by unscrewing the four 4-40 oval screws. Refer to the Getting Started section.

3. Press the Start key to put the instrument in the adjust mode.

4. Check the TILTS value and if necessary set Y = 0 ±2 and X = X2 = -150 ±10.

   You do not have to adjust X2 to the previous value.

5. Adjust the X Tilt Sensor Fine Adjustment potentiometer (see Figure 12) while you view the TILTS X value on the liquid crystal display until $X2' = X2 + X_E$

   Note: Potentiometer sensitivity is approximately 2.5 arcsec /turn and adjusting the pot. counter clockwise increases the reading.
   Example:

   X2' = -149 +(-5.6)
   X2' = -149-6
   X2' = -155

   Note: If the Fine Adjustment potentiometer runs out of range in step 5, refer to the section on the Tilt Sensor Coarse Zero Adjustment.

6. Repeat the measurement of X_E and make another adjustment if necessary.

Measuring Y_E

The following procedure is basically the same as that for measuring XE.

1. Press the Start key in order to display the TILTS value.

2. Rotate the rear footscrews until Y = 150 ±10 and if necessary, adjust the front footscrews until X = 0 ±5.

3. Wait for 5 minutes and then note the exact Y value (Y1) as shown on the display.

4. Take a reading, and record the reading as R1.

5. Adjust the rear footscrews until Y = -150 ±10 and if necessary, adjust the front footscrew until X = 0 ±5.

6. Wait for 5 minutes and then note the exact Y value (Y2) as shown on the display.

7. Take a reading, and record the reading as R2.

8. Calculate the zero error by using the following formula.

$$Y_E = \frac{R2 - R1}{Y1 - Y2} \times 4.3 \times 10^4$$

Where Y1, Y2 and Y_E are in units of arc sec and R1, R2 are in mGal. Refer to the Appendices for the derivation.

Example: Y1 = +156 R1 = 4236.58
Y2 = -149 R2 = 4236.54

$$Y_E = \frac{4236.54 - 4236.58}{156 - (-149)} \times 4.3 \times 10^4$$

$$Y_E = \frac{-0.04 \times 4.3 \times 10^4}{305}$$

$$Y_E = -5.6 \text{ arc sec}$$

Fine Adjustment of Y_E

If $Y_E \neq 0$, the Autograv must be adjusted so that the non-level readings are correctly compensated.

1. Leave the instrument in the Y = Y2, X = 0 orientation.

2. Remove the Autograv faceplate by unscrewing the four 4-40 oval screws. Refer to the Getting Started section.

3. Press the Start key to put the instrument in the adjust mode.

4. Check the TILTS value and if necessary set Y = Y2 = -150 ±10 and X = 0 ±5.

   You do not have to adjust Y2 to the previous value.

5. Adjust the Y Tilt Sensor Fine Adjustment potentiometer (see Figure 12) while you view the TILTS Y value on the liquid crystal display until $Y2' = Y2 + Y_E$

   Note: Potentiometer sensitivity is approximately 2.5 arc sec/turn and adjusting the pot. counter clockwise increases the reading.

   Example:

   Y2' = -149 +(-5.6)
   Y2' = -149-6
   Y2' = -155

Note: If the Fine Adjustment potentiometer runs out of range in step 5, refer to the section on the Tilt Sensor Coarse Zero Adjustment.

6. Repeat the measurement of Y_E and make another adjustment if necessary.

Tilt Sensor Coarse Zero Adjustment

This adjustment is performed if the fine adjustment potentiometer runs out of range during the Fine Zero Adjustment.

Coarse Adjustment of X_E

1. Remove the Coarse Zero Adjust cover. Underneath the cover is an O'ring seal. This ensures that no moisture or dust can enter into the adjustment pot. When you remove the O'ring seal place it in a dry clean place.

2. Place the Autograv into the Adjust mode.

3. Level the Autograv until X = 0 $\pm$2 and Y = 0 $\pm$10.

Note: Do not re-adjust the leveling of the instrument during the proceeding steps.

4. Centre the Fine Zero Adjustment by rotating the potentiometer clockwise for 25 turns followed by 10 turns counter clockwise.

5. Carefully rotate the X tilt sensor coarse zero adjustment until X = 0 $\pm$5

Note: Potentiometer sensitivity is 2000 arc seconds/turn and adjusting the pot. counter clockwise increases the reading. Carefully rotate the screw using very small increments while viewing the liquid crystal display.

6. Wait 10 minutes for the Autograv to stabilize and re-adjust if necessary.

7. Repeat the Fine Adjustment procedure.

Coarse Adjustment of Y_E

1. Remove the Coarse Zero Adjust cover. Underneath the cover is an O'ring seal. This ensures that no moisture or dust can enter into the adjustment pot. When you remove the O'ring seal place it in a dry clean place.

2. Place the Autograv into the Adjust mode.

Note: If the instrument turns off during the adjustment, press the On key.

3. Level the Autograv until Y = 0 ±2 and X = 0 ±10.

   Note: Do not re-adjust the leveling of the instrument during the proceeding steps.

4. Centre the Fine Zero Adjustment by rotating the potentiometer clockwise for 25 turns followed by 10 turns counter clockwise.

5. Carefully rotate the Y tilt sensor coarse zero adjustment until Y = 0 ±5

   Note: Potentiometer sensitivity is 2000 arc seconds/turn and adjusting the pot. clockwise increases the reading. Carefully rotate the screw using very small increments while viewing the liquid crystal display.

6. Wait 10 minutes for the Autograv to stabilize and re-adjust if necessary.

7. Repeat the Fine Adjustment procedure.

Tilt Sensor Sensitivity Adjustment

This adjustment is performed after both the tilt sensor zero adjustments are performed. In general, the tilt sensor sensitivity is more stable than the zero point, so it only needs to be checked once every four months.

Measuring X-axis Sensitivity

1. Initialize the software by setting the following parameters.

   MODE = FIELD
   READ TIME = 120
   TILT COMPENSAT = SELECTED
   TIDE COMPENSAT = SELECTED
   AUTO REJECTION = SELECTED
   STOP ERR < LIM = DISABLED

2. Place the Autograv on the tripod in a quiet location with a solid floor (concrete is preferable). A wooden floor or carpet is not suitable.

3. Press the Start key. The TILTS value appears on the display.

4. Level the instrument until X = 0 ±10, Y = 0 ±10

5. Take a reading and record it as R0

6. Adjust the tripod until X = 150 ±10 and Y = 0 ±5.

7. Wait for 5 minutes and then note the exact value (X1) as shown on the display.

8. Take a reading and record the reading as R1.

Adjustment of X-axis Sensitivity

1. Calculate the new value of the X-axis sensitivity.

$$TILTXS' = K \times TILTXS$$

where $$K = \sqrt{1 + 8.7 \times 10^{4}\left(\frac{R0-R1}{X1^{2}}\right)}$$

where X1 is in arcsec and R0 and R1 are in mGal. The derivation of this equation is given in the Appendix.

2. Replace TILTXS by TILTXS' in the Autograv initial constants.

3. Repeat measurement of X-axis sensitivity to check that the adjustments are correct.

Example:

X1 = +155 R0 = 4236.52

TILTXS = 195.3 R1 = 4236.56

therefore,

$$TILTXS' = \sqrt{1 + 8.7 \times 10^{4}\left(\frac{-0.04}{(155)^{2}}\right)} \times 195.3$$

$$TILTXS' = 180.6$$

Measuring Y-axis Sensitivity

1. Initialize the software by setting the following parameters.

MODE = FIELD
READ TIME = 120
TILT COMPENSAT = SELECTED
TIDE COMPENSAT = SELECTED
AUTO REJECTION = SELECTED
STOP ERR < LIM = DISABLED

2. Place the Autograv on the tripod in a quiet location with a solid floor (concrete is preferable). A wooden floor or carpet is not suitable.

3. Press the Start key. The TILTS value appears on the display.

4. Level the instrument until Y = 0 $\pm$10, X = 0 $\pm$10

5. Take a reading and record it as R0

6. Adjust the tripod until Y = 150 $\pm$10 and X = 0 $\pm$5.

7. Wait for 5 minutes and then note the exact value (Y1) as shown on the display.

8. Take a reading and record the reading as R1.

Adjustment of Y-axis Sensitivity

1. Calculate the new value of the Y-axis sensitivity.

$$TILTYS' = K \times TILTYS$$

where $$K = \sqrt{1 + 8.7 \times 10^4 \left(\frac{R0-R1}{Y1^2}\right)}$$

where Y1 is in arcsec and R0 and R1 are in mGal. The derivation of this equation is given in the Appendix.

2. Replace TILTYS by TILTYS' in the Autograv initial constants.

3. Repeat measurement of Y-axis sensitivity to check that the adjustments are correct.

Example:

Y1 = +155 R0 = 4236.52

TILTYS = 195.3 R1 = 4236.56

therefore,

$$TILTYS' = \sqrt{1 + 8.7 \times 10^4 \left(\frac{-0.04}{(155)^2}\right)} \times 195.3$$

$$TILTYS' = 180.6$$

Tilt Sensor Cross Coupling Measurement and Adjustment

This adjustment reduces cross coupling between the tilt sensors and reduces the effect that an adjustment about the X-axis has on the output of the Y sensor. It enables you to level the Autograv more quickly by following the steps in the Getting Started section. The cross coupling should be very stable and only needs to be measured and adjusted as required.

Tilt Sensor Cross Coupling Measurement

1. Place the Autograv on the tripod in a quiet location with a solid floor (concrete is preferable). A wooden floor or carpet is not suitable.

2. Rotate the tripod footscrews eight turns up from their bottom positions.

3. Press the Start key to set the Autograv into the ADJUST mode and level the instrument until X = 0 ±10, Y = 0 ±1.

4. Wait 5 minutes and observe the Y tilt. Record the value as Y0.

5. Rotate the front footscrews clockwise five turns. Observe the Y tilt and record the value as Y1.

6. Rotate the front footscrews counter clockwise five turns. Observe the Y tilt and record the value as Y2.

7. The cross coupling specification is:

$$|Y2-Y0| < 5$$

$$|Y1-Y0| < 5$$

If this specification is not met proceed to the Tilt sensor cross coupling adjustment section.

Tilt Sensor Cross Coupling Adjustment

1. Place the Autograv on the tripod in a quiet location with a solid floor (concrete is preferable). A wooden floor or carpet is not suitable.

2. On a piece of protective foam, lay the Autograv down on its front and view the bottom of the instrument. See figure below:

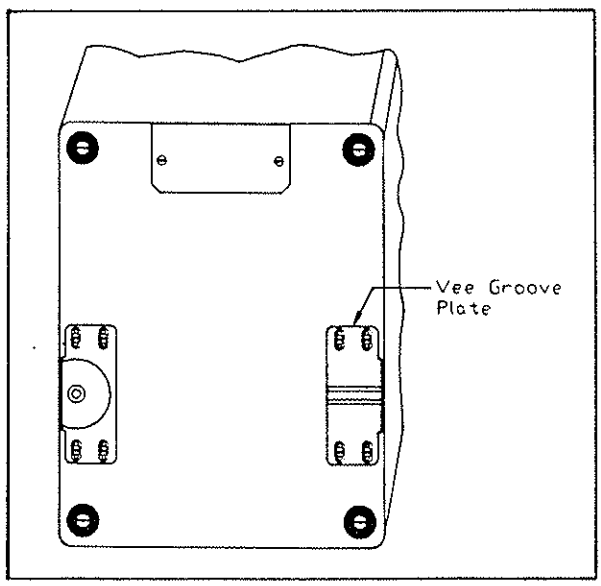

Figure 15: Bottom of Autograv

3. Loosen the four screws on the Vee groove plate (slot side) until the plate can just slide freely.

4. Raise the tripod feet eight turns from their bottom positions.

5. Place the instrument onto the tripod.

6. Press the Start key to place the instrument into the ADJUST mode. Level the instrument until X = ±10, Y = ±1

7. Wait 5 minutes and observe the Y tilt. Record the value as Yo.

8. Rotate the front footscrew clockwise five turns. Observe the Y tilt output.

9. Hold the tripod in place as it must not move during this step. Rotate the instrument on the tripod until Y = Y0 ±5 (if Y < 0 rotate instrument clockwise). The Vee groove block should slide relative to the case. If possible, have a second person hold the tripod.

10. Tighten the four screws on the Vee groove plate and repeat steps 7 and 8. The difference in Y (Y0-Y) should be less than 5 seconds. If it is not within this range repeat the adjustment procedure.

Tripod Maintenance

The tripod footscrew adjustment threads are protected by a stainless steel sleeve at the tripod base and a plastic wiper in the bottom of each footscrew. The stainless steel sleeve should be periodically maintained by winding the tripod footscrews to the top of their travel, and then cleaning and lightly oiling the sleeve.

Storing the Autograv

There are several steps that you must follow in order to obtain the best results from your instrument:

- Keep the Autograv connected to the powered-up battery charger when not in use.
- Store the Autograv with the powered-up battery charger in a dry secure place.
- During storage, remove the battery compartment door to prevent a build-up of gases which could vent from the battery.

Troubleshooting

The following is a brief outline of problems, possible causes and possible remedies to aid you in the event of system failures. Follow the natural progression of steps that is shown below for troubleshooting the Autograv.

Problems	Possible Causes	Possible Remedies
Autograv will not power up	Battery is depleted.	1. Plug in charger and charge battery.
	Battery compartment fuse is blown.	1. Replace battery compartment fuse. (See figure 13)
	Charger is not connected.	1. Connect charger cable to the Autograv connector.
	Charger is not plugged in.	1. Plug charger into AC outlet.
Charger light does not come on	Charger is not plugged in.	1. Plug into AC outlet.
	Charger fuse is blown.	1. Install correct fuse. (See section 6)
Keypad does not work	Display is stuck.	1. Push reset button by doing the following: 2. Remove battery compartment cover. 3. Remove battery but do not unplug. 4. Press the diaphragm that is between the two screws on the ceiling of the battery compartment. (See figure 13)
Reading appears to be out of range	Sensor may be latched	1. Gently tap the upper panel underneath the Autograv name with your finger several times. 2. Take a new reading so that the instrument does not average the incorrect reading. 3. If the reading is still incorrect, repeat the steps increasing the number of taps until the sensor unlatches.

TROUBLESHOOTING

Battery does not charge	Need new battery.	1. Replace with new battery and charge with the charger as outlined in the Getting Started section.
	Battery compartment fuse is blown.	1. Replace battery compartment fuse. 3 Amp fast acting (See figure 13)
Display changes slowly	Ambient temperature is too cold for the display to operate properly.	1. Keep console warm. Purchase optional heater.
Memory loss after Autograv is turned off	Miniature batteries on memory board need replacement.	1. Send Autograv Control Console to Scintrex Limited for repair.
Auxiliary Mode locked	Reset button needs to be pressed to unlock Aux mode.	1. Remove battery compartment door 2. Press diaphram to unlock Aux mode. (See figure 13).

AUTOGRAV SPECIFICATIONS

Reading Resolution	0.01 milligal.
Minimum Operating Range	7000 milligals, without resetting.
Residual Long-term Drift	Less than 0.02 milligal/day.
Typical Repeatability	Less than 0.01 mGal standard deviation.
Range of Automatic Tilt Compensation	±200 arc sec.
Dimensions	240mm x 310mm x 320mm.
Weight	11 kg, including standard battery.
Power Consumption	5 W at +25°C.
Operating Temperature Range	-40°C to +45°C. Optionally to +55°C.
Interval Between Readings in Cycling Mode	Adjustable from 42 to 99999 seconds
Standard Memory	16K RAM internal solid-state memory records up to 390 gravity observations. Memory can be expanded to 48K RAM.
Noise Rejection	Samples of more than 4 standard deviations from the average are rejected, if this feature is selected upon initialization of the instrument.
Displayed and Recorded Data	Corrected Gravity, Standard Deviation, Tilt about the X-axis, Tilt about the Y-axis, Gravity Sensor Temperature, Tidal Correction, Duration of Measurement, Time at start of measurement and Header Information (including date and initialization constants).
Digital Display	32 character, 2 line LCD display.
Keyboard Input	14 keys for entering all commands, co-ordinates, header and ancillary information
Real Time Clock	Day, month, year, hour, minute and second. One second resolution, one second stability over 12 hours.

SPECIFICATIONS

Digital Data Output	RS-232C serial interface. Data outputs in 7 or 8 bit ASCII, one start, two stop bits, no parity format. Baud rate is selectable at 110, 300, 600, 1200 and 2400 baud. Carriage return delay is keyboard selectable in increments of one from 0 to 999. X-on/X-off handshaking protocol.
Standard Accessories	
Tripod	Gravity meter tripod with built-in bubble level -1.0 kg, 0.5 m leg extensions - 1.0 kg.
Battery	5.7 Ah, 2.2 kg.
Battery Charger	115/230 V AC; 50/60 Hz
Optional Accessories	
Belt Battery Pack	The operator wears the Belt Battery Pack inside their coat during cold weather to keep rechargeable batteries warm. This extends the lifetime of the batteries.
RS-232C Cable and Adaptor	Includes a special RS-232C data transfer cable and adaptor. Uses for communicating with peripheral devices.
Minor Spare Parts Kit Display Heater	Includes 2 keyboard diaphragms and two fuses. Required for cold weather operation. Powered by main batteries, thermostatically controlled to turn off above -20°C
Chart Recorder Cable	This cable interfaces with any standard chart recorder
External Power Cable	Required for operation of the instrument from an external 12V DC power supply or battery
Carrying Case for Accessories	A case can be supplied which will accomodate the Tripod, Belt, Battery Pack, Battery Charger, RS-232C Cable with adaptor and manuals.
Memory Expansion	Memory can be added to complement the 16K RAM Standard Memory. This can be done in up to four 8K RAM increments to raise the system memory to a total of 48K RAM. Each 16K RAM increment holds as many readings as the Standard Memory.
Peripheral Devices	Scintrex can recommend and supply suitable digital printers, microcomputers, modems and cassette tape recorders.

Application Software

Scintrex supplies fully documented software written for the IBM family of microcomputers, and certain other microcomputers which use the MS DOS operating system. This software permits:

- archiving of data
- processing of data
- profile and contour plotting

APPENDIX A: INSTRUMENT PARTS LIST

Description	Part Number
CG-3 Gravity Meter includes: Case 858 012 Sensor 858 013 Tripod 858 076 Cover 858 077 Battery Changer 858 091 Console 858 092 Transport Case 858 095 Carrying Strap 858 099 Manuals 858 700	858 011
Options and Accessories	
RS-232C Cable	780 549
RS-232C Cable Adaptor	780 541
RS-232C Adaptor	738 093
RS-232C Female-Female Gender Converter	211 150
Battery Pack Belt	858 093
Minor Spare Parts Kit	858 028
Display Heater Kit	780 031
External Power Cable	858 078
Back Pack	858 021
Memory Expansion Options	
Expansion 8K	780 092
Expansion 16K	780 093
Expansion 24K	780 096
Expansion 32K	780 094
Chart Recorder Options	
Linear #142 Strip Chart Recorder with one roll of paper, one disposable pen and one manual	300 036
Chart Paper	300 024
Disposable Pen	300 225
Digital Printer w/one box of paper, one ribbon and one manual	200 112
Box of paper approx. 2000 sheets	200 122
Ribbon for Printer	200 123
220V AC Printer Converter kit for Printer	560 170

APPENDIX B: SPARE PARTS KIT

Description	Quantity	Part Number
Fuse - Fast Acting - 3 Amp	2	512020
Fuse - Slow Blow - 0.75 Amp	2	512039
Fuse - Slow Blow - 0.375 Amp	2	512041
Screw Driver - 5/32"	1	540062
Screw Driver - 3/16"	1	540063
Screw Driver - Jewellers Set	1	540064
Allen Wrench - 7/64"	1	540065

APPENDIX C: INITIAL CONSTANTS SHEET FOR AUTOGRAV

Serial #:

Gravity const. #1 (GCAL1) = 6748.19
Gravity const. #2 (GCAL2) = −43.171
Temp. const. (TEMP) = −0.1249
Tilt X sensit. (TILTXS) = 180.6
Tilt Y sensit. (TILTYS) = 183.8
At time of shipping Drift Constant (DRIFT) was: 0.67

APPENDIX D: WARRANTY AND REPAIR

Warranty

All Scintrex equipment, with the exception of consumable items, is warranted against defects in materials and workmanship for a period of one year from the date of shipment from our plant. Should any defects become evident under normal use during this warranty period, Scintrex will make the necessary repairs free of charge.

This warranty does not cover damage due to misuse or accident and may be voided if the instrument console is opened or tampered with by persons not authorized by Scintrex Limited.

To validate the warranty, the warranty card supplied with the instrument must be returned to Scintrex within 30 days of shipment from our plant.

Repair

Instruments shipped for repair from outside Canada should be addressed to Scintrex Limited, care of:

Murray and Robinson, Customs Brokers
Lester B Pearson International Airport
Canada

Since Scintrex instruments are manufactured in Canada there is no customer duty payable in Canada. It is advisable to state on customs documents :

Canadian Goods Returned to Canada for Repair

Shipments should be made by air. Within Canada, ship by air directly to:

Scintrex Limited
222 Snidercroft Road
Concord, Ontario
Canada
L4K 1B5

No instrument will be accepted for repair unless it is shipped prepaid. After repair it will be returned collect.