SERIAL # _____

S/W VERSION _____

DATE _____

PORTABLE GAMMA RAY SPECTROMETER

MODEL GR-256

WITH

MODEL GPS-21 DETECTOR

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GR-256 TABLE OF CONTENTS

GR-256 MANUAL

1. INTRODUCTION

The Exploranium GR-256 is a portable 256 channel spectrometer used to record and analyze the Gamma Ray Spectrum. It is a microprocessor based instrument and thus offers a large number of features never previously available in portable instrumentation. The 256 channels are spread equally over the entire Gamma Ray Spectrum of interest, thus all discrete phenomena may be studied.

The GR-256 has been designed as a versatile tool for a wide range of applications including - ground radiometric surveys for uranium, portable vehicle surveys for hydrocarbon, small airborne survey systems, laboratory data analysis, core logging services etc. The instrument is normally supplied with a 21 cubic inch detector (0.35L) but directly interfaces into 112 cubic inch and 256 cubic inch detectors. Via a special Exploranium interface a large variety of other multiple detectors, as well as such speciality units as borehole logging probes, may be used.

The GR-256 makes gain control essentially AUTOMATIC, a very critical feature for high accuracy Gamma Ray data analysis. It is the first spectrometer to internally store data conversion/correction constants to allow display of data in conventional counts/time period or directly in ppm eU, eTh and % K.

Previous instruments were limited to typically 4 windows, often permanently located in the spectrum, to record the natural isotopes of Uranium, Potassium and Thorium. The GR-256 allows selection of 8 windows which may be located anywhere in the spectrum with any channel width. We refer to these windows as ROI (Regions of Interest) to separate them from the 256 channels that cover the entire spectrum.

The unit has internal memory storage, thus a large amount of data may be stored inside the instrument for later data retrieval by computer or other data recording device. This allows much more efficient operation and permits very high resolution analysis of the data. Up to 4,000 samples of 4 channel ROI data may be stored or 62 complete 256 channel spectra.

The stored data may be transferred to an accessory cassette recorder or directly (via RS232) into a portable computer. Exploranium can provide transfer and plotting software for the IBM-PC computer.

The instrument may also be connected directly to a CRT display for real time spectrum analysis. Stored spectra may be also be plotted on an analog chart recorder.

The ROI (or Spectra) data may be transferred (on the RS232 port) directly to external storage or external processing devices, thus allowing unlimited data storage (a complete spectra may be transferred in approximately 0.6 seconds).

Internal clocks allow the instrument to record data in either a manual or automatic cycle rate. The automatic mode permits operation from 1 second to 999 seconds to cover all normal requirements.

Spectrum Stabilization is a feature built in to this instrument which allows optional use of an artificial radioactive isotope (typically Barium or Cesium) to automatically control system gain and protect from gain shifts caused by temperature effects or component aging.

The external computer may be used to control all operating functions of the instrument remotely by selecting the remote mode. This is often useful during specialized laboratory analysis.

The GR-256 is powered by 6 - D cell batteries. If the recommended alkaline batteries are used then typically a 50 hour life may be expected, depending on local conditions of temperature and instrument sample rate. Rechargeable batteries may also be used as well as other sources of external power.

N.B. In the following manual:
A) ALL FRONT PANEL PUSHBUTTON ACTIONS ARE IN UPPER CASE AND IN SQUARE BRACKETS e.g. [SHIFT]
B) ALL IDENTIFIER FLAGS ARE IN TRIANGULAR BRACKETS e.g. <SET>

2. SPECIFICATIONS

2.1 Detector - GPS-21

Crystal : Sodium Iodide (Thalium) [NaI (Tl)] crystal detector - 3" diameter by 3 inches long with an integral bi-alkali photo-multiplier tube.
Resolution : Better than 9.0 % FWHM for Cesium 137 at 662 KeV
High Voltage: 700 to 1000 Volts supply used to power the photomultiplier tube. Special electronics provide highly stable low-noise circuitry.
Output Pulses: Rise time 0.5 uS, fall time 22 uS
Maximum output level + 5 Volts
Gain setting 0.5 Volts typical for 662 KeV adjusted by internal 10-turn gain control
Output impedance 200 ohms.

Housing : Aluminum cylinder with water resistant seals and internal thermal protection and shock mounting.
Reference source : Typically Cesium 137 - 15 Kbq (1 microcurie) housed in an externally accessible mount on the base of the detector.
Dimensions : 4.5 ins. diameter by 16 ins. long
Weight 5 Kgs
Temperature : Operating range -10 to +60 deg C
Storage range -20 to +70 deg C.

2.2 GR-256 Spectrometer Console

2.3 Input Amplifier and Automatic Gain Control

Input signal : 0 - 3 volts from detector preamplifier output

Pulse Shaping :semi-Gaussian, 1 uS time constant with pole zero cancellation and DC restoration.

Gain : Automatic digital control by the microprocessor over a range of ± 25% in 256 steps.

2.4 Analog to Digital Converter

Type : Wilkinson 2 megahertz, Conversion time (6.5 + 0.5N) uS where N is the number of the channel being converted e.g. Channel 1 - 7 uS : Channel 256 - 134.5 uS

Channel Width : 10 millivolts

Input Voltage Range : 50 millivolts to 2.5 Volts

Linearity : Differential - maximum 1 % between 50 mV and 2.5V
Integral - maximum 0.3 % between 50 mV and 2.5V

Zero drift : 1 mV / deg C

Maximum input count rate : 20,000 counts per second when peak displacement due to zero shift is less than 1 channel

2.5 256 Channel Analyzer

Mean access time from ADC : 24 uS

Number of channels : 256

Maximum count per channel : 65,535

Dead time correction : Automatic by sample period extension

Sample Period : 1 to 999 seconds

Number of energy windows (ROI) : 8

ROI setting range : between channel 1 and 255 as required.

2.6 Digital Spectrum Stabilizer

Reference peak setting : within range of Channels 20 to 127 (setting Channel 0 switches the spectrum/stabilization OFF)

Control Mode: Automatic digital control by the microprocessor of the gain of the shaping amplifier

Control range : ± 25 %

Stabilization sensitivity : 0.2 % (0.1 channel for Cesium at Chn.55)

Period of control adjustment : before beginning of measurement and at intervals of 20 seconds thereafter.

Reference Source : Cesium 137 (662 keV) - setting the reference peak in Channel 55 gives an energy calibration of 12 KeV per channel.

2.7 Internal Data Storage - Memory

Memory Capacity : 4,000 measurement points or identifiers
OR 62 complete 256 channel spectra

Memory type : CMOS RAM, 32 Kilobytes with Lithium battery back-up

Data storage time : limited by battery life - typically 10 years
N.B. RAM memory will be preserved by the Lithium battery when the instrument is switched off or the batteries removed.

Memory checking : Memory is checked automatically when activated, Lithium battery condition is checked automatically when instrument is switched on.

2.8 Data Outputs

SERIAL CHANNEL - RS-232:

Use : To transfer data/spectra to an external computer
Also used for remote control of the spectrometer
by the computer.

Rate of Transfer : 300, 600, 1200, 2400, 4800, 9600 BAUD -selectable

Format : 10 bits - 1 Start, 8 Data, 1 Stop (no parity).

Output Voltage : Logical 1 : -7V, logical 0 : +7v

SERIAL CHANNEL - Kansas City II

Use : To record, check and read data or spectra into a
standard cassette recorder

Rate of Transfer : 300 BAUD

Output Voltage : 20 mV

Input Voltage : 1 V

Tape Winding Control : Tape winding is enabled when a relay
contact in the spectrometer is activated.
(max.voltage 50 V, maximum current 1A)

SLOW ANALOG CHANNEL:

Use : Plotting of spectra on analog recorders

Output Voltage : 0 to +2.5 V

Rate of transfer : 1 channel per second (can be adapted if
specified)

Range Control : Automatic selection of vertical range . The
microprocessor calculates the maximum data value
and sets range accordingly.

FAST ANALOG CHANNEL:

Use : Displaying spectra on an external oscilloscope

Rate of transfer : 256 channels / 10 mS

Output voltage : 0 to +2.5 V

Oscilloscope setting : Time base 1 mS / division
Vertical amplifier 0.5 V / division
Time base triggering negative, internal, DC

Switching of vertical range : Automatic or manual in steps of x2 and /2 by means of pushbuttons on the spectrometer

2.9 General Data

Display : Liquid Crystal (LCD), 8 digits - 9mm high, and 8 identifiers used as flags.

Keyboard : Membrane type, 17 pushbuttons, dust-resistant, waterproof and water-tight

Audio : Piezoelectric buzzer, frequency 4 KHz. Used to give audio feedback from the keyboard and audio warnings for end of measurement and error conditions

Power supply : Internal - 6 D-cells - Alkaline recommended
External - 8 - 15 V @ 200 mA

Battery life : Minimum of 50 hrs of measuring time with recommended alkaline cells

2.10 Dimensions

Size : 230 x 90 x 235 mm

Weight : Without Batteries - 2.8 Kg - 6 lbs

With batteries - 3.5 Kg - 7.5 lbs

2.11 Temperature

Operating : -10 to +55 deg C

Storage : -20 to +70 deg C

2.12 Accessories

Standard:

1 - GR-256 spectrometer console

1 - GPS-21 Detector assembly - 21 cu. ins.

1 - Coiled cable - detector to spectrometer

1 - Carrying case for the spectrometer

1 - Harness assembly and shoulder strap

1 - Aluminum carrying handle for the spectrometer (detachable)

1 - Disk with software programs for IBM-PC

1 - RS-232 cable for IBM-PC

1 - Reference source - usually Cesium 137

1 - Operating Manual

1 - Padded, compartmentalized carrying case

Optional:

A) P/N 92110 - Special Test Sample U/Th

B) P/N 92100 - Cassette recorder and cables

C) P/N 92040 - CPU PCB Assembly - Regular

D) P/N 92035 - Analog PCB Assembly

E) P/N 92045 - P.Supply PCB Assembly

F) P/N 92055 - Display PCB Assembly

G) P/N 92010 - Membrane Keyboard

H) P/N 84245 - Coiled Cable Assembly

I) P/N 92120 - Detector Electronics no Xtal

J) P/N 92009 - Extender Board

K) P/N 92098 - Complete set of components

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3. DESCRIPTION OF INSTRUMENT

3.1 GPS-21 Detector Probe

The detector assembly contains a 75 x 75 mm (3 x 3") Sodium Iodide [NaI (Tl)] scintillation detector which is enclosed in a single integral unit with a photomultiplier tube (PMT), a high-voltage supply and signal preamplifier. The detector is thermally insulated and housed in an aluminum cylinder. The unit is equipped with a handle and is connected to the spectrometer by a coiled cable. A reference isotope disc source [typically Cesium or Barium with an approximate activity of 15 kBq (0.5 uCi)] is mounted at the base of the probe under a removable case. Thus the source may be easily removed or changed if required without opening the probe.

N.B.1. The activity of the reference source is very low and does not qualify as a radioactive source of radiation under international regulations. There is, therefore, no danger for the user. Nevertheless, this source is registered and should only be operated by a person who is acquainted with the basic rules of work with radioactive substances.

2. Although the crystal assembly is well shockmounted in the detector, care should be taken to avoid mechanical shocks as the crystal is of course very fragile.

3. Keep the measuring probe clean. Contamination must be avoided particularly when measuring strongly active samples or during calibration.

3.2 Spectrometer Unit

The spectrometer unit contains circuits for processing and analyzing the measured signal including: a pulse shaping/amplifier with digitally controlled gain, an analog-to-digital converter, a microprocessor and other auxiliary circuits. The unit consists of a rectangular aluminum enclosure containing 4 circuit boards , a front panel keyboard and 2 Input/Output connectors. One connector is for the detector input and the other for connecting to external power and other peripheral units.

The internal battery housing is accessible from the lower part of the unit by a quick release door.

The unit is controlled by the front-panel keyboard which is a membrane type, has 17 pushbuttons and is watertight. Very little pressure is required to depress any of the pushbuttons and an audio tone as well as tactile feedback confirm a key depression.

The entire unit has been designed to be water-tight. The main unit is sealed by O-rings and the battery access door uses a compressible rubber gasket for water protection. The internal battery compartment is sealed from the main electronics unit. Thus any humidity present when the batteries are changed cannot enter and damage the electronics circuits.

A carrying case for the spectrometer is supplied as standard equipment. This case offers some level of shock protection as well as having loops which are utilized by the shoulder carrying harness to hold the unit snugly against the body. In addition a shoulder strap may be used or the adjustable aluminum carrying handle. This variety of carrying methods covers most user requirements.

3.3 Operating Controls - Fig.1

[ON/OFF] Pushbutton for switching the instrument on and off

[START/STOP] Pushbutton for commencing the measurement or for terminating any of the on-going activities including measurement

[STORE] Pushbutton for storing parameters (or measured data) including time of measurement, calibration constants, reference position peak, energy windows (ROI), sample heading, profile number, position of measured point, spacing along profile, results of measurement in memory

[SHIFT] Pushbutton for changing to functions in the upper part of the keyboard (RED functions)

[CLEAR] Pushbutton for clearing the display when the keyboard data are loaded and for erasing the contents of the data memory

[0 - 9] Pushbuttons for loading digits

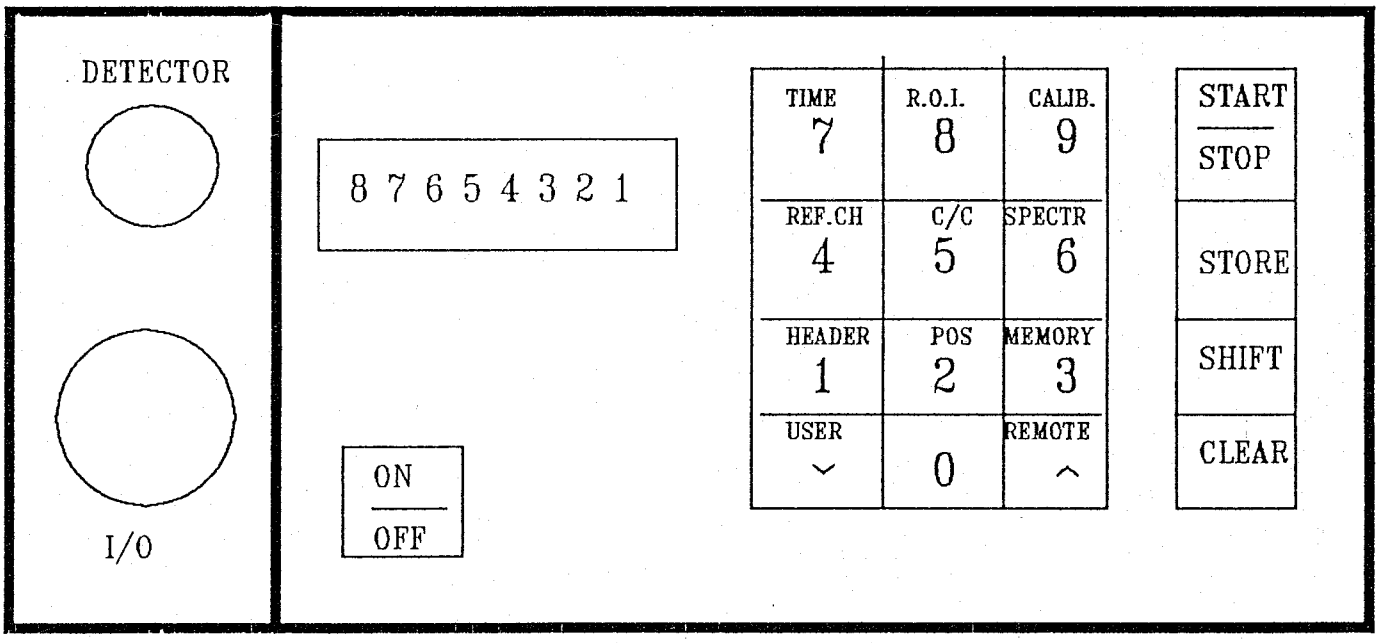
DETECTOR
I/O
8 7 6 5 4 3 2 1
ON
OFF
TIME 7
R.O.I. 8
CALIB. 9
REF.CH 4
C/C 5
SPECTR 6
HEADER 1
POS 2
MEMORY 3
USER
0
REMOTE
START
STOP
STORE
SHIFT
CLEAR

FIG. 1

[^] Pushbutton used to increment the display through its current functions e.g. contents of channels in spectra, energy windows, calibration constants, results of measurements, or data memory. In scanning spectra, the scanning rate is automatically increased in four stages if the push-button is kept depressed

[v] Preceding pushbutton similar to [^] but used to decrement the display

The following pushbutton functions are initiated after pushbutton [SHIFT] has been pressed. Note that this is a RED key and all the following keys use the RED designation:

[+/-] Pushbutton for changing the Sign of loaded data; it can also serve to produce a hyphen on the display, e.g. in the sample heading

[TIME] Pushbutton for checking or setting the Time of measurement

[ROI] (Regions of Interest) pushbutton for checking or setting channel integration regions - windows - (8 may be preset)

[CALIB] (Calibration Constants) pushbutton for checking or setting the calibration constants

[REFCH] (Reference Channel) pushbutton for checking or setting the position of the peak of the reference radionuclide

[C/C] (Counts/Concentrations) pushbutton for selecting the type of displayed results, i.e. in counts/time period or concentrations

[SPECTR] (Spectrum) pushbutton for manipulating the spectrum.

The next pushbutton determines the manner of manipulation and type of peripheral equipment:

(0) - Display of channel number and contents on the display, and of the complete spectrum on the external oscilloscope

(1) - Plotting of the spectrum on an analog recorder

(2) - Processing of the spectrum stored in working memory

(5) - Transfer of spectra to an external computer ONLY in the REMOTE mode (i.e. by external computer command on RS-232)

(6) - Automatic winding of tape in the cassette recorder beyond a particular spectrum recorded earlier

(7) - Recording of spectra on a cassette recorder

(8) - To verify spectrum recorded on a cassette recorder by re-scanning data and performing error analysis.

(9) - Transfer of a spectrum from the cassette recorder to the spectrometer

[HEADER] Check and setting of measurement sample heading (e.g. date) for recording of measurement results in data memory

[POS] (Position) - check or setting of the location identifier parameters of a measured point for recording in data memory

[MEMORY] Pushbutton for recalling data from memory.

The next pushbutton determines the manner of manipulation and the type of peripheral equipment:

(0) - Display of data stored in data memory

(5) - Transfer of data to an external computer ONLY in the REMOTE mode (i.e. by external computer command on RS-232)

(6) - Automatic winding of tape in the cassette recorder beyond a particular set of data recorded earlier

(7) - Recording data on a cassette recorder

(8) - Check that the cassette data was recorded correctly by playing the tape back and comparing the data

(9) - Transfer of data from the cassette recorder to the spectrometer

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[USER] Pushbutton for initiating other special activities according to the user's requirements. If the user does not specify these requirements, a standard set of activities will be provided (see Section 10 - Page 26).

[REMOTE] Pushbutton for transferring control of the spectrometer to an external computer. Note that ALL functions of the keyboard may be activated by external computer control.

3.4 Display

A Liquid Crystal Display (LCD) is used in the spectrometer which enables 8 digits and 8 identifiers (arrows) to be displayed. Apart from the digits 0 to 9, the following symbols are displayed:

.	Decimal point which can also be used as a separator
-	Minus sign which can also be used as a hyphen
H	(High) indicates UP direction on a profile, or the top
L	(Low) indicates DOWN on a profile, or the bottom
P	(Peak Position) indicates the channel position of the reference peak
SOL	(Step on Line) spacing along profile
E	(Error) error indication (see Section 14 - Page 40)

3.5 Meaning of Individual Identifiers

<BAT> (Battery) indication of batteries running low; measurements can be continued for about 1 hour

<CONC> (Concentrations) the data are DISPLAYED/STORED in calculated concentrations as follows:

1st ROI - Total Count channel (ppm U equiv)

2nd ROI - Potassium (%)
3rd ROI - Uranium (ppm)

4th ROI - Thorium (ppm)

<STAB> (Stabilization) indicates that the spectrum Stabilizer system is ON. A flashing indicator shows that the stabilization procedure is in progress.

<ACC> (Accumulation) indication of a measurement in progress

<I/O> (Input/Output) indication of a data input or output function with an external device is in progress.

<SET> (Setting) an instrument condition in which the displayed data can be changed from the keyboard

<RMT> (Remote) an instrument condition in which control has been transferred to an external computer

<MON> (MONITOR) basic instrument condition in which the user's command from the keyboard is to follow

4. OPERATIONAL INSTRUCTIONS

4.1 Battery Operation

The instrument is shipped without batteries installed. After removing the spectrometer from its case, the oval Battery Door may be removed by removing the 2 fasteners. Six "D" cell batteries are than placed into the battery compartment as indicated (see polarity labels inside the battery tube). Be careful of battery polarity. If the batteries are completely reversed the system will not function. However if a single battery is reversed serious damage can occur from chemical leakage of the batteries. Once the batteries have been placed correctly in the compartment and the door closed, the instrument is ready for use.

N.B. 1. Batteries should be changed only when instrument is switched OFF.

2. When the batteries are being changed, or the instrument is switched off, the preset instrument parameters and the measured data stored in the data memory are retained by the lithium battery.

3. If the instrument is to be stored for a longer period, always remove the batteries from the battery compartment. This will prevent the unit from being damaged should electrolyte leak from flat batteries.

4. Apart from ordinary batteries, rechargeable batteries can also be used. These batteries can be recharged without being removed from the instrument by means of a special charger which is supplied with the instrument as an optional accessory.

5. The instrument can also be operated from an external power source if required (8 - 15V DC). This may be necessary for vehicle operations or if the unit is being used when the ambient temperature is below 0 deg C, as at low temperatures the battery life falls off sharply.

See appendix E for use with RECHARGEABLE batteries.

4.2 On/Off Operation

The instrument may be operated even if the probe has not been connected. It is switched on by pressing pushbutton [ON/OFF]. The display should show eight hyphens and the identifier <MON>.

This condition is referred to throughout the manual as MONITOR.

The display may also show the error identifiers E1 or E2 - for details refer to Section 14. Any other symbol on the display, even after the instrument has been switched ON repeatedly, indicates a fault in the instrument. If a fault is indicated, see Section 12. The instrument may be switched off at any time by means of the same pushbutton.

4.3 Battery Condition Check

The batteries are checked automatically as soon as the instrument has been switched ON, and every 20 seconds during measurement. If the voltage drops below 6.5V, the identifier BAT will appear on the display. The batteries will then last approximately another hour. If the user does not change the batteries and the voltage drops below 5.5V, the display will show the error identifier E2 and the instrument can no longer be operated. It must be switched OFF and the batteries changed. This prevents the instrument producing errors and further discharging of the batteries which may cause damage, particularly if rechargeable batteries are being used.

The battery voltage can also be checked with the aid of the built-in digital voltmeter - User Program 2 - Section 10.2

4.4 Battery Back-up

A special Lithium battery. which serves to retain the instrument constants and memory data after the instrument has been switched off or when batteries are being changed, is soldered to the CPU board of the instrument. The lifetime of this battery is 10 years and it is tested each time the instrument is switched on. A faulty battery is indicated by the error identifier E1.
N.B. This battery is changed by Exploranium.

5. HOW TO PUT THE SPECTROMETER INTO OPERATION :

5.1 General

All functions of the instrument are controlled by the microprocessor. After the instrument has been switched ON, or after a particular procedure has been terminated, the instrument is switched to the MONITOR mode, i.e. awaiting input from the user via the keyboard. This condition is indicated by the identifier <MON> and usually also by 8 hyphens on the instrument's display. The pushbutton [START/STOP] can be used to interrupt any procedure and change to the MONITOR mode.

The basic parameters of the instrument have been set so that the instrument is ready for use immediately after it has been switched on for the first time with the following parameters in the supplied calibration sheet. The following default parameters are loaded from ROM if memory fails:

a) The period of measurement TIME is 240 seconds.

b) Energy windows ROI set as per:

ROI - #1 - Total Count:	Lower - chn.	70
	Upper - chn.	255
Potassium:	Lower - chn.	111
	Upper - chn.	125
Uranium:	Lower - chn.	133
	Upper - chn.	151
Thorium:	Lower - chn.	197
	Upper - chn.	219

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c) Background and calibration constants CALIB for computing Total Count activity and the concentrations of K, U and Th from G.S.C. test pads as follows:

Calibration Constants -	C1:	504	C8:	-59
	C2:	30	C9:	-52
	C3:	13	C10:	4213
	C4:	6	C11:	-2770
	C5:	587	C12:	118
	C6:	478	C13:	-436
	C7:	-399	C14:	13088

d) The position of the reference channel REFCH is 55 as the use of Cesium for Spectrum Stabilization is assumed. This value gives an energy calibration of 12 keV per channel.

e) Arrow <C/C> not shown on display. This means that, after the measurement has been terminated, the display will show the data in the individual ROI's in counts/time period

The parameters of the instrument can be modified by functions TIME, ROI, CALIB, REFCH and C/C from the MONITOR mode. The modified parameters are retained even after the instrument has been switched off or when the batteries are being changed, until the user modifies them again.

N.B. IF THE INTERNAL LITHIUM BATTERY IS DEFECTIVE, THEN WHENEVER THE UNIT IS POWERED OFF, ALL USER SET PARAMETERS ARE LOST.

Exploranium's original parameters are reset into the instrument if the error identifier E1 (faulty lithium battery) appears on the display. In this case user set parameters have to be reset each time the instrument is switched on, until the faulty Lithium battery can be replaced.

5.2 Period of Measurement - TIME

On pressing [SHIFT] [TIME], the display will show the period of measurement set earlier and the identifier SET informs the user that the data on the display may be modified.

Pushbuttons [0 - 9] and [CLEAR] can be used to select a new period of measurement. Pushbutton [STORE] is used to store the period of measurement shown on the display in the instrument memory, and control is switched to MONITOR. The period of measurement can be set between 1 and 999 seconds.

The [START/STOP] button may be used to terminate function TIME and control is switched to MONITOR, however, in this case the period of measurement will not change.

5.3 Energy Windows - ROI

On pressing [SHIFT] [ROI], 1L will appear on the left-hand side of the display, the lower limit of the Total Count window on the right-hand side and the identifier <SET> is ON.

Pushbuttons [0 - 9] and [CLEAR] can be used to select a new limit. The [STORE] button is used to store the limit shown on the display in the instrument's memory, and the display will then show the upper limit (1H) of Total Count. Once this is set then similarly the limits of the energy windows of Potassium (2L, 2H), Uranium (3L, 3H) and Thorium (4L, 4H). Four additional energy windows can be set (5/6/7/8) but they CANNOT be converted into concentrations by the unit. The limits of the energy windows may be chosen between channel 1 and 255.

N.B. For users who wish to process other ROI data (e.g. Health Physics), Exploranium can supply a special program for processing ROI's in an external computer.

Typical R.O.I. settings:

R.O.I. #	NAME	PEAK MeV	R.O.I. Lower	R.O.I. Upper
1	Total Count	---	70	255
2	Potassium	1.46	111	125
3	Uranium	1.76	133	151
4	Thorium	2.62	197	219
5	Cesium	0.66	51	59
6	Iodine	0.34	23	33
7	Barium	0.35	25	35
8	Cobalt 60	1.33	106	118

The upper ROI limit must be higher than or equal to the lower ROI limit. If the lower limit is 0 then the energy window is not used and three dashes appear on the display. For example, for sensitive monitoring of the total radiation intensity, the reference radionuclide can be removed from the probe and, with stabilization switched off, the Total Count energy window can be set from channel 10 - 255, i.e. from 120 keV to 3 MeV.

Pushbuttons [^]/[v] are used to scan the preceding/following window (ROI) setting without changing their value.

Pushbutton [START/STOP] commences testing of the settings of the energy windows. Testing checks that the lower limit is equal or smaller than the upper limit and whether the first four windows are of non-zero limits. An occurrence of a zero limit in the fifth and higher energy window automatically causes zeroing of limits of higher windows, terminates function [ROI] and control is switched to MONITOR. However, the last limit shown on the display does not change even if it has been modified. If an error is found then the lower limit of an incorrectly set window is shown on the display, and the user must correct the error before the system will switch to MONITOR.

5.4 Background and Calibration Constants - CALIB

On pressing [SHIFT] [CALIB], 1- is shown on the left-hand side of the display, a background value for the total activity energy window (counts/sec) on the right-hand side and identifier <SET> is ON.
e.g. 1- 32767

Pushbuttons [0 - 9] and [CLEAR] can be used to select a new background value. Pushbutton [STORE] is used to store the value shown on the display in the instrument's memory, and the display will show:

2 - together with the background value of the Potassium window.
Then 3 - and the background value of the Uranium window
and 4 - with the background value of the Thorium window.

The background value may be selected in the interval 0 to 65,535.

The calibration constant C_5 is used to calculate the Total Count.

Total Count Activity = Q_{TOT} (ppm U equiv) = $10^{-5} \cdot C_5 \cdot n_1$.

The other data shown on the display marked 6 to 14 are the calibration constants C_6 to C_{14} for computing the concentrations Q_K, Q_U and Q_{Th}:

$$\begin{bmatrix} Q_K \\ Q_U \\ Q_{Th} \end{bmatrix} = 10^{-5} \cdot \begin{bmatrix} C_6 \cdot C_7 \cdot C_8 \\ C_9 \cdot C_{10} \cdot C_{11} \\ C_{12} \cdot C_{13} \cdot C_{14} \end{bmatrix} \cdot \begin{bmatrix} n_2 \\ n_3 \\ n_4 \end{bmatrix},$$

Where n_1, n_2, n_3, n_4 are the Total Count, Potassium, Uranium and Thorium ROI (in counts/min), with subtracted background. The calibration constants may be chosen in the interval from -32,767 to 32,767. Change of sign is effected by pushbutton [SHIFT] and [+/-]. Pushbuttons [v], [^] allow the constants to be monitored without change and [START/STOP] switches the system to MONITOR.

5.5 Position of Reference Channel - REFCH

The gain of the shaping amplifier is digitally controlled by the microprocessor so that the peak of the reference source is maintained in a selected channel. If low activities are being measured, e.g. during geophysical mapping, it is convenient to use Cesium with an energy of 662 keV. The energy calibration of 12 keV/channel then corresponds to the position of Cesium in Channel 55. If high activities are being measured, e.g. in measuring Uranium mineralization, Barium at 356 keV has to be used, because the gain stabilization on the Cesium 662 keV peak is disturbed by the 609 keV peak of Bismuth 214. The position of the peak of Barium in channel 30 then corresponds to an energy calibration of 12 keV/channel.

On pressing pushbuttons [SHIFT] and [REFCH], P will appear on the left-hand side of the display, the existing position of the reference channel on the right-hand side and identifier <SET> is ON.

Pushbuttons [0 - 9], [CLEAR] and [STORE] allow a new channel to be selected and stored. [START/STOP] switches the system to MONITOR.

The position of the reference channel may be set between channel 20 to 120. If 0 is selected then the Spectrum Stabilization is switched OFF.

5.6 Concentration/Counts - C/C

The identifier <CONC> on the display indicates that the display will show the total activity (ppm U equiv) concentrations of K (%), U and Th (ppm) after the measurement has been concluded. If it is NOT shown, the display will indicate the number of pulses counted during the measurement period.

Pressing pushbuttons [SHIFT] then [C/C] allows toggling between Concentrations and Counts/Time Period. [START/STOP] switches back to MONITOR.

6. MEASUREMENT

Holding pushbutton [START/STOP] depressed for about 0.5 seconds will cancel the spectrum measured previously and initiate the measurement of the next spectrum.

If the Reference Channel = 0, the measurement is begun immediately. The display will show the identifier <ACC> and the selected period of measurement (in secs) which is decreased each second by 1 (time count down). In this case the gain is not stabilized and only the batteries are tested every 20 seconds. If the battery voltage is less than 6.5V, the display will show the identifier <BAT>. This is a warning to the user that the batteries are coming to the end of their useful life, but measurements can still be continued for about 1 hour. If the battery voltage drops below 5.5V during the measurements, the display will show the error identifier E2. The measurements then cannot be continued, the instrument must be switched off and the batteries changed.

If the Reference Channel is not 0, then when a sample period is started a 4-second measurement is begun. During this period the <STAB> identifier flashes on and off. After this measurement has been concluded, the microprocessor will evaluate the position of the reference peak and correct the system gain if required. The spectrum is then erased, the identifiers <STAB> and <ACC> are displayed and the actual measurement is started. The subsequent activity of the instrument is the same as in the previous case, the only difference being that, in addition to the battery check, the position of the reference peak is evaluated and the gain corrected every 20 seconds.

If the microprocessor is unable to adjust the gain to the correct level, the display will show the error identifier E3 and control is switched to MONITOR. Provided the Reference Channel is set correctly and the reference radionuclide is located in the compartment at the bottom of the probe, then this error indicates a fault in the measuring probe. [see Section 12]

The end of measurement is indicated by an audio signal. At the same time, -1- is displayed on the left side of the display and the Total Count activity on the right-hand side. If identifier <CONC> has been set, then the reading will be corrected for the background and expressed in ppm U equiv. If the <CONC> arrow is NOT displayed, then the Total Count is shown as the number of counts recorded during the measurement in this energy window.

The next/previous energy window can be displayed by pressing buttons [^]/[v]. If identifier <CONC> has been set, the concentrations of window 2 - K (%) , of 3 - U (ppm) and 4 - Th (ppm) are displayed in turn. If identifier <CONC> is NOT displayed, then the number of counts recorded in the appropriate energy windows are displayed. Pushbuttons [1 - 8] can also be used to select the appropriate energy window; however if a display of Concentrations is required then ONLY pushbuttons [1 to 4] can be used.

If the data memory has been initiated, then the [STORE] button can be used to store the number of counts, recorded in the energy windows, in the memory of the instrument (see Memory Operations - Section 7), and control is switched to MONITOR.

The [START/STOP] button can be used to interrupt the scanning of results at any time, and control is switched to MONITOR. The measurements are then not stored in the data memory. The sequence [SHIFT] [SPECTR] [2] generates the same conditions as if the measurement had been concluded i.e. the results of the measurements can be displayed again (see Section 8 - Spectrum Manipulation).

N.B. This unit utilizes automatic dead time correction by sample extension, thus the actual time of measurement is extended to compensate for dead time, ensuring no loss of data. Thus in areas of high activity the actual time of measurement maybe substantially longer than was preset but, since this is an automatic function, no user correction is required.

7. MEMORY OPERATIONS

The data memory of the instrument is capable of storing as many as 4000 measurement results or identifiers. These data can then be displayed on the instrument's display, loaded via RS-232 into an external computer, or recorded on a cassette recorder.

This internal memory may also be used to store 62 complete 256 channel spectra as well as special programs input from an external cassette recorder.

Recording of Measured Data

7.1 Initiation - HEADER:

Before the memory can be used, it must be initiated. Before beginning the initiation procedure, press [SHIFT] [TIME] to check whether the required period of measurement has been set. This is necessary because, during initiation, the period of measurement is also stored in the memory. Later, when the results of measurements are being recorded, the period of measurement is compared with the period of measurement stored in the memory during initiation. If these two periods disagree, the error identifier E8 is displayed and the memory will not store the data.

On pressing pushbuttons [SHIFT] [HEADER], the display will show the first 8 bytes of the memory - usually the previous header. By pressing any button but [CLEAR], control is switched to MONITOR, and this prevents the memory from being erased in error.

The [CLEAR] button is used to continue the initiation procedure, and this is indicated by two digits of the display being replaced with hyphens. The next depression of the [CLEAR] button replaces the next three digits with hyphens. In this condition, the initiation procedure can still be interrupted by pressing any other button. After the [CLEAR] button has been pressed for the third time, the testing of the data memory is begun and any data in memory is now erased. THIS PROCESS CAN NO LONGER BE INTERRUPTED.

During memory testing, "0" flashes on the left-hand side of the display and when the testing is completed available memory is displayed on the right hand side of the display.. Different memory sizes give different results:

1 x 8K memory	- flashing "0" test	= 10 secs - size displayed	892
2 x 8K	-	= 20 secs -	1916
3 x 8K	-	= 30 secs -	2940
4 x 8K	-	= 40 secs -	3964

N.B. UNITS ARE NORMALLY SUPPLIED WITH 4 X 8K MEMORY INSTALLED. IN THE EVENT THAT A MEMORY ERROR IS DISCOVERED ERROR IDENTIFIER E5 WILL BE SHOWN AND THE RESULT SHOWN ON THE DISPLAY AS MEMORY AVAILABLE MAY BE LOWER THAN LISTED ABOVE. THIS INDICATES A PROBLEM IN RAM THAT SHOULD BE REPAIRED BUT THE INSTRUMENT MAY STILL BE USED SUCCESSFULLY TO THE LIMITS OF RAM INDICATED BY THIS TEST.

Indicator "H" is displayed after the test has been concluded, and the user loads the Header (e.g. the date of measurement) by means of pushbuttons [0 - 9] and [CLEAR]. The [STORE] button stores the header shown on the display in the memory.

After this procedure, control is automatically passed to function POS, i.e. SOL (Step on line) will appear on the left-hand side of the display, and the default spacing along the profile will appear on the right-hand side.

N.B. IF SPECTRA ARE TO BE RECORDED AND/OR COORDINATE DATA IS NOT REQUIRED, PRESS [STORE] [STORE] [STORE] TO SWITCH TO MONITOR.

7.2 Location on Profile - POS:

This procedure defines the spacing along the profile, i.e. the distance between two points of measurement, referred to as "step". Also the direction of measurement along the profile is defined and the profile number and position of the first point of measurement on the profile are determined.

This function is initiated automatically by the [HEADER] function or by pressing the [SHIFT] [POS] buttons. <SOL> (Step on line) is displayed on the left-hand side and the "step" on the right-hand side. Pushbuttons [0 - 9] and [CLEAR] can be used to modify its size. By means of the [STORE] button the "step" size, shown on the display, is stored in the memory, and the procedure continues with the definition of the position of the next point of measurement. The size of the "step" can be set to values from 1 to 99.

The display will show three sets of data. The data which can be modified are marked with dots. Pushbuttons [v] and [^] are used to choose:

a) The letter H/L on the left-hand side of the display defines the direction up/down along the profile. The [SHIFT] and [+/-] buttons can be used to change H to L and vice versa.

b) The next 3 digits define the profile number. With push-buttons [0 - 9] and [CLEAR] the profile number can be set to values from 0 to 999.

c) The next 4 digits define the number of the station along the profile. With pushbuttons [0 - 9] and [CLEAR] the station number can be set to values from 0 to 9999.

The [STORE] button is used to store the displayed data in the memory and control is switched to MONITOR. The stored data remain displayed. Although this identifier has already been stored, it can be corrected by repeating this procedure until the time the next measurement is stored in data memory.

The initiation of the memory is thus concluded and the results of the measurements can be stored in the memory.

7.3 Storing of Data in Memory - STORE:

Once the data memory has been initiated by functions HEADER and POS, the [STORE] button can be used (after the measurement has been concluded) to store the number of counts recorded in the first four spectral windows, in the memory. If this procedure is carried out correctly, the control switches to MONITOR and the display shows the

specification of the next point of measurement, whose coordinates correspond to the given step and direction along the profile. In this case the coordinate data of the points of measurement do not take up any space in the memory.

If the proper progress along the profile has to be interrupted either by omitting one or several points, or due to a change in the "step" or profile, the keyboard must be used to load the identifier of the next point of measurement. In this case the next identifier requires space in the memory store, i.e. that of one measurement. IF MANIPULATION IS INCORRECT, the display will show an error identifier and the instrument will automatically prevent:

a) The recording of the data in memory without previous initiation of the data memory or when the data memory is being used for recording spectra (see sections 10.3/10.6) - error E6.
b) The recording of the data without the measurement being made, or the same data being recorded twice - error E7.
c) The recording of data which were measured over a different sample period from the one set at the time the memory was initiated - error E8.
d) The recording of data obtained at a point whose location on profile exceeds the value N > 9999 or N < 0 - error E8.
e) Memory full - error E9.

Note: If the memory range is exceeded at the next point, error message d) is preceded by a warning. The measurement which was still within the memory range is stored. However, instead of the number of the next point along the profile, four hyphens are displayed. The [POS] procedure then has to be used to define the position of the next point of measurement.

7.4 How to Check for Remaining Capacity of Memory - FREE MEMORY

Pressing [STORE] again after data is stored in memory will give the error identifier E7 as well as the remaining memory capacity of the data memory.

7.5 Retrieval of Measured Data:

The data stored in memory can be displayed, loaded via RS-232 into an external computer, recorded on a cassette recorder or recorded from a cassette recorder. The data manipulation is commenced by pressing [SHIFT] [MEMORY] and the [Specifier] button which determines the number of the peripheral device and type of manipulation; the transfer itself is indicated by identifier <I/O>.

7.6 Display of Data Stored in Data Memory:

Press [SHIFT] [MEMORY] [0]

The display shows the location coordinates of the last point at which measurements were made and stored in memory:
e.g. L. 34. 960 (L=Down the Line: 34=Line #: 960=station #)

The [v] button is used to scan in turn the coordinates of the preceding points, whose measurements have been stored in memory. With the [v] button depressed, the scanning rate is about 3 points per second. The last to appear on the display is the sample header. Pushbutton [^] can be used to scan the memory in the opposite direction.

The scanning can be interrupted at any time, and pushbuttons [1 to 4] can be used to display the contents of the ROI for the selected data. If identifier <CONC> has been set, concentrations are displayed, otherwise the numbers of counts recorded during the sample period are shown. The [SHIFT] key is used to toggle the system from Count Rate to Concentrations and vice versa.

The scanning of memory can be terminated at any time by pressing the [START/STOP] button and control switches to MONITOR.

7.7 Transfer of Data in Memory via RS-232 to an external Computer:

First set the Baud Rate - see Section 10.8

Press [SHIFT] [REMOTE] to switch the instrument to external control and <RMT> is set on- see Section 13 on external control of the spectrometer.

From the external computer the sequence [SHIFT] [MEMORY] [5] is transmitted which then transfers data from the spectrometer via RS-232 to the computer. A sample program written in BASIC for an computer and/or an IBM-PC may be obtained from EXPLORANIUM.

N.B THE DATA TRANSFER COMMAND SEQUENCE CAN ONLY BE USED BY THE COMPUTER AND NOT FROM THE SPECTROMETER KEYBOARD.

7.8 To Position the Cassette Recorder to the end of a Record Specified by it's Header:

This function is convenient for finding the required place on the cassette automatically. e.g. If there are 5 blocks of data on tape with Headers of 111, 222, 333, 444, 555 then if the tape is not sitting at the end of Record 555 and more data is to be recorded then the following sequence may be used to position the tape correctly.

Unplug the REM jack. Rewind the cassette recorder to the start of tape by using REWIND. Press STOP, plug REM jack back in and press PLAY.

On the GR-256 ensure that the system is in MONITOR then press [SHIFT] [MEMORY] [6]. An H will appear on the display and the user must now enter the required Header e.g. 555 and then press [STORE].

The tape will now start to move and will halt when the end of the specified record is found.

7.9 Recording of Data Stored in Data Memory on a Cassette Recorder:

Prepare the cassette recorder for data recording by unplugging REM jack. Press REWIND until the cassette is at the start of tape, press STOP, plug REM jack in then press RECORD and PLAY controls simultaneously and set VOLUME to 5.

Ensure the required data is in the spectrometers memory, then press [SHIFT] [MEMORY] [7]. The letter H is now displayed on the left side of the display and the record Header is entered by the user - a maximum of 5 digits - e.g. 111 -which is also recorded on the cassette. The user then commences recording the data by depressing the [STORE] button. The recorder will now start (red LED on) and the tape will run. The GR-256 display shows 0IH and the Header.

The data are recorded on the cassette in blocks of 32 measurements. The recording time of one block is 9 seconds. The synchronization block (frequency 2.4 kHz) is transmitted first for a period of 10 seconds. This is followed by transmission of the data blocks, separated by a 2.4 kHz synchronization block of 2 seconds. The termination block, with a frequency of 1.2 kHz, is transmitted for 5 seconds after the last data block. This recording pattern also enables simple orientation along the tape by removing the EARPHONE jack and listening to changes in the audio tone. During data transmission, the left side of the display shows 01H and right-hand side the external header. The left side of the display increments as data is stored from 02H to a maximum E4H (equal to 124 blocks of data). A full record is transmitted into memory in 2 minutes 25 seconds, and the instrument is then switched to MONITOR. If all 64 spectra have been recorded then data transfer time is approx. 20 mins.

Data recording can be interrupted by means of the [START/STOP] button and the instrument switched to MONITOR. However, this pushbutton is only checked by the microprocessor after the transmission of each data block has been terminated so it is necessary to hold the key or press it repeatedly to ensure the system reads it.

Once data transmission is complete press STOP on the cassette recorder to switch the unit off.

7.10 Verification of Data Recorded on the Cassette:

Recorded data may be verified by playing it back into the spectrometer and comparing it to the original data still stored in memory.

Prepare the cassette for playback by pressing [STOP], then rewind the tape to just before the record of interest. If the user keeps track of the cassette footage counter it is relatively simple to locate a given record quickly. If footage is not recorded then an approximate guess is usually adequate as the system does not transfer its data until the CORRECT Header is located.

Press [SHIFT] [MEMORY] [8] - the display will show the letter H and the user is required to load the header of the data block to be tested. The [STORE] button is used to start the cassette. The record headers are shown in sequence on the instrument's display and, in this mode, the user is able to accelerate the location of the required data block by using the Fast Forward and Rewind buttons.
After the correct header is located, the data contents on tape are then transmitted to the spectrometer and compared with the data in the data memory. If there is no error in the record, control is switched to MONITOR, otherwise an error identifier is displayed - see Section 14. If an error occurs, repeat the above procedure and if the error is still there data must be recorded again. If the verification procedure fails again, the fault must be located in the cassette recorder or the connecting cable.

The [START/STOP] button can be used to interrupt the record check and switch to MONITOR.

7.11 Transmission of Data from Cassette to the Spectrometer:

Any data recorded on the cassette can be transmitted back to the spectrometer.

Press [SHIFT] [MEMORY] [9], the display shows letter H on the left side and the user loads the header of the required data sample e.g. 111. The cassette is prepared by removing REM jack, REWIND then STOP, insert REM jack, press PLAY. The [STORE] button is used to commence data transmission from cassette to spectrometer.

After the spectrometer has found the required sample on tape, the contents of the record are transmitted into the Working Memory of the spectrometer. If the data transmission was successful, control is switched to MONITOR once the transmission is terminated. If an error is discovered (disagreement of check sum) the display will show an error identifier - see Section 14.

The [START/STOP] button can be used to interrupt the data transfer at any time. The transfer of further measured data to the Data Memory may only be continued after running the POS procedure.

8. SPECTRUM MANIPULATION

After a measurement has been concluded, the spectrum is stored in the internal Working Memory of the instrument. This spectrum can be displayed on the instrument's display, on an external oscilloscope, plotted on a analog chart recorder, transmitted via RS-232 to an external computer or recorded on a cassette recorder.

The transmission of the spectrum is commenced by pressing pushbuttons [SHIFT] [SPECTR] and the [Specifier] button which determines the number of the peripheral device and type of manipulation; the transmission itself is indicated by the I/O arrow.

8.1 Output data to LCD display and external Oscilloscope

Press [SHIFT] [SPECTRUM] [0]. The left-hand side of the display will show the channel number and the right-hand side the number of counts in this channel. Both parts are separated by a full stop. If the external oscilloscope is connected to the analog output of the instrument, the whole spectrum can be observed. The channel numbers (i.e. energy) from 1 to 255 are displayed horizontally, and the corresponding channel contents (number of counts) are displayed vertically. The representation is linear in both directions. The spectrum is transmitted by the analog output in 10 mS with a pause of another 20 mS then repeated. The channel shown on the instrument display pulses on the oscilloscope. The oscilloscope is adjusted as follows:

1mS/Division - 0.5 V/Division
Trigger - Negative, Internal, D.C.

Pushbuttons [v]/[^] can be used to scan the channels. Channel 0 is used to store the sample period.

The vertical range of the spectral image on the oscilloscope can be controlled automatically or manually. The vertical scale of the display on the CRT is set automatically relative to the highest channel in the spectrum. In most cases this is the peak of the reference radionuclide. If weak peaks are to be observed, it may be necessary to increase the vertical sensitivity. This can be done by pressing [SHIFT] and [^], which multiplies the spectrum by a factor of 2. This can be repeated up to the range which corresponds to 256 counts per 2.5V. In this case, the contents of the channels whose values have exceeded the set range remain at maximum value, and do not optically disturb the scanning of the weak peaks. The spectrum vertical scale is divided by two if pushbuttons [SHIFT] and [v] are pressed.

The [START/STOP] button is used to terminate the display of the spectrum and to switch to MONITOR.

8.2 Plotting a Spectrum on an Analog Chart Recorder:

The analog output (Slow Analog) is connected to an external chart recorder. The recorder must be set to 2.5V FSD. The horizontal time scale of the recorder may be set as required by the user. The data is output at a rate of 1 channel/sec so a scale of 10 sec/cm is usually appropriate.

Press [SHIFT] [SPECTRUM] [1]. The full scale range is set automatically to contain the maximum channel amplitude. The range is then shown on the display and the analog output transmits the maximum value. The user sets the sensitivity of the plotter and after pressing the [STORE] button, the transmission of spectrum is begun at a rate of 1 channel per second, i.e. the whole spectrum is transmitted in about 250 seconds, and control is then switched to MONITOR. (This data transfer speed may be adjusted by Exploranium to suit specific recorders if required).

The transmission of the spectrum can be interrupted by pressing the [START/STOP] button and control is switched to MONITOR.

8.3 Processing of Spectra

This function enables the spectrum, stored in the Working Memory, to be processed. When a data sample is taken the entire spectrum for that sample period is stored in the Working Memory. Once the sample is in memory, an automatic processing calculation is carried out to allow R.O.I. window data to be viewed on the display. If the R.O.I.'s are changed then by pressing [SHIFT] [SPECTRUM] [2] the spectrum is reprocessed allowing the new R.O.I. data to be displayed using the same spectrum.

When a spectrum is input to Working Memory from a cassette recorder - see section 8.8 - is necessary to press [SHIFT] [SPECTRUM] [2] to process this data before viewing it on the display.

The end of processing is indicated by an audio signal. At the same time, 1- is displayed on the left side of the display and the Total Count activity on the right-hand side. If identifier <CONC> has been set, then the reading will be corrected for background and expressed in ppm U equiv. If the <CONC> arrow is NOT displayed, then the Total Count is shown as the number of counts recorded during the measurement in this energy window. The other R.O.I. can be viewed by pressing [^] [v].

8.4 Transmission of the spectrum via RS-232 into an external computer:

Set the Baud rate to (usually) 9600 - see section 10.8 and then press [SHIFT] [REMOTE] to switch the unit to the REMOTE mode - see Section 9. The sequence [SHIFT] [SPECTRUM] [5] from the computer then initiates data transmission from the GR-256 to the computer via RS-232. A BASIC program for transmitting the spectrum into an IBM PC may be obtained from Exploranium.

8.5 Positioning the Cassette Tape to the end of a File Specified by it's Header:

This procedure is used to position the tape to a particular position without recording any data. It is a similar function to Section 7.8 but is used when SPECTRA are recorded on tape. This function is convenient for finding the required place on the cassette automatically.

Prepare the cassette for use by unplugging the REM jack, press REWIND to rewind the tape, STOP to terminate rewind. Then insert REM jack and press PLAY. Then press [SHIFT] [SPECTRUM] [6] on the spectrometer. The display will show S and the user must input the header of the file required. Press [STORE] to commence the procedure.

The tape will now advance and stop at the end of the specified file - the system then switches to MONITOR.

8.6 Recording the spectrum on a Cassette Recorder

With a spectrum in Working Memory and the spectrometer in MONITOR press [SHIFT] [SPECTRUM] [7], the letter S appears on the left-hand side of the display and the user is required to load the external header of the spectrum, a maximum of 5 digits - e.g. 11111 - which is also recorded on the cassette. Set the cassette recorder for recording by unplugging REM jack and pressing REWIND then STOP. Insert the REM jack, ensure that Volume is at 5, zero the footage counter and press RECORD and PLAY simultaneously. Now press [STORE] to start the transmission of the spectrum to the cassette recorder.

The spectra are recorded on the cassette in two data blocks. A synchronization block with a frequency of 2.4 kHz is first transmitted for a period of 10 seconds. This is followed by the transmission of the 1st data block, a 2.4 kHz synchronization block for 2 seconds, the 2nd data block and finally the termination block with a frequency of 1.2 kHz for 5 seconds. This recording pattern enables orientation on the tape by removing the ear jack and listening to the data transmission. During the transmission, the display shows:
-1- on the left and the Header on the right.
After a few seconds the display changes to:
-2- and the Header which signifies that the second half of the spectrum is being recorded on tape. The whole spectrum is recorded on the cassette in 35 seconds and control is then switched to MONITOR. The transmission of the spectrum may be interrupted by the [START/STOP] button and control switched to MONITOR. However, this pushbutton is only tested after the transmission of each data block has been terminated.

If you have many spectra in memory (e.g. after a visit to the test pads), it is possible to record them all in one block as follows:

- Follow procedures in section 7.9
- When required to transmit this data back to the 256, follow procedure in section 7.11

- When display returns to monitor press - SHIFT - USER - 6 - N - STORE
  Where N = number of stored spectra plus 1
- All the original spectra may now be retrieved as normal

8.7 Data Verification of Spectral Data Recorded on the Cassette:

After a spectrum has been recorded on the cassette recorder, it can be checked for data errors. The tape in the cassette is rewound by means of the REWIND button (after REM jack is removed) to a point before the record to be checked, the REM jack inserted and the recorder switched to PLAY.

On pressing [SHIFT] [SPECTRUM] [8], the letter S appears on the display and the user is required to load the header of the spectrum to be tested - e.g. 11111. The [STORE] button is used to commence the playing of the cassette. The block headers are displayed in turn on the instrument display, and in this mode the user is able to accelerate the search for the spectrum to be checked by using the FAST FORWARD and REWIND buttons.

Pushbuttons [0 - 9] are controlled by transmitting the button designator (0 - 9) from the computer to the spectrometer. The other buttons have the following designators (the four highest bits are zeroed by the reading procedure of the spectrometer):

[v]	10
[^]	11
[START/STOP]	12
[STORE]	13
[SHIFT]	14
[CLEAR]	15

The spectrometer sends character "U" (ASCII - 85) to the external computer to acknowledge completion of the required function.
The communication protocol can be seen from the programs supplied on disk and listed in Appendix 'D'.

The [REMOTE] mode can be terminated from MONITOR by means of the [START/STOP] button on the spectrometer.

9.1 Transmission of the Spectrometer Display Contents to the Computer

If the spectrometer is controlled by an external computer (REMOTE mode) and if control is switched to MONITOR, then character "?" (ASCII - 63) transmitted via RS-232 to the spectrometer, will cause the contents of the display to be transmitted immediately via RS-232 to the computer (8 bytes). In this way the contents of the display can be transmitted to the computer at any time, decoded and, if necessary, the user can be informed of any error conditions.

10. USER PROGRAMS

Part of the program memory of the spectrometer is reserved for special user programs which Exploranium may produce at the user's request and load in the EPROM memory. As a matter of routine, this memory contains 10 special programs, some of which have a diagnostic character. These programs may be loaded into RAM from a cassette recorder but the standard set listed below are incorporated in the instruments EPROM.

ALL USER PROGRAMS CAN BE INITIATED ONLY WHEN THE SPECTROMETER IS IN THE MONITOR MODE.

By pressing the [SHIFT] and [USER] buttons, a hyphen will appear in the position of the second digit from the left on the display; this indicates that the user memory is in the instrument. Pushbuttons [0 - 9] can then be used to select the required user program. The execution of most of these programs is indicated on the left-hand side of the display by the number of the user program and a hyphen.

10.1 Program # 1 - GAIN

This program displays the current value of the gain set by the automatic digital stabilizer. Pushbuttons [0 - 9] and [CLEAR] can be used to set the gain to values of 0 to 255, and the [STORE] button to store it in the memory; then control is switched to MONITOR. The [START/STOP] button can be used to switch to MONITOR without changing the gain value.

Press [SHIFT] [USER] [1], the display will show 1- (User 1) on the left side and the gain setting on the right. A gain setting of below 50 or above 200 indicates the automatic gain system is nearing the end of its control range. See Section 12.5 if this is the case.

This program has a diagnostic character and can be used to test, for example, the correct functioning of the gain stabilizer.

10.2 Program # 2 - VOLTMETER

This program serves to measure the voltage of the battery after all power has been switched on, i.e. under full load. The measurement is carried out periodically each second. By holding the [START/STOP] button depressed for about 1 second this function can be terminated, and control switched to MONITOR.

Press [SHIFT] [USER] [2], the display shows 2- (User 2) on the left and the measured voltage on the right.
Should the voltage be in the range 5.5 - 6.5 V the sign <BAT> will be displayed. Should the voltage be lower than 5.5 V error message E2 (change batteries) will be displayed and the unit should be switched off.

10.3 Program # 3 - FETCH SPECTRUM

Before using this program, the user should first study the section on storing the spectra - Program 6 below.

Press [SHIFT] [USER] [5], the display shows 5- (User 5) on the left and the counts or concentrations on the right which is updated at the TIME sample rate.

Should the spectrometer be in the REMOTE mode, the contents of the 1st [ROI] (5 digits) is transmitted to the computer - the next measurement continues after receiving character "C" (ASCII - 67) from the computer. By holding the [START/STOP] button depressed for about 1 second, the program is terminated and control switched to MONITOR.

10.6 Program # 6 - STORE spectrum

The data memory of the spectrometer can also be used to store as many as 62 complete 256-channel spectra. To avoid overwriting data already in memory the memory must be erased by means of the HEADER function (Section 7.1) before this program is used.

The sequence [SHIFT] [USER] [6] [N] [STORE] can be used to store the measured spectrum in memory, N being the spectrum number N=1 - 62. After a spectrum has been stored using this procedure, the recording of other measurement results by the STORE function is inhibited. If the [STORE] button is pressed the data are not recorded and error identifier E8 appears on the display.

Once the spectrum has been stored control is automatically switched to MONITOR and the recorded spectrum number N will remain displayed in on the right-hand side of the display as a reminder.

A spectrum may be recalled from memory by User program # 3 above.

10.7 Program # 7 - TIME

This program reads and displays the period of measurement stored in the data memory by function HEADER - Section 7.1 - and switches control to MONITOR. This may be used to check that sample time is correct PRIOR to storing data. AFTER data has been stored this function is no longer operative.

Press [SHIFT] [USER] [7], the display shows sample period set into memory during Initiation

10.8 Program # 8 - BAUD RATE

This program is used to set the Baud rate of the RS-232 channel.

Press [SHIFT] [USER] [8], the display shows 8- (User 8) on the left and the current Baud rate will be displayed in the right. By depressing buttons [v]/[^] a Baud rate of 300, 600, 1200, 2400, 4800 and 9600 Baud can be selected. When [STORE] is pressed the new value of the Baud rate is stored in the spectrometer memory and control is switched to MONITOR. This function can be terminated without changing the Baud rate by pressing the [START/STOP] button and control is switched to MONITOR.

10.9 Program # 9 - ADC

This program is used exclusively for diagnostic purposes. The program serves to adjust the gain of the shaping amplifier and ADC of the spectrometer using a pulse generator.

The sequence [SHIFT] [USER] [9] commences measurement, the display shows 9- (User 9) on the left, the gain of the shaper amplifier in the middle and the number of the channel into which the impulse just being processed has been stored, on the right. The <v>/<v> buttons can be used to decrease/increase the gain. If any pushbutton (with the exception of [START/STOP]) is kept depressed the processing of further counts is blocked, allowing the user to see which channel the last pulse went into. Releasing the button causes the system to continue scanning.

The [START/STOP] button terminates the program and control is switched to MONITOR.

10.10 Program # 0 - EXECUTE

Exploranium has other special programs available on cassettes. These programs can be loaded into the memory of the spectrometer as follows.

Load the cassette containing the Test Programs (optional Exploranium Test cassette) in the recorder. Remove REM jack, REWIND the tape to the start and press STOP. Ensure that the spectrometer is in MONITOR, insert REM jack and press PLAY. Press [SHIFT] [MEMORY] [9], the display will show H(Header). Enter 11 as the Header for Test #1 and press [STORE], the tape will move and the record headers will appear on the display until the record with Header #11 is read into memory then control is switched to MONITOR. STOP the cassette recorder.

The sequence [SHIFT] [USER] [0] commences the execution of the loaded program. If the program has not been loaded, the attempt at execution is ignored and control is switched to MONITOR. [START/STOP] may be used to terminate the Tests.

11. QUANTITATIVE CALIBRATION OF SPECTROMETER

The spectrometer has been quantitatively calibrated by Exploranium, i.e. the limits of the ROI, the background and the calibration constants for computing the total activity, concentrations of K, U, and Th have been set - see Section 5.4. However, to maintain system accuracy the calibration should be checked twice a year by measuring at a calibration base and, if necessary, new calibration constants should be loaded into the spectrometer by means of functions ROI and CALIB or by use of the CALIBRATION program on an external computer.

The calibration of currently used four-channel spectrometers is time-consuming and laborious due to the search for the energy windows optimal for the measured radioactive elements prior to the actual quantitative calibration. This is not necessary in calibrating the 256-channel spectrometer - only the spectra of the standards and background are measured, from which the energy windows and calibration constants are determined by computer. The CAL256 program was produced for this purpose.

11.1 Measuring of Spectra on the Calibration Pads

a) Set the sample period to 300 secs by [SHIFT] [TIME] [300] [STORE]. It is preferable to measure for 500 seconds if time allows.

b) Erase the data memory of the spectrometer by [SHIFT] [HEADER] [CLEAR] [CLEAR] [CLEAR]. After 40 secs the memory space is shown i.e.3964. Press [STORE] [STORE] [STORE] then the <MON> indicator should come on

c) Measure the Test Pad spectra for the Radiation standards and background which are loaded into data memory by means of [SHIFT] [USER] [6] [N] where N is the number of the spectrum. In this way many calibration pad standards and background spectra can be stored in memory.

11.2 Processing of Calibration by the CAL 256 Program

This program has been written in BASIC for the IBM-PC - see Appendix D for further programs. The following description assumes use of an IBM-PC computer.

By inspecting the spectra in the neighborhood of the anticipated peaks, or by scanning them on the oscilloscope, their positions and the limits of the ROI can be determined. The position of the 1.46 MeV Potassium peak should be near Channel 122 and the recommended width of the energy window 15 channels (180 keV). The 1.76 MeV Uranium peak near Channel 146 and the recommended width 19 channels (228 keV). The 2.62 MeV Thorium peak near Channel 215 and the recommended width is 25 channels (300 keV). The determined limits of the ROI's are then loaded into the spectrometer by means of the ROI function - Section 5.

b) The spectra of the standards are again transmitted in turn by means of function USER - 3 from the Data Memory to the Working Memory, and the SPECTR function - Section 8 - used to determine the intensities in the individual energy windows. These values are then employed in the usual way to determine the calibration constants and interference (stripping) factors. The calibration constants C_1 to C_{14} calculated using the following relationships:

$C_1 = B(TOT)$ all data in Counts/Min
$C_2 = B(K)$
$C_3 = B(U)$
$C_4 = B(Th)$
$C_5 = 10^5/K_{TOT}$
$C_6 = 10^5/K_3$
$C_7 = -10^5 Y/K_3$
$C_8 = -10^5(B - aY)/K_3$
$C_9 = 0$
$C_{10} = 10^5/K_2$
$C_{11} = -10^5 a/K_2$
$C_{12} = 0$
$C_{13} = 0$
$C_{14} = 10^5/K_1$

B(TOT), B(K), B(U), B(Th) are the backgrounds in the 1st, 2nd, 3rd and 4th ROI in counts/min.

$K_{TOT} = [N_{1U}/T - B(TOT)]/Q_U$
$K_1 = [N_{4Th}/T - B(Th)]/Q_{Th}$
$K_2 = [N_{3U}/T - B(U)]Q_U$
$K_3 = [N_{2K}/T - B(K)]/Q_K$

Q_{Th} is the Th concentration in the Th standard [ppm]
Q_U is the U concentration in the U standard [ppm]
Q_K is the K concentration in the K standard [%]
N_{4Th} is the number of counts recorded in the 4th ROI on the Th standard in time T [min]
N_{3U} is the number of counts recorded in the 3rd ROI on the U standard in time T [min]
N_{2K} is the number of counts recorded in the 2nd ROI on the K standard in time T [min]
N_{1U} is the number of pulses recorded in the 1st ROI on the U standard in time T [min]

$a = N_{3Th}/N_{4Th}$ expresses the contribution of Th to the U ROI (N_{3Th} is the number of impulses recorded in the 3rd ROI on the Th standard)
$B = N_{2Th}/N_{4Th}$ expresses the contribution of Th to the K ROI (N_{2Th} is the number of impulses recorded in the 2nd ROI on the Th standard)
$Y = N_{2U}/N_{3U}$ expresses the contribution of U to the K ROI (N_{2U} is the number of impulses recorded in the 2nd energy window on the U standard)

Note: 1. The use of this method requires mono-element calibration standards. However, this condition cannot be satisfied practically and this results in inaccurate determination of the calibration constants.

2. This method neglects the U contribution to the Th energy window, i.e. it assumes constant $C_{13} = 0$. The result is that this leads to a systematic increase in the values of the Th concentrations. Under high concentrations of U this increase is about 3.5%.

12. SUPPLEMENTARY INFORMATION

12.1 Design of the Spectrometer

The block diagram of the detector and spectrometer is shown in Appendix G.

DETECTOR: The signal from the photomultiplier is fed to a charge sensitive pre-amplifier and then to a variable gain amplifier. The pre-amp gain is manually adjusted by Exploranium during manufacture to place the detector output signal within the range of the following electronics. This adjustment is made only when the crystal is changed otherwise the gain need not be changed. The photomultiplier is supplied from a stabilized HV source which has been adjusted by Exploranium.

SPECTROMETER: The signal from the detector is input to a circuit providing "pole-zero" compensation, a semi-Gaussian shaping amplifier

with time constant T = 1 us, a diode base line restoration circuit and an ADC. A Wilkinson's ramp circuit has been used to convert the analog radiation pulses to digital data which also performs dead-time correction. The digital data is then fed to the CPU board. This analog conversion technique is described in some of the recommended literature.

The heart of the processing unit is the microcomputer which controls the measurements and simultaneously corrects the gain of the shaping amplifier, thus performing spectrum stabilizer function. It also controls the data memory and the input/output circuits.

To conserve power mainly CMOS circuitry have been used.

12.2 Use of Spectrometer

The basic use of the instrument is for measuring naturally radioactive elements K, U, Th and the total radioactivity in the field. The method of measurement itself and the processing are not described in these instructions but can be found in currently available geophysical literature. Nor are the basic terms of gamma radiation spectrometry explained in these instructions. The recommended literature can be found in Section 12.

However, the spectrometer may also be used for other purposes e.g. in Environmental monitoring, in industrial applications, for laboratory analysis, core-logging etc. For these special applications Exploranium offers accessories to the spectrometer as well as single-purpose functions as outlined in Section 10. Exploranium may be willing to develop special interfaces for speciality projects in some cases.

For more flexible use of the spectrometer, Exploranium offers a laboratory probe in lead shielding which, in connection with the spectrometer and an or IBM-PC microcomputer, enables laboratory measurements of natural radioactivity to be made.

In general, the use of the spectrometer with other types of detection units than those supplied by Exploranium is not recommended. The GR-256 is designed for specialized use and it is not recommended that any other detection unit to be connected to it.

12.3 Use of a Cassette Recorder

The cassette recorder is used for temporary recording of measured data, or spectra, if the measured data cannot be transmitted directly from the Data Memory of the spectrometer to the processing system, e.g. desk calculator at the base, or if more than 62 complete spectra have to be stored.

For this purpose, Exploranium supplies a cassette recorder and a connecting cable as an option. The recorder has been modified by Exploranium for remote control of tape winding. The wiring of the interface cable is shown in Appendix F.
To achieve a reliable record, the principles of use as set out by Exploranium have to be adhered to - see the Operating Instructions for the cassette recorder.

If other recorders are used, care should be given to the following:

a) the polarity of the recording and sensed signal - the two signals are assumed to be of opposite polarity
b) the output and input signal level - it must be adjusted to agree with the data given in Section 2.
c) Remote control capability - tape transport control contact closure.

If the recorder does not operate reliably, Exploranium should be consulted.

12.4 Interface RS-232C

The GR-256 spectrometer can be connected directly to a computer by means of the RS-232 interface. The majority of currently used desk calculators or minicomputers have this capability.

To guarantee correct functioning, the interface of the selected computer should be adjusted according to the parameters given in Section 2, i.e. 8 data bits, no parity, 1 stop bit the correct baud rate -see Section 10.

The spectrometer and computer are connected by means of the cable (optional). There are two different configurations of cables, consult Exploranium for correct selection.

12.5 Adjusting the Gain of the Detector

If the detector is damaged, or the crystal has to be changed, the amplitude of the output signal must be adjusted to the required level - see Section 2. The following procedure is to be used:

1. Disconnect the probe cable and unscrew the top half of the detector by removing 4 screws.

2. Remove the top half of the detector being careful not to damage the interconnect cable.

3. Remove the detector carefully and pull the crystal and electronics from the cylindrical part of the housing.

4. Connect an oscilloscope to the output of the measuring probe (e.g. to the point that the output coax is soldered to.
5. Connect the cable to the spectrometer, switch on spectrometer and initiate a measurement.

6. By turning the multiturn trimmer on the amplifier PCB (middle PCB)in the probe, set the required gain (the amplitude of the impulses from the 662 KeV ^{137}Cs peak should be set to 0.5 V),

7. Set REFCH to Channel 55, carry out a measurement. Use function USER 1 (section 10.1) to determine the value of the actual gain.

8. Set this Gain value to 127 +/- 10 by fine-adjusting the trimmer and repeating 6. above.

9. Switch the instrument off, disconnect the probe and re-assemble.

12.6 Maintenance and Repairs

Under normal operational conditions the spectrometer requires no special maintenance. It should only be kept clean, especially the measuring probe, and heat and mechanical shocks, which are a danger to the crystal in the measuring probe, should be avoided. It is recommended that the contacts in the battery compartment should be checked if they are clean regularly, and that dead batteries should be removed from the instrument when the spectrometer is not being used. The electrolyte from the batteries may damage the contacts of the battery holder, or it may become impossible to remove a swollen battery from the battery compartment.

Due to the complexity of the instrument, the electronics should on no account be tampered with. Apart from setting the probe gain (Section 12.5) no circuit inside the spectrometer need be adjusted.

If the instrument fails or is functioning improperly, Exploranium or its distributor should be contacted. A high standard of servicing the instrument is required.

12.7 Storage and Transportation

The packed instrument can be stored and transported at temperatures of -30 to +70 C and relative humidity up to 90%.

NOTE: The instrument should be stored or transported with the batteries removed.

12.8 Warranty

All information relating to warranty is given in the Warranty Certificate - Appendix H.

12.9 Recommended Literature

[1] Adams J., Gasparini P.: Gamma Ray Spectrometry of Rocks. Elsevier Publishing Co., 1970.

[2] Siegbahn K.: Alpha, Beta and Gamma Ray Spectroscopy.
North Holland Publishing Co., 1968.
[3] Knoll: Nuclear Electronics.

[4] Hansen D.A.: Geological Applications Manual for Portable Gamma Ray Spectrometers. Geometrics company brochure, Toronto, 1975.

[5] Lovborg L.: The Calibration of Portable and Airborne Gamma Ray Spectrometers - Theory, Problems and Facilities.
Riso National Laboratory, Roskilde, 1984.

APPENDIX A

BRIEF DESCRIPTION OF THE SPECTROMETER CONTROL FUNCTIONS

a) To interrupt all ongoing activities and switch to MONITOR

STOP

FOR ALL THE FUNCTIONS DESCRIBED BELOW IT IS ASSUMED THAT THE SPECTROMETER IS IN THE **MONITOR** MODE, WHICH IS INDICATED BY <MON>.

b) Check of sample time:

SHIFT TIME STOP

c) Setting Sample Period (e.g. 120 s):

SHIFT TIME 1 2 0 STORE

d) Check of R.O.I. limits:

SHIFT ROI ^ ^ etc. STOP

e) Setting of R.O.I. limits:
(e.g. CHN 1 - LOWER =70 UPPER = 255, etc.)

SHIFT ROI 7 0 STORE 2 5 5

STORE etc. STOP

f) Check of calibration constants:

SHIFT CALIB ^ ^ etc. STOP

g) Setting of calibration constants (1 - 252, 2 - 23, 3 - etc.):

SHIFT CALIB 2 5 2 STORE 2 3

STORE etc. STOP

h) Check of reference peak setting:

SHIFT REFCH STOP

i) Setting of reference peak position (e.g.30):

SHIFT REFCH 3 0 STORE

j) Switching <u>off</u> the spectrum stabilizer:

SHIFT REFCH 0 STORE

k) Change display of measurement results from counts/time period to Concentrations and vice versa:

SHIFT CONC

l) Initiation of data memory - for manual sample storage:

Typical Data: Date - 06/14/89
Step along profile - 5 meters (Max. 99)
Line (profile) number - 34 (max. 999)
First point on profile - 980 (max. 9999)
Direction of measurement - change of direction

(1) Clear Existing Data From Memory

SHIFT HEADER CLEAR CLEAR CLEAR

---

n) Initiation of data memory - for calibration spectra storage:

(a) Clear entry data:

SHIFT HEADER CLEAR CLEAR CLEAR

(b) Press: STORE STORE STORE

The <MON> indicator should now be on to indicate that Initiation is complete.

o) To store a Spectrum in Memory

SHIFT USER 6 1 STORE

APPENDIX B

REVIEW OF ERROR MESSAGES

ERROR IDENTIFIER	TYPE OF ERROR	WHAT TO DO NEXT
E1	Data in data memory damaged probably due to faulty lithium battery Automatic setting of default parameters executed - see Section 5	Measurements may be con tinued without using Data Memory. Change Lithium battery by Exploranium
E2	Voltage of main batteries has dropped below 5.5V	Measurements cannot be continued Change batteries
E3	The Spectrum Stabilizer is unable to adjust the gain to the required energy calibration	Check setting of REF Ch Adjust probe gain according to section 12.5
E4 a)	In manipulating spectra data no spectrum found in Working Memory	Take a new sample
b)	Faulty probe or connecting cable during measurement	Check probe connection Repair probe
E5	Data memory store found to be defective	Measurements may be continued without using Data Memory. Repair by Exploranium
E6	Data memory has not been initiated	Initiate by means of function [HEADER]

E7	a) Measurement has not been carried out b) Attempt to store the same measurement twice	Continue with measurement
E8	a) Attempt to record measurement with identifier outside permitted range	Measurements must be made on profile with points numbered from 0 to 9999
	b) Attempt to record measurement whose time does not agree with time of measurement at instant of memory initiation	Measurement must be carried out over period set prior to recorder initiation See USER - 7 to check time of measurement
E9	Data memory full, no further measurement results can be recorded	Empty data memory by transfer to a computer or cassette recorder; follow by initiation
E10	Attempt to transmit from Data Memory in which no measurement has been recorded	Carry out measurement and store in Data Memory
E11	Data transmitted from cassette do not agree with data stored in memory	Repeat transmission and also recording if necessary
E12	Incorrect check sum of tested block	Repeat transmission and also recording if necessary

E13	"Drop-out" on cassette tape Data still transmitted correctly	This error indicates worn cassette. Change cassette
E20	Digital voltmeter does not operate	Repair by Exploranium
E21	The reference peak position cannot be determined due to channel overflow	To determine energy resolution capability, cut period of measurement under 500 s.

APPENDIX C

TEST PAD CALIBRATION OF GR-256 SPECTROMETER

At Test Pads

At the test pads it is normal practice to accumulate data for as long a period as possible. We recommend 5 minutes as being a good compromise between efficiency and poor statistics.

a) Set time of measurement - for example 300 secs.
SHIFT-TIME-3-0-0-STORE.

b) Clear Memory - SHIFT-HEADER-CLEAR-CLEAR-CLEAR.
0 will flash, after 40 secs display will show H-3964.

c) Enter on appropriate header (e.g. Date - 5 Nov. 1987).
Press 5-1-1-8-7-STORE.

d) Display shows SOL-XXX where X is an arbitrary number.
Press STORE-STORE. MON flag should now be on. Press CLEAR to revert to MONITOR.

The spectrometer now has an empty memory. Go to test pad #1 and accumulate a spectra with the spectrum stabilization set for Cesium at Channel 55.

Store spectra as required - for this example lets use Spectrum #1 = K, Spectrum #2 = U, Spectrum #3 = Th, Spectrum #4 = Background.

In the Office

Need an IBM-PC or equivalent. System needs 1 disk drive, 256K of memory and a printer.

1. Load DOS, BASIC and then CAL256 Program. Press"RUN".
   CRT says "Calibration of the GR-256 Spectrometer
   Set 9600 BAUD rate on GR-256 (User 8)
   Set Remote - Press enter when done"
   On GR-256 press SHIFT--USER-8, then the arrow key to set to 9600 BAUD - press STORE.
   Press SHIFT-REMOTE (Remote Flag should now be on).

---

2. CRT asks Serial Number - XXXX. Enter the Serial Number (must be in the range of 150-1600), press ENTER when done.

3. CRT asks "Calibrated by" - enter name of the operator, press ENTER.

4. Enter the time period of measurement, - for example 300 secs. Enter 3-0-0-ENTER.

   N.B. The time of the measurement must be the same as was recorded on the test pads, otherwise the program will abort.

5. CRT shows "Standard K - Spectrum #?" Enter the spectrum # for the Potassium data, for example 1, press ENTER. CRT then asks for the test pad data to be entered in the format K in %, U in ppm, Th in ppm.

Thus for the G.S.C. Pads = 3.16, .24, 1.23 - ENTER.
The computer will now load and display the specified spectra and highlight its peak as a visual check that the correct spectrum has been loaded. At PAUSE? request on the CRT, press ENTER and then the U spectrum number - for example 2 - and the data (G.S.C. pads = 0.39, 42.6, .79) is entered.

This peak is then read, processed and displayed. At PAUSE?, enter the Thorium spectrum number - for example 3 and data (G.S.C. = 0.24, 3.86, 79.8) then press ENTER. After processing this spectra then at the next pause pressing ENTER will bring the message "Any more test pads Y or N?" - usually you enter No (N for No) - then ENTER. The background spectra number is then requested, for example, number 4. After the display of the background spectra, at the next PAUSE?, press ENTER and the display shows "Under Evaluation", then the CRT and printer list the calibration data.

The next query "Do you want to store CAL data on disk - Y or N?" - answer as required. After this the CRT asks "Do you want to calibrate the GR-256 - Y or N?". If you answer "Y" to this then the data will be transferred to the GR-256 and the four ROI's, #1, #2, #3 and #4 window width and positions will be set, as well as all 14 of the calibration constants. The program will then terminate and display END on the CRT.

Checking

Since the spectra will still be in memory, it is good procedure to verify that the matrix calculations and conversion constants are accurate. To do this proceed as follows:

a) Bring the Potassium spectrum back to the working memory (for example spectrum 1) as follows: SHIFT-USER-3-N-STORE where N is the spectrum number of interest, in this case, it would be 1. This brings the Potassium spectrum into the working memory. Pressing SHIFT-SPECTRUM-2 forces the spectrum in the working memory to be reprocessed and displayed on the front panel.

b) If SHIFT is now pressed to revert to the concentrations mode by stepping through the data and comparing it to the original test pad data a check of system performance can be verified. This should then be repeated for the Uranium and Thorium spectra to ensure correct data analysis.

APPENDIX D
PROGRAMS SUPPLIED FOR IBM-PC AND COMPATIBLES

All programs are written in uncompiled GWBASIC. Hardware requirements are an IBM-PC or compatible with one disk-drive, 256K memory, and an Epson MX-100 Printer. Users will need a copy of GWBASIC (or similar) to sun these programs.

All programs are self explanatory using CRT prompts. All following programs require the RS-232 cable for the IBM-PC.

1. DAT256 - Used to retrieve ROI data from GR-256 memory and display on screen and printer.

2. CAL256 - Used to calibrate the system using test pad spectrum in memory - see Appendix C.

3. CALNOP - Same as CAL 256 but does not require printer.

4. USER 5 - Used to run the GR-256 in the automatic mode and retrieve and display on the CRT the ROI number 1 data. Time periods are set by TIME function.

5. SPE257 - Retrieve spectrum from the GR-256 working memory to the CRT, plot on CRT, can save spectrum to disk.

6. R257LIN - Reads a spectrum stored on disk by the SPE257 program and displays it on the CRT as a LINEAR plot.

7. R257LOG - Reads a spectrum stored on disk by the SPE257 and displays it on the CRT as a LOG plot.

8. SPEHC - Reads a spectrum from the working memory of the GR-256, displays on the CRT, allows you to enter any ROI you want by channel number, highlights selected ROIs on the CRT and allows plotting of the complete spectrum on the printer.

9. DEMO1 - Demo of the features of the GR-256.

APPENDIX E

RECHARGEABLE BATTERY OPERATION

The unit as shipped from the factory is set for use of regular batteries. If Rechargeable Batteries are used which require charging IN the unit, please make the following adjustments:

-Remove screws which hold front panel to the instrument case.

-Carefully remove the instrument.

-On the rear of the Mother/Display board there is a small RED switch with both switches set in the OPEN position.

-Switch both to the opposite position.

-Carefully remount the electronics in the case taking care not to damage or compress the power wiring.

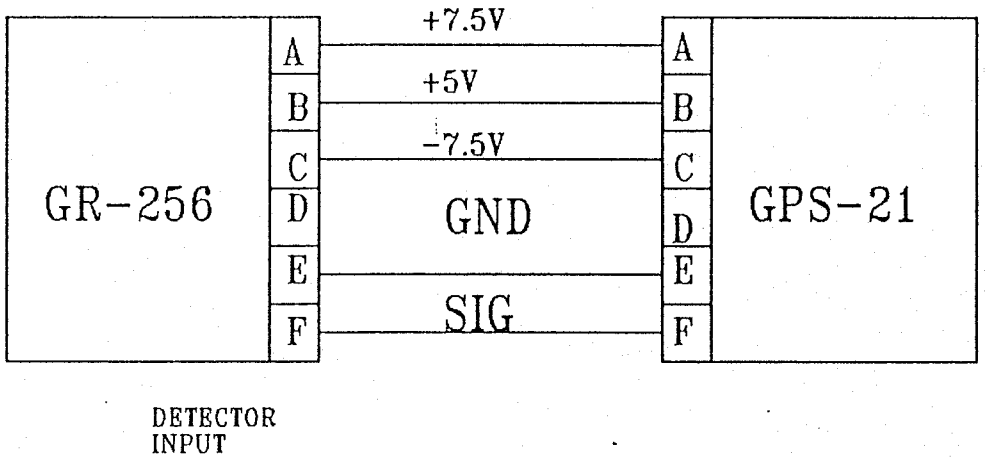
-Mount rechargeable batteries in the unit and charge them via front panel I/0 connector (10 pin) with PIN K being (+) and PIN H being (-).

N.B. IN THIS MODE - IF NORMAL BATTERIES ARE PLACED IN THE UNIT AND EXTERNAL POWER APPLIED, SERIOUS DAMAGE WILL OCCUR AND THE WARRANTY IS VOIDED.

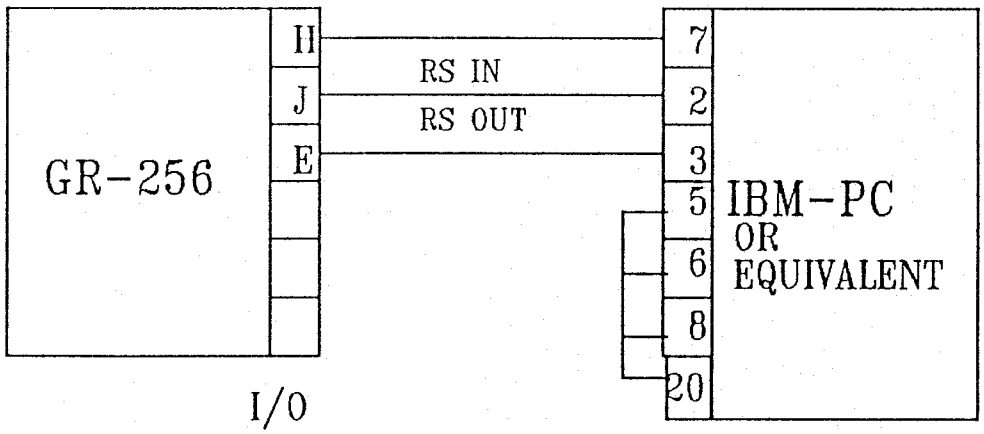
APPENDIX F

CABLE CONNECTIONS

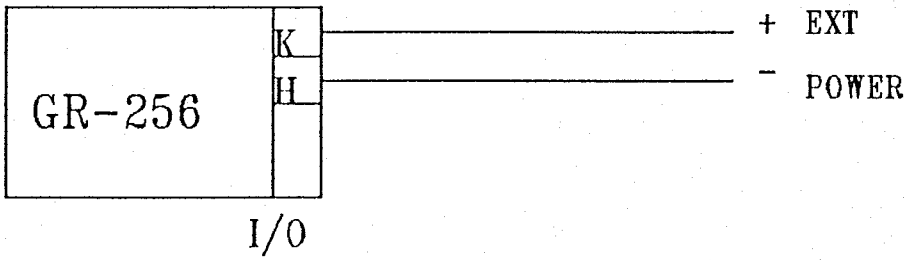
1. SPECTROMETER to DETECTOR



2. RS-232 CONNECTIONS to IBM-PC COMPUTER



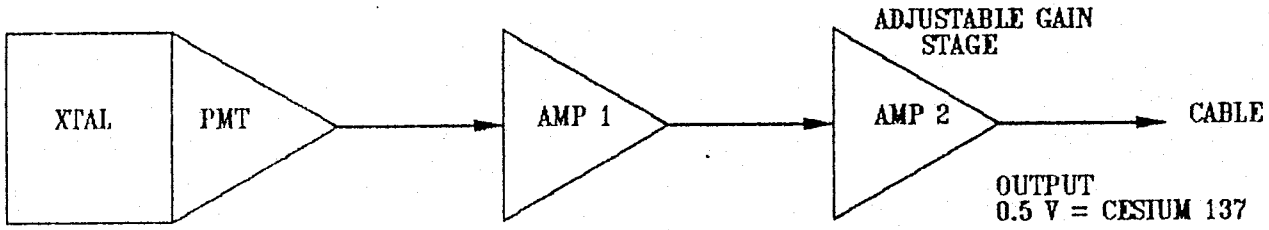
3. EXTERNAL POWER



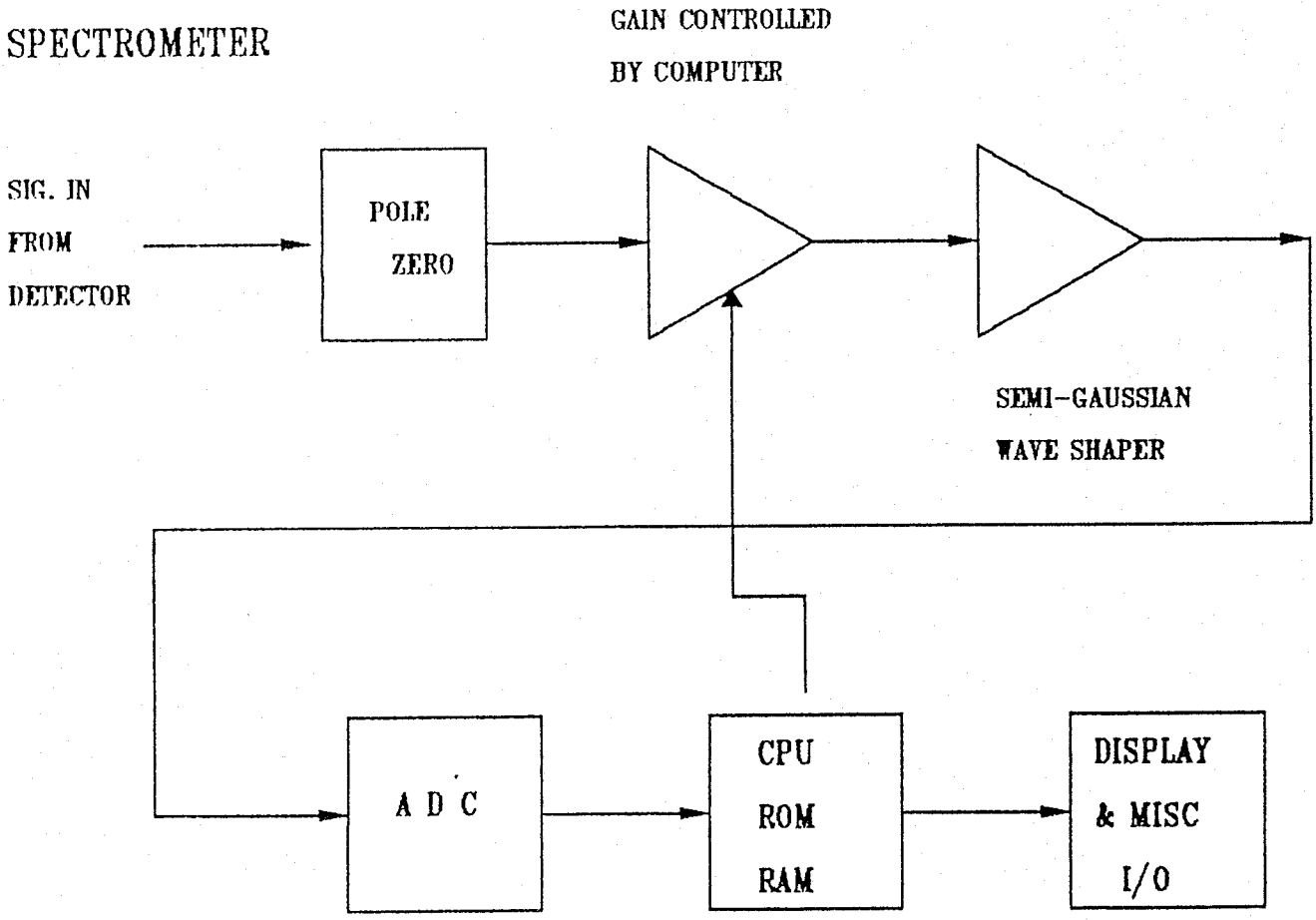
APPENDIX G

SYSTEM BLOCK DIAGRAM

DETECTOR



SPECTROMETER



APPENDIX H

WARRANTY

EXPLORANIUM FULLY WARRANTS ITS RADIATION INSTRUMENTS AND PARTS OF ITS MANUFACTURE TO BE FREE OF DEFECTS IN MATERIAL AND WORKMANSHIP, FOR A PERIOD OF ONE YEAR FROM DATE OF ACCEPTANCE - BUT NOT LONGER THAN 15 MONTHS FROM THE DATE OF SHIPMENT FROM THE FACTORY. THIS WARRANTY DOES NOT APPLY TO SODIUM IODIDE DETECTORS WHICH HAVE A SPECIAL WARRANTY PROVISION - SEE BELOW.

ALL WARRANTY REPAIRS ARE FREE OF CHARGE FOR PARTS/MATERIALS, FOB TORONTO, ONTARIO. ALL BROKERAGE CHARGES FOR IMPORTATION/EXPORT OF WARRANTY REPAIR GOODS WILL BE FOR CUSTOMERS ACCOUNT.

IT IS SOMETIMES POSSIBLE FOR A LOCAL REPAIR AGENCY TO PERFORM WARRANTY REPAIR BUT THESE COSTS WILL NOT BE PAID BY EXPLORANIUM UNLESS PRIOR AUTHORIZATION IS RECEIVED.

DETECTOR WARRANTY

EVERY EFFORT HAS BEEN MADE TO RUGGEDIZE AND PROTECT THE SODIUM IODIDE GAMMA RAY DETECTOR ASSEMBLIES FOR THEIR INTENDED USE. DUE TO THE FRAGILE NATURE OF THE CRYSTAL DETECTOR ASSEMBLY, AND DIFFICULT OPERATING ENVIRONMENTS, EXPLORANIUM'S WARRANTY DOES NOT INCLUDE BREAKAGE OF THE CRYSTAL FOR ANY REASON. EXPLORANIUM HOWEVER DOES WARRANT THE DETECTORS TO BE COMPLETE AND FULLY OPERATIONAL TO THEIR PUBLISHED SPECIFICATIONS AT THE TIME OF DELIVERY AND TO MAINTAIN THE STATED MINIMUM RESOLUTION AND PERFORMANCE FOR A PERIOD OF ONE YEAR UNDER NORMAL OPERATING CONDITIONS.