BASCOM-TURNER

INSTRUMENTS

GAS-SENTRY® DETECTORS

OPERATION MANUAL
GAS-SENTRY DETECTORS
CGA-411 AND CGA-412

COMBINED METHANE, CARBON MONOXIDE/ HYDROGEN SULFIDE, AND OXYGEN DETECTORS

Part Number OM-0100

LIMITED WARRANTY

Bascom-Turner Instruments warrants Gas-Sentry Detectors to be free from defects in materials and workmanship for one year following the date of shipment. Sensors are warranted for three years and the electronics for five years following the date of shipment. This warranty is limited to the original purchaser of the Detector and is not transferable except by Bascom-Turner's authorized Distributors.

During the warranty period, we will repair or replace, at our option, any defective products or parts at no additional charge, provided the Detector is returned with hose and water block filter, shipping prepaid to Bascom-Turner Instruments. A return merchandise authorization (RMA) number must be assigned prior to returning the product. All replaced part and products become the property of Bascom-Turner Instruments.

This warranty does NOT extend to any Detectors which have been damaged as a result of accident, abuse, modification, misuse such as failure to follow the operating instructions or other contingencies beyond our control. No other warranty is expressed or implied. Bascom-Turner is not liable for consequential damages.

CAUTION

Personnel who operate, calibrate, or repair this instrument must first read and fully understand this manual in its entirety.

CAUTION

For use in Class I, Division 1, Groups A, B, C, D atmospheres.

This product has not been tested for intrinsic safety in oxygen enriched atmospheres.

Change batteries only in areas known to have non-hazardous atmospheres.

CAUTION

Instruments should always be stored with a full complement of batteries.

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FEATURES

The Gas-Sentry® portable, combined methane, carbon monoxide/hydrogen sulfide, and oxygen detectors are intrinsically safe, microprocessor based instruments designed to test ambient air over a wide temperature range.

These detectors have many features for easy and reliable operation:

- **Continuous Four-Gas Monitoring**

Methane, carbon monoxide, hydrogen sulfide, and oxygen

- **Measurements Over the Full Range of Natural Gas**

The instrument detects methane over the full range (0-100%) of concentration

- **TRACK GAS Scale**

A sensitive scale with quick response makes it easy to find gas leaks

- **Automatic Calibration**

Calibration is performed automatically using Bascom-Turner's calibration gas

- **Automatic Sampling**

An intrinsically safe pump automatically samples ambient air or flue gas

- **Automatic Self-Tests**

Automatic checks of battery, sensors, pump. Tests for blockage and for tight connections from probe to instrument

- **Automatic Zero**

Automatic zero adjustment without knobs to turn

- **Audible and Visual Alarms**

Audible and visual alarms for each gas

- **Easy-to-Read, Bright Display**

A bright, high efficiency LED display is easy to read indoors or outdoors

- **A Water-Block and Dust Filter**

A special Teflon® filter keeps dust and water out

- **A Tough, Light-Weight Package**

Housed in high impact ABS, the instrument weighs only 20 ounces

- **Carryall**

Leatherette carryall with shoulder strap for hand-free portability

1. THE GAS-SENTRY CGA-411 AND CGA-412 DETECTORS

The CGA-411 and CGA-412 detectors monitor continuously natural gas (methane), carbon monoxide and hydrogen sulfide, and oxygen, and display the concentration of a particular gas selected by a front panel switch and alarm acoustically and visually if any of the monitored gases exceed preset limits. These detectors may be used to:

* test the atmosphere of an enclosed space prior to entry and monitor it after entry
* test ambient air for natural gas
* bar hole
* locate and track gas leaks in pipes and other conduits
* test for carbon monoxide and hydrogen sulfide in ambient air
* test for carbon monoxide in flue gas and other gases given off by appliances

Displays for the CGA-411 and CGA-412 detectors are selected by a front panel switch. They include:

% GAS - Displays the concentration of methane in air in percent by volume

PPM CO - Displays the concentration of carbon monoxide in parts per million (ppm) by volume; this display also shows the detector response to hydrogen sulfide

% OXYGEN - Displays the concentration of oxygen in volume percent

In addition, the TRACK GAS scale may be selected by the front panel switch. This scale operates as follows:

TRACK GAS - Detects and displays the concentration of natural gas (methane) and operates a beeper for locating a gas leak.

The gas concentration on the TRACK GAS scale is displayed as:

Model CGA-411 Display is % LEL
Model CGA-412 Display is % GAS

This is the **only** difference between Models CGA-411 and CGA-412.

Alarms

The CGA-411 and CGA-412 detectors alert the user acoustically (with a sound alarm or beeper) and visually (by "flashing" on the display the appropriate symbol) whenever the concentration of a detected gas rises above or falls below a preset limit. The alarm limits can be set by the user as described later in this manual.

2. SPECIFICATIONS

Gases Detected	Natural Gas (Methane) Carbon Monoxide (CO) Hydrogen Sulfide (H_2S) Oxygen (O_2)	
Sensors	Catalytic Combustion (CH_4) Thermal Conductivity (CH_4) Electrochemical (CO and H_2S) Electrochemical (O_2)	
Ranges		
% GAS	0 to 100% by volume of methane Steps of 0.05% up to 4.0% Steps of 1% from 4 to 100%	
% LEL	0 to 100% (Model CGA-411)	
PPM CO	0 to 9999 ppm carbon monoxide in steps of 1 ppm	
PPM H_2S	0 to 1000 ppm of hydrogen sulfide	
% Oxygen	0 to 40% by volume in steps of 0.1%	
Accuracy (5^o to 45^oC)	GAS	±0.1% from 0 to 4% ±2% from 4% to 100%
	LEL	±2% from 0 to 100%
	CO	±5% of reading, ±5 ppm (±10% from 1000 ppm to 9999 ppm)
	O_2	±5% of reading for % oxygen

Lower Limit of Detection	0.03% GAS, 1 ppm CO
Warm-Up Time	30 seconds
Operating Temperature (with fresh batteries)	-25^oC to 55^oC (-10^oF to 130^oF)
Storage Temperature	-40^oC to 60^oC (-40^oF to 140^oF)
Continuous Operating Time per Battery Set	12 hours (25^oC), typical
Humidity	0 to 98% RH (non-condensing)
Power Supply	Four AA Alkaline (1.5V Type AM-3) or Four AA Ni/Cd Rechargeable (1.25V, 0.850 Ah)
Dimensions and Instrument	Height 7.25" (18.4 cm) Width 3.62" (9.2 cm) Depth 1.70" (4.6 cm)
Weight	Weight 20 ounces (570 g)

3. OPERATION

A. Overview of Essential Operating Practice

Gas-Sentry detectors are easy to use. However, a few general rules **must** be followed to insure reliability and accuracy.

Pump. Gas-Sentry detectors have a built-in pump and depend on this pump for their operation. If the pump is not functioning normally, the instrument will not function properly. It is therefore essential to check the pump each time the instrument is first turned on.

Pump Test: Connect the probe you plan to use and select any display. When the display shows a number, normally zero, block the probe tip with your finger until the display shows *"bloc"*.

If "bloc" does not appear, there may be a leak along the probe. Tighten all connections and repeat the test. If a block condition is still not observed, remove the hose and block the inlet to the instrument. If "bloc" still does not appear, return the instrument to the factory for repair.

WARNING:	**The instrument should never be used when *"bloc"* fails to appear upon blocking the inlet**

Filters. Dust and water-block filters protect the sensors and the pump from dust and accidental intake of liquid water. Just as a car would not be operated without air and fuel filters, do **not** operate a Gas-Sentry detector without a filter on the hose. Operation without this filter will eventually degrade the pump; it also voids the limited warranty.

From time to time, examine the filter on the hose. If loose dirt has accumulated, shake it out. Do **not** poke at the filter with a tool or any other implement which may puncture it. If the filter is substantially discolored by dirt, replace it.

Zero Check. All sensors drift to some extent over time. Sensor drift is corrected by using the AUTO ZERO position (see Section 6). Zeroing takes about 30 seconds and is normally required no more frequently than once a day. It is important that the zero adjustment be done in clean air, for example, outdoors. If the sampled gas is not clean, a systematic error will be introduced in subsequent measurements.

Test and Calibration. Gas-Sentry detectors must be checked and calibrated periodically with gas of known composition. The catalytic combustion and carbon monoxide sensors depend on catalysts which may loose activity or get poisoned during use. When this happens, there will be diminished response to gas or CO.

The necessary frequency of calibration depends on actual use and on the concentration of catalyst poisons in the sampled gas. This concentration is, or course, not generally known.

A detector can be tested with "bump" gas. Such tests only verify that the gas sensor(s) are in operating condition; to adjust their sensitivity they must be calibrated.

A detector can be automatically calibrated in less than one minute using Bascom-Turner's calibration gas (2.5% methane and 100 ppm CO in air). Given the ease and speed of automatic calibration, it pays to calibrate as frequently as possible, and certainly, no less than monthly. Calibration with pure gas (methane) is generally not required more frequently than once a year unless the composition of the system gas is known (or suspected) to have changed significantly.

Accuracy. A properly operating and calibrated detector will respond to gas, CO, H_2S, and oxygen with the specified accuracy. If combustible gases other than the gas used for calibration are likely or suspected, the instrument **cannot** be relied upon to give a proper indication of their concentration and hence of how close to their combustible limits they may be. For example, the detector responds quite differently to gasoline, methane, and propane. Accordingly, readings of % GAS refer only to the calibration gas and can be relied upon only in this respect in assessing an atmosphere sampled by the detector. Furthermore, concentrations displayed by the detector refer to a local sample at the tip of the probe. Low gas concentrations at one place do **not** necessarily mean that the gas concentration is low throughout a much wider area.

WARNING:	**The detector responds to the four gases for which it was designed. Other toxic or dangerous gases are not detected or monitored.**

B. Operational Description

To conserve the batteries, the switch should be in the OFF position when the detector is not in use. A display can be selected in any order from any position of the switch. When a display is selected from the OFF position, the detector requires about thirty seconds for warm-up. During this period, the display shows sequentially a single dot (when the microprocessor becomes operational) followed by two dots while the on-board memory is tested, and by the symbol for the selected display (*"GAS", "CO", "O2"*). After warm-up is complete, the display shows readings for the appropriate gas.

All detected gases are monitored at any setting of the selector switch. The selector switch merely determines the gas whose concentration is displayed.

To Display Gas with the "% GAS" Display. Connect an appropriate probe to the dust and water-block filter and set the selector switch to "% GAS". After warm-up, the display shows the concentration of gas (methane) in air in percent by volume. If the air is clean (contains no methane), the display should read zero. If it does not, switch to "AUTO ZERO". After automatic adjustment of zero is complete (the display shows *"End"),* return the switch to the "% GAS" position.

* The % GAS display spans the whole range of methane (0 to 100%) with the following sensitivities:

Readings from 0 to 4.0%	-	Steps of 0.05%
Readings from 4.0 to 100%	-	Steps of 1.0%

To Display Carbon Monoxide with the "PPM CO" Display. Connect an appropriate probe to the dust and water-block filter and set the selector switch to "PPM CO". After warm-up, the display shows the concentration of CO in parts per million (ppm) by volume. If the air is clean (contains no carbon monoxide), the display should read zero. If it does not, switch to "AUTO ZERO", wait until the display shows *"End",* and return the switch to the PPM CO position.

* The "PPM CO" display spans the range 0 to 9999 ppm with a resolution of 1 ppm.
* The "PPM CO" display also displays hydrogen sulfide as described in Section 4.

To Display Oxygen with the "% Oxygen" Display. Connect an appropriate probe to the dust and water-block filter and set the selector switch to "% Oxygen". After warm-up, the display shows the ambient concentration of oxygen in percent by volume. If ordinary air is being sampled, the display should read 20.9 ±0.2. If it does not, switch to "AUTO ZERO", wait until the display shows *"End",* and return the switch to the "% Oxygen" position.

* The "% Oxygen" display spans the range 0 to 40.0% with a resolution of 0.1%.

C. Alarms

A detector alerts the user acoustically, with a sound alarm or beeper, and visually by "flashing" the symbol(s) for the detected gas(es) whose concentration exceeds preset limits. Visual alarms are displayed in-between readings for the particular display in use. For example, if the display is showing readings for natural gas (switch at "% GAS") and the concentration of CO rises above its alarm limit, the display will flash *"CO"*, approximately every two seconds, in-between displays of the concentration of natural gas. If the concentration of natural gas also rises above its alarm limit, the display will show a reading, then *"GAS"*, then a reading, then *"CO"*, and so on. Simultaneously, the acoustic alarm will be on.

Visual alarm symbols are *"GAS"* for natural gas, *"CO"* for carbon monoxide, *"LoO2"* for low oxygen, and *"HiO2"* for high oxygen.

If a particular display is used to show concentration levels expected to be regularly above the alarm limit, for example, the % GAS display when bar holing, the alarm for natural gas on this display may be turned off. Similarly, if flue gas testing is done on a regular basis, the alarm for CO on the PPM CO display may be turned off**. Alarms on the % Oxygen display cannot be turned off** since this display is used for monitoring ambient air.

If the alarm for a display (% GAS or PPM CO) is turned off, alarms for other detected gases (CO and oxygen in the case of % GAS, and natural gas and oxygen in the case of PPM CO) will still be given if these gases exceed their alarm limits. However, the alarm frequency is reduced (once every 15 seconds) to minimize interference with readings.

Alarms for the % GAS Display. The alarm for the % GAS display may be set ON or OFF. If ON, the alarm concentration may be up to 1.0% methane (20% LEL), but no higher. **Factory set alarm is ON with an alarm limit of 1.0% methane (20% LEL).** The alarm for carbon monoxide may be selected by the user, or, if the alarm for CO is OFF, a default value of 200 ppm is used. Alarms for oxygen are 19.5% (LoO2) and 23.0% (HiO2)

Alarms for the PPM CO Display. The alarm for the PPM CO display may be ON or OFF. If ON, the alarm concentration may be up to 200 ppm CO. **Factory set alarm is ON with an alarm limit of 200 ppm CO**. The alarm for methane is the same as for the % GAS display, or, if the alarm for % GAS is OFF, a default value of 1.0% (20% LEL) methane is used. Alarms for oxygen are 19.5% (LoO2) and 23.0% (HiO2).

Alarms for the % Oxygen Display. Alarms for the % Oxygen display are 0.5% methane (10% LEL), 35 ppm for CO, and 19.5 for low oxygen and 23.0% for high oxygen. These alarms are always ON; the alarm concentrations are fixed and independent of the limits set for the % GAS and PPM CO displays.

Table 1. Alarm Concentration Limits

	Alarms for % GAS Display		Alarms for ppm CO Display		Alarms for % Oxygen Display
	ON	OFF	ON	OFF	Always ON
Methane	1% or less	No alarm	1% or less	1% or less	0.5% (10% LEL)
CO	200 ppm or less	200 ppm or less	200 ppm or less	No alarm	35 ppm
Oxygen	19.5% LoO2 23.0% HiO2	19.5% LoO2 23.0% HiO2	19.5% LoO2 23.0% HiO2	19.5% LoO2 23.0% HiO2	19.5% LoO2 23.0% HiO2

Alarms for TRACK GAS Scale. The alarm for gas may be set up to 1.0% methane (20% LEL) but no higher. Factory set alarm is at 1.0% methane (20% LEL). The alarm for CO is that selected by the user or a default value of 200 ppm. Alarms for oxygen are 19.5% (LoO2) and 23.0% (HiO2). Alarms for CO/H_2S and oxygen are given once very 15 seconds.

4. ENCLOSED SPACES, LEAK DETECTION, BAR HOLING, AMBIENT AIR AND FLUE GAS TESTING FOR CO

A Test and Monitor an Enclosed Space Atmosphere

The CGA-411 and CGA-412 detectors may be used to test and to monitor an enclosed space atmosphere.

WARNING: The detectors respond to natural gas (methane), carbon monoxide, hydrogen sulfide, and oxygen. These detectors cannot be relied upon for testing or monitoring other gases.

To Test an Enclosed Space Atmosphere. Connect an appropriate probe to the detector, turn the instrument on by switching to the % Oxygen display, and allow it to warm up. Do not use any filter other than a dust and water-block filter (the filter attached to the coiled hose). After warm-up, insert or lower the probe into the space to be tested. Wait for at least 45 seconds to make sure that all sensors have reached full response. If there is no alarm, check the readings on the PPM CO and % GAS displays. If an alarm does sound, switch to the display whose symbol appeared and verify the gas level causing the alarm condition. Do not enter an enclosed space if an alarm for any gas is given.

To Monitor an Enclosed Space. To monitor an enclosed space for the gases detected by the CGA-411 and CGA-412, first proceed as above to test the space atmosphere and then continue to monitor using the % Oxygen scale. If an alarm is given, exit the space and then verify the gas and its concentration by switching to the appropriate display. Alarm levels and their visual symbols are:

Table 2. Alarms for % Oxygen Display

	% Oxygen Display	
Gas	Alarm Limit	Display Symbol
Methane	0.5% (10% LEL)	GAS
Carbon Monoxide	35 ppm	CO
Hydrogen Sulfide	9 ppm	CO
Oxygen	Less than 19.5%	LoO2
	More than 23.0%	HiO2

WARNING: A detector should always be warmed-up in ambient air, never in an enclosed space atmosphere.

B. Leak Detection

The TRACK GAS scale may be used to test for gas leaks and to locate their source. To use this feature, connect an appropriate probe and turn the selector switch to the TRACK GAS position. The display will show *"Snif"* (sniff) for about 10 seconds. After this initial warm-up, the display shows the concentration of methane (natural gas) in air in % LEL (Model CGA-411) or in % GAS (Model CGA-412). If ambient air is clean (contains no methane), the display should read zero. If it does not, use the AUTO ZERO to adjust the instrument zero.

To locate a leak, advance the probe along a pipe or other conduit at a rate of about one foot per second. Since methane is lighter than air, track a gas pipe from above wherever possible. The beeper will sound once every two seconds at ambient concentrations of natural gas, will speed up with rising concentration, and will beep continuously at 2% LEL (or 0.1% gas) above ambient. By listening to the beeper or by reading the display, the source of the gas leak can be located.

The TRACK GAS scale displays readings in increments of 0.2% LEL (CGA-411) or 0.01% GAS (CGA-412). The ambient gas concentration used to establish the lowest beep frequency is automatically reset every time the TRACK GAS scale is selected.

The instrument response time depends on the length of the probe attached to the detector. To shorten the response time (to about half a second) use a gooseneck probe and filter (see Section 9). A gooseneck probe is also convenient for one-hand operation of the detector.

C. Bar Holing

The CGA-411 and CGA-412 may be used to measure gas levels in sampling holes used for locating underground natural gas resulting from seepage or a leak in a conduit. Gas concentrations in a bar hole near a significant leak will be several percent. Therefore, an alarm for gas is likely, but it has no relevance to the ambient atmosphere above ground. Under these conditions, the alarm for the % GAS display may be set to OFF (see Section 11). The % GAS display is now a measuring scale. Alarms for CO and low or high oxygen will still be given, but at a reduced frequency (once every fifteen seconds) so as not to interfere with the display of gas concentrations.

Bar holing may be done with optional probes available from Bascom-Turner. These include a 36" long plastic probe, a fiberglass probe, and a steel probe with an electrically insulated handle (see Section 9). An optional accessory, the Water-stopper, may be used to minimize interruptions from accidental aspiration of ground water (see Accessories).

D. Ambient and Flue Gas Testing for Carbon Monoxide

Ambient Air. The PPM CO display is used for measurements of carbon monoxide in ambient air. Accessible concentrations are 1 ppm to 9999 ppm. Readings above 1000 ppm are precise to about ±10%.

A general guide on the adverse effects of CO at various concentrations is given in Table 3. A concentration above 35 ppm in breathable air is cause for concern. The time-weighted limit (8 hr.) for CO in the workplace is 50 ppm and the short-term (15 min.) limit is 200 ppm. The effect of higher concentrations becomes more severe with increasing exposure time. A concentration above 200 ppm may be life-threatening, if exposure is long enough.

Table 3. Effects of Carbon Monoxide

Concentration	Inhalation Time and Symptoms
50 ppm	Time-weighted (8 hr.) limit in the workplace
200 ppm	Short-term (15 min.) limit in the workplace
400 ppm	Headache in 1-2 hrs., life threatening after 3 hrs.
800 ppm	Headache, nausea in 45 min., death in 2-3 hrs.
1,600 ppm	Headache, nausea in 20 min., death in 1 hr.
3,200 ppm	Headache, nausea in 5 min., death in 30 min.
6,400 ppm	Headache, nausea in 1 min., death in 10 min.

The electrochemical cell used for CO measurements will respond to other substances that are oxidized by the cell (see Section 5). Measurements of CO in ambient air can be made more specific to CO by using the filter and probe provided for flue-gas measurements (see below). The filter removes most, but not all, easily oxidizable vapors including some given off by common household chemicals.

Flue Gases. To carry out flue gas measurements, select the PPM CO display, connect the flue gas probe with its attached filter, and after warmup, insert the probe into the flue to read the CO concentration in ppm. The standard flue gas probe is intended for flue gas checks which last a minute or two. Longer sampling times may lead to a display of *"bloc"* as water condenses in the probe, filter, or hose and blocks the gas intake to the instrument. If checks for CO in flue gas are needed over longer periods use an Extended Duty Flue Gas Probe and Filter (see Accessories). These probes have larger heat sinks and contain a water-removing substance in their filters extending sampling times up to about half-an-hour.

If flue gas measurements are to be made on a regular basis, the alarm for the CO display may be turned OFF (See Section 11) if the flue gas is expected to contain over 200 PPM CO.

CAUTION: When measuring CO in flue gas, the filter provided with the probe must be used to avoid interference from nitrogen oxides. A filter is good for at least three months of ordinary use. It should be replaced or refilled when about 90% of its purple materials has changed color to brown, or when it gets clogged or flooded (see Accessories and Spare Parts).

WARNING: Do not touch the flue probe immediately after a measurement. Running the instrument for a short time in ambient air helps cool the probe quickly and also removes condensed water.

"Air-free" CO Flue Measurements. Flue gas measurements of CO can be displayed on an "air-free" basis if this feature is selected (see Section 11). When this selection is made, the measured CO concentration is referred to air-free flue gas according to:

$$\text{"Air-free" PPM CO} = \frac{20.9}{20.9 - \text{measured \% } O_2} \text{ (measured ppm CO)}$$

The instrument measures CO and % Oxygen and displays CO concentrations on an air-free basis using the above relation. This calculation is used up to 16.0% Oxygen. If the oxygen concentration is above 16.0%, measured values are displayed without conversion, i.e., the "air-free" formula is **not** used.

E. Hydrogen Sulfide Detection

The electrochemical cell used to detect CO also responds quantitatively to hydrogen sulfide (H_2S). The response to 1 ppm H_2S is registered as 4 on the PPM CO display. This ratio holds for all values of H_2S up to about 1000 ppm H_2S. Thus, 10 ppm H_2S will register as 40 on the PPM CO display, 50 ppm H_2S will register as 200 on the PPM CO display and 100 ppm H_2S will register as 400 on the PPM CO display. The CGA-411 and CGA-412 detectors thus monitor ambient levels of hydrogen sulfide, as well as CO, and will alarm if the H_2S concentration rises above one quarter of the limit set for the CO alarm. In particular, when the % Oxygen display is selected, a detector will alarm at 9 ppm H_2S (approximately one quarter of the 35 ppm alarm limit for CO).

The response of the electrochemical cell to H_2S is automatically calibrated whenever the unit is calibrated with CO. No separate calibration with H_2S is required.

If an atmosphere contains both CO and H_2S, the response of the detector is additive, that is, the reading on the PPM CO display includes both the response to CO and to H_2S. If a reading for CO only is needed or desired, the flue gas probe and its attached filter can be used for sampling ambient air. The filter removes H_2S and the reading then corresponds to the CO concentration.

WARNING:	**A detector will <u>not</u> respond to H_2S when the sampled gas is drawn through the flue gas probe and filter.**

5. INTERFERENCE FROM OTHER GASES OR LIQUIDS

Methane detection uses a catalytic combustion filament and a thermal conductivity sensor, both calibrated with methane. The filament is used up to about the lower flammable limit (5.0% by volume) of methane and the thermal conductivity sensor from about 5% to 100% of methane.

Carbon monoxide (CO) and hydrogen sulfide (H_2S) detection is carried out with a three-electrode, electrochemical cell. Oxygen detection is carried out electrochemically with a two-electrode, diffusion membrane electrochemical cell.

Gases, or liquids with appreciable vapor pressure, which may interfere with the detection of methane include substances which can be combusted on the catalytic combustion filament. Examples are ethane, propane, ethylene, propylene, octane, and the like. Also, substances which differ in thermal conductivity from air. Examples are hydrogen, helium, carbon dioxide, other hydrocarbons.

Gases or vapors which may interfere with carbon monoxide detection include substances which can be electrochemically oxidized or reduced on the working electrode of the electrochemical sensor. Examples are hydrogen, oxides of nitrogen, alcohols, and unsaturated hydrocarbons.

Interference in CO Measurements

If the ambient concentration of oxidizable substances is relatively high, it is likely that CO measurements will be affected. Many of these substances are removed by the flue gas filter attached to the telescoping metal probe. This filter can be used for both flue gas measurements and for ambient air measurements of CO whenever the ambient concentration of other oxidizable substances is significant.

CAUTION:	**DO NOT** attach the flue gas filter to the standard probe. It is designed to be used only with the CO probe (flue probe).

Catalyst Poisons

WARNING:	**Both the methane sensor and the CO sensor use catalytically active surfaces which may be poisoned by air contaminants. These sensors should not be exposed to atmospheres that contain silicones, halogens and halides, such as chlorides, and volatile compounds containing lead or antimony. If exposure to atmospheres that adversely affect the sensors is suspected, the detector should be recalibrated promptly.**

6. INSTRUMENT CHECKS

Pump Checks

If the intake is blocked, the display shows *"bloc"* (block) and the detector beeps until the problem is cleared. This check is carried out whether or not a probe is being used. To check for tight connections, block the probe inlet to sow *"bloc"* on the display within a few seconds. If *"bloc"* fails to appear, there may be a leak (see "Troubleshooting").

WARNING:	**The instrument should not be used if it doesn't display *"bloc"* when the intake is blocked.**

Automatic Zero

To adjust the zero automatically, advance the selector switch to "AUTO ZERO". Zero adjustment, which takes 25 to 35 seconds, is typically required only once a day.

Display	Automatic Operation
Air (O_2)	The oxygen sensor is adjusted to 20.9%.
GAS 1	The zero of the thermal conductivity sensor is adjusted.
CO	The zero of the CO/H_2S sensor is adjusted.
GAS 2	The zero of the combustion sensor is adjusted.
End	The instrument beeps briefly after it has been zeroed and is ready to use.

If automatic adjustment of zero cannot be carried out, for example, because the methane concentration is too high, or because a sensor has drifted too far from its previous null (zero), the display will show *"nogo"* (no go) alternating with the symbol of the gas indicating which sensor cannot be adjusted.

If an automatic zero attempt leads to *"nogo"*, subsequent selection of some display mode (% GAS, PPM CO, or % Oxygen) will display *"nogo"* alternating with the symbol for the display. The instrument must then be zeroed as described below.

WARNING:	**Zero adjustment <u>must</u> be carried out with clean air. If the air is not clean, a systematic error will be introduced. The instrument will auto zero if methane is below 0.5% and CO below 35 ppm. At higher concentrations of methane or CO, the instrument will not change its zero, and the display will show *"nogo"* (no go).**

Coarse Zero

To adjust the zero of a sensor which has drifted too far, remove the instrument from its carryall, and remove the elongated rubber plug on the right side of the instrument (as you face it) to access two push-button switches. Place the instrument on a flat surface and set the selector switch at the % oxygen display. Hold down push-button #1 (see Figure 1) with a pencil, pen, or other small implement while switching the selector switch to AUTO ZERO. Release button when zeroing begins. The instrument will proceed to zero all sensors.

Please note that the round rubber plugs to the right of the elongated plug need not be removed. Please be sure to replace the elongated plug before re-inserting the instrument into the carryall.

WARNING: The coarse zero procedure overrides the limits for autozeroing. This procedure must be carried out in clean air.

Automatic Sensor Check

If a gas sensor fails (opens up), the display shows *"FAIL"* (see Troubleshooting Section).

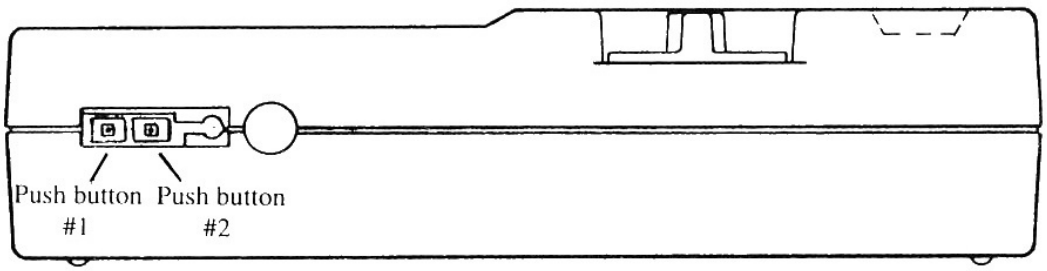

Fig. 1.

Radio Frequency Interference (RFI)

Gas-Sentry detectors have an interior coating on their cases to suppress RFI.

7. CHANGE OF BATTERIES

Automatic Battery Check

The Gas-Sentry CGA-411 and CGA-412 can be powered by four (4) alkaline (non-rechargeable) AA batteries (1.5V, Type AM-3) or by four (4) Ni/Cd rechargeable batteries (1.25V, 0.85 Ah). If the estimated battery life is less than about 1 hour, the display flashes *"Lo"* (low) between readings. The batteries should be changed at a convenient time. If the battery life is over, the display stays on *"Lo"*. The batteries must then be changed to make the instrument operational.

WARNING:	**The batteries must be changed in an atmosphere known to be non-hazardous.**

To replace batteries:

1. Remove batteries

   Snap open the bottom part of the carryall, partially withdraw the instrument, and slide out the battery cover by depressing latch with thumb while pressing down on cover with fingers.

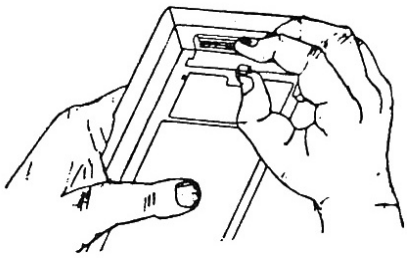

Fig. 2.

2. Discard four alkaline AA cells or remove four Ni/Cd cells.

   Insert four, fresh AA alkaline batteries or recharged Ni/Cd batteries. Insert each battery with the correct polarity as shown on rear of instrument. Replace battery cover and lock into place. **Always replace a set of batteries, do not mix new and used batteries**.

If the instrument does not operate after battery replacement, or if the display is dim, there is a high probability that one or more cells have been inserted with the wrong polarity. Re-insert the batteries taking extra care to insert each battery correctly.

Note: The CO cell is powered by the four batteries in the unit even when the instrument is OFF. The instrument should not be left without power for more than one minute during battery replacement. If the instrument is without batteries for an extended period, the CO cell will require about 10 minutes to return to a proper operating condition.

CAUTION:	Always store the instrument with a full complement of batteries.

WARNING:	**Use only alkaline or Ni/Cd batteries in a Gas-Sentry. Do not attemp to charge the alkaline (non-rechargeable) batteries as they may leak or vent.**

8. TROUBLESHOOTING

Problem	Probable Cause	Action
1. Display is blank and pump does not operate.	• Batteries are too low or spent.	• Replace batteries (see Section 7 ("Change of Batteries").
2. Batteries are replaced but display is blank and pump does not run.	• One or more batteries were inserted with the wrong polarity.	• Re-insert batteries with proper polarity.
	• One or more batteries are too low.	• Replace batteries with a new set.
3. The Display shows *"bloc"*.	• The intake to the instrument is blocked.	• Check probe tip and water-block and inlet filters, and clean or replace if necessary.
	• There is water in the probe.	• Detach probe from water-block and inlet filters, and dry probe and filter by shaking.
4. The display does **not** show *"bloc"* when the probe tip is blocked.	• There is a leak between the probe tip and the pump.	• Tighten connections of probe. Check hose and probe for cracks. • Disconnect hose and block intake. If *"bloc"* does not appear, clean pump.
5. The display shows "nogo" prior to "End" when on AUTO ZERO scale.	• Ambient concentration of methane or CO is too high.	• Repeat zero in clean air. If necessary, leave instrument on in clean air to purge.
	• Detector will not purge on LEL or GAS scale.	• Check pump by blocking probe's tip. If *"bloc"* appears repeat zero in clean air following "coarse zero" procedure in Section 6.
	• The CO sensor has failed.	• Replace sensor.
6. The display shows *"FAIL"*.	• The gas or the oxygen sensor has failed.	• Replace sensor.

WARNING: Do not open a sensor under any conditions. Sensors must be replaced only by personnel trained in instrument service.

WARNING: Do not operate an instrument which fails to show "bloc" when the intake is blocked. Clean the pump or return the instrument for repair. See the inside of the front cover (limited warranty) on how to return an instrument.

9. PROBES AND FILTERS

Standard Probe

The standard probe (Part No. SP-207) is a rigid tube which connects to the water-block filter. If extra length is desired, an extension (7") is screwed finger-tight onto the end of the probe. A rubber gas collector (Part No. RT-107) on the end of the extension is useful for finding leaks under windy conditions.

WARNING:	**Do not use this probe for flue gas measurements. The plastic probe will become soft, deform, or decompose.**

Flue Gas Probe

The flue gas probe (Part No. FP-110) is a telescoping metal probe screwed finger-tight into the flue gas filter cartridge. The other end of the filter cartridge attaches to the water-block filter. This probe, together with its filter cartridge, is recommended for CO measurements in flue gas and ambient air.

WARNING:	**Never attach the filter cartridge directly to the sample hose - always use a water block filter.**

WARNING:	**Hold the probe without touching the metal while it is in the flue and immediately afterwards. Running the instrument in air after a measurement will help cool the probe and dry the filters.**

Gooseneck Probe

The optional gooseneck probe (Part No. GP-014) is 14" long and attaches directly to the inlet port of the detector. The short length and low internal volume of this probe reduces the time required to pull a gas sample from the probe tip to the gas sensors. This probe optimizes the response time on the TRACK GAS scale. To increase sensitivity in windy conditions, use a rubber gas collecting tip (Part No. RT-107) on the end of the probe.

Bar Hole Probes

There are four optional probes suitable for bar holing:

Bar Hole/Ceiling Probe (Part No. BP-034) 34" long, clear, one hole at end.
Bar Hole Probe (Part No. BP-134) 34" long, clear, side holes.
Bar Hole Probe (Part No. BP-436) 36" long, fiberglass, one hole at end.
Bar Hole Probe (Part No. BP-536) 36" long, steel, side holes.

The bar hole/ceiling probe has a single inlet on the end and comes with a rubber gas collector (Part No. RT-030) useful for finding leaks in overhead pipes. The stainless steel probe has an

electrically insulated handle. **Bar hole probes are designed to be attached to the water block filter on the coiled hose**. A more convenient hose for bar hole measurements, five feet of straight tubing, is available as Part No. SH-060.

CAUTION:	Hold the steel bar hole probe only by the insulated handle to avoid electrical shock from buried power lines.

Dust and Water-block Filter

A Teflon® filter removes particles of dust and dirt and blocks water. The white disk in the filter should be inspected periodically for accumulated dirt which may slow air sampling. A filter can be cleaned by removing the probe and tapping the filter on a hard surface to remove dry dust and dirt. Do not insert objects into the water block filter while attempting to clean it as they may puncture the Teflon. Typically, the filter needs to be replaced once or twice a year. Replacement water-block filters are available as Part No. WF-305 (package of 5 filters).

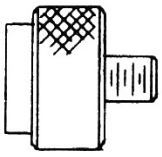

Fig. 3. Dust and water-block filter.

Inlet Dust Filter

Removal of the intake connector (used to attach the sampling hose) exposes a metal filter cup pressfit onto the intake. These filters are not a substitute for water-block filters since they will not block water. If this filter gets blocked, it may be cleaned with compressed air or replaced.

Water-block Filter for Gooseneck Probe

A Teflon® filter, housed in a knurled nut, removes particles of dust and dirt and blocks water (see the Dust & Water-block Filter section above for details on cleaning). Replacement filters are available as Part No. WF-205 (package of 5 filters).

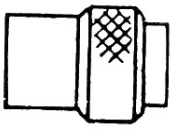

Fig. 4. Water-block filter for gooseneck probe.

WARNING:	**Do not use a Gas-Sentry without a dust and water-block filter. Do not use a dust and water-block filter with a puncture in the Teflon disk.**

Dust Filter for Gooseneck Probe

A dust filter in the tip of the gooseneck probe can be cleaned by removing the probe from the detector and tapping the probe's tip on a hard surface to remove dry dust and dirt. The dust filter can be popped off the end of the probe and replaced. Replacement dust filters are available as Part No. DF-005 (package of 5 filters).

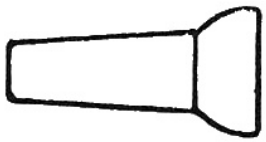

Fig. 5. Dust filter for gooseneck probe.

Flue Gas Filter

This filter is designed to be screwed finger-tight between the telescoping metal probe and the water-block filter. It must be used for CO measurements in flue gas and may also be used for CO measurements in ambient air. The beads in the filter cartridge should be replaced when about 90% of the material has changed color from purple to brown or when it becomes blocked by soot or water. Filter beads for refilling approximately 50 cartridges are available as Part No. PR-050. Replacement flue gas filters are available as Part No. FF-005 (package of 5 filters).

To refill the filter cartridge, remove threaded top and pour out spent filter material. Retrieve the plastic retainer disk from the spent filter material. Fill cartridge with fresh filter material to bottom of threads and place the plastic retainer disk flat on top of the filter material. Screw in top until finger tight and check seal with block test.

WARNING:	**Do not remove or puncture the white filter in the bottom of the filter cartridge. If this filter becomes damaged, discard the filter cartridge.**

Heavy Hydrocarbon Filter

A heavy hydrocarbon filter, filled with activated carbon, is designed to be used with the standard probe or the bar hole probe on a one-time-only basis. Activated carbon adsorbs gasoline and other heavy hydrocarbons (for example, propane or butane) which interfere with methane detection. In order to keep the filter material from adsorbing hydrocarbons prior to use, the filter is fitted with plastic endcaps which must be removed just before use. The filter should be either discarded after use or refilled with activated carbon and recapped with the plastic endcaps. This filter is designed to be screwed finger-tight between the probe and the water-block filter. Activated carbon for refilling approximately 50 cartridges is available as Part No. HR-050. The refill procedure is the same as described for the gas filter. Heavy hydrocarbon filters are available as Part No. HF-005 (package of 5 filters).

Water-stopper

The water-stopper (Fig. 6) is a floating check-valve, with push-button water release, to stop water from being pumped while bar-holing. It provides a quick way to continue bar-holing if water is encountered in a bar-hole.

The water stopper is inserted between the water-block and dust filter and the bar-hole probe. The float inside the water-stopper is connected to a plunger which blocks flow whenever the float is lifted by water. Water is released and the plunger is returned to its normal position by depressing a release push-button.

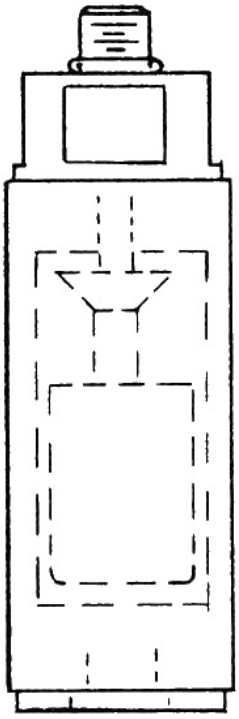

Fig. 6. Water stopper for bar-holing.

PART 2. CALIBRATION AND ALARM LEVEL SELECTION

10. AUTOMATIC CALIBRATION WITH A-CAL™

The A-CAL firmware calibrates instruments automatically using calibration gas available from Bascom-Turner

Calibration Gas. The gas required for automatic calibration of the catalytic combustion and CO sensors is Bascom-Turner's methane and CO calibration gas (Part No. MC-105) containing 2.5±0.05% methane and 100 ppm ±2 ppm CO in air. It is provided in a disposable aluminum tank containing 105 liters of gas, sufficient for at least 300 calibrations.

The thermal conductivity sensor can be calibrated with either pure methane or system gas provided by the user.

The oxygen sensor is calibrated with ambient air whenever the instrument is autozeroed.

Calibration Gas Dispenser. The calibration gas must be delivered at or near atmospheric pressure to ensure accurate calibration. Bascom-Turner recommends using the Calibration Gas Dispenser (Part No. CGD-001) which regulates and displays the delivery pressure, approximately 6-7 inches of water.

A-CAL Operation. In carrying out automatic calibrations with the A-CAL firmware, **always calibrate the catalytic combustion and CO sensors first**, that is, use the Bascom-Turner methane and CO calibration gas first. Then, if necessary, recalibrate the thermal conductivity sensor. This sequence of calibration gases ensures that no errors are introduced from residual gas in the detector.

A-CAL Calibration with the Methane and CO Calibration Gas

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1. Place the selector switch in "AUTO ZERO" and zero the instrument in clean air. The usual series of displays will appear on the detector display, depending on the model.

2. After *"End"* appears on the display and the instrument beeps, insert the tip of the standard probe partially into the outlet port of the gas dispenser. If a manual calibration apparatus (for example, Part No. PCA-001) is used, attach the detector's water-block filter to the threaded hose bar (TB-512) with the regulator's valve off and wait for *"bloc"*.

3. After *"bloc"* appears on the detector display, push the probe completely into the dispenser port. The *"bloc"* display will be replaced by *"go"* and the instrument will proceed to calibrate the catalytic combustion and CO sensors.

   If a manual apparatus is used, open the regulator's valve and observe *"go"* on the display.

4. The detector display will show *"GAS 2"* while the catalytic combustion sensor is being re-calibrated and *"CO"* when the CO sensor is being re-calibrated.

5. After calibration, the detector will show *"CAL"* and the instrument will beep briefly. Remove the probe from the gas outlet. The instrument is ready for use.

Note: When the Gas Dispenser is used, it may be useful to attach the 7" extension (with the white Teflon tip) to the end of the standard probe. The white Teflon tip is designed to fit the Gas Dispenser port.

Note: During calibration, the selector switch remains in the AUTO ZERO position. After calibration is complete and *"CAL"* is displayed, the selector switch must be placed at some other scale (or the OFF position) to return the detector to a normal operating mode.

CAUTION:	Automatic calibration presupposes and depends on using Bascom-Turner's calibration gas (Part No. MC-105). Do not use a different gas for automatic calibration.

A-CAL Calibration with the Methane or System Gas

The thermal conductivity sensor is calibrated at the factory with methane. Routine re-calibration of this sensor is not necessary. The thermal conductivity sensor is checked operationally using air as the reference gas every time the AUTO ZERO routine is used. However, the thermal conductivity sensor should be re-calibrated if it has been re-calibrated by the user with system gas since the gas composition varies seasonally and sometimes more frequently.

To calibrate the thermal conductivity sensor, proceed as follows:

1. Place the selector switch on "AUTO ZERO" and zero the instrument in clean air. The usual series of displays will appear on the detector display. Note that if the instrument had just been calibrated with the methane and CO calibration gas, the selector switch must be moved to some other scale and given 30 seconds to purge residual gas before the AUTO ZERO routine is repeated.

2. After *"End"* appears on the display and the instrument beeps, block the probe tip manually until *"bloc"* appears on the display. Now release the block. The display will show *"go"* and the instrument is ready for calibration.

3. Connect the probe to a source of pure methane or system gas. The gas should not exceed 6" or 7" of water. The display will show *"GAS 1"* while the thermal conductivity sensor is being calibrated. When calibration is complete, *"CAL"* will appear on the display and the instrument will beep briefly.

4. Disconnect the probe from the gas and let the instrument run briefly in clean air to purge residual gas. Monitor the purging by placing the selector switch on the GAS scale. When the reading on this scale returns to zero, the instrument is ready for use.

Note that while the probe is being connected to a source of methane or system gas, "*bloc"* may appear briefly on the display, for example, if some time elapses between connection to the gas outlet and opening of a valve that allows calibration gas to flow. This will not interfere with proper calibration.

Error Codes during Automatic Calibration. The only special error code that may appear during automatic calibration is *"nogo"* (no go). This code, which denotes that automatic calibration cannot proceed, may appear in the following circumstances:

i). More than 30 seconds elapse between the *"go"* display and the introduction of calibration gas. If this is the case, wait for an additional period up to 60 seconds, with gas flowing through the instrument. The *"nogo"* display will be replaced by *"CAL"* when the sensors are calibrated.

ii) A sensor is outside the normal range for automatic calibration. If this is the case, the *"nogo"* display will alternate with a display indicative of the sensor which cannot be calibrated. Thus, *"nogo"* alternating with *"GAS 2"* indicates that the catalytic combustion sensor is outside the range for automatic calibration. Similarly, *"nogo"* alternating with *"CO"* indicates that the CO sensor is outside the range for automatic calibration. If this result is obtained, the detector must be calibrated manually.

iii) A sensor is not sufficiently stable for calibration to proceed normally or the gas composition is varying with time. This last condition may hold if the calibration system has not been purged (e.g., first calibration of the day). If this is the case, wait for an additional period of up to 60 seconds with gas flowing through the instrument. If response is stable, the detector will be calibrated and *"CAL"* will appear on the display. If the instability persists, the *"nogo"* display will persist. The instrument must then be tested manually and the cause of the malfunction corrected.

CAUTION:	Do not use a calibration gas other than Bascom-Turner's calibration gas (Part No. MC-105) and pure methane or system gas for automatic calibration. If some calibration gas other than those stipulated here is to be used, calibration should be carried out manually as described in the Service Manual.

11. ALARM LEVEL SELECTION. "AIR-FREE" CO OPTION SELECTION

The instrument has an alarm activated at preset levels. Factory set alarm limits are given in Section 3C. The TRACK GAS scale has both an alarm and a beeper which may be disabled without disabling the alarm.

To review or change alarm limits, remove the instrument from its carryall and take out the elongated rubber plug on the side of the instrument. Two push button switches, labeled #1 and #2 in Figure 7, will be exposed. Set the front panel selector switch to AUTO ZERO and after *"Air"* is displayed, press switch #2. The pump will stop running and the instrument will enter a display/set-up mode for alarms and other options.

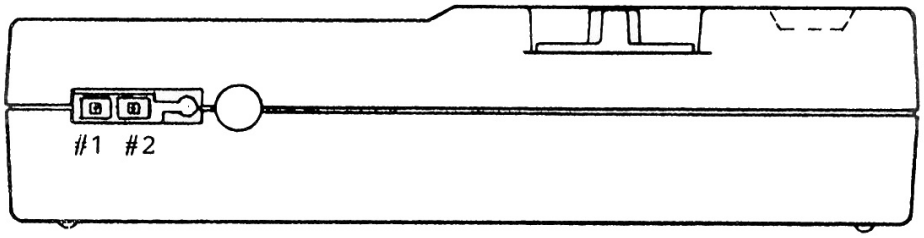

Fig. 7.

To Display Alarm Levels Without Changing Them. Each time switch #2 is pressed, the display advances through the sequence shown in Table 4. The display shows whether an alarm or other option is ON or OFF, and if ON, at what level.

To Turn Off or On Alarms or Select Options. Alarm levels for gas and CO/H_2S can be adjusted within certain limits or turned OFF, the beeper for the TRACK GAS scale may be turned OFF, the CO display may be put on an air-free basis, and the block limit for the pump may be adjusted by using switches #1 and #2. The oxygen alarm limits are always ON at the factory set levels.

To turn an alarm OFF or select an option, enter the alarm display mode as described above (set selector switch to AUTO ZERO and press switch #2 once), advance to the relevant display by pressing switch #2 an appropriate number of times, and then press switch #1. Each time switch #1 is pressed, the display changes from OFF to ON (and the reverse). If the change to be made is to turn off a particular alarm or operating mode, once OFF appears on the display, press switch #2. The display will show a symbol followed by OFF (see Table 4). Exit by turning the selector switch out of the AUTO ZERO position or continue, by pressing switch #2, to a subsequent display of another alarm or option to be changed.

The oxygen alarms and the block level for the pump cannot be turned OFF. If OFF is entered with switch #1, when switch #2 is pressed, the display will show *"LoO2"* or *"HiO2"* or "*Pu"* followed by a number (19.5 for LoO2, 23.0 for HiO2 and the block limit for the pump).

Table 4. Display Sequence

Display	Statement	Use/Comments
bEEP followed by ON or by OFF	The TRACK GAS beeper is active. The TRACK GAS beeper is silent.	Used only for turning beeper ON or OFF. The alarm limit is set by *SniF* display (see below).
SniF followed by a number or by OFF	The TRACK GAS alarm is at value shown. The TRACK GAS alarm is OFF.	If ON, displayed number is % LEL (CGA-411) or % GAS (CGA-412). Maximum setting is 20% LEL or 1.00% GAS.
GAS followed by a number or by OFF	The % GAS display alarm is at value shown. The % GAS display alarm is OFF.	If ON, displayed number is % GAS. Maximum setting is 1.00% gas.
AFCO followed by a number or by OFF	The air-free CO option is enabled. The air-free CO option is disabled.	Used only for enabling or disabling air-free CO option.
CO followed by a number or by OFF	The PPM CO display alarm is at value shown. The PPM CO display alarm is OFF.	If ON, displayed number is PPM CO. Maximum setting is 200 PPM CO.
LoO2 followed by a number	The lower alarm limit for oxygen is at value shown.	This alarm is always ON. Lower limit may not be set less than 19.5% oxygen.
HiO2 followed by a number	The upper alarm limit for oxygen is at value shown.	This alarm is always ON. Upper limit may not be set higher than 23.0% oxygen.
Pu followed by a number	The block limit for the pump is at value shown.	Factory set number is 2500. Can be changed to adjust the pump (see Section 12E).
Air	The instrument reverts to the normal operating mode at AUTO ZERO.	Exit from set-up mode to AUTO ZERO (alternatively, exit by placing selector switch at a position other than AUTO ZERO).

To Change Alarm Levels. If an alarm level is to be changed, rather than turned OFF, select the relevant display by pressing switch #2 an appropriate number of times, then press switch #1 until ON appears, then press switch #2. The display will show a number (the previous alarm level) with a flashing first digit. If this digit does not need to be changed, press switch #2 again. The next digit will now be flashing. To change the digit, press switch #1 to advance sequentially through 1,2,3,...0. Once the proper digit is reached, press switch #2 to advance the flashing digit to the next position. Repeat until all digits are adjusted. At the end, the display will show the relevant symbol followed by the new alarm level.

Examples of Selection or Adjustments

To Disable the Beeper on the TRACK GAS Scale. Set selector switch to AUTO ZERO and press switch #2.

Press	Display	Followed By
	BEEP	ON
Switch #1	OFF	
Switch #2	BEEP	OFF

Exit by placing the front panel switch to a position other than AUTO ZERO. The beeper on the TRACK GAS scale can be activated again by repeating the above procedure.

To Change the Alarm Level for the % GAS Display to 0.5% Gas. Set the front panel selector switch to AUTO ZERO and press switch #2 three times. The display will advance to GAS followed by a number (the current alarm limit). Continue by

Press	Display	Comment
Switch #1	ON	
Switch #2	01.00	Underlined digit is flashing
Switch #2	01.00	Underlined digit is flashing
Switch #1		Continue pressing switch #1 until
	00.00	0 appears as the second digit
Switch #2	00.00	
Switch #1		Continue pressing switch #1 until
	00.50	5 appears as the third digit
Switch #2	00.50	
Switch #2	GAS followed by 0.50	

Exit by placing the front panel switch to a position other than AUTO ZERO.

To Change the Alarm Level for the CO Display to 35 PPM CO. Set the front panel switch to AUTO ZERO and press switch #2 five times. The display will advance to CO followed by a number (the current alarm level). Continue by

Press	Display	Comment
Switch #1	ON	
Switch #2	0200	Underlined digit is flashing
Switch #2	0200	Underlined digit is flashing
Switch #1		Continue pressing switch #1 until
	0000	0 appears at the second digit
Switch #2	0000	
Switch #1		Continue pressing switch #1 until
	0030	3 appears as the third digit
Switch #2	0030	
Switch #1		Continue pressing switch #1 until
	0035	5 appears on the last digit
Switch #2	CO followed by 35	

Exit by placing the front panel switch to a position other than AUTO ZERO.

12. MANUAL CALIBRATION, SENSOR REPLACEMENT, PUMP ADJUSTMENT

Manual calibration is required if a sensor has drifted too far to be calibrated automatically and sometimes when a sensor is replaced. Since the procedures described below accesses basic operating parameters, safeguards have been built to ensure that the set-up mode is not entered accidentally.

To access the set-up mode, remove the instrument from its carryall and take out the elongated rubber plug on its side. Place the instrument on a flat surface with some stop to keep the instrument in place. Set the front panel switch to the % Oxygen position and press both switches #1 and #2 (see Figure 7) simultaneously with a small implement wide enough to reach both switches. While switches #1 and #2 are depressed, turn the frontpanel switch from the % Oxygen position to AUTO ZERO. The instrument will enter the set-up mode for manual calibration and adjustment; the display will show *"Pu"* (pump).

The parameters that can be accessed in the set-up mode are described in Table 5. Each state is reached sequentially by pressing switch #2 and can be adjusted by using switches #1 and #2 in the same way as described in detail for setting alarm levels (see Section 11). Ordinarily, only some of the parameters need be adjusted during manual calibration or when installing a new sensor. The main adjustments to an instrument in the field are described separately below.

A. Manual Calibration

If the sensitivity of a sensor has drifted too far to be automatically adjusted, *"no go"* will appear during autocalibration. The sensor must then be calibrated manually.

To calibrate, enter the set-up mode (see above) and press switch #2 until GAS 2 appears on the display (4 depressions). If clean air is being pumped through the instrument, the display should show 0.00 or -0.00. Introduce calibration gas (2.5% methane) and adjust the display by using switch #1 and switch #2, as described in Section 11 and in the example below, until the display reads 2.50.

Example: The display reads 1.45 with calibration gas. To adjust, press switch #1. The display will flash the left most digit, a zero. Press switch #2. The display will now flash the second digit, 1. Press switch #1 to advance to 2; press switch #2. The third digit, 4, will now be flashing. Press switch #1 to advance the third digit to 5. Press switch #2; the last digit, 5, will now be flashing. Press switch #1 until this digit is zero, and then press switch #2. The display will show *"GAS 2"* followed by a number which ought to be 2.50. If this number is more than 2.52 or less than 2.48, repeat the procedure (beginning with switch #1) to adjust again to 2.50.

The procedure for calibrating manually the CO sensor is similar. After entering the set-up mode, switch #2 is pressed until *"CO"* appears on the display followed by a number (7 depressions). The number is adjusted to 100 (assuming the calibration gas contains 100 ppm CO) by using switches #1 and #2 as described in Section 11.

Table 5. Display Sequence in Set-Up Mode

Display*		Parameter	Use/Comments
Pu	followed by a number	Pump current in arbitrary units	Used to adjust block limit for pump (see Section 12E)
bA	followed by a number	Battery voltage	Should be between 2.15 and 3.15 (Do NOT Adjust)
^{o}C 1	followed by a number	Room temperature (^{o}C)	For installing a new sensor (Sect.12B)
^{o}C 2	followed by a number	Filament temperature (^{o}C)	For installing a new sensor (see Sect. 12B)
GAS 2	followed by a number	In Calibration Gas: % GAS	For manual calibration or installing a new sensor (Sects. 12A and 12B)
GAS 1	followed by a number	In Pure Methane: % GAS	For manual calibration or installing a new sensor (Sects. 12A and 12C)
^{o}C 3	followed by a number	Room temperature (^{o}C) of the on-board temperature sensor	Should read room temperature (^{o}C) (Do NOT Change)
CO	followed by a number	In Calibration Gas: PPM CO	For manual calibration or installing a new CO/H_2S Cell (Sects. 12A and 12B)
GAS 3	followed by a number	Not used for CGA-411/412	Not used
O2	followed by 9999	Not used in the field	May be used when installing a new oxygen cell.
Air		Beginning of AUTO ZERO sequence	Normal operating mode

*After each depression of switch #2.

B. Methane Sensor Replacement

The Bascom-Turner methane sensor is housed in a sintered metal flame arrestor and is connected to the board by a short length of cable terminating in a 6-pin connector. A hold-down plate, used to secure the methane sensor to the gas manifold, is captive on the cable.

The tools required for replacement of a methane sensor are a Phillips #1 screwdriver and a small implement wide enough to reach both push button switches on the right side of the instrument.

I. Replacement of the Methane Sensor

The following stepwise procedure will result in an efficient and trouble-free installation:

1. Place the selector switch to OFF and remove the two Phillips-head screws from the back of the case (see Fig. 8).

2. With the instrument facing up, lift the top cover off exposing the main circuit board. Remove the two rubber plugs on the side of the case. Unscrew the cable clamp nearest the 6 pin connector on the board, disconnect the cable from the 6 pin connector, and remove the clamp from the cable.

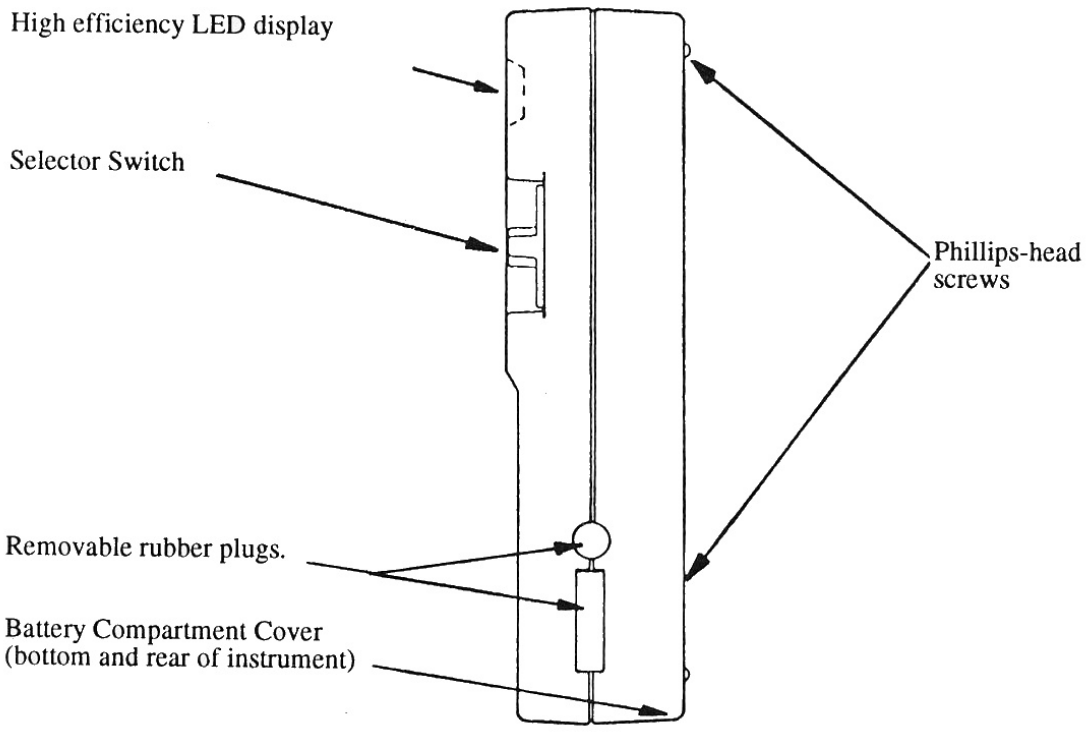

Fig. 8.

3. Remove four screws from the aluminum block manifold freeing the sensor hold-down plate and cable strap, and lift the methane sensor out of its well. Verify that an O-ring remains positioned on the shelf at the top of the well.

4. Install the new sensor assembly and press down until it sits in the well with its cable aligned directly toward the 6 pin connector on the main circuit board. Align the four holes in the new sensor hold-down plate with the corresponding holes in the manifold, and insert and tighten the four screws.

5. Reconnect the 6 pin filament connector to the main circuit board with the label on the connector facing upward. Put the cable clamp around the new cable and secure the clamp to the manifold with a screw.

Note: If the 6 pin filament connector is inverted, the display will show FAIL when the instrument is turned on.

6. Replace the top cover on the instrument and move it gently until the post of the selector switch falls into the slotted switch on the main circuit board. Replace the two screws holding the top to the bottom half of the case.

II. Adjustment and Calibration of the Methane Sensor

Access the set-up mode by setting the front panel switch to the % Oxygen position, pressing simultaneously the two push button switches, and turning the front panel switch to the AUTO ZERO position. The display will show *"Pu"* followed by a number.

1. Press switch #2 twice. The display will advance to: "^{o}C 1" followed by a number.

   By pressing switch #1 and #2 as described in detail in Section 11, set the number at the ambient room temperature, in degrees centigrade, within ±0.2^{o}C. The final depression of switch #2 will show: "^{o}C 1" followed by the room temperature (^{o}C).

2. Press switch #2 again. The display will show: *"^{o}C 2"* followed by a number.

   By pressing switch #1 and #2 as described in detail in Section 11, set the displayed number to 400.0. The final depression of switch #2 will show: *"^{o}C 2"* followed by 400.0.

The displayed number may be ±0.4, i.e., 399.6 to 400.4.

3. Exit the set-up mode and return to a normal operating mode by placing the front panel switch a position other than AUTO ZERO. Then switch back to AUTO ZERO, allow the instrument to zero and calibrate the sensor automatically (block intake after *"End"* appears on the display and introduce calibration gas after *"go"* - see Section 10).

4. If *"nogo"* appears on the display during AUTO ZERO, use the coarse zero procedure described in Section 6. If *"nogo"* appears during automatic calibration, calibrate manually as described in Section 12A.

5. Replace the two rubber plugs on the side of the instrument.

C. Replacement of the CO/H_2S Sensor

The CO/H_2S cell should not be opened since it contains a corrosive sulfuric acid electrolyte. The old cell should be returned to Bascom-Turner for proper disposal. Please use the container furnished with the replacement cell for the return.

The tool required for replacement and calibration is a Phillips #1 screwdriver.

I. Replacement of the CO/H_2S Cell

The following stepwise procedure will result in an efficient and trouble-free installation. In carrying it out, please note carefully which cables are plugged in each connector on the board and the orientation of each connector to avoid swapping or forcing a connector.

1. Make sure the selector switch is in the OFF position, then remove the two screws from the back of the case and lift the top cover exposing the main circuit board. Remove the two rubber plugs on the side of the case. Unscrew the plastic cable clamp near the 6 pin connector and leave it on the cable.

2. Disconnect the 6 pin connector noting that the printing on this connector is visible when oriented correctly.

3. Remove the battery compartment cover and the four AA batteries. Slowly lift the main circuit board by raising the side of the board away from the 6 pin filament connector to expose the connectors on the underside of the main circuit board (Fig. 9). Unplug the 2-connector cables to the motor and alarm. The 2 pin connector further from the display connects the pump motor to the main board, the one nearest the display connects the alarm. Unplug the keyed, 3-pin connector to the CO cell (middle of the board) and the 2 pin connector next to it (this last connects the oxygen cell). Remove the board.

4. Remove the four screws which hold the CO sensor to the manifold and remove the CO sensor from the manifold. Verify that an O-ring is in position in the manifold's well and the well is clean.

5. Remove the plastic (mylar) gasket from the old CO cell and place it on the bottom of the new CO sensor. Place the new CO sensor into the manifold and tighten the four screws to hold the sensor firmly against the O-ring.

Note: Do not press down in the center of the corrosive warning label on the CO sensor as this may damage the electrical connection to the sensor.

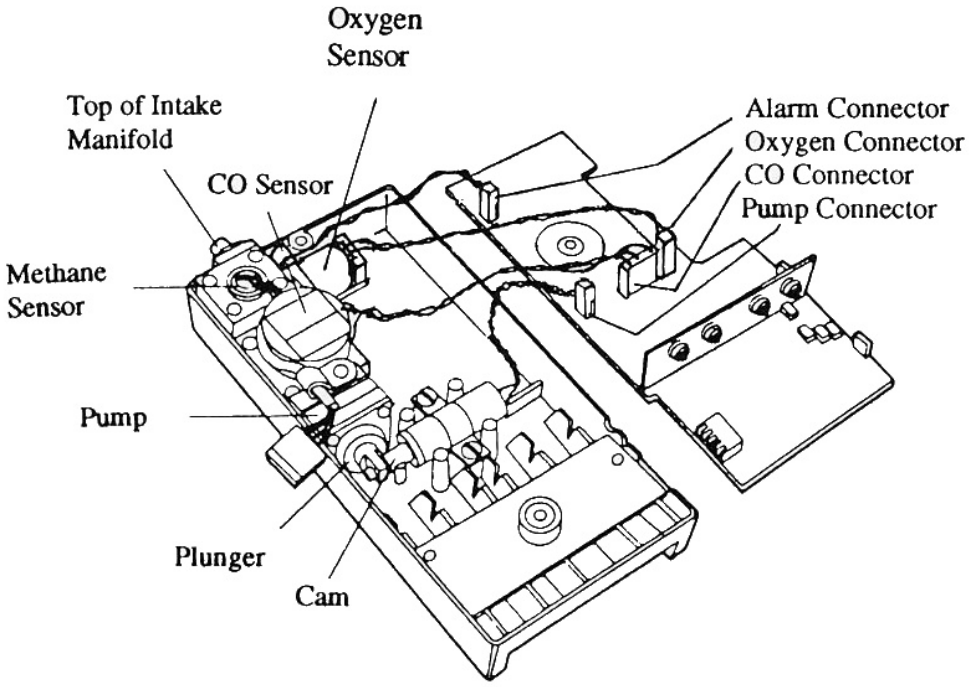

Fig. 9. Intake manifold assembly and connectors inside a detector.

6. Reconnect all connectors on the bottom of the board (see Fig. 9). Make sure each connector has the proper orientation. All 2-pin connectors are keyed, but they can still be forced contrary to their proper orientation. The 3-pin CO connector is also keyed (4-pin connector with one position blocked).

   Return the main circuit board into place verifying that the connector leads are not crimped or strained. Reconnect the cable to the 6 pin connector on top of the board and secure the cable clamp to the manifold with the screw.

7. Position the top cover on the instrument, move the top gently until the selector switch post falls into place in the slotted switch on the board, replace the two Phillips-head screws in the back of the case, and replace the batteries, the battery compartment cover, and the two rubber plugs on the side of the detector.

8. Allow ten minutes for the new CO cell to stabilize. Place the front panel switch at the PPM CO display position and verify that the reading is close to zero (or reading of less than 10 on the display). If it is not, allow further time for settling. Then switch to AUTO ZERO, allow the instrument to zero, and calibrate the sensor automatically (block intake after *"End"* and introduce calibration gas after *"go"* - see Section 10).

D. Replacement of the Oxygen Sensor

The oxygen cell should not be opened since it contains a corrosive electrolyte. The old cell should be returned to Bascom-Turner for proper disposal. Please use the container furnished with the replacement cell for the return.

The tool required for replacement is a Phillips #1 screwdriver. If the new sensor requires adjustment, then a small implement wide enough to reach both push-button switches on the side of the instrument is also required.

I. Replacement of the Oxygen Cell

1. Follow steps 1 through 3 for replacing the CO/H_2S cell and remove the main board from the instrument.

2. Locate the oxygen cell, a white cylinder about 1" in diameter resting against the side of the gas manifold. Lift the clip that secures the cell against the manifold and remove the cell.

3. Verify that an O-ring is in place at the sensor port. Place the new oxygen cell in position with the screened opening against the O-ring. Slide the clip in place taking care not to crimp or damage the electrical leads of the cell.

4. Reconnect the four connectors to the bottom of the board and return the main board into place in the case by following instructions 6 through 8 for replacing the CO/H_2S cell (Section 12C). Be sure to allow sufficient time for the CO cell to stabilize before autozeroing. After AUTO ZERO, place the selector switch at the % Oxygen position and verify that the detector reads 20.9 ±0.1 % Oxygen.

II. Adjustment of the Oxygen Cell

Verify that the oxygen cell is working correctly by sampling low pressure (6"-7" of water) system gas for about one minute. The detector should read 0.2 (or less) % Oxygen with the selector switch at the % Oxygen display. If it does not, the detector must be adjusted as described below.

Enter the manual calibration mode (see the beginning of this Section 12) and press switch #2 until O2 appears on the display followed by 9999 (9 depressions of switch #2). Introduce low pressure system gas, or pure methane, for at least 40 seconds. Press switch #1 to "flash" the first digit of the display. Press switch #1 again to advance the first digit to 0 (zero). The display will now read 0999 with the underlined digit flashing. Press switch #2 once to advance the display to *"Air"*, the beginning of the normal AUTO ZERO routine. Do **not** allow to autozero, but turn the front panel switch to the % Oxygen position and verify that the reading is 0.2 or less. Remove the system gas, allow the instrument to purge in air for at least 40 seconds, and AUTO ZERO. If *"nogo"* appears during AUTO ZERO, use the coarse zero routine described in Section 6.

E. Adjustment of the Block Limit of the Pump

If a *"bloc"* signal is not displayed when the air intake to the instrument is blocked, the problem may be corrected by adjusting the block limit used to detect this condition.

Before any adjustments are attempted, determine that the absence of a block signal is not due to a leak in either the probe, the hose, or some connection along the way. Remove the hose and block the air intake directly to make certain the air intake is actually blocked.

1. Observe Pump Current in Normal Operation and When Blocked

If no mechanical reason for the absence of a *"bloc"* signal is found, determine the behavior of the pump by entering the set up mode described at the beginning of this Section 12 (press switches #1 and #2 simultaneously while switching the front panel switch from % Oxygen to AUTO ZERO) and note the reading that appears on the display following *"Pu"* (see Table 5). The reading represents in arbitrary units the current supplied to the pump; it should be between 900 and 1200 with the hose and filter attached. If the end of the probe is blocked, a reading of about 320.0 to 350.0 is normally displayed. The decimal point appears if the pump current exceeds the block limit (2500).

If a number greater than 250.0 is not displayed when the air intake is blocked and if the number is above 2000, adjust the block limit, as described below, to some lower value, for example, 2000. The block limit should not be set to a value less than one and a half times (1.5x) the value observed when the probe is **not** blocked. Otherwise, a *"bloc"* signal may appear in normal operation, even when the probe is not blocked. If this margin between normal operation and a *"bloc"* condition cannot be maintained, the pump must be mechanically re-adjusted.

2. Adjust Block Limit

To adjust the block limit, place the front panel switch to % Oxygen and then back to AUTO ZERO and press switch #2. The instrument will be in the alarm setting and option selection mode (Section 11). Press switch #2 until *"Pu"* appears on the display followed by 2500. Press switch #1 to show *"On"* on the display, then press switch #2 to show 2500 with the underlined digit flashing. Press switch #2 again to advance the flashing digit to the second position. Now press switch #1 to advance this digit to 0 and then press switch #2 three more times until Pu appears followed by 2000. Exit by either pressing switch #2 again or by placing the front panel switch at some position other than AUTO ZERO.

APPENDIX I

SET UP AND PURGE OF THE CALIBRATION GAS DISPENSER

Calibration Gas. The gas required for automatic calibration of the catalytic combustion and CO sensors is Bascom-Turner's methane calibration gas (Part No. MC-105) containing 2.5 ±0.05% methane and 100 ppm ±2 ppm CO in air. It is provided in a disposable aluminum tank containing 105 liters of gas, sufficient for at least 300 calibrations.

The thermal conductivity sensor can be calibrated with either pure methane or "pure" system gas provided by the user.

Calibration Gas Dispenser. The calibration gas must be delivered at or near atmospheric pressure to ensure accurate calibration. Bascom-Turner recommends using the Calibration Gas Dispenser (Part No. CGD-001) which regulates and displays the delivery pressure, approximately 5 to 10 inches of water, with a front panel pressure gauge.

The components of the calibration gas dispenser shown assembled in Figure 10 include:

Description	Part Number
Calibration gas dispenser	CGD-001
Methane calibration gas	MC-105
Flow regulator	FR-001
Mounting bracket for gas	MB-001

SAFETY PRECAUTIONS: For your safety please read these instructions carefully. To operate the flow regulator on a compressed gas cylinder, it is required that you be trained in its proper use or be under competent supervision.

1. Wear safety glasses when installing a gas regulator on a gas cylinder.
2. Never heat or expose a gas cylinder to temperatures above 125^{o}F.
3. Be certain that the gas stream is shut off at the regulator when not in use.
4. Vent all calibration gas to outside air.

INSTALLING CALIBRATION GAS TANK

1. Inspect cylinder's and regulator's Standard Compressed Gas Association (CGA) connections for damage, dirt, dust, oil, or grease. Do not use if either is damaged. Remove all traces of foreign materials with a clean, lint-free cloth.
2. Be sure both the regulator and cylinder have compatible CGA fittings. Do not attempt to use an adapter to connect incompatible CGA fittings.

3. Attach the regulator to the cylinder and tighten the CGA connection nut (i.e., turn the tank clockwise while holding the regulator).

4. Verify that the regulator's valve is closed.

5. Secure gas cylinder to a wall, bench or stand with the mounting bracket (Part No. MB-001) so it will not tip over or fall.

6. Observe the inlet supply pressure gauge, which will verify cylinder pressure.

PURGING THE GAS DISPENSER: Purging air from the gas dispenser should be done each time a new tank of calibration gas is installed and prior to instrument calibration.

1. Open the regulator's valve and observe 5 to 10 inches of water column pressure on the gas dispenser's gauge.

2. Leaving the regulator's valve open insert the tip of the detector's extended standard probe as far as it will go into the outlet on the front panel of the gas dispenser.

3. Switch to the % LEL scale and wait several minutes. The % LEL reading will slowly climb to a maximum and stabilize.

4. When finished purging close the regulator's valve.

CALIBRATING DETECTORS

1. Calibrate gas detectors following the procedure for A-CAL calibration (Part 2, Section 1).

2. When finished calibrating close the regulator's valve.

Figure 10. Calibration gas dispenser (Part No. CGD-001) delivering calibration gas to a Gas-Sentry®.

APPENDIX II

SET UP OF THE MANUAL CALIBRATION APPARATUS

These instructions should be followed when setting up and using the manual calibration apparatus (Part No. PCA-001).

The components of the manual calibration apparatus are shown assembled in Figure 11, they include:

Description	Part Number
Methane gas dispenser	MC-105
Flow regulator	FR-001
Tubing and connector	TB-512
Mounting bracket	MB-001

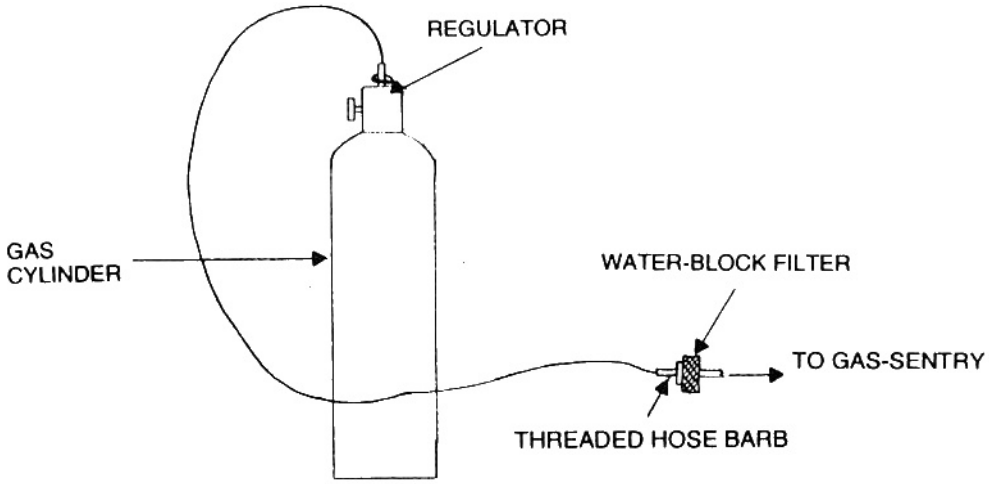

Fig. 11. Manual calibration apparatus (Part No. PCA-001).

SAFETY PRECAUTIONS

For your safety please read these instructions carefully. To operate the flow regulator on a compressed gas cylinder, it is required that you be trained in its proper use or be under competent supervision.

1. Wear safety glasses.
2. Never heat or expose a gas cylinder to temperatures above 125^{o}F.
3. Be certain that the gas stream is shut off at the regulator when not in use.
4. Vent all calibration gas directly to outside air.
5. Always use the flow regulator to prevent pump damage.

REGULATOR AND HOSE INSTALLATION

1. Secure gas cylinder to a wall, bench or stand with the mounting bracket (Part No. MB-001) so it will not tip over or fall.
2. Be sure both the regulator and cylinder have compatible CGA fittings. Do not attempt to use an adapter to connect incompatible CGA fittings.
3. Inspect cylinder's and regulator's Standard Compressed Gas Association (CGA) connections for damage, dirt, dust, oil, or grease. Do not use if either is damaged. Remove all traces of foreign materials with a clean, lint-free cloth.
4. Attach the regulator to the cylinder and tighten the CGA connection nut (i.e., turn clockwise).
5. Verify that the regulator's valve is closed.
6. Observe the inlet supply pressure gauge, which will verify cylinder pressure.
7. Connect the 3/16" ID tubing with a threaded hose barb (Part No. TB-512) to the hose barb on the regulator and secure with a cable clamp.

CALIBRATION

1. Use either the automatic or manual calibration procedure described in Part 2, "Calibration and Alarm Level Selection".
2. When finished close the regulator valve.

CAUTION:	Always attach the detector's water-block filter to the threaded hose barb (TB-512) with the regulator off, wait for *"bloc",* then open regulator's valve. Blocking the flow with the regulator's valve open can result in a pressure surge when the flow is resumed which will damage the detector's pump.

ACCESSORIES AND SPARE PARTS

	Description	Part Number
1.	**Probes and Hoses**	
	Standard Probe & Rubber Tip (two sections)	**SP - 307**
	Ceiling/Bar Hole Probe & Rubber Tip (34 inch long, clear)	**BP - 034**
	Bar Hole Probe (34 inch long, clear, side holes)	**BP - 134**
	Fiberglass Bar Hole Probe (36 inch long, side holes)	**BP - 236**
	Metal Bar Hole Probe (36 inch long, side holes)	**BP - 536**
	Standard Telescoping Flue Gas Probe & Filter (10 inch long)	**FP - 110**
	Extended Duty Flue Gas Probe & Filter	**FP - 012**
	Gooseneck Probe (14 in. ### = 014 for threaded & 114 for QC-001)	**GP - ###**
	Coiled Hose (5 feet long when extended)	**CH - 060**
	Straight Hose (5 feet long)	**SH - 060**
	Straight Hose (10 feet long)	**SH - 120**
	Quick Connect Hose Option	**QC - 001**
	Rubber Gas Collecting Tips (for SP-307, 5/pkg)	**RT - 107**
	Rubber Gas Collecting Tips (for BP-034, 5/pkg)	**RT - 030**
2.	**Filters**	**-**
	Water-block Filter for Gooseneck Probe (5/pkg)	**WF - 205**
	Dust & Water-block Filter (5/pkg)	**WF - 305**
	Water-stopper (with push-button release)	**WS - 001**
	Standard Flue Gas Filter - Refillable (5/pkg)	**FF - 005**
	Extended Duty Flue Gas Filter - Nonrefillable (5/pkg)	**FF - 105**
	Heavy Hydrocarbon Filter - Refillable (5/pkg)	**HF - 005**
	Inlet Filter & Threaded Air Intake (5/pkg)	**IF - 105**
	Inlet Filter & Quick Connect Air Intake (5/pkg)	**IF - 205**
3.	**Sensors**	
	Methane Sensor (for CGA-411 & CGA-412)	**MS - 001**
	Carbon Monoxide Sensor (for CGA-401,411, and 412)	**CO - 002**
	Oxygen Sensor (for CGA-401, 411 and 412)	**OS - 002**
4.	**Replacement Parts and Manual**	
	Main Circuit Board (### = Model No.)	**CB - ###**
	Pump Motor	**PM - 001**
	Pump Assembly with Installation Procedure	**PA - 201**
	Pump Heads, Diaphragm, Plunger Assembly (5 sets) & Repair Procedure	**PD - 205**
	Intake Manifold with Pump and Alarm (### = Model No.)	**IM - ###**
	ABS Case (without BC-001, ### = Model No.)	**AC - ###**
	Battery Compartment Cover	**BC - 001**
	Rubber Plugs (set of two)	**RP - 002**
	Operating Manual	**OM - 0100**
	Training CD (detector operation & maintenance)	**CD - 001**
5.	**Carryall and Instrument Case**	
	Carryall with Shoulder Strap & Detachable Window	**CC - 001**
	Rubber Boot with Shoulder Strap & Belt Clip	**RB - 001**
	Instrument Case	**IC - 101**
	Detachable Window	**DW - 001**
	Shoulder Strap	**SS - 001**
6.	**Accessories for Calibration & Maintenance**	
	Two in One Bump Gas (5/pkg)	**BG - 005**
	Manual Methane & CO Cal. Apparatus (with MC-105 & FR-001)	**PCA - 001**
	D-CAL Upgrade for Any Detector	**DC - 001**
	Threaded Hose Barb (with 3 feet of tubing)	**TB - 512**
	Methane & CO Calibration Gas (2.5% CH_4 & 100 ppm CO)	**MC - 105**
	Flow Regulator for MC-105	**FR - 001**
	Pump Repair Kit (with 1 can of UJ-206)	**PK 201**
	Ultrajet Compressed Gas (6x8 oz. cans/pkg)	**UJ 206**
7.	**Filter Material for Refilling Filters**	
	Activated Carbon & Spare Retaining Disks (50 refills of HF-005)	**HR - 050**
	Purple Beads & Spare Retaining Disks (50 refills of FF-005)	**PR - 050**

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