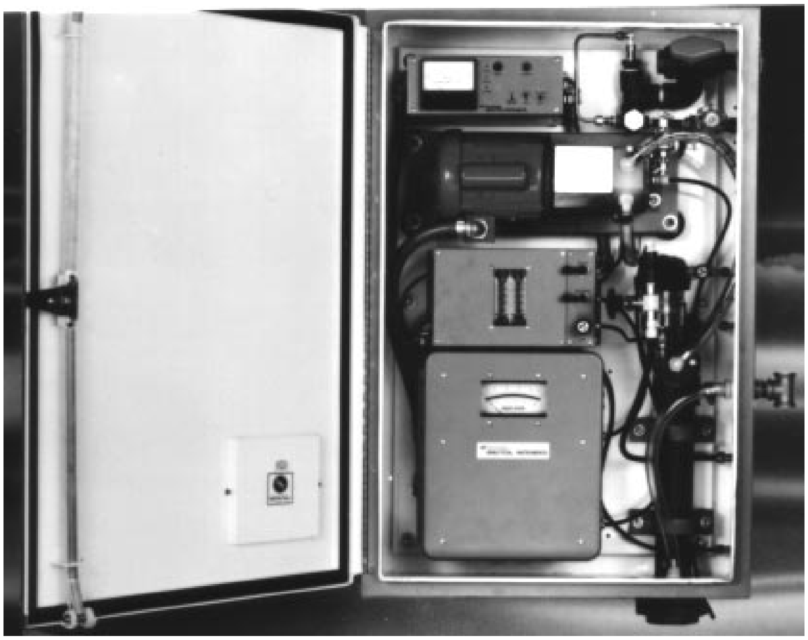
Model 9700
Flue Gas Analysis System

Instruction Manual



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Warranty

This equipment is sold subject to the mutual agreement that it is warranted by us free from defects of material and of construction, and that our liability shall be limited to replacing or repairing at our factory (without charge, except for transportation), or at customer plant at our option, any material or construction in which defects become apparent within one year from the date of sale, except in cases where quotations or acknowledgements provide for a shorter period. Components manufactured by others bear the warranty of their manufacturer. This warranty does not cover defects caused by wear, accident, misuse, or neglect. We assume no liability for direct or indirect damages of any kind and the purchaser by the acceptance of the equipment will assume all liability for any damage which may result from its use or misuse.

We reserve the right to employ any suitable material in the manufacture of our apparatus, and to make any alterations in the dimensions, shape or weight of any parts, in so far as such alterations do not adversely affect our warranty.

Important Notice

This instrument is intended to be used as a tool to gather valuable data. The information provided by the instrument may assist the user in eliminating potential hazards caused by the process that the instrument is intended to monitor; however, **it is essential that all personnel involved in the use of the instrument or its interface with the process being measured be properly trained in the process itself, as well as all instrumentation related to it.**

The safety of personnel is ultimately the responsibility of those who control process conditions. While this instrument may be able to provide early warning of imminent danger, it has no control over process conditions, and can be misused. In particular, any alarm or control system installed must be tested and understood, both as to how they operate and as to how they can be defeated. Any safeguards required such as locks, labels, or redundancy must be provided by the user or specifically requested of Teledyne when the order is placed.

The purchaser must be aware of the hazardous conditions inherent in the process(es) he uses. He is responsible for training his personnel, for providing hazard warning methods and instrumentation per the appropriate standards, and for ensuring that hazard warning devices and instrumentation are maintained and operated properly.

TBE/AI, the manufacturer of this instrument, cannot accept responsibility for conditions beyond its knowledge and control. **No statement expressed or implied by this document or any information disseminated by the manufacturer or his agents is to be construed as a warranty of adequate safety control under the user's process conditions.**

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Introduction

1 Overview

The Model 9700 analyzer system (see Figure 1) is an integrally housed combination of analyzers designed to continuously monitor the two primary components of flue gas which are the best indicators of combustion efficiency and safe operation. Through use of volumetric percentage measurements of oxygen and combustibles, it is possible to optimize the air-fuel ratio and approach the idealized condition of stoichiometric combustion. Additionally, monitoring of combustibles will assure a safe margin to prevent combustible mixtures from approaching LEL levels as a result of a malfunction, before boiler startup, etc. When necessary, appropriate regulation of the combustion process can be made to reduce nitrogen oxide (NOx) emissions and resultant air pollution.

The system is composed of the necessary components to educt a flue gas sample, condition it for analysis, and monitor on a continuous basis the percentage content of oxygen and combustible gases (see Figure 2).

When required, multipoint configurations, which automatically monitor from two to twelve points on a time shared basis, are available. Multipoint sequencing utilizes a stepping switch/timer which operates in conjunction with a solenoid valve on each sample input to control the time duration of the inflow. Indicating lights plus a recorder output show which sample points are being monitored at any given time. Override switches can be operated to omit any number of sample points from the **monitoring program.** If necessary, time delays can prevent the inadvertent tripping of alarms during the sample sequencing.

2 Sample Conditioning

When the flue gas is drawn into the analyzer system, it enters at a relatively high temperature and carries a significant content of moisture, dirt and corrosives. The sample stream is preconditioned to cool the gases and remove contaminants. This processing of the sample assures clean and continuous operation of the instrument.

A sample stream of flue gas, drawn into the sampling system by negative pressure, flows through a two-way sample-calibration selector valve installed at the sample inlet. The valve is used to introduce sample gas into the system However, when the valve is rotated so that the handle index faces the inside of the case (open port), atmospheric air is drawn into a T-joint where a spray nozzle introduces a fine water mist. This mist cools and wets the sample. A strainer is built into the system to prevent the nozzle from being clogged by particulates in the cooling water.

Figure 1: Model 9700 Analyzer System

Next, the gas and water mixture enter the pump. The pump contains no valves or packing and will handle the dirtiest of samples without any detrimental effect

Exiting the pump under positive pressure, the sample mixture is forced through a mixer which contains a series of baffles which function to thoroughly scrub the sample gas.

At the next stage of conditioning, the sample solution enters a separator where water is gravitated to drainage. The scrubbed flue gas sample then exits the separator through a sample outlet and enters a filter-condensate trap for final removal of particulates and water before undergoing analysis.

The sample gas stream, having passed the final filtration trap, flows into a tee. Here, the stream is divided with most of the sample gas being vented to atmosphere, while the balance is routed to the oxygen analyzer section. Total flow rate is approximately 20 to 30 SCFH. A back pressure control valve is adjusted to permit proper flow past the oxygen analyzer sensor where the percentage of oxygen concentration in the flue gas sample is determined and displayed on the oxygen analyzer meter.

Following oxygen analysis, the sample passes to the combustible analysis section.

Figure 2: Sample Conditioning

3 Oxygen Analyzer Section

The analysis system (see Figure 3) employs a Model 326B Analyzer which features a TBE/AI unique, patented Micro-Fuel Cell oxygen sensor. This electrochemical transducer provides an electrical signal that is directly proportional (and specific) to the oxygen concentration in the gas phase immediately adjacent to its sensing surface.

The analyzer is capable of oxygen measurements as small as 0.05% and is unaffected by flow rate changes. Since the sensor is incapable of producing a significant electrical signal without the presence of oxygen, any measurable signal produced is “specific” to oxygen.

The Micro-Fuel Cell is completely enclosed, maintenance-free, and has a predictable life span that is covered by warranty. When the cell is expended, it is discarded in the same fashion as a worn-out flashlight battery. TBE/AI’s extensive line of Micro-Fuel Cell equipped oxygen-measuring instruments are all designed so that the sensor cell can be replaced in a matter of moments by nontechnical personnel without the use of tools.

3 .1 Standard Features

The oxygen analyzer is housed in a fiberglass equipment case designed to resist the invasion of moisture and dust. The following features are standard in the Model 326B analyzer:

- Three Ranges of Analysis

  Three ranges of analysis are offered 0–5% (Lo), 0–10% (MED), and 0–25% (HI). Range control is achieved through the positioning of a panel-mounted RANGE selector switch; the switch also controls the power on/off to the analyzer. Since one of the three available ranges of analysis is always 0–25% O_2. ambient atmospheric air (20.9% O_2) can always be used to calibrate the analyzer. A CAL mark on the oxygen meter scale facilitates calibration. (Although the ranges selected best cover the oxygen content of flue gas, any three ranges of analysis, from 0–1% to 0–100%, can be provided.)

Figure 3: Oxygen Analyzer Section

- Integral Meter Readout

  The analyzer is equipped with a 5" panel meter for direct readout of the analysis. A linear scale (mirror equipped to eliminate parallax) promotes reliable, accurate readout of the analysis at any point on the scale. Resolution and accuracy of the meter eliminates the necessity of an accessory readout device, unless permanent recording or remote indication is required.

- Output Signal

  A linear output signal of from 0–1mV dc to 0–1 V dc is available for those applications requiring a remote indication and/or recording of the sample oxygen. Unless otherwise specified, the output signal will be 0–1 V dc.

- Temperature Control and Compensation

  To eliminate the inaccuracies caused by varying temperature conditions that are inherent in most methods of analysis employing transducers, a system composed of a combination of temperature compensation and control is used in the analyzer.

To protect the Micro-Fuel Cell against damage from low ambient temperatures and reduce the range required of the compensation circuit, the analyzer is equipped with a thermostatically controlled heating system that will not permit the interior of the instrument to drop below 85 deg F.

To eliminate inaccuracies accompanying the positive temperature coefficient of the Micro-Fuel Cell, a specially selected thermistor and network of precision resistors are utilized to produce a negative coefficient of matching characteristics .

The variable element (thermistor) in the compensation network is physically located in the same assembly as the Micro-Fuel Cell so that both devices are exposed to essentially the same temperature conditions.

- Integral Sample Pump Control

  Because the analyzer was essentially designed to measure the oxygen content of flue gas, provisions for powering and controlling an electrically driven accessory sample pump have been built into the analyzer. Terminal strip connections as well as protective fusing are provided. Pump power is controlled through the same RANGE switch that controls analyzer power (see Dwg. B-l0913).

- Modular Electronics

  The analyzer is equipped with integrated circuit (IC) semiconductor electronics. Components are mounted on a plug-in printed circuit board, as are various optional electronic features, i.e., alarms and converter. Printed circuit assemblies are preset and adjusted for immediate replacement.

3.2 Optional Features

The following optional features are available with the system.

- Integral Alarm Circuitry

  One (Model 326B-1) or two (Model 326B-2) adjustable, full-scale alarm and/or control circuits are available.

  Control over an external circuit is achieved by a relay whose solenoid coil is operated by an electronic “comparator” circuit. The switch contacts of the relay (NC/C/NO) are available for interconnection with customer circuitry at the terminal strip within the analyzer. The control point at which the analyzer operates is determined by the setting of a calibrated dial-equipped potentiometer on the control panel.

  The 0–10% range of the standard Model 326B is directly related to the decade nature of the turns-counting dial; the 0–5% and 0–2% ranges require a simple extrapolation exercise to determine the proper dial reading for a given oxygen level within the limits of their range.

  The integral control circuitry can be arranged so the relay is energized above or below the setpoint. Unless otherwise specified, the control relay in a single setpoint instrument (Model 326B-1) will be **energized** downscale from the set position: relays in a double setpoint instrument (Model 326B-2) will be energized when the oxygen level is reading in the scale region-ion between setpoint #1 in the **lower** region of the scale) and setpoint #2 (in the **upper** portion of the scale). These configurations provide power supply as well as oxygen alarm information. The relays are arranged to be in an energized condition when the oxygen concentration of the sample is in the safe region of the scale.

  The form “C” SPDT relay contacts are rated at 3 amperes (non-inductive).

- E-to-I Converter

  A voltage (E) to current (I) conversion of the output signal generated by the analyzer is available. This conversion allows I (current) to P (pneumatic) devices, as well as low-impedance current-operated indicating and/or recording and controlling instruments to be directly driven without the need of accessory equipment.

  One of the following three ranges of current output is available:

  - 1 to 5 mA dc,
  - 4 to 20 mA dc
  - 10 to 50 mA dc.

The designation 326B-I signifies an analyzer equipped with an E to I converter.

- Differential Power Supply

  Both integral alarm and E-to-I converter options are plug-in printed circuit boards for quick replacing. When either or both of the options are employed in an instrument, a highly regulated differential power supply (also a plug-in printed circuit board) is included to supply the positive and negative voltage required by the semiconductor circuitry.

  The basic Model 326B employs a simple unregulated power supply. The rectifying diodes and filtering capacitors are located on the same circuit board as the detection and amplifier circuitry. The alarm comparator and converter circuits, however, require that the supply voltage remain at a constant level to all circuitry in the interest of accuracy. When options are employed, the unregulated power supply components are deleted from the amplifier board, and the amplifier, as well as the option circuit, are fed from the regulated differential power supply.

4 Combustible Gas Analyzer Section

The combustibles analyzer (see Figure 4) is a compact detector for reliably sensing all combustible gases. The analyzer consists of two parts:

(1) The control unit housing the calibration controls, analyzer circuitry, meter readout, alarm relays and power supply.

2) The sensor unit including the sensor, flowmeters, valves and heater circuit. (Heater power is controlled through the same RANGE switch that controls oxygen analyzer power (see Dwg. B-l0913).

Figure 4: Combustible Gas Analyzer Section

The sample is sent through one side (SAMP) of twin indicating flowmeters. Since it is necessary that there is sufficient oxygen in the sample being analyzed to insure full combustion of any combustible gases present, the sample is blended, or diluted, with an equal amount of “clean” compressed air. The compressed air is introduced through the second (AIR) of the two flowmeters. Two flowmeters are used so that an equal volume of both sample and air flow can be visually set.

The flowmeters, valves, sensor and associated plumbing are installed within a temperature controlled box. Temperature is held at about 130 deg F to keep all components above the dew point of the sample gas.

The sample stream is routed past the combustible gas sensing element. This element is a low-temperature, catalytic bead type transducer in a constant current-excited Wheatstone Bridge circuit. Two legs of the bridge are exposed to the sample gas. The other two legs are passive elements in the control unit. Gas diffuses into the sensing element and oxidizes at the catalytic surface of the active or measuring bead, causing its temperature to rise. The reference bead is not catalytically coated and, consequently, is not heated by the combustibles. The difference in resistance of the otherwise matched pair of catalytic beads creates a signal in the bridge circuit. Use of the uncoated reference bead compensates for the effects of temperature variations, humidity changes, ambient pressure changes and variations in line resistance. The signal from the bridge is amplified and displayed on a meter with a 0–5% combustible range. A diagrammatic illustration of the combustible sensor is shown in Figure 5.

The beads are installed in a housing which has a flashback arrestor screen at the sensing aperture to prevent flame propagation back into the process.

Response of a catalytic bead sensor to a number of gases is shown in Table I.

An adjustable alarm can be set at any value within the full range. The latching or non-latching alarm relay can be wired to auxiliary lights, horns, fans, or used for equipment shutdown.

At completion of combustibles analysis, the sample stream is vented from the analysis circuit.

TABLE 1: Detector Response To GASES

COMPOUND	LEL*	RESPONSE FACTOR
Methane	5.0	1.00
Hydrogen	4.0	0.86
Carbon Monoxide	12.5	0.32
Ethane	3.0	1.20
Ethylene	2.7	1.26
Acetylene	0.5	1.39
Propane	2.2	1.42
Propylene	2.0	1.33
Butane	1.9	1.54
Hexane	1.1	1.50
Cyclohexane	1.3	1.44
Heptane	1.05	1.59
Benzene	1.3	1.50
Pentane	1.5	1.45
Toluene	1.2	1.48
Ethylene oxide	3.6	0.76
Methyl Ethyl Ketone	1.8	0.96
Methyl Acrylate	2.8	0.59

* Taken from Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids, National Fire Protection Agency.

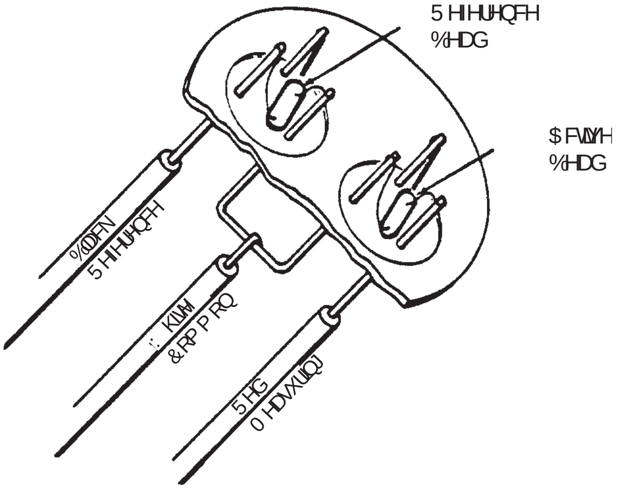

Figure 5: Combustible Gas Sensor

4.1 Operating Controls and Indicators

- The POWER toggle switch is used to turn the combustible gas analyzer ON and OFF.
- The meter displays the gas concentration at the detection point as a percentage of the combustible gas and is graduated from 0–5% combustibles.
- The green SAFE light is illuminated during normal operation and indicates that the combustible gas sensing element is operating.
- The red ALARM light is illuminated either when the combustible gas concentration rises above the adjustable ALARM setpoint, or in the event of a sensing element circuit malfunction. The two conditions can easily be distinguished by observing the meter reading. In a gas alarm, the meter pointer will be upscale above the predetermined level. In a malfunction type alarm, the meter needle will be pegged downscale below zero. A malfunction alarm will be caused by low or no sensing element current.
- (optional) The blue FAILURE light is illuminated in the event of failure of the detector element. The internal buzzer will also be activated with this type of failure.
- (optional) The amber CAUTION light is illuminated when the gas concentration rises above the adjustable CAUTION setpoint.
- The BUZZER toggle switch enables the internal buzzer to sound if the unit goes into alarm.

Note: This switch is a three position switch. For units that do not contain a "CAUTION ALARM" , this switch must be in the "full up" position to activate the AUDIO-BUZZER ALARM. The center and "full down" positions are "OFF" conditions.

- The AUTO/MAN toggle switch determines the mode of the alarm relay. In the AUTO mode, the alarm relay will pull in and drop out automatically as the gas concentration goes above and below the setpoint. In the MANual position, the alarm relay will be in a latching mode such as to pull in if the gas concentration goes above the setpoint. The alarm system can be reset to normal by switching back to AUTO.

4.2 Recessed Secondary Controls

NOTE: The recessed potentiometric controls are provided for calibration purposes. They should not be changed once calibration is established.

- The SPAN control adjusts for manufacturing variations in sensitivity between elements and for various gases.
- The ZERO control adjusts for zero meter reading with zero gas (air) flowing through the sample cell.
- The ALARM control allows the point at which the unit goes into alarm to be adjusted anywhere between 0% and 5% combustibles as shown by the meter reading.
- (Optional) The CAUTION control allows the point at which the unit goes into alarm to be adjusted anywhere within the range of the instrument as shown by the meter indication.

4.3 Meter Trim

The small potentiometer (P5) located on the main circuit board below the meter is used to trim the meter to full scale deflection at the rated output. The potentiometric control is set at the factory.

4.4 Analog Output

An analog (voltage or current) signal is provided for remote monitoring or recording. The type of signal is a customer option.

- Voltage Output

  0–1 Volt full scale or less.

NOTE: The remote meter or recorder should have an input impedance greater than 1K-Ohm.

- Current Output

  One of the following milliampere outputs may be provided:

CURRENT OUTPUT (mA)	MAX LOAD IMPEDANCE (Ohms)
4–20	1K

NOTE: The remote meter or recorder should have an input impedance less than the indicated values.

Theory of Operation

2.1 Oxygen Analyzer

The cathode of the oxygen cell sensor is connected to electrical ground, while the anode is connected to input amplifier A1., a current-to-voltage transducer. The output voltage from A1 is equal to the input current multiplied by the resistance of the feedback resistor (R1, R2, or R3). The feedback resistance can be varied by RANGE switch SW1.

Field effect transistor (FET) Q1, connected across A1—2 and A1—3, is used to short circuit the oxygen cell when the RANGE switch is turned to OFF. The FET has the property that when the gate is at the same potential as the source, it is turned ‘’on’’. The ‘’on’’ resistance is about 60 Ohms. When power is turned ‘’on”, the -15 VDC turns off the FET (or causes FET resistance to become greater than 10 Megohms so that it appears as an open circuit). Thus, when power is turned “on”, the FET is energized, opens the circuit, and allows cell current to flow through the feedback resistor instead of through the FET. The reason for this circuit arrangement is to insure that the oxygen cell is short circuited when power is turned ‘’off”. The liquid electrolyte in the cell will be depleted of residual oxygen and, consequently, the cell will be ready to operate and measure low concentrations of oxygen immediately after being placed into service. If the oxygen cell was not shorted when the analyzer was out of service, the electrolyte within the cell would become saturated with oxygen and, when the analyzer was placed in service, operational delay would occur while the cell burned up residual oxygen through the process of electrolysis. Only after the oxygen is reduced to a low enough concentration can the cell be used to measure the flue gas sample.

The signal from the first amplification stage is connected to a non-inverting second stage (A2) which contains a thermistor in its feedback loop: the thermistor is mounted adjacent to the oxygen cell and is used to measure temperature of the cell rises and cell output increases, thermistor resistance decreases and the gain of amplifier A2 decreases in order to maintain a constant net output voltage for a given concentration of oxygen.

The signal from the first amplification stage is connected to a non-inverting second stage (A2) which contains a thermistor in its feedback loop: the thermistor is mounted adjacent to the oxygen cell and is used to measure the temperature of the cell. As temperature rises and cell output increases, thermistor resistance decreases and the gain of the amplifier A2 decreases in order to maintain a constant net output voltage for a given concentration of oxygen. Potentiometers R7 and R8 are used to correct for internal offset errors in operational amplifiers A1 and A2, respectively.

The output of A2—6 is scaled to about 2 Volts, then divided down by SPAN (calibration) potentiometer P1 to 1 Volt, nominal. Readout of the percent oxygen concentration is provided by meter M1. Resistor R11 is a meter trimpot potentiometer.

The analyzer circuitry requires 115 VAC, 50/60 Hz, single phase power which is connected through RANGE switch SW1 to the fused primary of transformer T1. Rectification, by diodes D1 through D4 connected across the transformer secondary, provides +/- 15 VDC unregulated to the operational amplifiers. Capacitors C7 and C8 provide a bypass for stray electrical noise picked up on the power lines, transients, and RF.

AC input power is also connected to a Triac controlled heater circuit. When temperature rises above the setpoint of thermal switch SW3, heater H1 is turned off. When the heater contacts close, the Triac is shut off. When the temperature falls below the setpoint, the Triac and heater are turned on. The heater and thermal switch are physically located in the combustible sensor compartment.

2.2 Combustible Analyzer

The detector assembly and resistors R7 and R8 form a Wheatstone Bridge. The signal for the bridge is taken from the junction of R7 and R8 for the reference signal which is applied to A1—A3, and from the junction of the measuring (or active) and reference beads of the detector for the measuring signal which is applied to A1—2 (See drawing C-11751. Integrated circuit A1 is a differential amplifier whose output (at pin 1) is proportion l to the difference between the two input signals. Diodes D7 and D8 provide protection to amplifier A1 from high voltage spikes, transients that might be caused from the long lines connected to the detector, etc.

The ZERO adjustment is made at the potentiometer P1. The adjustment is made by unbalancing the bridge. Potentiometer P1 is connected to the same supply voltage as the bridge with resistor R9 connected to the center of the reference side of the bridge. This arrangement provides sufficient unbalance voltage to compensate for the unbalance of the sensor.

Amplifier A1 is set up with a gain of about 20, nominally for 5% methane. The output at A1-1 is about 2 volts nominal full scale. One volt is picked off at the center of the SPAN potentiometer P2 in order to drive the voltage follower (the other half of A1) which provides isolation of the first-stage amplifier from the remainder of the circuitry. Resistor R32 and Capacitor C18 filter out any noise that might have come in on the detector lines, electrical transients, etc.. The output from A1—7 also provides an analog signal output that is selectable by varying the values of R28 and R29.

ALARM potentiometer P3 is the setpoint adjustment for the alarm. When the output from the gas amplifier goes higher than the setting of P3, transistor Q1 is turned on and relay K2 is energized, resulting in an alarm. A BUZZER toggle switch, when placed in the ALARM setting, allows an internal buzzer to sound, indicating that the unit has gone into alarm. Additionally, illumination of a red ALARM light indicates an alarm (while illumination of the green SAFE light indicates normal operation). If the AUTO/MAN toggle switch is set to MAN, the alarm latches and it is necessary to switch to Al, to AUTO to unlatch the alarm.

As noted previously, relay K2 is energized when an alarm occurs. With no alarm, the normally closed contact is closed and the normally open contact is open. When an alarm condition occurs, the contacts transfer and reverse their normal state.

An optional CAUTION alarm circuit utilizes potentiometer P4 to establish the setpoint. When the setting of P4 is exceeded. transistor Q2 is turned on and relay K1 is energized, resulting in an alarm.

The optional FAILURE alarm circuit is set up so that if the detector opens up, an alarm comparator will trip and turn off a relay, which is normally energized, i.e., during the non-alarm condition, the normally open contact will be closed and the normally closed contact will be open.

The power supply circuitry includes transformer T1 which is a 40-volt center-tapped unit. Two sets of rectifiers are used to supply two regulated power circuits and +/-24 VDC unregulated. The circuit that includes Zener diodes ZD2 and ZD3 supplies +/-15 VDC regulated. Regulator VR2 is the current regulator for the detector. This regulator is set up so that current through the detector is determined by resistors R4 and R5. Current output of 0.3A can be measured at a pair of test points. Capacitor C9, connected across the input, gives protection from line transients, high voltage spikes, etc.

2. 3 Detector

The basic elements of the combustible gas detector are shown in Figure 5. The two beads each consist of a very small coil of wire coated with an appropriate material. The active (or measuring) bead coating is a mixture of a catalytic material with an inert binder. This catalytic material is selected to enhance the oxidation of combustible gases. The reference bead coating is an inert material having similar thermal properties to the other bead.

Upon exposure of the detector to an atmosphere containing combustible gases and oxygen, these will combine at the surface of the measuring bead. Energy produced by this reaction will heat the active bead and cause the electrical resistance of its wire coil to change. The change in resistance of this coil is, then, for a particular gas, a measure of the reaction rate at the bead surface. The reaction rate and energy production depend strongly on the nature of the gas. By raising the temperature of the bead, the reaction rate can be increased, making the effects of different gases more nearly equal. Thus, the sensitivity of the detector is made greater and more nearly equal for different gases. This heating is accomplished by passing a constant electrical current through the wire coil supporting the bead.

The temperature of the active bead will be influenced by other factors such as initial gas temperature, gas thermal conductivity, flow rates and the temperature of its housing. The reference bead, having similar electrical and thermal properties and being heated by the same current, but lacking the catalytic material will be similarly affected by these extraneous factors but not significantly affected by oxidation of the combustible gas.

These two beads are placed in close proximity. to one another so that they are affected by the same environmental factors. Thus, the differences between the changes in resistance of the two coils is directly related to the concentration of combustible gases.

Installation

3.1 Electrical Connections

All wiring is to be connected to the barrier type terminal strips on the back plate assembly within the analyzer. Refer to Figure 6, Interconnection Diagram, and be certain that the wiring installation complies with the directions contained in the illustration and in the following discussion.

3.1.1 Power

Refer to the drawings in the supplement at the back of this manual. All power inputs are fused in order to protect the pump in addition to the analyzer electronics.

3.1.2 Output Signal Voltage

All models of the analyzer are equipped to provide an output signal voltage. The magnitude of the signal, which is determined at the time of purchase, can be preset at the factory to any value between 1 mV and 1 V. Unless otherwise specified, the outpur will be set to 0–1 VDC.

The output signal, regardless of magnitude, is suitable for high-impedance devices only (10K Ohms min.).

For interconnection purposes, 22 guage AWG shielded cable conductor is recommended. Polarize the signal connections as shown in Figure 6 and connect the shield to the analyzer only.

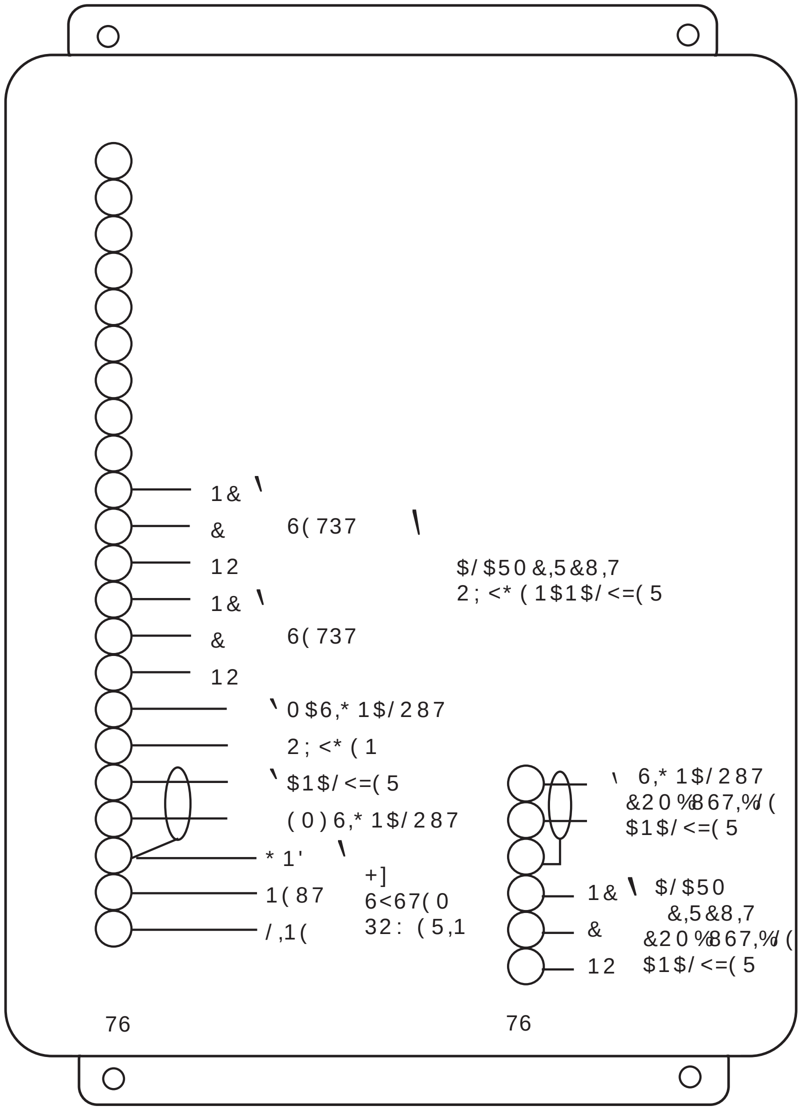

Figure 6: Interconnection Diagram

Note: Ground the shield of the signal cable at the analyzer only as shown in the diagram. Do not ground either output signal lead. Power and signal leads should be placed in separate conduits.

Wire recommendations:

Signal: 22 Ga. shielded cable (no shield required for mA signal).

Power and Ground: 16 Ga

Alarm Circuit Wiring: 16 Ga.

3.1.3 Alarm and/or Control Circuitry

Models having a -1 or -2 as part of their model number are equipped with single (-1) or double (-2) alarm and/or control circuits.

The SPDT form "C" (NC/C/NO) contacts of the relay (or relays) are available on the terminal strip within the oxygen analyzer. To properly use the switch that the relay contacts represent, the customer must determine when the relay (or relays) is energized (above or below the setpoint). The appropriate terminal strip connections are identified on the interconnection diagram (see Figure 6).

For those not familiar with relay terminology, the terms normally open (NO) and normally closed (NC) refer to the relay contact configuration when the relay is in a de-energized condition.

The load current per relay must be limited to 3 Amperes non-inductive.

3.1.4 Output Signal Current

Instruments which include the designation "I" as part of their model number are equipped with an E-to-I converter to provide a DC milliampere (mA) output signal as well as a DC voltage signal.

A separate $^1/_4$ ampere slow-blow fuse, located on the analyzer control panel, protects this circuitry.

The range for current output is:

- 4–20 mA dc

  Suitable for devices with 0–1500 Ohms impedance (resistive).

The appropriate terminal strip connections are identified on the interconnection diagram (see Figure 6).

Operation

4.1 Startup of Oxygen Analyzer

4.1.1 Preliminary

Before applying power to the instrument, TBE/AI suggests that the electrical wiring installation be checked against the interconnection diagram (see Figure 6), especially if the installation has been made by personnel other than those responsible for startup and operation. In many instances, proper attention to this preliminary check will prevent severe damage due to accidental wiring transpositions.

4.1.2 Meter Zeroing

Before turning power to the analyzer on, (RANGE switch in any position but OFF), the mechanical zero of the meter should be checked and adjusted, if necessary. The meter indicating pointer should be in precise coincidence with the scale zero mark. Use the mirror to eliminate parallax; adjust the screw on the face of the meter to zero the pointer. Zeroing of the meter is important to achieve maximum accuracy of the meter, and even more important if remote indicating and/or recording equipment are involved in the system. An offset zero on the meter will result in a tracking error between the two devices which would be significant if the meter is used to calibrate the analyzer (normal procedure).

CAUTION: Never attempt to make this adjustment with the power on.

The Micro-Fuel Cell is supplied separately in a controlled atmosphere package and must be installed prior to startup. To install the cell, use the following procedure:

Note: Do not open the sealed package until the system is to be started and a flue gas sample is available .

(1) Make sure that the RANGE switch is in the OFF position (power “off”).

(2) Locate the cell holder assembly (white unit on the back plate assembly) and withdraw the cell probe from its holder, using a twisting motion. Remove the cap by unscrewing counterclockwise **(**CCW).

(3) Open the cell package and remove the shorting clip .

(4) Place the Micro-Fuel Cell in the probe with the gold colored sensing surface facing toward the outside, and the printed circuit contact end facing the contacts inside the probe body. Replace cap previously removed (refer to instructions in the cell box).

(5) Insert the cell probe back into the probe holder bv pushing it in with a slight twist until the the probe strikes bottom.

4.1.4 Initial Calibration and Equilibration

Before stable, reliable operation can be achieved, the Micro-Fuel Cell requires a period of time to adjust to its new environment. When observing the integral meter, this period of time will appear to be about 15 minutes. In actuality, however, true stability is not achieved for many hours, which can be demonstrated by recording the output on a circular chart recorder, then analyzing the results of the first 24 hours of operation. The user will note a few percentage points of drift covering a period of hours after the initial first 15 minutes of equilibration.

If speed is of the essence, TBE/AI suggests that the instrument be placed in service atter it appears to have stabilized (usually about 15 minutes), and the slight instability of the ensuing hours tolerated. Any error incurred during this period will be eliminated during the first operational calibration.

If, on the other hand, reliable analysis, free of instrument distortion, is required from the very onset of operation, TBE/AI recommends a 24 hour run-in period before operational calibration and service .

In either case, emlploy the following procedure:

(1) Set the analyzer RANGE switch to the 0–25% position. Power has now been applied to the instrument circuitry and to the sample pump.

(2) Rotate the sample-caibration selector valve so that calibration or span gas is being delivered to the analyzer.

Note: When the valve is rotated so that the handle index faces the inside of the case (open port), atmosplleric air is drawn in by the pump and flows through the oxygen analyzer. Be sure that the valve is returned to the sample inlet position after calibration is completed. Never leave the valve in the half-way (closed) position with the pump running.

(3) Allow air to flow through the unit for 3 to 5 minutes.

(4) Unlock and adjust the SPAN control until the meter pointer is in coincidence with the CAL mark (20.9% O_2) on the meter scale. Relock the SPAN control.

(5) Rotate the selector valve so that sample gas is flowing through the analyzer.

(6) Select the range of analysis that will provide the best possible resolution of the oxygen content of the sample gas.

(7) Allow sample gas, not calibration air, to flow through the analyzer for the duration of the equilibration period.

Note: It is particularly vital to the condition of the A-3 cell employed in flue gas (or high CO_2 content applications) that the cell not be exposed to a CO_2 free environment for a prolonged period of time.

4.1.5 Operational Calibration

After the equilibration period following the installation of any new cell, or whenever it is desirable to recheck the calibration of the instrument, use the following calibration procedure:

(1) Place the RANGE selector switch on the 0+25% Position.

(2) Rotate the selector valve so that calibration (or span) air is flowing.Allow air to flow for 3 to 5 minutes.

(3) Unlock and adjust the SPAN control until the meter pointer is in precise coincidence with the scale CAL mark (use the mirror to eliminate parallax) and relock the SPAN control.

(4) Return the instrument to service by restoring sample flow and selecting the range that provides the best possible resolution of the sample oxygen .

(5) To prevent generating ambiguous alarms during calibration of alarm equipped instruments, simply unlock and rotate the setpoint dial (or dials) until the limits of travel in the NORMAL (rather than ALARM) direction have been attained. After sample flow has been reestablished and the proper scale of analysis selected, the alarm point can be precisely reset by simplre-dialing the setpoint.

(6) For converter-equipped instruments, the current output of the converter always tracks the output of the measuring circuit amplifier. No provision for interlocking the converter to a particular range of analysis has been provided. If the current output is being used to operate a pneumatic control device, the customer will be required to provide whatever necessary electrical or mechanical interlocks necessary to safeguard his system against the signal changes that will occur during calibration.

4.1.6 Routine Operational Calibration

Span calibration should be checked every two to four weeks on a routine basis. Whenever there is the slightest suspicion of abnormal performance, an inspection of the possible trouble should be made, followed by span calibration. Use trouble shooting procedures as required.

4.2 Startup of Combustibles Analyzer

4.2.1 Procedure

The combustibles monitor comes ready to operate. Power is connected to it through a terminal strip in the oxygen analyzer (see Figure 6). The combustibles monitor has Its own POWER switch located on the front panel of the control unit. Alarm relay and analog output terminals are located in the oxygen analyzer.

When ready to operate, follow the startup procedure in Section 4.3 Startup Procedures, except as follows:

(1) Turn on the air supply and adjust the AIR regulating valve on the valve panel until I flow rate of 2–3 SCFH is indicated on the lefthand flowmeter.

(2) Open the SAMPLE toggle valve and open the sample/bypass control valve fully CCW. The sample/bypass control valve is the valve on the outlet of the filter.

(3) Start up the svstem pump and with either calibration air or sample flowing, slowly close the sample/bypass valve until a flow of 2–3 SCFH (matching air flow) is indicated on the righthand flowmeter. The flowmeter ball will have some bounce due to water column fluctuation in the system. Adjust for an average value.

Note: **Do not attempt to run a higher flow rate than 3 SCFH. Higher flow rates will cause the water trap to break and all flow will be lost through the drain.**

(4) Turn ON the POWER switch of the combustible monitor control unit. Wait about five minutes for the unit to warm up.

(5) Shut off the SAMPLE toggle valve and let only air flow through the unit.

(6) After air has been flowing for a couple of minutes, adjust the ZERO control on the control unit (use the small screwdriver supplied) until the meter pointer lines up with the zero mark on the dial (be sure that the mechanical zero of the meter is first adjusted with the power off.)

(7) Turn on supply of span gas and open the SPAN toggle valve. Then adjust the SPAN flow control valve until a flow rate of 2–3 SCFH is indicated on the right hand flowmeter.

Note: Flow rate of span gas should be set to match that of the air as closely as possible. It does not matter what they read as long as they are both the same.

(8) Adjust the SPAN control with the small screwdriver until the meter pointer reads the analyzed value ot the span gas.

(9) If only a very small or no adjustment was required, no further calibration should be needed. If, however, a fairly large adjustment was made, the ZERO adjustment should be rechecked and readjusted, as necessary. If ZERO readjustment was made, check the SPAN adjustment again.

(10) Adjust alarm setpoint to the desired level. The alarm is adjusted by turning ZERO control until the meter reads the desired alarm point. The ALARM level control is then adjusted until the alarm light just comes on. The ZERO control must then be reset to produce a zero reading.

(11) Once the above adjustment has been made, the unit is ready for service.

(12)After calibration is completed, re-establish sample flow and be sure the flow rate is set to match that which was used for span gas.

4.2.2 Span Gas

It is recommended that the span gas have a concentration of 4.0–4.8% methane or other desired combustible gas with the balance being nitrogen.

Note: **It is important that the dilution air flow is never turned off during operation or calibration. Combustibles without at least a 2 : 1 ratio of oxygen should never be allowed to flow past the sensor. If this occurs, a loss of sensitivity will result and the unit will require complete recalibration and possible sensor replacement.**

Note: **The range of the combustible monitor is 0–5% combustibles, however, it is actually operating, at a sensitivitv of 0–2.5% combustibles (methane equivalvent) due to the 1 : 1 dilution with air.**

4. 3 System Startup

4.3.1 Analyzer Startup

Refer to Sections 4.1 and 4.2 for startup procedures for the oxygen and combustibles analyzers, respectively.

4.3.2 Sample System Startup

Start the pump by turning ON the oxygen analyzer RANGE switch. Then turn on the water by opening the shutoff valve inside the case. Water should be observed passing through the transparent plastic hoses. Water flow rate will be determined by the supply pressure. With 10 psig, flow rate will be approximately $^1/_4$ gpm maximum pressure should be 100 psig. This will give a flow rate of about $1^1/_2$ gpm. Generally, the dirtier the sample, the more water required. However, a $^1/_4$ gpm flow rate will normally be adequate, and the pressure should be reduced accordingly.

After analyzer startup and calibration procedures have been accomplished, make certain that the sample-calibration selector valve is in the proper position to draw in the sample (see the cautionary note in step (2) of Section 4.1.4, Initial Calibration and Equilibration, and step (5)).

Maintenance & Troubleshooting

5.1 Maintenance

5.1.1 Routine Maintenance

No moving parts other than the meter movement and the relay contacts are contained in the analyzers. Periodic service, therefore, other than oxygen cell replacement, is not required. The periodic calibration contained in Sections 4.1 and 4.2 should be adequate to keep the analyzers functioning. If troubles develop, refer to the trouble shooting procedures contained in Section 6.

5.1.2 Oxygen Cell Replacement

When the Micro-Fuel Cell nears the end of its useful life, sensitivity will decline very rapidly. The initial response to this phenomenon will be recalibration of the analyzer. If many turns of the SPAN control are required to recalibrate the instrument, or more commonly, the control does not have sufficient range to recalibrate the analyzer, a new Micro-Fuel Cell will be required.

Wipe off contact pins (P/N A-6544) in the probe assembly with a clean tissue before installing the new cell. If, after long service, the contact pins become pitted or worn, they may be replaced by unscrewing the hold-down plate.

To offset the possibility of not having a replacement cell available when it is needed, TBE/AI recommends that a spare cell be ordered shortly after the instrument is placed in service, and each time the cell is replaced thereafter.

Note: Do not over-order or stockpile Micro-Fuel Cells. Only one cell per instrument should be kept in reserve.

When installing the oxygen cell in the probe housing, make certain that the shorting clip is re- moved and that the cell membrane is facing up (or outward). Do not install the oxygen cell upside down.

Caution: When replacing the oxygen cell, use care not to scratch the membrane covering the gold-plated electrode. If the membrane is ruptured or damaged in any way, the sensor must be replaced.

The oxygen cell contains a caustic liquid (potassium hydroxide solution). If the Teflon membrane is ruptured, the liquid in the cell can leak out. The liquid has a characteristic slippery feel and if contact with the skin or eyes occurs, wash with copious amounts of water and seek medical attention, if required.

Note: Do not install an oxygen cell into a system that is in storage or in a non-operating condition. The oxygen cell will commence the oxidation process and eventually will become useless as a sensor. Also, when the on-line system is shut down for a short time, every effort should be made to adjust the controls in the system to prevent air from coming into contact with the Micro-Fuel Cell.

5.1.3 Cell Warranty

The A-3 Micro-Fuel Cell carries a warranty that covers its normal life expectancy. Cell warranty is for 6 months of continuous service in normal flue gas applications.

Customers having warranty claims should return the cell in question to the factory for evaluation. If it is determined that failure is due to faulty material or workmanship, the cell will be replaced free of charge.

Note: Evidence of tampering or abuse will render the warranty null and void. If the cell was working satisfactorily, but fails short of its warranty period, the customer will receive credit, on a prorated basis, towards the purchase of a replacement cell.

5.1.4 Spray Nozzle

It will be necessary to clean the mineral deposits from the spray nozzle periodically (see Figure 1). If water flow through the system diminishes significantly, it is an indication that the nozzle is plugged. The nozzle can easily be <cleaned by removing it and soaking it in a 25% hydrochloric acid solution.

CAUTION: Use extreme care when using hydrochloric acid. Do not allow any solution to contact the skin or clothing. If acid contacts the skin, flush the exposed areas continuously for 5 to 10 minutes or until medical attention can be obtained. Do not breath hydrochloric acid vapors. Use only in an approved vented safety hood.

5.1.5 Water Strainer

It may be necessary to clean the screen in the strainer periodically (see Figure 1). This is accomplished by unscrewing the brass hex plug on the front of the unit and removing the screen.

5.1.6 Filter Condensate Trap

Any accumulated water must be emptied from the condensate trap before the water level reaches the filter element (see Figure 1). This is accomplished by simply pressing sideways on the flexible drain spout on the bottom of the bowl. The filter element should also be cleaned periodically by washing it with kerosene and blowing it dry with compressed air. The part number of the element is listed in Table 3.

5.1.7 Combustible Sensor

The combustible sensor is installed along with the H-28 heater and T-199 thermoswitch in the sensor unit enclosure. These components can be removed for replacement, if required.

5.1.8 Pump

The pump (shown in Figure 1) uses a flexible Nordel liner which is actuated by a roller on an eccentric. This liner requires oiling weekly. The pump is equipped with an oiler which holds a large supply of oil. Use the following procedure to oil the liner:

- Fill the oiler. (This needs to be done only occasionally.)
- Once the oiler is filled, it is only necessary to open the toggle valve on the top of the oiler.
- Shut off the pump and let 7 or 8 drops of oil fall in the sight glass of the oiler.
- After about two minutes, restart the pump.
- Close the toggle valve on the oiler when finished.

If the liner is oiled routinely, it should last about 6 months to a year. Replacement of the liner will restore any noticeable loss in pumping efficiency.

Any water coming out of the pump liner vent line (at the bottom of the separator) is an indication that the liner is worn through and needs to be replaced. Detailed pump maintenance instructions can be found in the Appendix of this manual.

Note: Use only Venton Pump oil or pure silicone oil of 2000 centistokes viscosity. Do not use organic oil.

5.2 Troubleshooting

5.2.1 General

Trouble shooting information contained herein is limited to the electronics of the system. It is felt that malfunctions occurring in the pneumatic portion of the system can be remedied by personnel familiar with valving, regulation, and standard mechanical engineering. The electronics portion of the system, however, includes advanced solid state, integrated circuitry. Technicians involved with trouble shooting the electronics of the system should be familiar with common diagnostic equipment and techniques.

When subjecting the analyzer circuits to checkout, it is appropriate to first check the power supplies for correct output. If voltages are incorrect, then take corrective action with power supply components .

5.2.2 Oxygen Analyzer Section

5.2.2.1 Inability to Calibrate

If the oxygen analyzer cell circuit exhibits insufficient amplifier gain, or if it is impossible to adjust the output signal with the SPAN potentiometer, the oxygen cell is probably used up. This process will require some time; it will not happen immediately. Before replacing the cell, however, check the sample circuit to make sure that the sample is actually getting to the cell.

If the cell is functional, or there is still no output with installation of a new cell, then a check of the electronics should he undertaken.

- First, check the power supply. Make sure that proper voltages exist at A1-7, (+15 VDC), A1-4 (-15 VDC), A2-7 (+15 VDC), and A2-4 (-15 VDC).
- If voltages are satisfactory, check output of A1 at pin 6. (It will be easier to check the output of A1 at the tiepoint of resistors R1/R2/R3.) Use the tiepoint of C7 and C8 as the power common. The voltage (output of A1) should be 0.125 V with a full scale signal. If the oxygen cell is exposed to 20.9% oxygen, the voltage at A1-6 should be about 0.1 VDC.
- If the voltage at A1-6 is satisfactory, then check the output of A2 (at A2-6). (It will be easier to check the output of A2 at the tiepoint of R9 and C6.) Use the tiepoint of C7 and C8 as the power common. The voltage (output of A2) should be 2 V full scale. If the oxygen cell is exposed to 20.9% oxygen, the voltage at A2-6 should be 1.5 to 1.75 VDC .

In addition to possible malfunctions occurring in Al and/or A2, the FET (Q1) could be malfunctioning, i.e., not being turned off. If Q1 is “on” all the time, the oxygen cell will be shorted and no signal will be able to get through the feedback resistors for A1.

The best way to check Q1 is to remove it, then check it, or substitute a replacement .

The meter drive circuitry, as shown on Dwg. B-l0913, is straightforward and relatively simple to follow. If any troubles occur in this circuitry, consult the schematic diagram.

The heater (H1) control is controlled by SW3, R15 and the Triac (SCR1). During various periods of the heater cycle, both R15 and SW3 are required to carry a heavy load. Consequently, it is possible for either component to fail.

The Triac can fail as well. If it fails in the “open” condition there will be no heat from the heater. If it fails in the “closed” condition, the heater will be on all the time. Heater malfunction will probably be evident with calibration problems involving the combustibles sensor, since the heater is installed in a compartment with this particular sensor.

5.2.3 Combustible Analyzer Section

Refer to drawing C-11751 for the following discussion.

5.2.3.1 Inability to Calibrate

The most common cause of an inability to zero and/or span the instrument is detector failure. The combustible detector will drift in both span and zero with time. However, if it fails, it is most likely to be an abrupt phenomenon, unlike the oxygen cell which “dies” slowly. Upon failure, the output of the instrument will go up or down full scale depending upon which bead fails.

The standard combustible analyzer used in the Model 9700 system includes a failure alarm circuit that is described in Section 2.2. As described, a failure will cause the meter to deflect full scale downward (pegged to the lefthand side of the meter) and the alarm will be energized. This situation will indicate a sensor failure.

The sensor circuit can be checked either with a new sensor or a dummy sensor, constructed with two 7.5 Ohm 3 to 5 Watt resistors installed between pins 14 and 15, and 14 and 13 (see Dwg. C11751). With the dummy sensor, the zero and span potentiometers will both function and the and the electronics can be checked. If the span and zero controls operate satisfactorily with the dummy sensor, then the original detector is probably defective and requires replacement. If problems still occur in the detector circuit, then the dummy sensor will give a signal that can be tracked through the system.

- Measure the voltage at the tiepoint of R7, R8 and R10 with respect to terminal 14 which is the center of the sensor bridge. With the zero potentiometer adjusted up and down, the voltage should change by about $^1/_4$ volt. If this does not occur, then there is probably something wrong in the Wheatstone Bridge circuitry, i. e., the resistors that constitute the bridge along with P1, the zero potentiometer.
- Measure the voltage at the output of A1 (A1-1). (The easiest place to check the output voltage of A is at the tiepoint of R15, R30 and C11.) Use the tiepoint of C7 and C8 (oxygen analyzer) for power supply common. The signal should be tracked through the system. With a voltmeter attached to A1–1 move the zero potentiometer up and down. Pin 1 of A1 should reflect this voltage movement by a couple of volts.
- With the zero potentiometer set so there is a voltage at A1-1, follow the signal through the circuit, i.e. through to A1-7 and see if the meter deflection is appropriate to the voltage at A1-7. The meter should indicate full scale deflection with 1 V at A1–7. If it does not, replacement of A1 is indicated.
- The preceding discussion concerning signal checkout assumes that the power supplies have been verified and are operating properly (see Section 5.2.1.). The regulated power supply should be checked at C8 and C7 for +/- 15 VDC.
- The output of the current supply for the detector can be checked at the two test points (located on each side of R6). The voltage should be 0.3 V, which indicates that 300 mA is flowing through the detector.

5.2.3.2 No Alarm With High Gas Level

If there is trouble with the alarm comparator, A3 or transistor Q1, there will be no alarm indication even though the gas level goes above the setpoint. Also, there will be no alarm if the relay coil K2 fails, although relay coil failure is not likely.

5.2.3.3 Lamp Failure

For failure in any circuit involving a lamp, always check the lamp for failure before embarking upon more involved diagnostic checkout. The lamps are the most failure-prone components of the system .

Appendix

Specifications

SYSTEM	
Operating Power:	115 VAC, 50/60 Hz, single phase (other voltages available as option)
Power Consumption:	6 A
Operating Temperature:	32 deg F to 125 deg F (0–52 deg C) (Optional auxiliary heating available for operation in below freezing ambient environment.)
Output Signal:	0–1 VDC or less (Optional mA output available)
Enclosure:	Sheet steel equipment case
Dimensions:	
width:	24" (60.96 cm)
length:	36" (91.44 cm)
depth:	11 1/2 " (29.21 cm)
Mounting:	Wall or bulkhead
Weight:	185 lbs (83.25 kg)

OXYGEN ANALYSIS SECTION

Ranges:	0–5%, 0–10%, 0–25% O_2
Sensitivity:	0.5% of full scale
Accuracy:	+/- 2% of full scale at const. temp. +/- 5% of full scale across temp. range
Response Time:	90% of O_2 in 45–60 seconds
Calibration:	Air
Cooling Water:	10–100 psi, $\frac{1}{4}$–$1\frac{1}{2}$ gpm
Sensor:	Class A-3 Micro-Fuel Cell (warranted for 6 months in normal flue gas applications)
Alarms (optional):	1 or 2 (3 Amp resistive)

COMBUSTIBLE GAS SECTION

Ranges:	0–5%, combustibles (CH_4 equiv. standard)
Sensitivity:	0.5% of full scale
Accuracy:	+/- 2% of full scale
Response Time:	90% of combustibles in 15 seconds
Calibration:	With span gas composed of 4.0–4.8% methane content (balance nitrogen)
Air Supply:	Compressed air regulated to 5–25 psig, 2 SCFH typical required consumption
Sensor:	Low temperature catalytic bead (warranted for 6 months)
Alarms Contacts:	1 SPDT (3 Amp resistive) non-latching

OPTIONAL CALIBRATION KIT

6 size (G-4l) cylinder of span gas (4–4.8% methane, bal. nitrogen)

Pressure and flow regulators

Adapter: 5 ft. (152.4 cm) of 3/16 " (4.74 mm) ID silicone tubing

Recommended Spare Parts List

Model 9700 System

(Standard Unit Only)

PART NO.	DESCRIPTION	QTY
F-77	Fuse, Tvpe 3AG, 6-1/4A, Slo-Blo	5
S-81	Triac, G. E. #SC45B	1
T-199	Thermoswitch, Fenwall #32410-2 (130 deg F)	1
T-267	Thermoswitch, H-B #7920A (85 deg F)	1
H-2	Heater, Vulcan #1208	1
H-28	Heater, Chromalox #A-00, 125 W	1
N-49	Nozzle, Spray, Spraying Systems #1/8 GD 3.5	1
C-11577	Control Unit, Combustible Analyzer	1
F-6.	• Fuse, Type 3AG, 1/4A, Slo-Blo	5
R-179	• Relay (K2), P.B. #KHP 17D11-24V	1
T-231	• Transistor (Q1)	1
P-122	• Potentiometer (P5)	1
R-564	•Regulator, Voltage (VR2)	1
A-38	•Amplifier, Operational (A1, A3)	2
A-9348	P.C. Board Assy, Oxygen Analyzer	1
A-19	• Amplifier (A1, A2)	2
T-261	• Transistor, Field Effect (FET)(Q1)	1
S-89	• Diode (D1-D4)	4
P-l00	• Potentiometer (R7, R8, R11)	3
B-12115	Sensor Probe Assy, Comb.	1
P-146	Pump, Flex-I-Liner, Vanton #18 Nordel	1
C-6689	Cell Assy, oxygen, A-3	1
F-96	Filter Element, MP #lO3-3PE	1
G-26	Gasket (for separator)	1
L-32	Lamp, G. E. #327 (Comb. Control Unit)	2
A-6544	Pin, Cell Contact (O2)	2
A-7023	Spring, Cell Contact	2

* For spare parts used with optional configurations, see any addenda attached to this manual.

Important: Orders for spare parts should include the part number, and the model and serial number of the system for which the part(s) is intended.

Orders should be sent to:

Teledyne Brown Engineering
Analytical Instruments
16830 Chestnut Street
P.O. Box 1580
City of Industry, CA 91749-1580 U.S.A.

Telephones (818) 961-9221
(213) 288-7181
TWX (910) 584-1887 TDYANYL COID

Reference Drawings

B-10913	Schematic Diagram — Oxygen Analyzer
C-11751	Schematic Diagram — Combustible Analyzer
C-10896	PC Board Assembly — Oxygen Analyzer
B-10906	Wiring Diagram — Oxygen Analyzer
B-10981	System Wiring Diagram — Combined Oxygen and Combustible Analyzer

Response of Combustible Sensor to Various Gases

Response factors have been determined to relate the sensor output of a specific compound to the output obtained using methane. A list of some typical compounds is given in Table 1 along with their LEL (Lower Exposure Limits) values. To determine the output of the sensor for any of the gases listed, compared to the same concentration of methane, multiply the reading obtained by the factor listed. For example, if the output is calibrated with methane at 2%, the output for ethylene at 2% would be 2.0% X 1.26 = 2.52% methane equivalent.

TABLE 1: Detector Response To Various Gases

COMPOUND	LEL*	RESPONSE FACTOR
Methane	5.0	1.00
Hydrogen	4.0	0.86
Carbon Monoxide	12.5	0.32
Ethane	3.0	1.20
Ethylene	2.7	1.26
Acetylene	0.5	1.39
Propane	2.2	1.42
Propylene	2.0	1.33
Butane	1.9	1.54
Hexane	1.1	1.50
Cyclohexane	1.3	1.44
Heptane	1.05	1.59
Benzene	1.3	1.50
Pentane	1.5	1.45
Toluene	1.2	1.48
Ethylene oxide	3.6	0.76
Methyl Ethyl Ketone	1.8	0.96
Methyl Acrylate	2.8	0.59

* Taken from Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids, National Fire Protection Agency.

NOTE: For compounds not listed in Table 1, consult the factory.

To determine the concentration of a compound present at the sensor from a meter reading, when calibrated with methane, divide the reading (in percent methane) by the factor. For example, if ethylene is flowing by the sensor, and a meter reading of 2.0% is obtained, the concentration of ethylene would be:

For hydrogen:

For carbon monoxide:

For a mixture of 70% hydrogen and 30% carbon monoxide:

CAUTION: In most cases, the concentration of any particular compound that the sensor is exposed to should not exceed the LEL of that compound, or sensor damage could occur.

The concentration of combustibles should never exceed that which will react completely with the available oxygen present in the sample (stoichiometric burning), otherwise, "coking" (the deposition of carbon from incomplete combustion) will occur at the sensor, and drift and a loss of sensitivity will result.

Supporting Equipment for Flue Gas Analysis Systems

Two basic types of sample probes for flue gas applications are shown in Figures A-1 and A-2. The straight, dry type of probe (Figure A-1) consists of a length of 1" 316 stainless-steel pipe with a mounting flange or coupling welded to the outboard end for connection to the duct or stack (length of probe, as required). The second type is similar to the first except for the addition of a water spray nozzle .attached to the Outside end of the probe. This type of probe is used in applications containing large amounts of particulate matter such as coal-fired boilers, cement and lime kilns, and high sulfur fuel-oil fired boilers.

Experience has shown that the best service from probes can be obtained by eliminating any cooling or spray water in the portion of the probe inside of the duct or stack, and that the practice of adding spray nozzles inside the probe only increases their inclination to plug up. It is beneficial, however. to add spray water on the outside end of the probe. This cools the gas quickly and keeps acids and particulate concentrations from building up in the sample line. It is necessary to run the sample line so that it slopes continually from the probe to the analyzer system inlet to allow the spray water to keep the line flushed and prevent the accumulation of particulates or acid. All sample lines should be run in this manner for best results.

When using a spray nozzle on the probe end, it is recommended that a drop-out pot be installed on the analyzer system inlet to drain off the water containing the contaminants before it enters the system. This also prevents water from building up in the sample line during routine calibration or system shutdown.

Sample lines can be made from a variety of materials including stainless steel, PVC, steam hose, Teflon tubing and copper pipe. Tubing I. D. should be from $^{7}/_{16}$" to $^{5}/_{8}$". When using dry-type probes without water washed lines, it is beneficial to use heated lines such as “Dekron” to prevent condensation. This is necessary for any sample line which would be subject to ambient temperatures which are below freezing.

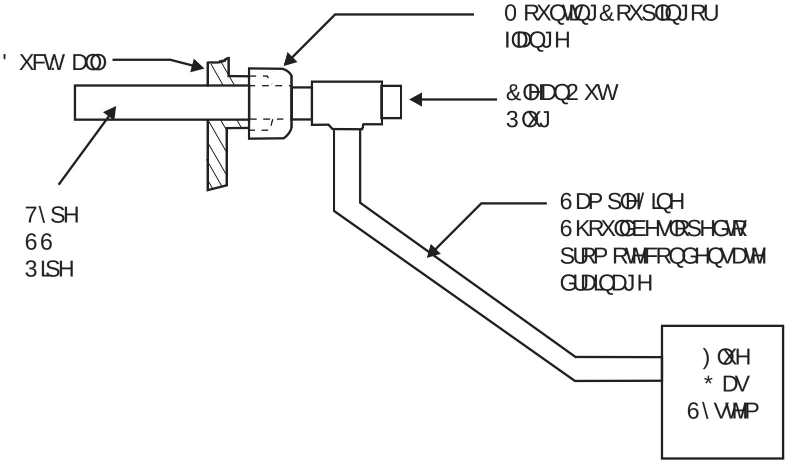

Figure A-1: Typical Dry Probe

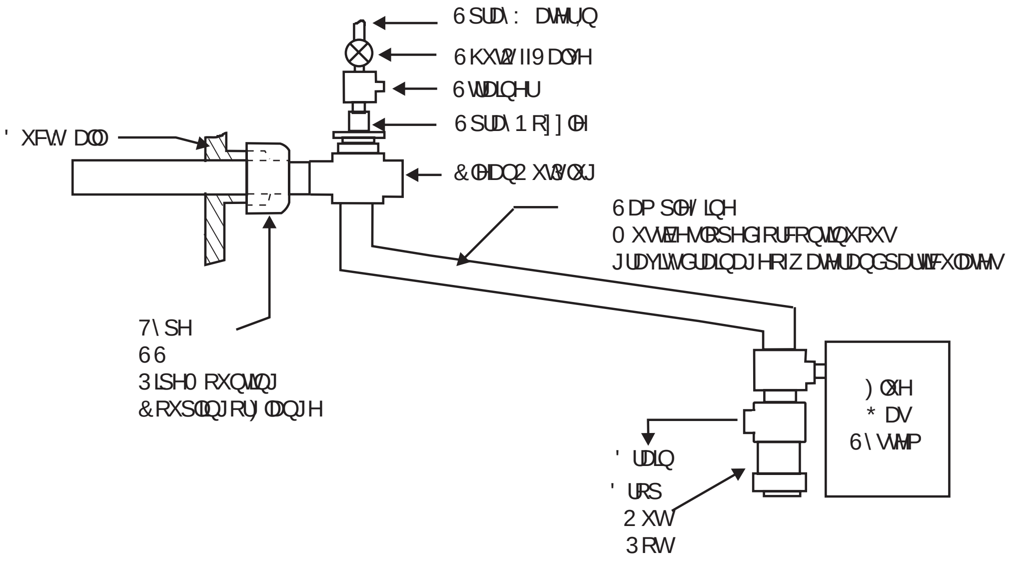

Figure A-2: Typical Wet Probe

General Maintenance for CC-2B Series Pumps

Maintenance

The pump is equipped with a Gits-type oiler which permits the occasional lubrication of the Flex-I-Liner interior with Vanton Pump oil or pure Silicone oil of 2000 centistokes viscosity. If the pump is used in continuous service, add a small amount of this oil each week (about 7 drops); less often for less severe service. This servicing is accomplished by stopping the pump, raising the spring-loaded cover of the Gits oiler and adding the oil.

CAUTION: Organic oil must not be used. The only recommended oil for the specified above is Vanton Pump oil or pure Silicone oil.

The Vanton Pump employs ball bearings which have been packed with grease at the factory and require no further lubrication.

Repair

Usually the repair of the Vanton CC-B Pump is an extremely simple procedure. After long or severe service, the Flex-I-Liner (item 4) may become worn or break. Replacement of this part restores the pump to its original performance. The steps for doing this are as follows:

Note: Refer to Figure A-3 for part item numbers.

(1) Obtain the following items:
  - 1/2" open-end wrench, or box wrench, or socket ratchet
  - Replacement Flex-I-Liner and Vanton oil

(2) Remove four bolts (14) using the 1/2" wrench or socket.

(3) Remove cover plate (1).

(4) Remove expansion ring from the now exposed Flex-I-Liner (17).

(5) Grasp the body block (2) and pull it away from the bracket (30).

(6) Remove the worn Flex-I-Liner from within the body block.

(7) Install new Flex-I-Liner: clean all chemicals from exposed parts of pump.

(8) Apply a liberal amount of Vanton Pump oil to the inside of the Flex-I-Liner. Spread this oil over the inside interior to the very edge.

(9) Push the body block back onto the bracket. Shaft should be rotated at the same time that pressure is being applied to the block to push it “home”. This will allow the Flex-I-Liner to seat over the Pilot of the bracket. It is suggested that the shaft be left in top dead center position once the block has been forced “home”. If the Flex-I-Liner is properly seated, the block will remain close to the bracket when hands are removed from the block; if improperly seated, the block will spring back from the bracket. Failure to have Flex-I-Liner properly seated prior to taking the next step will result in Flex-I-Liner crimping and improper pump performance.

(10) “Snap” expansion ring into Flex-I-Liner.

(11) Replace cover plate.

(12) Replace the four bolts and tighten each a little at a time, like one tightens a tire rim. Rotate shaft a number of times before bolts are drawn tight.

The pump is now ready for operation. Usually, the foregoing is all that will ever be required in maintenance because of built-in protection features of the CC-B Series Pump. Should the bracket assembly, after long service, require repair, the following procedure should be followed:

(13) Remove body block, casing cover plate, four bolts and support bracket as described in steps (1) through (12).

(14) The entire assembly remaining on the motor should then be detached from the motor by removing four socket-head cap screws (12) along with their shakeproof washers (11) and finally loosening the coupling set screw (10). Tap subassembly gently to remove.

(15) Remove flexible coupling by tapping out the groove pin (8) and then withdrawing coupling from pump shaft. The shaft (26) can then be pressed out of the bracket (7) by tapping or pushing on the coupling end. An arbor press can facilitate this operation.

(16) When the shaft is pressed out it will still be assembled to the rotor (19), the rotor bearing (20) the bearing guard (23), bearing guard spacer (22), and retaining ring (3).

(17) Remove plastic plug (16) and retaining ring (18) using a special pliers which can be obtained from Vanton or a local industrial distributor. The shaft can then be pressed out of the rotor.

(18) Remove the bearing guard (23), bearing guard spacer (22), and bearing retaining ring (3) from the plastic rotor, using special internal pliers obtained from Vanton or a local industrial distributor.

(19) Using an $^{11}/_{16}$" plug, press out outboard bearings (5) and bearing spacer (6). The pump is now completely disassembled.

In reassembling the pump, attach the flexible coupling to the shaft, using the groove pin (8) and then install the bearings (5) and the bearing spacer (6) onto the shalt as shown in Figure A-3. Make sure the outermost outboard bearing rests firmly against the coupling shoulder. This entire subassembly can then be inserted into the bracket.

The rotor (19) should be completely outfitted with rotor bearing (20), bearing guard (23), bearing guard spacer (22), and retaining ring (3) prior to installation onto the shaft, which previously was installed into the bracket.

The rotor should be installed onto the eccentric portion of the shaft protruding through the bracket by supporting the entire bracket unit in this fashion, Insert a $^{1}/_{2}$" X 5" long rod through the coupling end into the hole of the shaft. Set the rotor on end, lower the shaft into the rotor and gently tape the inserted $^{1}/_{2}$" rod or use an arbor press until the rotor is ‘’home”. Install rotor bearing ring (18) and replace plastic block with Flex-I-Liner (16) as previously described. The subassembly can then be bolted to the motor and while this operation is not particularly critical due to the unique coupling employed; nonetheless, good practice dictates that the faces of the bracket and the motor, which are to be bolted together, be clean and free from burrs.

NO.	QTY	DESCRIPTION	PART NO.
30	1	Support Bracket	8-86-051
29	1	Handle (opt)	
28	4	5/16 x 5/8 Dowel Pin	
27	1	1/4hp 1725rpm Motor	8-24-103
26	1	Shaft	
25	1	Alemite Hydr. Fitting	1729
24	3	Shims	8-66-061
23	1	Bearing Guard	XB-45
22	1	Bearing Guard Spacer	8-70-030
21	2	Hose Adaptors	8-75
20	1	Rotor Bearing	HD-77600
19	1	Rotor	8-15
18	1	Retaining Ring	5100-39W
17	1	Expansion Ring	8-30
16	1	Pipe Plug 1/2" NPT	
15	1	Silicone Oil Cup	XB-25
14	4	Hex Head Cap Screw	
13	4	SAE Flat Washer	
12	4	Soc Hd Cap Screw	
11	4	Shake Proof Washers	
10	1	Set Screw	
9	1	Coupling	8-23-030
8	1	Groove Pin	
7	1	Bracket	8-07
6	1	Bearing Spacer	8-50-032
5	2	Outboard Bearing	HD-29502
4	1	Flex-I-Liner	8-40-030
3	1	Retaining Ring	5000-37W
2	1	Body Block	8-25-030
1	1	Cover Plate	8-25-030

Pump Model	F	H-Tap
S2, S6, S12, S18	3/4	1/2-14 NPT
P2, P6, P12, P18	3/4	1/2-14 NPT
PY2, PY6, PY12, PY18	3/4	1/2-14 NPT
B2, B6, B12, B18	3/4	1/2-14 NPT
T2, T6, T12, T18	3/4	1/2-14 NPT
S90	1	3/4-14 NPT
P30, PY30, B30, T30	1	3/4-14 NPT

Figure A-3: Pump Assembly

Supplementary Instructions for Servicing the CC-60B Flex-I-Liner Pump

Except for a greater overall length, this pump is essentially the same as the following models CC-2B, CC-6B, CC-12B, CC-18B and CC-30B.

(Refer to Figure A-3). Important differences include:

(1) The first outboard bearing (13) on the abovementioned drawing is of extra heavy-duty double roll construction. Although counterpart bearings used on the other pumps are interchangeable with this bearing, they should not be substituted for the specified bearing due to the heavier loads encountered during operation.

(2) The bearing spacer (32) is somewhat narrower due to the greater width of the first outboard ball bearing.

(3) The interior of the rotor (5) contains one extra part (item 16) — the bearing guard spacer.

(4) The rotor bearing (14) is of heavy-duty roll construction and not interchangeable with the ball bearing used in the remainder of the series.

(5) The size CC-60B pump employs a 1/2 HP motor, the remainder of pumps in this series employs 1/4 HP motors.

Even though the pump contains additional and somewhat different parts, the method of disassembly and assembly is identical to the instructions for the CC-2B through CC-30B series and should be closely followed.

Replacing the Liner in the Flex-I-Liner Pump

On occasion, it will be necessary to replace a worn liner. It is imperative that this member be correctly installed to insure maximum longevity of the liner and satisfactory future performance and operation of the pump.

In Figure A-4, the bracket shown in the top photo is that for close-coupled models. The bracket in the other photos is for pedestal mount models. Other components remain basically the same for all Vanton Flex-I-Liner pumps.

To assemble:

Wipe Vanton Silicone oil on the ID of the liner before assembling.

Grasp liner and block. Push the liner through the back side of the block. Using your finger, wipe the inside diameter of the liner thoroughly with Vanton Silicone oil. Also apply some of this oil to the rotor.

The object is to push the liner over the rotor and metal boss (see arrow) of the back plate.

As you can see from the photograph, the liner has now seated itself over both the rotor and metal boss of the back plate and the flanges of the liner have seated in the recess provided.

Once the liner is in place in the proper recess, apply pressure to the block until the block seats over the guide pins. Now install the expansion ring and cover plate.

Figure A-4: Replacing the Flex-I-Liner

Note: When tightening bolts, apply even pressure. Tighten the bolts in a sequence of: upper left — lower right — lower left — upper right.