GAS MONITORING SYSTEM REVIEW AND DESIGN RECOMMENDATIONS

Metro Rail Transit Consultants
DMJM/PBQD/KE/HWA

January 1985

METRO RAIL TRANSIT CONSULTANTS
DMJM/PBQD/KE/HWA

MEMORANDUM

February 18, 1985

TO : SEE DISTRIBUTION

FROM : A. M. Dale

SUBJECT : COMMUNICATIONS SYSTEM -- GAS MONITORING SYSTEM

FILE : W001A640
ME.4.2

The attached "Gas Monitoring System Review and Design Recommendations Report" reviews the gas monitoring system design developed during Preliminary Engineering and recommends a change from remote sensors to central analyzers supplemented by remote sensors at certain locations. The recommended changes are reflected in the Communications System In-progress Design and Industry Review Package which is currently in reproduction. The change has significant impact on the Systems Design Criteria, Volume 4, Section 8, "Miscellaneous Mechanical/Electrical Subsystems".

A change request covering the affected Systems Design Criteria will be prepared and will include resolutions to comments received on the report. Please review the report and submit comments by March 8, 1985. The report, and the resulting specifications will be a significant topic of discussion at the forthcoming Communications In-progress Design Review.

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SYST

ITEM NO. 29

ACTION ITEM TRACKING SHEET

DATE: February 21 '85

TO: Becher, M.
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DUE DATE: March 8 '85

SUBJECT: GAS Monitoring System Review

ACTION REQUIRED:

Comments Requested by the Due Date

FDB, LSD 3/12

RETURN TO:

RTD 81-1
EFF 3/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

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REVIEW / COMMENT SHEET

RTD

Reviewer R. L. Bauermann File No. ______ Date 3/12 1985

Dept. / Section TSD/ESD4 Submittal No. and/or Date 2/18/85 Sheet 1 of 4

Design Review / Submittal Title Gas Monitoring System Review

REF NO.	PAGE NO.	DRAWING NO. / DOCUMENT SECT	COMMENT	RESPONSE / ACTION
1	4	3.1	Change "disbursed" to "dispersed".	
2	6	3.2.3	Fourth paragraph, change "drainage" to "evacuation".	
3	11	Table I	This table seems to tell us that the smaller the air flow, the smaller the infiltration that can be detected. This contradicts one of the basic premises of the detection system, which establishes a sizeable air flow requirement to enable small gas infiltration detection. Further, following the trend in the table, if we have zero air flow we can detect the smallest gas infiltration.	

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METRO RAIL PROJECT
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RTD

Reviewer R.L. Beuermann File No. ____ Date 3/12 1985

Dept. / Section TSD/SDA Submittal No. and/or Date 2/18/85 Sheet 2 of 4

Design Review / Submittal Title Gas Monitoring System Review

REF NO.	PAGE NO.	DRAWING NO. / DOCUMENT SECT	COMMENT	RESPONSE / ACTION
4	12	3.3.D.	This statement is not entirely true. Gas concentration in the air stream will diminish with distance from the source. Concentration will remain constant only if the gas-air mixture is perfect, which will not be the case.	
5	12	3.3	Statements A, B, C, D, do not seem to support the summary conclusion. The case should be made for 1) improving the sensitivity of detectors, and 2) placing them where gas is certain to arrive at relatively soon, this is, at ventilation shafts, and at high points.	
6	16	3.4	Third line, change "drained" to "vented".	

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SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT
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RTD

Reviewer R. L. Bluermann File No. ______ Date 3/12 1985

Dept. / Section TBD/SDA Submittal No. and/or Date 2/18/85 Sheet 3 of 4

Design Review / Submittal Title Gas Monitoring System Review

REF NO.	PAGE NO.	DRAWING NO. / DOCUMENT SECT	COMMENT	RESPONSE / ACTION
7	19	4.1.C	The second paragraph is not correct. NDIR analyzers are ideal for HHC detection. Further, an NDIR system will detect fluctuations in ambient HHC.	
8	19	4.1.D	Stainless steel should be the preferred tubing. PVC and TFE will not meet smoke emission requirements.	
9	24	4.4	Add "Perform a reading at any selected probe, on Command from ~~OCC~~"	
10	27	5.1.C.1	The 0.5 man-hour per calibration includes travel-along-the-tunnel time. It takes less than 5 min. to perform the actual calibration.	
11	27	5.1.C.2	Same reasoning. One person can calibrate all station	

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METRO RAIL PROJECT
REVIEW / COMMENT SHEET

RTD

Reviewer R.L. Beuermann File No. ______ Date 3/12 1985

Dept. / Section TSD/SDA Submittal No. and/or Date 2/18/85 Sheet 4 of 4

Design Review / Submittal Title Gas Monitoring System Review

REF NO.	PAGE NO.	DRAWING NO. / DOCUMENT SECT	COMMENT	RESPONSE / ACTION
11	27	5.1.C.2 Cont.	detectors in one shift, at 18×12×8×25 = $43,200 instead of $114,000.	
12	28	5.2.B	Cost of additional ventilation power is included, but not the capital cost for the corresponding fans and installation. Please include these.	

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TABLE OF CONTENTS

LIST OF TABLES

Section 1
INTRODUCTION AND SUMMARY

This report reviews the design and criteria for the Gas Monitoring System for the Southern California Rapid Transit District Metro Rail Project Starter Line. The report recommends that the current design basis be changed from remote sensors only to central analyzers. The central analyzers will be augmented by remote sensors in certain areas if required.

This recommendation is based on the hazardous gases being predominantly methane with some hydrogen sulfide (H_2S) and occasional heavy hydrocarbons (HHC) mixed with the methane, as reported in the cited gas and geological surveys.

The current design criteria requires remote sensors to monitor for the presence of hazardous gases. The sensors activate alarms if gas concentrations approach an unsafe level. The proposed alternative uses central analyzers to monitor ambient levels of gas concentrations in the exhaust ventilation shafts, and to activate alarms if there are any significant variations from the norm.

The proposed central analyzer system will provide more sensitive and reliable detection of gas than the remote sensor system. The capital, operating, and maintenance costs will be lower for the central analyzer system.

This report further recommends that remote sensors be provided as a backup at locations where there is a high probability of significant gas inleakage.

To be effective, the Gas Monitoring System, whether central analyzer or remote sensor, depends on the ventilation system to transport the gases to sensors or analyzer probes. The current ventilation system design can provide this function, except when a work train is in a tunnel section during nonrevenue hours. Procedures are needed to assure adequate air flow for sample transfer in a tunnel section being blocked by a work train. Also, it is suggested that computer programs be used to sequence fans to provide air flow in the tunnel during nonrevenue hours, and to assure air flow in the stations.

In keeping with industry practice, the term "gas monitoring" refers to a continuous sampling-analyzing process. The term "gas detection" refers to a periodic or sporadic sampling-analyzing procedure, usually done with portable, hand-held units.

Section 2
SCOPE

Home Office MRTC Task Order No. 0018 dated September 13, 1984, consists of the following items:

- Review existing criteria regarding gas sensor locations and recommend revisions and additions.
- Review operations and maintenance philosophy for gas sensors and establish criteria as required.
- Perform alternative analyses as required to support the work items above.

The study does not address:

- Construction techniques to reduce or eliminate the chance of gas infiltration
- Estimating the quantities of gas that might penetrate into the system
- Changes to the scope of system, such as reducing the coverage of the system where gas infiltration is highly improbable.

It is anticipated that more data will become available during construction. Appendix A contains a protocol for reevaluating the design criteria during construction.

Section 3
REVIEW AND RECOMMENDATIONS

3.1 CURRENT DESIGN BASIS - REMOTE SENSOR SYSTEM

The current design basis was selected as a result of report WBS 14 CAE 12, "Alternative Analyses, Miscellaneous Mechanical/Electrical Subsystems" prepared in August, 1983. That report compared a disbursed analyzer system with a remote sensor system. The remote sensor system was recommended. The current system has since been developed to the design shown in preliminary drawings DD 006, 7, 8, 9, 10, 11, and SK 283. That design calls for H_2S and combustible sensors. The H_2S sensors would be calibrated to read 0 to 50 parts per million (ppm) H_2S and have a sensitivity of 5 ppm. The combustible sensors would be calibrated to read 0 to 100 percent Lower Explosive Limit (LEL), and would have a sensitivity of 2 percent of full scale.

A. Tunnels

In the current design, combustible sensors for methane would be located at the top of the tunnels, adjacent to every crosspassage (approximately 500 to 800 feet apart) throughout the subway. Combustible sensors for HHC and sensors for H_2S would be located towards the bottom of each tunnel adjacent to each crosspassage between Union Station and Fairfax/Santa Monica Station. The limits on HHC and H_2S sensor locations were based on the areas where those gases were found by subsurface investigation [1,2].

B. Crosspassages and Sump Rooms

Methane sensors would be located at the top of all crosspassages. H_2S sensors would be located in all sumps 6 inches above water level to detect any H_2S transported by seepage water. Between Union Station and Fairfax/Santa Monica, H_2S sensors would be added to all crosspassages and HHC sensors to all sumps.

C. Stations

In the stations, methane sensors would be located in all normally closed rooms that contact the soil. If these rooms are on the lowest level, HHC and H_2S sensors would be included from Union Station through Fairfax/Santa Monica Station.

3.2 RELEVANT CONSIDERATIONS

In order to critique this system design, it was necessary to review the following points:

A. Location of Gassy Conditions

Gas and geological surveys have found gassy or potentially gassy conditions from Union Station to Fairfax/Santa Monica Station [1,2]. Test borings in the vicinity of the Starter Line alignment yielded methane, HHC, and H_2S. In each case of HHC or H_2S, it was mixed with methane and measured at significantly lower concentrations than the methane. This means the gas mixture can be considered to act like methane. Furthermore, the need to monitor for HHC is negated by the overwhelming influence of the methane. Monitoring for H_2S is still required because of its toxic properties and malodorous nature.

North of Fairfax/Santa Monica Station, slight amounts of methane were found. This indicates that the need for gas monitoring may be mollified (see Appendix A).

B. Mitigating Construction Techniques

Three mitigating measures are being recommended for the subway design to prevent gas infiltration into the system, and other measures are under consideration. Between Wilshire/Western and Fairfax/Santa Monica, it has been recommended that the tunnel line will be constructed of gasketted steel sections. Other methods are being investigated.

Precast concrete tunnel liners are used in most other sections. They will be coated externally with a gas-resistant membrane. In addition, they will be oversized (17 ft-10 in. diameter) to allow future installation of steel liners if necessary. Alternate construction using cast-in-place concrete with a membrane will be permitted.

Cast-in-place concrete will be used for crosspassages and stations. Details of membrane requirements and installation are being developed.

In addition, if sustained high-pressure gases are encountered at specific locations during construction, they can be relieved by installing gas drainage systems.

It is believed that these measures will be generally successful and that gas infiltration will be limited to relatively low quantities through most of the subway system.

C. Comparison with Gassy Mines

The report WBS 14 CAE 12 and the current design are based on methodology from the mining industry. This was done because most of the gas detecting and monitoring system technology was developed for use in mines. Similar methodology will be appropriate for use during subway construction. However, the environment during subway operation differs from that found in a mine or during construction. The differences warrant consideration of other gas monitoring methods.

In the U.S., checks for methane in gassy mines must be performed by using hand-held detectors (gas detection vs. gas monitoring) at the start of each shift and at 20-minute intervals during the shift [3]. Measurements are made near the face, roof, and rib. Continuous monitors are mounted on automatic mining equipment working at the face. Continuous monitoring for methane throughout the mine is not a common practice, although it has been done and is gaining new interest [3, 9, 10, 11]. Outside of the U.S., regulations may require continuous methane monitoring. In West Germany, for example, continuous monitoring is required in entry headings and return air ways from coal faces [9].

One of the primary purposes of the ventilation system in a gassy mine is to maintain any gas concentration below safe limits by dilution and removal. For methane, the usual contaminant gas, this level is 20 percent LEL. A meter calibrated 0 to 100 percent LEL (for methane, 100 percent LEL is approximately 5 percent methane by volume) provides useful measurements in this environment.

The completed subway system is not truly analogous to a working mine. Gas leakage is expected to be minor and sporadic rather than continuous as from a seam of coal. However, the possibility of a sudden leak developing, which could result in a significant inflow of hazardous gas, cannot be ignored. This leakage could occur as a point source, for example, at a flaw in the concrete, or as an area source, for example, where gas leaks in behind the liner and diffuses through the concrete.

It is anticipated that normal methane levels in the major part of the subway will be close to the Los Angeles area normal atmospheric concentration of 1 or 2 ppm [7]. Any levels higher than the above-ground ambient should be a cause for investigation and, if necessary, corrective action as discussed later in this report.

D. Discussion of Transport of Infiltrated Gas

Movement of infiltrated gas is controlled by four mechanisms: buoyancy, ventilation, eddy diffusion, and molecular diffusion.

1. Buoyancy:

Gas mixtures predominanted by methane are lighter than air and will rise. If, for example, a tunnel is sloping, the gas will tend to move along the roof in an uphill direction. The gas velocity in still air will depend on the concentration of the methane and the tunnel slope. The velocity could be as high as 600 ft/min when rising vertically. Methane velocities of 30 ft/min have been reported in a 3 percent grade tunnel [4].

The velocity will fall as the concentration of methane in air becomes more dilute and the density of the mixture increases (i.e., approaches the density of air).

2. Ventilation:

Gas will tend to follow and move at the same velocity as natural or induced currents. These currents can be caused by above-ground pressure differentials, or forced ventilation from fans, or vehicle movement (the piston effect). However, lighter-than-air gas may accumulate in a layer at the roof. A certain air velocity is then required to mix the gas with the air. This velocity, known as the layering velocity, is discussed below.

3. Eddy Diffusion:

When gas is introduced into an air stream whose flow is in the turbulent regime, the gas will spread by eddy diffusion through the air stream. The diffusion (spread) will be perpendicular to the direction of air flow. Consequently, the gas can be detected anywhere in the cross-section of a duct after having moved about 10 duct-diameters from the point of introduction. (The layering velocity discussed below is well into the turbulent flow regime.)

4. Molecular Diffusion:

This is the mechanism by which a gas will diffuse through still air and some solids. It is much slower than the mechanisms discussed above, for example, in still air molecular diffusion is often measured in feet/hour where the others are measured in feet/minute.

E. Layering

Layers of lighter-than-air gases can exist at the roof of structures even where turbulent air flow is present. This is because work must be done against gravity to mix the lighter gases with the heavier air. The work is provided by the turbulent stresses in the air flow. At low velocities these stresses are low and, therefore, limit the amount of mixing that can take place.

The quantity of methane that can be immediately mixed into the air flow can be calculated from a relation reported by Bakke and Leach [5]. Table I show quantities for several air velocities in a 17 ft-6 in. diameter tunnel having a 3 percent slope.

It can be seen in Table I that methane infiltration rates of less than 1 ft^3/min can be detected by a sensitive instrument if the ventilation flow is greater than 30 ft^3/min (i.e., 0.06 ft^3/min at 60 ft/min with an alarm setpoint of 5 ppm methane).

3.3 DESIGN CRITIQUE

The following statements can be made relative to the current design basis for the Gas Monitoring System:

Table I

The Effect of Methane Infiltration Rate on Methane Concentration at Different Air Flows in a 17 ft-6 in. Diameter Tunnel

Ventilation Rate (u) in ft/min	Airflow(1) in ft^3/min	Maximum(2) Methane Rate(V) in ft^3/min	Methane Concentration at Sensor in ppm	Minimum(3) Methane Infiltration Detected in ft^3/min
30	6,300	0.032	5	0.032
60	12,600	0.26	21	0.06
100	21,000	1.2	57	0.11
200	42,000	9.6	228	0.21

(1) 210 ft^2 cross sectional area assumed.

(2) $L = \frac{u}{37} \frac{(W)^{1/3}}{(V)^{1/3}}$; L, the Layering Number = 6 for 3 percent slope per [5]
u = ventilation rate ft/min
V = methane flow rate ft^3/min
W = 17.5 ft x 3/4

(3) Assuming detector will alarm at 5 ppm.

A. When the air is still, i.e. with no ventilation and the trains are not operating, a small gas leak could accumulate to an unsafe concentration without triggering an alarm if the nearest remote sensor in the direction of gas flow is 500 to 800 feet away. It is not practical to locate remote sensors at the 50 feet, or less, spacing required for reliable detection in still air.

B. It is good practice to locate remote sensors at high points in the tunnel to take advantage of methane buoyancy. With few exceptions, the tunnel high points occur at stations.

C. If the air in the tunnel is moving, whether due to fan operation, natural air movement, or piston effect, low concentrations of gas are likely to go undetected by the remote sensors. The gas, which could indicate the start of a gas leak, will be diluted by turbulence to below the sensitivity of the sensor within a short distance from the infiltration source.

D. The gas concentration in the air stream will not change significantly from the time the gas is well mixed with the air flow until the next ventilation shaft is reached.

In summary, the overall gas monitoring effectiveness will be improved by using sensitive instruments having probes located in each ventilation shaft, instead of using closely spaced remote sensors.

3.4 RECOMMENDATION - CENTRAL ANALYZER SYSTEM

It is recommended that the Gas Monitoring System be designed with a central gas analyzer located at each station and at each of the midtunnel ventilation shafts.

The Gas Monitoring System for a typical station will have six probes, that is, one in each blast relief shaft and one in each station ventilation exhaust shaft. The midtunnel analyzers will have two probes, i.e., one in each tunnel ventilation shaft. Each probe will be sampled at regular intervals, for example, 5 minutes every half hour. Each central analyzer will have two gas measuring instruments: one combustibles analyzer reading 0 to 25 ppm full scale, and one H_2S analyzer reading 0 to 1 ppm full scale. These range recommendations should be reviewed after tunnel construction is underway.

The combustibles analyzer could be selected to measure either "methane only" or "total hydrocarbons" (which would include methane and HHC). Because the gas mixtures are dominated by methane, a "methane only" analyzer will provide indication of a combustible gas leak. The "methane only" analyzer will, also, be more reliable because of less ambient gas background interference. If, during construction, HHC independent of methane is encountered, the use of "total hydrocarbon" analyzers should be evaluated for the affected section.

Table II (methane) and Table III (H_2S) list some instrument types for measuring gas concentrations in the recommended ranges, and compares them with the remote sensors.

Automatic calibration capability will be included for each analyzer. This feature will minimize false alarms.

Table II

Concentration Comparison

Methane and HHC Detectors

	Parts per Million	Percent by Volume	Percent Lower Explosive Limit (LEL)
Lower Explosive Limit*	50,000	5	100
CATALYTIC SENSOR (Total Hydrocarbon)			
Minimum Range	0 to 50,000	0 to 5	0 to 100
Maximum Range	0 to 50,000	0 to 5	0 to 100
Sensitivity	1,000	0.1	∿ 2
INFRARED ANALYZER (Methane Specific)			
Minimum Range	0 to 10	0 to 0.001	0 to 0.02
Maximum Range	0 to 10^6	0 to 100	0 to 2,000
Sensitivity	0.1	0.00001	0.0002
FLAME IONIZATION ANALYZER (Total Hydrocarbon)			
Minimum Range	0 to 4	0 to 0.0004	0 to 0.008
Maximum Range	0 to 100,000	0 to 10	0 to 200
Sensitivity	0.1	0.00001	0.0002

AMBIENT CONCENTRATIONS -
L.A. NO MAIN STATION
JULY - SEPT 1983: Total hydrocarbon daily high readings range from 3 to 9 ppm [8]. Normal atmospheric methane concentration is 1.5 ppm [7].

*Lower explosive limit for methane.

Table III

Concentration Comparison

Hydrogen Sulfide Detectors

	Percent Threshold Limit	Parts Per Million
Threshold Limit Value*	100	10
ODOR THRESHOLD	0.25	0.025
REMOTE SENSOR		
Minimum Range	0 to 500	0 to 50
Maximum Range	--	--
Sensitivity	50	5
ELECTRO-CHEMICAL ANALYZER		
Minimum Range	0 to 10	0 to 1
Maximum Range	0 to 1,000	0 to 100
Sensitivity	0.1	0.01
PULSED FLUORESCENT ANALYZER		
Minimum Range	0 to 5	0 to 0.5
Maximum Range	0 to 50,000	0 to 5,000
Sensitivity	0.05	0.005
AMBIENT	<0.01	<0.001

*Threshold Limit Value - Time Weighted Average (TLV-TWA) - the time weighted average concentraction for a normal 8-hour workday or 40-hour workweek to which nearly all workers may be repeatedly exposed, day-after-day, without adverse effect -- from the American Conference of Governmental Hygienists.

Methane and H_2S levels will be monitored during construction for safety purposes. Any known source of gas infiltration should be sealed off or drained as part of the construction work. If, despite these procedures, there is reason to doubt the effectiveness of the gas barrier at a specific location, remote sensors should be installed at that location. These remote sensors will be in addition to the central analyzer system.

3.5 IMPACT ON VENTILATION SYSTEM DESIGN

Positive ventilation must be provided to all areas where gas monitoring is required. This is to assure the infiltrating gases will reach the analyzer probe or remote sensor, and is discussed later.

As most areas are now ventilated, few equipment changes will be necessary to meet this requirement. Positive ventilation is already provided in the crosspassages, sump rooms, station passenger areas, and most station (and midtunnel shaft) rooms. Other station areas not in contact with the soil do not need gas monitoring.

Where the ventilation systems are thermostatically controlled, a timer override will be required to operate the system at a minimum duty cycle of 1 hour per day immediately prior to start of service, and 1 hour every 4 hours in cases of prolonged shutdown. These override functions could be provided by a computer program in the Rail Central Control (RCC).

During revenue service, the tunnels will be well-ventilated by the piston effect. Nonrevenue service ventilation of at least 60 ft/min can be provided by operating the station supply fans in one station in conjunction with the UPE fans in the next [6], unless a work train (or other significant blockage) is in that section of tunnel. The UPE and station fans will have to be sequenced in order to provide the needed 1 hour of air flow in each tunnel section during the 4 hours of nonrevenue service. This sequencing can be done by a computer program in RCC.

Procedures based on actual air flow measurements should be developed to assure 60 ft/min of air flow for 1 hour for the tunnel section where the work train is located.

Section 4
OPERATIONS AND MAINTENANCE PHILOSOPHY

4.1 CENTRAL ANALYZER EQUIPMENT

A. Design Objectives

The design objectives for the central analyzer equipment are:

1. Sensitive enough to detect ambient levels of methane and H_2S

2. Simple, reliable, and requiring minimum maintenance

3. Compatible with the Communications System.

B. Components

Each central analyzer system will consist of the following subsystems:

1. Sample collection

2. Sample conditioning

3. Methane analyzer

4. H_2S analyzer

5. Calibration

6. Control and Communications System interface.

Although the gas measurement equipment is the most critical component of the central analyzer, it is essential that the other subsystems operate reliably.

C. <u>Gas Analyzers</u>

The gas analyzers are the heart of the system and are fairly complex instruments. Fortunately, there are many industrial applications that require sensitive gas analyzers that are also reliable and robust. Several manufacturers make a range of suitable equipment. More detail is provided in Appendices B and C.

A nondispersive-infrared-type analyzer (NDIR) is recommended for measuring methane. The NDIR methane analyzer does not detect other combustibles or HHC. This is advantageous because the ambient background level of methane stays fairly constant, whereas the ambient HHC concentration in Los Angeles varies with the daily smog cycle [7,8]. The NDIR will, therefore, allow more reliable alarm settings than a total hydrocarbon-type analyzer.

An ultraviolet, pulsed fluorescent analyzer appears to be better suited at H_2S monitoring for this application; however, other analyzers are under consideration at this time.

D. <u>Support Subsystems</u>

The sample collection subsystem consists of a set of valves, tubing, probes, and pumps. The tubing can be either stainless steel or a high quality synthetic such as Teflon (TM) or PVC. Teflon or PVC tubing is recommended because they can be routed through the conduits presently in the design for the remote sensor wiring. The valves are usually solenoid valves and the pumps positive displacement pumps. A moderate degree of overdesign is recommended to minimize maintenance requirements. A sample pump will continuously draw a sample from each probe to maintain a current sample in the sample line. A second pump will draw the sample through the gas measuring instruments.

The sample conditioning subsystem will consist of filters and other gas treatment components, such as drying, heating, or scrubbing devices, that may be required for the analyzer selected. These components will be selected for minimum maintenance and maximum protection of the gas measurement equipment.

The calibration subsystem will consist of sample gas containers and solenoid valves controlled by the analyzer microprocessor. The subsystem will provide automatic routine calibration and will confirm gas measurements that deviate from the norm.

The control and Communications System interface subsystem consists of the hardware and software required to control the other subsystems and to transmit the gas measurements, alarms, and status indications to the Communications System. The subsystem will allow RCC to interrogate the gas monitoring system and to adjust the sampling sequence.

4.2 DETECTION EFFECTIVENESS

Ideally, a gas sensor (or probe) should be located as close as possible to the source of the gas. As the distance between the sensor and the source increases, the representativeness of the reading decreases. In still air, the rate at which the gas diffuses toward the sensor is slow. The detected concentration can be well below the source concentration, even with relatively closely spaced sensors.

If the air velocity is sufficient to prevent layering, good mixing will occur within 10 duct diameters of the gas source. The air movement will, however, dilute the gas to a lower level than could potentially build up. For example, a leakage rate of 1 ft^3/min could generate an unsafe concentration of methane if allowed to accumulate overnight. With air flow, the mixture will measure 50 ppm when diluted by 20,000 ft^3/min of air. The 50 ppm would not be detected by the remote sensors proposed under the current design (their lower detection limit is 1,000 ppm, see Table II).

During revenue service, the peak air velocity in the tunnel may reach 1,300 ft/min (275,000 ft^3/min) for short durations in front of the trains. Even though the 1 ft^3/min leak will be diluted to 4 ppm, it will be detected by the central analyzer system.

Thus, effective ventilation, which is required to transport the gas from its source to the sensor, will dilute the gas to a level where a sensitive analyzer is required. Similar considerations apply to station monitoring.

The operating philosophy will be to maintain adequate ventilation in all areas that require gas monitoring. Areas that are not ventilated during nonrevenue hours will be ventilated for at least 1 hour before service resumes.

Normal variations in gas concentration readings will be established during the commissioning phase, and appropriate alarm levels will be set. Alarms which occur will be verified by the automatic calibration feature before being transmitted to RCC via the Communications System.

Depending on the actual concentration, the appropriate action will include checking for leaks with handheld detectors during nonrevenue hours. If the concentration exceeds a high set point, service interruptions will be required until the source of the gas can be located and corrective action taken.

4.3 TRANSFER OF GAS TO PROBES

A. General

The ventilation system is complementary to the Gas Monitoring System and serves three related functions:

- Purge: The air flow will remove gas from an area.
- Dilution: The air flow will be used to dilute gas concentrations.
- Transfer: The airflow will transport the gas from its source to the Gas Monitoring System and to the atmosphere.

The following discussions only address the transfer function.

B. Stations

Station (and midtunnel shaft) ventilation systems are being designed to provide at least 10 air changes per hour in most areas. This is adequate to allow detection of gas infiltration long before an unsafe level occurs.

However, providing a ventilation capability does not assure that it will be used. For example, a methane sensor would not be removed or deactivated unless a deliberate decision had been made to ignore the methane hazard. A decision to deactivate ventilation in a certain area could be made by someone unaware of the potential implications. This can be mitigated by properly placed signs - such as a: "POTENTIAL GAS HAZARD, CONTINUOUS VENTILATION REQUIRED."

As stated earlier, timer override, or equivalent, is required to activate ventilation in all station areas on a regular schedule for gas monitoring purposes. The monitoring system for stations will be most sensitive when Under Platform Exhaust (UPE) fans are not running (less dilution in the station vent shafts), therefore, a daily check immediately before service starts is recommended.

C. Tunnels and Crosspassages

During revenue hours, the piston effect will provide enough ventilation to move representative air samples from any part of the tunnel to the central analyzer probes.

During nonrevenue hours, the air sample transfer function can be provided by using the UPE fans and the station supply air fans [6]. The velocity of 60 ft/min obtained is adequate to meet the sample transfer requirements of the Gas Monitoring System, although higher velocities may be required for gas purging. As stated earlier, procedures are needed for assuring an airflow of 60 ft/min when a work train is blocking a tunnel section.

Gases in crosspassages and sump rooms will be detected because the crosspassage ventilation fans are used to move the gases into the tunnel airflow.

4.4 COMMUNICATIONS AND ALARMS

The gas analyzer will be controlled by its own microprocessor, which will perform the following functions:

- Select probes for monitoring.
- Display the last reading from any selected probe, on command from RCC.
- Adjust the monitoring sequence on command from RCC.
- Initiate an alarm if any reading is outside normal limits; initiate calibration functions to confirm alarm readings before transmitting the alarm.
- Initiate calibration functions on a regular schedule or on command; inhibit alarms when calibration is being performed.
- Initiate "probe plugged" alarm if a probe is plugged.
- Initiate "calibration fail" alarm if the calibration procedure is not completed successfully.
- Provide self-diagnostic functions, and initiate "failure" alarm when warranted.

Outputs from the microprocessor will interface with the Communications System for transmission to EMP, AEMP, FSCP, and RCC as appropriate.

4.5 CALIBRATION AND MAINTENANCE

A. Calibration

The proposed analyzers will be equipped with self-calibration capability. Any readings can be verified from RCC. Routine calibration will be performed automatically.

B. Maintenance

Routine maintenance will consist of regular inspections to check for leaks, plugged probes, low calibration gas level, replace filters, etc.

Repair-type maintenance will be in response to alarms from the analyzer microprocessors and will consist of normal instrument repair activities.

Section 5
ALTERNATIVE ANALYSIS

This analysis compares on the current remote sensor design with the concept of one central analyzer system per station and one at each midtunnel shaft.

5.1 REMOTE SENSOR SYSTEM

A. Equipment Cost

Equipment cost for a remote sensor system is based on $1,100/sensor which includes the sensor and one control module for 16 sensors.

1,308 sensors @ $1,100/sensor =	$1,438,000
Calibration tubing	64,000
Total	$1,502,000

(Does not include installation cost)

B. Operating Cost

Cost of Power @ 25w/sensor
x 8,760 hr/yr
$0.07/kwhr
1,308 sensors = $20,000/yr

C. Maintenance Cost

The primary component of maintenance cost is the calibration cost.

1. Tunnel Sensors

There are 548 sensors in the tunnels
allowing 0.5 man-hour/calibration
12 calibrations/year/sensor
= 3,288 hours/yr

Travel time in the tunnel, 18 miles long, is
(18 + 50%) miles
x 1/2 hr/mile
x 12 trips/yr = 327 hours/yr

Total calibration time in tunnel = 3,615 hours/yr
@ $25/hr = $90,000/yr

2. Station Sensors

760 Sensors x 0.5 x 12 = 4,560 hours/yr
x 25 = $114,000/yr

3. Allow one man full-time for shop support

= 2,080/hr / yr x 25 = $52,000/yr
TOTAL MAINTENANCE LABOR = $256,000/yr

5.2 CENTRAL ANALYZER SYSTEM

A. <u>Capital Cost</u>

H_2S analyzer	$11,000
Methane analyzer	10,000
Probes, valves, pumps, pre-conditioning, and tubing	12,000
Microprocessor	13,000

Cabinet and assembly	4,000
Calibration equipment	9,000
Cost/Analyzer	$59,000
Total cost for 20 analyzers	$1,180,000

B. Power Cost

Central Analyzers - 0.7 kw x 20 systems = 8,760 hours/yr
x $0.07/kwH = $8,500/yr

Cost of additional ventilation power
Crosspassages 115 x .06 kw x 8,760 x .07 = $ 4,231/yr
Stations (Allow 0.5 kw) = 6,132/yr
Total $18,863/yr

C. Maintenance Cost

Allow one man full-time = $25/hr x 2,080 hr/yr = $52,000

5.3 COST SUMMARY

	Cental Analyzer	Remote Sensor
Capital Cost (Equipment)	$1,180,000	$1,500,000
Operating Cost		
Power	18,600	20,000
Maintenance Labor	52,000	256,000
Total (SAY)	$70,000/yr	$276,000/yr

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APPENDIXES

Appendix A
GAS MONITORING SYSTEM REVIEW PROTOCOL

The Gas Monitoring System will provide gas monitoring throughout the subway system. Both the central analyzer system and the remote sensor system can be retrofitted. No criteria have been prepared for deciding if gas monitoring is not required for a particular line section. The purpose of this appendix is to develop a protocol for reviewing data obtained during construction to determine whether installation of the Gas Monitoring System can be safely deleted or postponed in certain sections of the subway. It also addresses the location of remote sensors in those areas where a significant probability of gas leakage is anticipated.

The circumstances under which areas of the subway would be relieved from the requirement for gas monitoring are:

1. Where there is no evidence of gas or oil bearing geological strata in the vicinity of the structure.

2. Where the underground construction is demonstrated to be permanently impervious to gas infiltration by design and construction techniques which are verified by a quality assurance and testing program.

The following steps are necessary before determining if the gas monitoring system is needed in a particular section of the summary:

1. A gas detecting survey program is required by CAL/OSHA during construction. Although the primary

reason is for construction safety, the program requirements and results should be coordinated with the District.

2. Using the results of the gas survey program and working with CAL/OSHA, determine if a section of the line is considered nongassy. It is tentatively recommended that if no measurements of methane at or above 5 percent LEL are observed during construction of a line section, then there will be no need for gas monitoring of the tunnel section during operation. The deletion of gas monitoring for the station should also be considered. Periodic surveys using portable detectors may be desirable in certain of these areas.

   A review of the geological strata encountered during tunnelling by a qualified geologist will be required to support this recommendation, as will confirmation of the construction techniques used for preventing gas leakage.

Areas where methane in excess of 5 percent of the LEL, or where the odor of H_2S continues to be observed after construction is completed, will require remote sensors to augment the central analyzers.

Appendix B
EQUIPMENT SURVEY

Central analyzer systems have been developed for many applications, such as monitoring by the EPA, process control in the chemical and electrochemical industries, industrial toxic gas monitoring, stack gas emission monitors, and carbon monoxide (CO) detection for fire prevention in coal handling systems. Component and material selections must be suitable for the operating environment. The environment in the subway will be among the least hostile of the applications cited. Reliable components can be selected without resorting to exotic materials.

This appendix will discuss the gas analyzers only, because they are critical to the operation of the system. However, it is important that the quality of all the subsystems be at the same high standard. Any subsystem failure will render that analyzer inoperative.

In Appendix C are data packages from four vendors: MSA, Thermo-Electron, Interscan, and KVB. The first three manufacture analyzers and central analyzer systems. KVB manufactures central analyzers systems and selects the analyzers from the marketplace according to the requirements of the application. KVB tentatively recommends Hariba & Monitor Labs as potential suppliers for the gas analyzers.

A. Methane Analyzers

1. Nondispersive Infrared Analyzers, e.g. TECO Model 48A, measures the characteristic

absorption of infrared light by a gas at a specific frequency. Although interference can be a problem when two gases with similar infrared spectrums are present, methane is essentially interference-free.

The sensitivity can be as low as 0.01 ppm for methane, and full scale ranges are available between 0 to 0.5 ppm and 0 to 10,000 ppm.

An analyzer can cost up to $10,000.

Because this type of analyzer can be used for detecting many gases, several manufacturers make rugged units for different industrial applications.

2. Flame Ionization Analyzers, e.g. MSA Total Hydrocarbon Analyzer, measure the ionization produced when carbon atoms are oxidized in a flame. Although they are typically less rugged than an infrared analyzer, flame ionization analyzers are the EPA standard means for measuring the hydrocarbons in ambient air.

   The measurement is not specific to methane, which allows the detection of HHC. This is a disadvantage because the concentration of nonmethane hydrocarbons varies significantly on a daily cycle in the Los Angeles area atmosphere because of photochemical reactions with nitrogen dioxide. A "methane only" analyzer will have a more stable background.

B. H_2S Analyzers

1. Electrochemical Analyzers, e.g. Interscan, measure the electric current generated by a chemical reaction between the gas and the sensor chemical, which for H_2S is lead oxide.

   The main disadvantage with electrochemical analyzers is interference from other species. Interference from captans, other sulfur compounds, and oxides of nitrogen can be expected with H_2S monitoring devices, and a scrubber is required.

   These devices are normally used for industrial air quality monitoring. They are rugged enough to be portable, sensitive to 0.01 ppm, and relatively inexpensive ($6,000).

2. Ultra Violet Pulsed Fluorescent Analyzers, e.g. Thermo-Electron Model 45, use the fluorescent properties of sulfur dioxide (SO_2). When exposed to a pulse of ultra violet light, SO_2 fluoresces for a period after the exposure. The intensity of the fluorescence is measured.

   To be effective with H_2S, the gas sample must first be scrubbed of SO_2, oxidized to SO_2, and then measured. A sample time of up to 5 minutes is required to complete this procedure.

   Sensitivity is 0.002 ppm, and cost is approximately $10,000.

Appendix C

VENDOR DATA

MSA

THERMO ELECTRON

INTERSCAN

KVB

MSA

Mine Safety Appliances Company · 600 Penn Center Boulevard · Pittsburgh, Pennsylvania 15235
412/273-5000
1-800-MSA-INST
Writer's Direct Dial Number

October 11, 1984

R. Kaiser Co.
Attention: Mr. Cris Rayner
Box 23210
Oakland, CA 94623

Gentlemen:

In response to your request to this office, we are pleased to provide MSA Data Sheets for the Total Hydrocarbon Analyzer and the Multi-point Air Monitoring System.

We trust the enclosed information will be sufficient to fulfill your current requirements. Should you require additional information or if MSA may be of any further service, please do not hesitate to contact this office or your local MSA Sales Engineer, Mr. John Riehl.

Sincerely,

Richard Bryer

Richard Bryer
Instrument Division

aw

Enclosures

5/8/81 S.E.L.

A Guide To The Selection And Specification Of MSA Multipoint Area Monitoring Systems

Preface

The ever increasing emphasis on protecting the health and safety of the individual in the workplace or other specific environment has dramatically increased the equipment available.

Many manufacturers now offer such equipment. The equipment is offered with many levels of performance, quality and degree of engineering sophistication. To further complicate the picture many options are available.

Obviously all applications are not the same. Each must be evaluated to determine the optimum system design. Over 30 years' experience in area monitoring has provided MSA with the engineering data base necessary to match system performance with the real life field environment.

The following guide is provided to insure the user obtains a system that most closely fits his needs.

PART I

THE STANDARD BASIC SYSTEM

The following describes the basic MSA Multipoint Area Monitoring System. The design and materials selection reflects the field experience gained on hundreds of similar systems.

A. The System Enclosure

The system is housed in a general purpose steel cabinet. The controls and readouts are available on the front panel. A rear access door allows convenient access to all sample system components. The cabinet finish is a textured blue polyurethane paint; the front panel is black.

Size: 1 - 12 Points 84" high, 28" wide, 28" deep

13-24 Points 84" high, 56" wide, 28" deep *

B. The Sample Flow System

The sample handling system is as important in assuring performance as the Analyzer itself. It must provide a continuous regulated flow of clean, well filtered sample, undiluted by leakage. Its parts must be nonreactive and nonadsorbent to the component of interest in the sample. No constituent of the sample should cause deterioration.

The need for sample system integrity is readily apparent when you consider that a system with a 30 second dwell time per point must switch sample streams over 1,000,000 times in a year.

1. The Pump

MSA uses a dual head ADI pump. One head feeds the sample to the Analyzer; the other provides a continuous bypass (sample draw) on all points not being fed to the Analyzer. Continuous bypass is essential in insuring a fresh sample flow. If a system has more than twelve sample points a four head pump is used with three heads in parallel providing bypass.

MSA uses the ADI pump because it has demonstrated superior quality and long term reliability.

* Note: Under some circumstances 13 through 18 points can be provided in a 28" wide cabinet.

2. Internal Sample Lines

All lines where flow or back pressure are critical are 3/8" O.D. polyethylene tubing. These lines offer the high strength and chemical compatibility necessary for most applications.

Note: Complete compatibility of the sample system parts with all constituents of the sample must be considered. Optional sample system materials are available when the application dictates. Always state the expected sample composition when specifying a system.

3. Sample Fittings

High quality brass Swagelok(R) fittings are used to eliminate leakage that could lead to error or hazard. Bulkhead fittings are provided at the top of the cabinet for zero, span, exhaust and sample lines.

4. Solenoid Valves

High reliability discreet solenoid valves mounted to a common bracket and connected with individual lines and fittings, are used for stream switching.

This method has proven superior to the common manifold or common rotary valve approach in eliminating cross-leakage between sample lines and the leakage of outside air into the system. The discreet method also offers advantages in maintenance and in reducing the possibility of total system failure.

5. Sample Filtration

A clean sample is necessary for proper Analyzer function. Costly Analyzer maintenance and increased system downtime is the penalty paid for insufficient sample filtering. End-of-line filters are simply not enough!

The MSA system uses three internal filter stages:

(1) Balston Filter Coalescer to filter down to 0.6 microns and remove condensate water.

(2) Special 0.3 micron, large volume MSA filter.

(3) In-line 0.3 micron filter just before the Analyzer.

All filters have easy to replace cartridges.

6. Three Way Selector Valve

A front panel mounted three way selector valve is provided to select manually either the sample zero or span gas stream.

7. Flowmeters

A flowmeter with flow adjustment is mounted on the front panel of the system cabinet to indicate and tune the sample flow to the Analyzer.

A second flowmeter is provided to monitor the bypass flow of the sample stream being fed to the Analyzer. The rate of bypass flow is an indication of pump performance and that the sample line is clear.

C. Solid State System Programmer

1. Arrangement

The MSA solid state system is a modular arrangement of circuit boards designed to perform all of the sequencing, timing, alarm, horn and other functions required for the operation of multipoint monitoring systems.

All circuit boards are mounted inside the NEMA 12 cabinet. All controls and indication lamps are mounted on a hinged panel located behind the cabinet door, which has a polycarbonate window, permitting all controls and indications to be visible. The cabinet door is lockable, thus limiting access to the controls to authorized personnel. Optional horn silence and manual reset push-button operators are available on the cabinet door allowing these functions to be reset without unlocking the door.

It should be noted that a recorder is not used as the system programmer. The recorder is slaved to the solid state programmer with synchronization controlled by the programmer. Recorder failure will not affect the rest of the system.

2. Operation - General

The system has three modes of operation.

(1) The normal operating mode is "automatic", whereby all points are sampled sequentially for a preset time interval. The optional alarm circuits are activated in this mode.

(2) The "calibrate" mode deactivates all sequencing and alarm functions and allows the analyzer to be calibrated without disturbing any other circuits in the system.

(3) The manual mode allows a single sample point to be selected and sampled indefinitely if desired. Alarm circuits, if included, are active in this mode.

3. Detailed Operation

The "automatic" mode will be described in detail in conjunction with the optional two level selective alarm with horn. The sequencer board samples each point for a preset interval adjustable from 10 to 180 seconds, typically 30 seconds per point. The output triacs of this board power the solenoid valve and sample light associated with each point. After approximately 25 seconds of sampling each point a permissible alarm pulse is generated. During the period of this pulse, the alarm detector board output is enabled to see if an alarm condition exists. This delay period (25 sec. nominal) allows the analyzer sufficient time to stabilize on the gas being sampled for that point. If the concentration exceeds the set point for warning (the lower of the two alarm levels), the horn will sound and a warning lamp (amber) associated with that point will illuminate. The horn may be silenced by depressing the "horn silence" button momentarily. The sequencer will continue scanning the other sample points. The next sampling cycle around when the sequencer reaches that point, one of three possible conditions will exist:

(1) If the concentration has fallen below the warning set point, the amber light will go out (after the alarm delay pulse).

(2) Conditions will remain unchanged, in which case the amber lamp continues being lit and the horn does not sound, since it had been silenced on the original cycle.

(3) The gas concentration could have increased beyond the alarm (higher level) set point. This would cause the horn to again sound, since it is a new condition for that point, and a red alarm lamp associated with that point would illuminate.

4. Serviceability

Liberal use of light emitting diodes (LEDS) throughout all circuit boards permit the operator to observe visually the operation of the system. Although the system has been designed with reliability in mind, it has also been designed for ease of service. No special test equipment is necessary other than an ordinary multimeter. By observing the patterns of LED's and possibly making a few key voltage measurements, a technician can rapidly diagnose a faulty board and replace it in a few minutes.

D. Readouts - Displays

1. Concentration - The concentration of the component being measured is displayed on the meter of the Analyzer. The Analyzer is mounted in the front panel of the system cabinet.

2. The following incandescent indicator lamps are provided on the front panel of the system programmer:

   . Main Power
   . Pump Power
   . Calibrate (shows system is in the calibrate mode)
   . Sample point (one lamp per point)

E. Analyzer

The Analyzer selected will depend on the specific analysis to be made. It may be a Combustible Gas Model 513, an Infrared Model 202 or 303 Lira or some other Analyzer.

In all cases the Analyzer is mounted in the front panel of the systems cabinet. All adjustments and Analyzer service can be performed from the front.

Separate data sheets are available for each Analyzer.

F. System Power

The system operates on 120 VAC 60 Hz power. Power consumption depends on system size and the specific Analyzer, but is usually less than 1000 VA.

A separate circuit breaker-switch is provided on the front panel of the programmer for pump power and main power.

The system will also work with 50 Hz, 120 volts.

G. General Considerations

1. When the sample line length exceeds 600 ft additional pump capacity may be needed.

2. If the shortest sample line is less than 70% of the longest, line balance valves should be used.

3. In the standard flow systems sample wetted materials are:

Polyethylene	-	Tubing
Brass	-	Fittings
Aluminum	-	Filter housing
Polycarbonate	-	Balston filter bowl
Buna N	-	O- rings

PART II

OPTIONS AVAILABLE TO THE BASIC SYSTEM

1. <u>System Cabinet</u>

   (a) Nema 12 Industrial Use - Dusttight and Driptight - Indoor.

   Designed for use in those industries where it is desired to exclude such materials or dust, lint, fibers and flyings as well as splashing, seeping or dripping of noncorrosive liquids.

   (b) Nema 4 Watertight and Dusttight - Indoor.

   Designed to protect the system against splashing or seepage of water, hose directed water and severe external condensation.

2. <u>Sample System Component Material</u>

   (a) Copper lines with brass fittings.

   (b) Aluminum lines with aluminum fittings.

   These materials are used where adsorption of the sample component of interest might take place in the standard polyethylene lines.

   (c) Stainless Steel.

   Stainless steel sample lines, fittings and flowmeters are used where a corrosion problem exists.

3. <u>Line Balance Valves</u>

   Used where the flow rate tuning of each sample line is desired. These valves are mandatory where large differences in external sample line lengths exist.

   Note: Always state approximate lengths of sample lines when specifying a system.

4. NonSelective Alarm

(a) Single Level

One alarm light common to all sample points. Sample point sequencing will stop and the system remain on the sample point where an alarm first occurred. Sequencing will continue on manual command or when the alarm condition clears and the system is manually reset.

(b) Dual Level

Same as 4 (a) except that there are two levels of alarm with a light for each.

5. Single Alarm Level - Selective Type

A discreet alarm is provided for each sample point. An alarm light is provided for each sample point. System sequencing continues normally if there is an alarm. Three versions are available: *

(a) The alarm will reset automatically if the level goes below the alarm point when that point is on sample or it can be reset manually when that point is not on sample.

(b) Automatic reset only.

(c) Manual reset only.

6. Dual Alarm Level - Selective Type

This is the same as option 5 except there are two alarm levels. Two alarm lights are provided for each point (one for each level). It is available in the same three versions as option 5*

(a) Automatic and manual reset.

(b) Automatic reset only.

(c) Manual reset only.

* Version can be changed in the field by moving jumpers on the programmer circuit board.

7. Audible Alarm (Used With Options 4 Through 7)

A 90 dB horn will sound when the alarm level is reached. A horn silence button is provided on the programmer panel.

Two versions are available:

(a) Single alarm level or dual alarm level where the horn is activated by the low and high level.

(b) Dual level alarm where the horn may be activated by one level only (either level).

8. Trouble Package

This option is an electronic module with individual LEDs to indicate specific system problems. It is mounted inside the programmer housing. A common trouble light is located on the front of the swing-out programmer panel. If the audible alarm option (7) is included, the module can pulse the horn with adjustable pulse duration. The horn cannot be silenced until the condition is corrected.
available:

The trouble package indicates the following:

. Flow failure to Analyzer.

. Power failure on power or sequencing boards.

. Failure to sequence.

. Analyzer below zero by 5% or more

Three combinations of the trouble package are available:

(a) Used with single level alarm.

(b) Used with dual level alarm.

(c) Used with dual level alarm; does not have Analyzer below zero feature.

9. Lamp Test Circuit

A switch circuit that lights all sample point and alarm indicator lamps at once to check for burned-out indicator bulbs.

10. Alarm Level Adjust With Visual Indicator

An analog meter with two pointers (one for each alarm level) is used to set the alarm level value. The value is set by moving the indicator to the desired reading using an adjusting knob.

11. Sample Point Cutout

A switch for each sample point is located on the front of the swing-out programmer panel. Turning off the sample point switch allows it to be skipped in the sequencing.

12. Recorder

(a) The preferred recorder is the Westronics M 11E. The M 11E has an eleven inch chart width. It is available for any number of sample points.

(b) Westronics M 5E. Same as (a) but has a chart width of five inches.

(c) L & N Model W - Chart with approximately 10 inches. Available for systems with 2, 3, 4, 6, 12 and 24 points only.

(d) L & N Model H - Chart with six inches. Available for systems with 2, 3, 4, 6 and 12 points only.

(e) Honeywell Class 15 - Chart width ten inches. Available for systems with 2, 3, 4, 6, 8,10, 12, 16, 18, 20 and 24 points only.

(f) Honeywell Class 111 - Chart width ten inches. Available for systems with 2, 3, 4, 6, 12 or 24 points only.

13. Customer Contacts

A set of 5 amp contacts (one normally open, one normally closed) can be provided for each alarm level and sample point. Connections to the contacts are made on a convenient terminal block inside the programmer housing. There are four options. To use optious (a) through (c) an alarm option must be specified.

(a) One set (one NO, one NC) of contacts for each alarm level. An alarm on any sample point initiates contact action with this option. The relays are located on the alarm circuit board in the programmer housing.

(b) One set of contacts for one alarm level at each sample point. If the dual level alarm option is being specified, the customer should state which level the contacts are for.

(c) One set of contacts for each alarm level at each point. The dual level alarm option must also be specified.

(d) One set of contacts for each sample point to indicate when that point is on sample. (Cannot be specified with 13 (c).

Note: For options (b), (c), and (d) the relays are the plug-in type located on the front of the programmer panel.

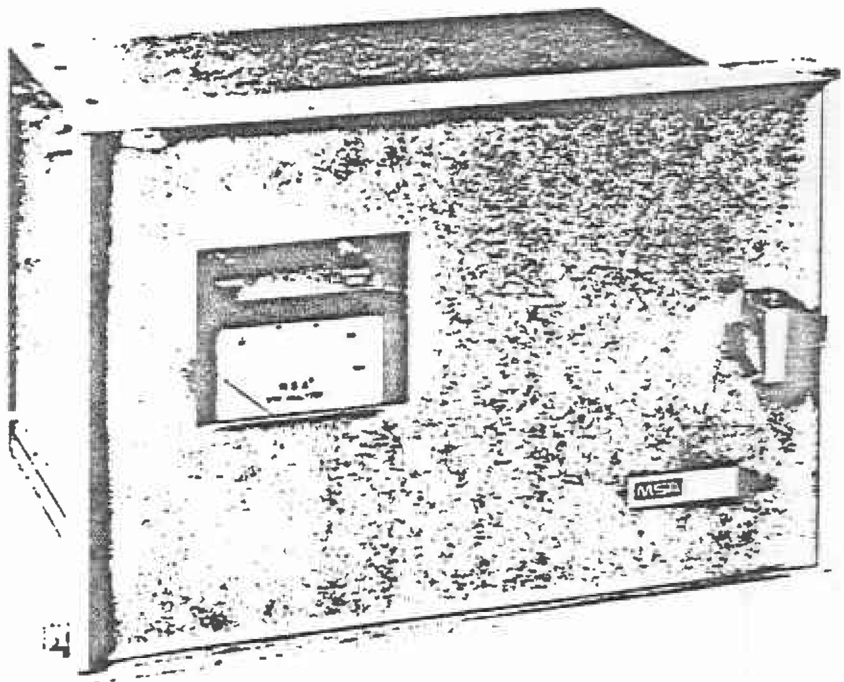
MSA
INSTRUMENTS

Total Hydrocarbon Analyzer

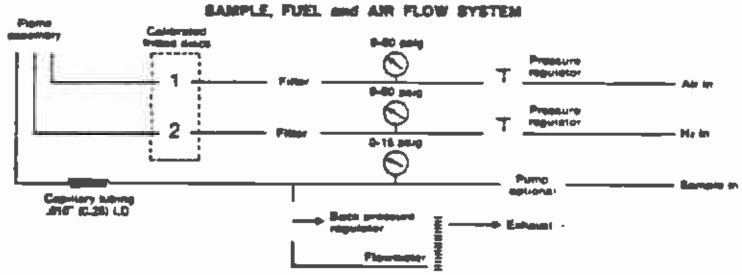
Application

The MSA® Total Hydrocarbon Analyzer is a continuous, low-level (0-4 ppm), multi-range monitoring instrument designed to detect and measure trace contaminants in various atmospheres. In air pollution control applications, the Total Hydrocarbon Analyzer can detect hydrocarbons as atmospheric pollutants, or measure automobile exhausts for hydrocarbon emissions. In safety applications, the Analyzer can monitor atmospheres for toxic gases or vapors; monitor gas mains, sewers, tunnels, garages, etc., for flammable gases or vapors; or monitor fuel handling or storage areas for leakage. In industrial processes, the Analyzer can detect leaks in aerosol packaging plants; measure "off gases" for hydrocarbon content; test purity of inert and LOX streams; monitor combustion efficiency or detect refrigerant leakage.

The Total Hydrocarbon Analyzer may be wall- or panel-mounted.



SAMPLE, FUEL and AIR FLOW SYSTEM



Description

The Total Hydrocarbon Analyzer contains four elements: a sample flow system; a combustion gases system; a burner assembly; an electrometer and power supplies.

The operation of the Analyzer is based on the ionization of carbon atoms in a hydrogen flame. Normally, a flame of pure hydrogen contains an almost negligible number of ions. Adding organic compounds—even traces—results in a large number of ions in the flame.

In the Analyzer, the sample is mixed with a hydrogen fuel and passed through a small jet. Air supplied to the annular space around the jet supports combustion. Any hydrocarbon carried into the flame results in the formation of carbon ions. An electrical potential across the flame jet and an "ion collector" electrode suspended above the flame produce an ion current proportional to the hydrocarbon count. This is measured by an electrometer circuit whose output then provides an analog analysis signal for the direct reading meter, graduated 0-100, or for an optional potentiometric recorder.

The Analyzer features an electric range attenuator, with change factors of X1, X3, X10, X30, X100, X300, X1000, and X3000. The stabilized zero setting is unaffected by range change factors. Calibration is by span potentiometer, for greater accuracy than is provided by adjustment of sample flow. The solid-state dc power supply eliminates the need for batteries. The Analyzer also features sintered metal filters for sample, air, and fuel capillary tubing. The cabinet is heavy-gauge sheet metal with an attractive polyurethane finish.

Instrument includes a flame-out alarm and automatic fuel shutoff for maximum safety, and an optional integral sampling pump.

Specifications

Performance

Full-scale range: 0-4 ppm to 12,000 ppm by volume, expressed as methane
Sensitivity: 1% of full-scale reading in one second or less
Response: 90% of final reading in one second or less
Drift: less than 1% of full-scale range per 24 hours
Noise: less than ±½% of full-scale range
Reproducibility: meter graduated from 0-100 for readout of linear analysis signal. Single turn potentiometer (trim pot) provided to match analyzer signal to potentiometer type recorder (0-5 mV, 0-10 mV, 0-50 mV, 0-100 mV)

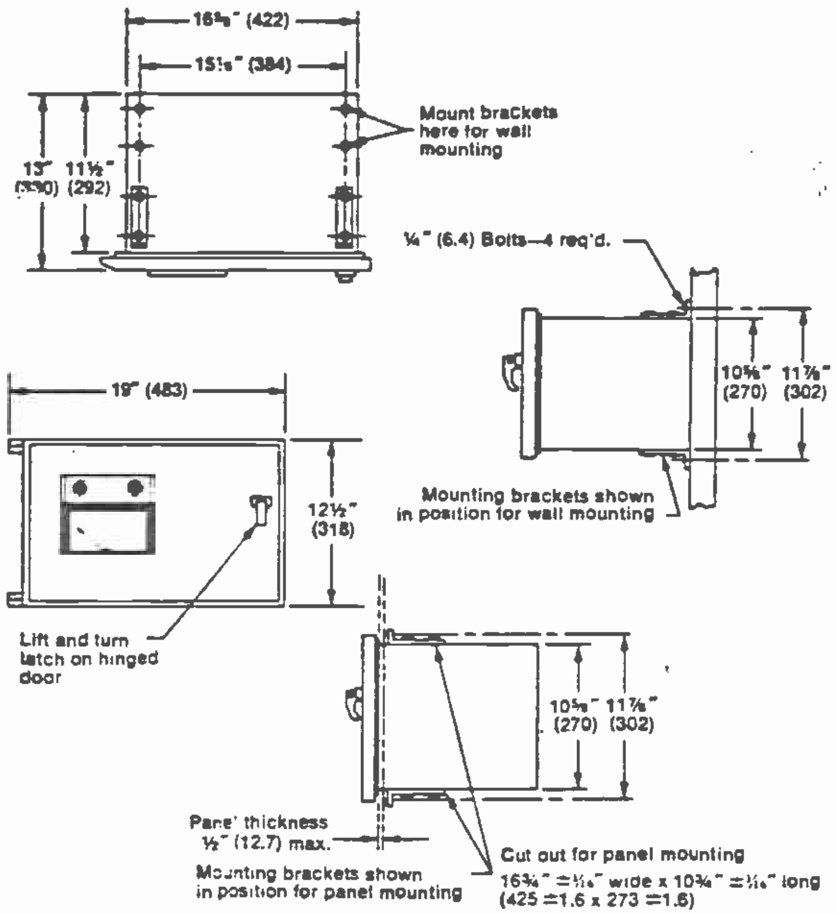
Operating

Power Requirements: 50 VA, 120 V, 50/60 Hz
Warmup time: 4 hours from cold start to stability; 1 hour after temporary shutdown
Controls: (external) on-off switch; range attenuator; recorder adjust; flame ignition control; air pressure regulator; hydrogen pressure regulator; zero and span controls

Physical

Dimensions (LHW): 13" x 12½" x 19" (330 x 318 x 483 mm)
Weight: approx. 35 pounds (15.9 kg)

Cabinet Dimensions and Mounting Instructions.
Dimensions in inches: millimeters shown in ( ).



Ordering information

Catalog number

455874 Total Hydrocarbon Analyzer

Note: This Data Sheet contains only a general description of the MSA Total Hydrocarbon Analyzer. While uses and performance capabilities are described, under no circumstances should this product be used except by qualified, trained personnel and not until the instructions, labels, or other literature accompanying the product have been carefully read and understood and the precautions therein set forth followed. Only they contain the complete and detailed information concerning this product.

MSA
Mine Safety Appliances Company
Instrument Division
600 Penn Center Boulevard
Pittsburgh, Pennsylvania 15235

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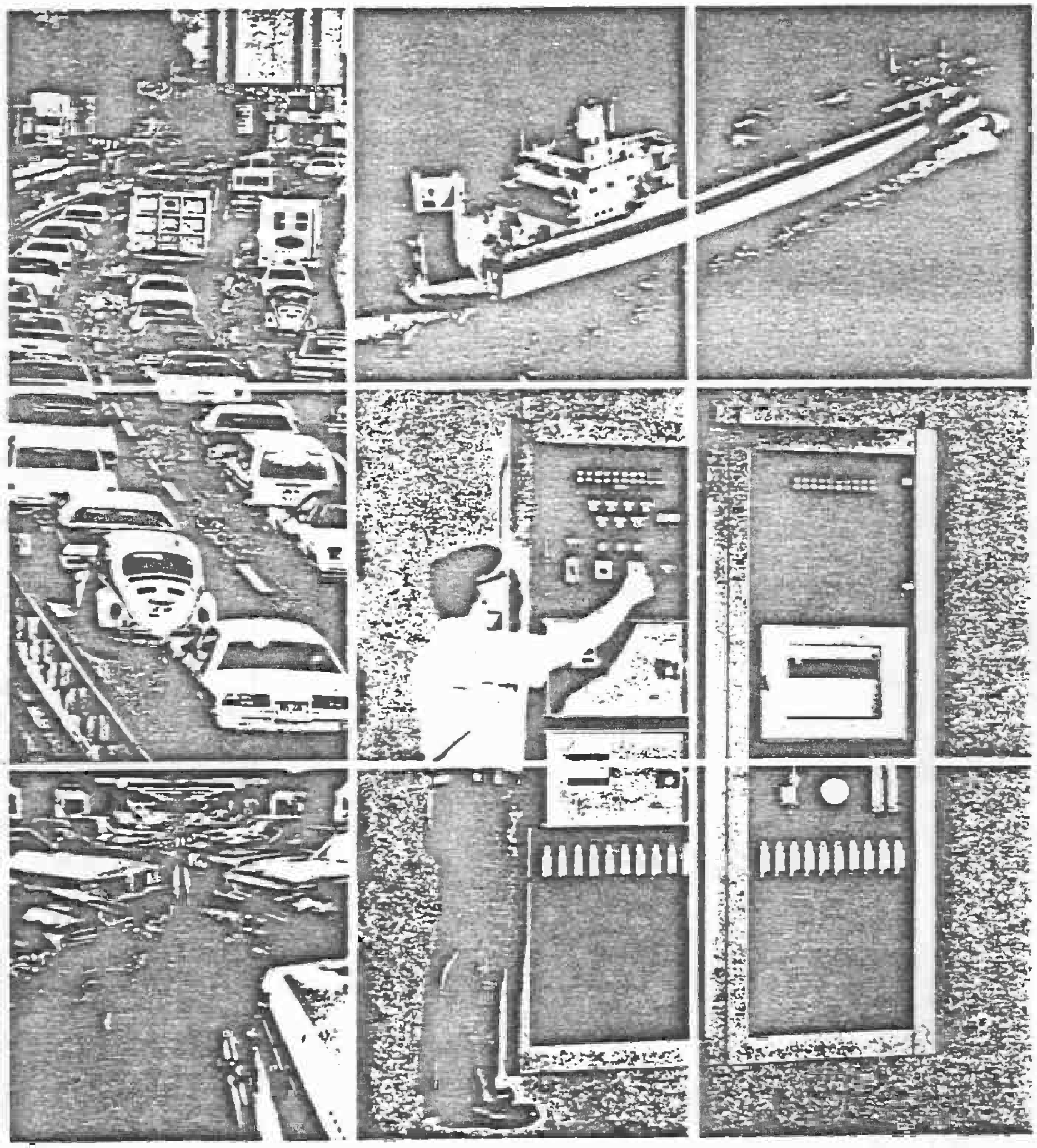
MSA
INSTRUMENTS

Multi-point Air Monitoring Systems

Area air monitoring for the detection and measurement of flammable or toxic components



Application Bulletin 07-0005

Multi-point Air Monitoring Systems

Solve problems in the control of environments, processes and personnel protection

The need

Health, safety and production control increasingly demands the monitoring of air in enclosed spaces for flammable and toxic components. In industry, hazardous concentrations of solvent vapors, process gases and the like must be detected and eliminated. Monitoring is also important in enclosed parking garages, ships, tunnels and mines to detect accumulations of lethal or explosive gas concentrations.

The solution

Custom-designed, permanently installed systems for remotely analyzing air: MSA Multi-point Monitoring Systems. Typically, these systems can be arranged to:

- Sample air on a sequential basis from a number of different locations at distances of 500 feet or more from the cabinet.
- Analyze, measure and record the amount of a particular constituent.
- Actuate alarms at preset concentration levels.
- Actuate ventilation equipment.
- Provide contacts to shut down the process equipment creating the hazard.

The typical system in operation

MSA Multi-point Systems are customized to meet the needs for each particular installation. Typically, they are tailored to monitor CO, CO_2, solvents or concentrations of process vapors in the TLV or LEL ranges. A Multi-point System can also be provided to analyze oxygen in order to detect local oxygen deficiency areas.

Operation (see flow chart) is on a programmed sequential basis. Timer-actuated solenoid valves (1) introduce samples of air from each of up to 24 remote sensing points (2) in sequence, sniffing for 15 to 60 seconds at each point. The system can also be set to sample air from a single point continuously. Filters (3) and traps (4) are provided for each remote sampling point.

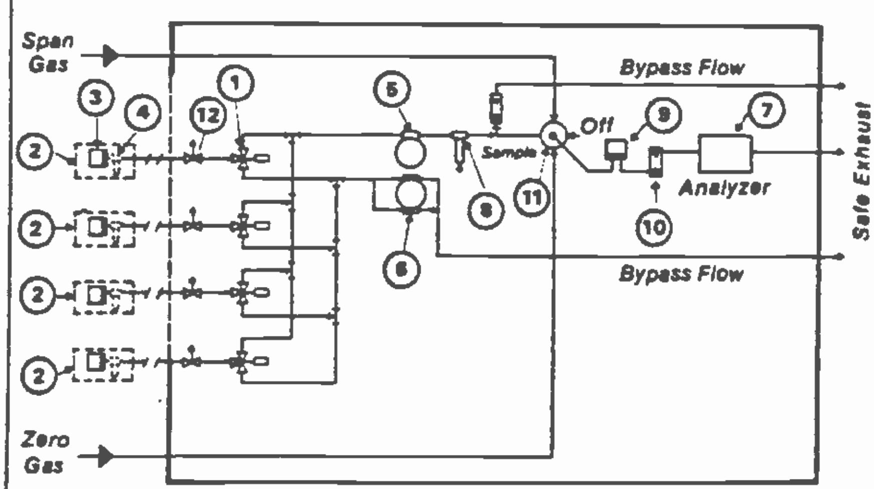
At the cabinet, further filtering or sample conditioning may be done. Here two pumps are provided, one for sample (5) and one for bypass (6). The sensor (7) analyzes the specific sample and provides an analog concentration signal of the sample to a recorder, or to an alarm or control unit. A filter-separator (8), an ultrafilter (9) and flow meter (10) measure flow, condition samples and protect the analyzer. A multiport valve (11) permits selection of zero, span or sample gas for calibration purposes. Flow control valves balance gas flow where sample lines enter cabinet.

Applicable instruments

The analyzer(s) supplied in an MSA System depend on the components of interest. To monitor SO_2, NO, CO, CO_2 and hydrocarbons, Lira® Luft-type Infrared Analyzers by MSA are supplied. These are capable of continuous and extremely accurate determinations over long periods of time. They can be calibrated to read out in percentages or low ppm and, in cases of hydrocarbons or solvent vapors, in LEL or ppm ranges. For measuring O_2, MSA can supply a Model 802 magnetic field-type analyzer for a range of 1% or 100% full scale. For total hydrocarbon analysis in ranges of 0-4 ppm to 12,000 ppm, an MSA Total Hydrocarbon Analyzer can be installed. Any of these analyzers, in addition to detecting and measuring air contaminants, can generate output signals to interface with computers, distant recorders, alarms or ventilation systems. Literature on analyzers for specific integration into a Multi-point System is included in this folder. Specific needs should be discussed with your MSA representative.

Base cabinet

The Monitoring System controls, indicators, sample acquisition apparatus and analyzer are housed in a steel cabinet. For up to 12-location monitoring, an 84" high x 28" wide x 28" deep cabinet is supplied. For up to 24-location monitoring, a cabinet of twice the width, or 56", is supplied. Cabinet elevations, floor diagram, and controls and indicators are illustrated on the back page.



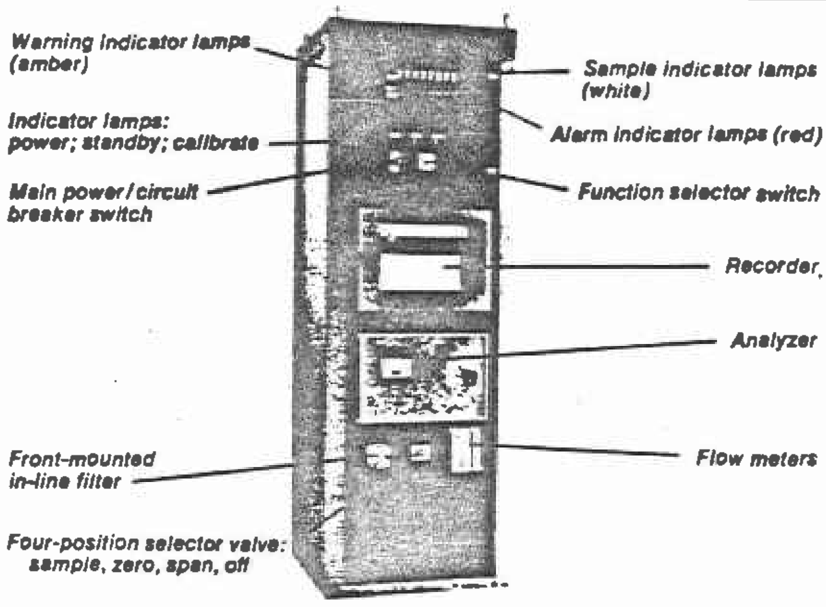
Multi-Point Monitor System

Indicators and controls

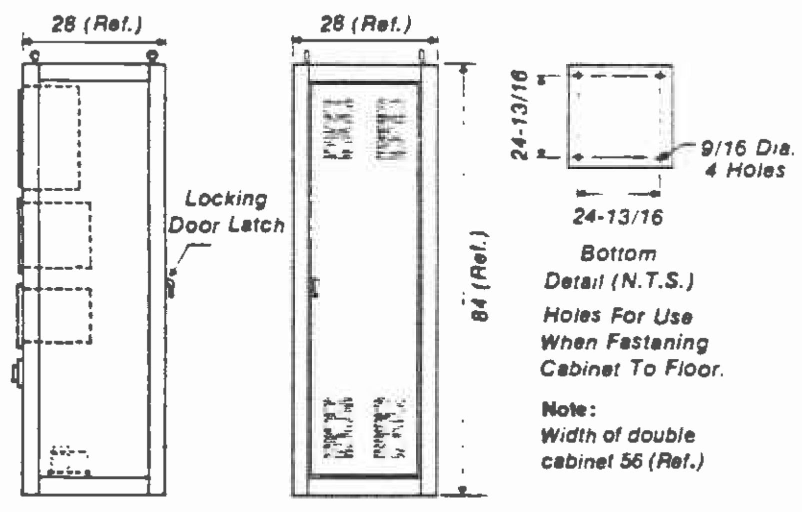
Selector switch permits selection of: a) zero and span calibration gases and samples; b) automatic multi-point mode; c) single-point-only sample mode.

Signal lamps for each sample point indicate: (white) sample being analyzed; (amber) low-level warning set point concentration reached; (red) danger concentration reached.

Alarm options include **Manual Reset:** If alarm concentration at one point is reached, sample program stops at danger location. Alarm is actuated and continues until manually reset. **Auto Reset:** multi-point sample program continues and alarm operates only when danger point is subsequently sampled. **Selective Auto Reset:** alarm continues as well as sampling program. When danger sample point is next sampled, the alarm circuit is reset for a fresh sample.



Typical 8-point analysis system for carbon monoxide in air.



Typical single cabinet dimensions

Note: This bulletin contains general descriptions of certain Mine Safety Appliances Company products. While uses and performance capabilities are described, under no circumstances should the products be used except by qualified, trained personnel, and not until the instructions, labels, or other literature accompanying the products have been carefully read and understood and the precautions therein set forth followed. Only they contain the complete and detailed information concerning these products.

MSA Instrument Division
600 Penn Center Boulevard
Pittsburgh, Pa. 15235 USA

Atlanta · Boston · Chicago · Cleveland · Dallas · Detroit · Houston · Los Angeles
Milwaukee · New York City · Philadelphia · Pittsburgh · San Francisco · St. Louis.
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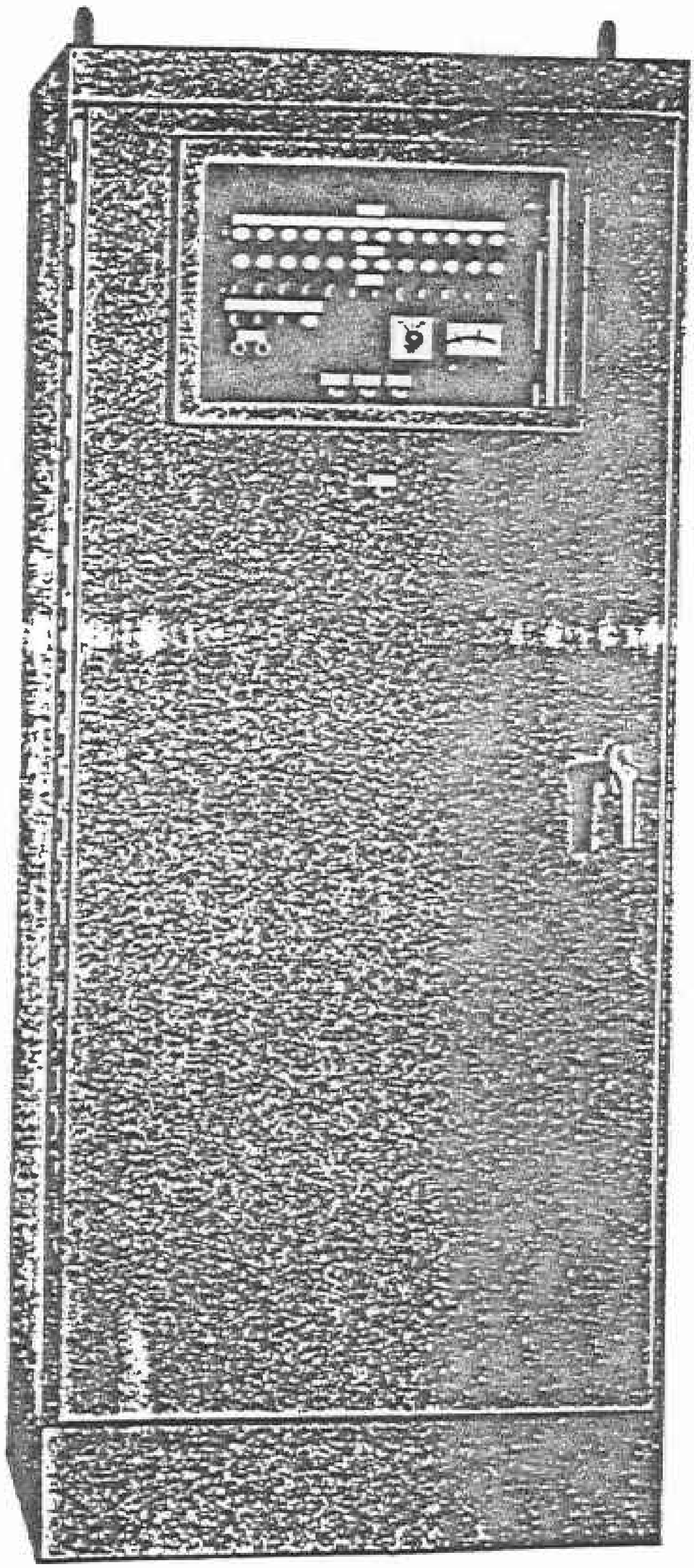


Figure 1
12 Point Lira System
Nema 12

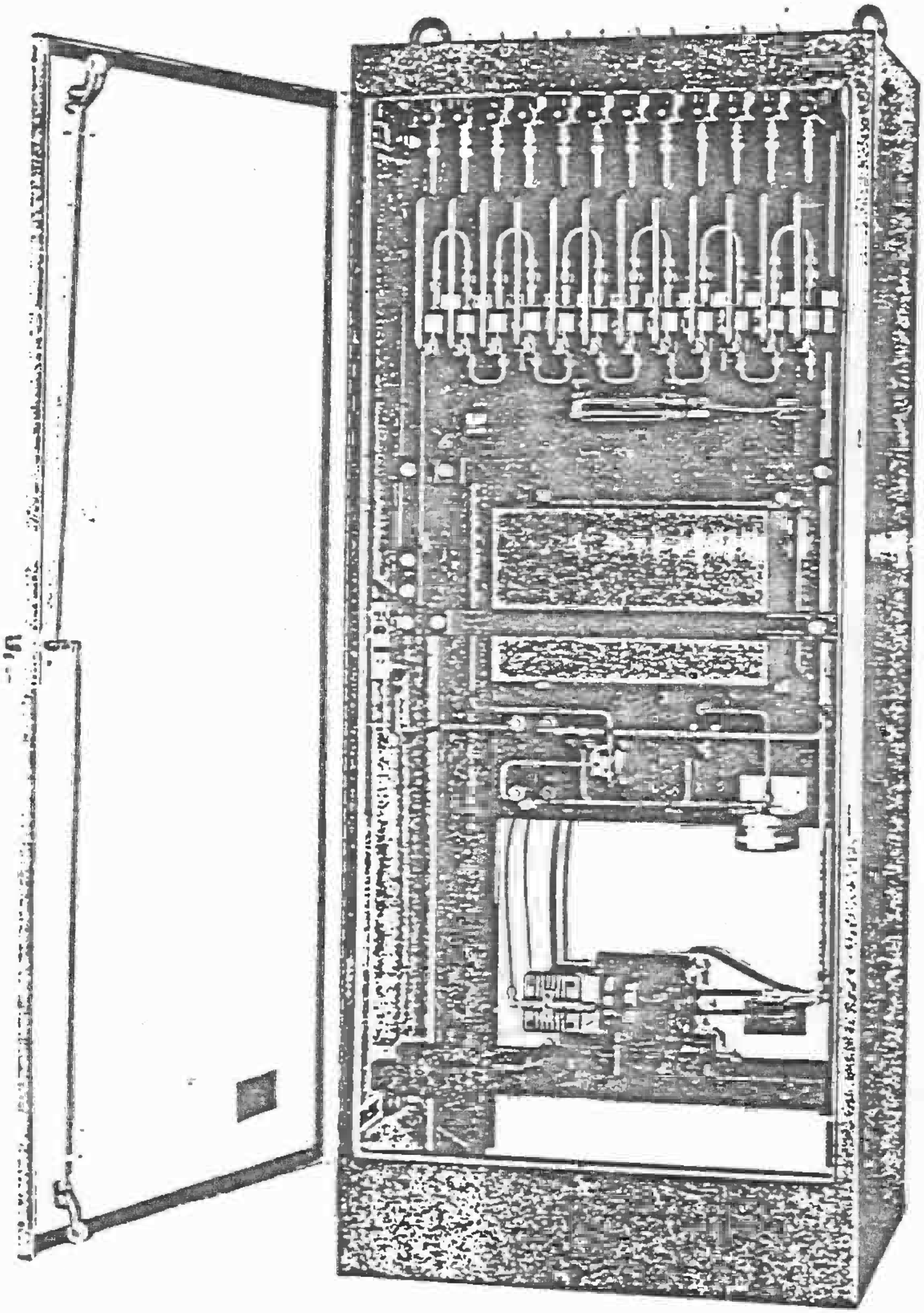


Figure 2
12 Point Lira System
Nema 12 Rear View
Door Open

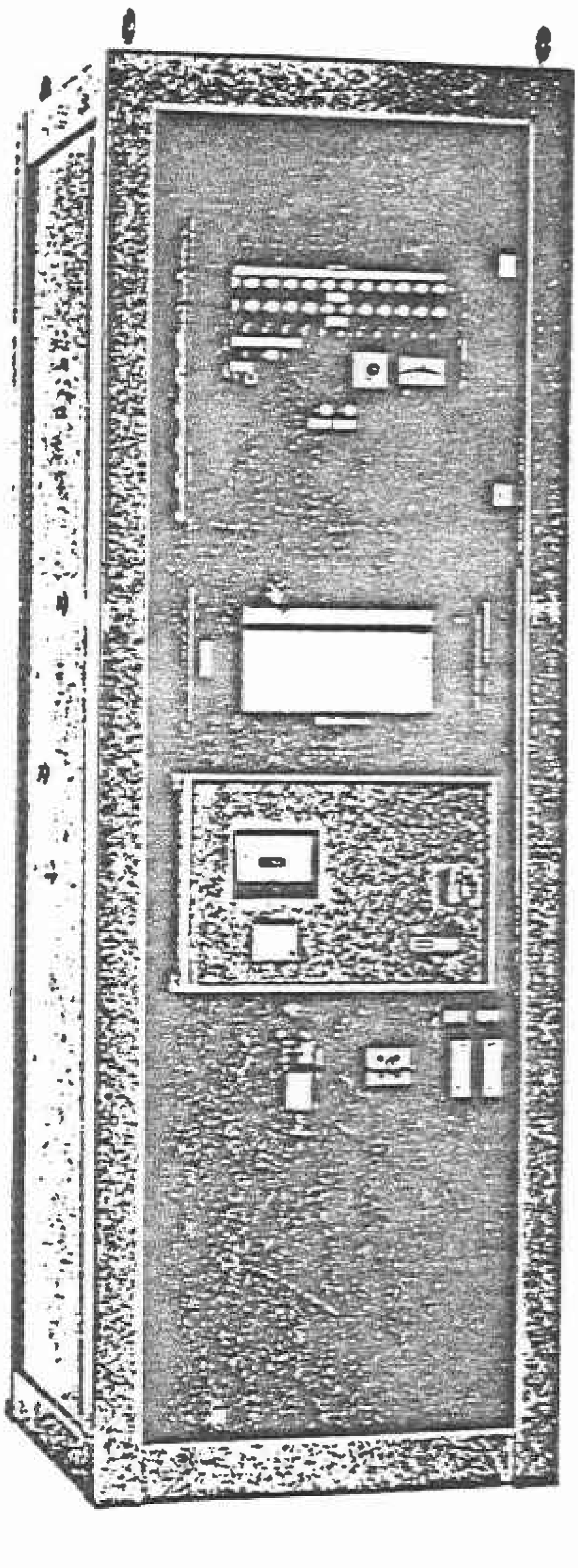


Figure 3
12 Point Lira System
General Purpose

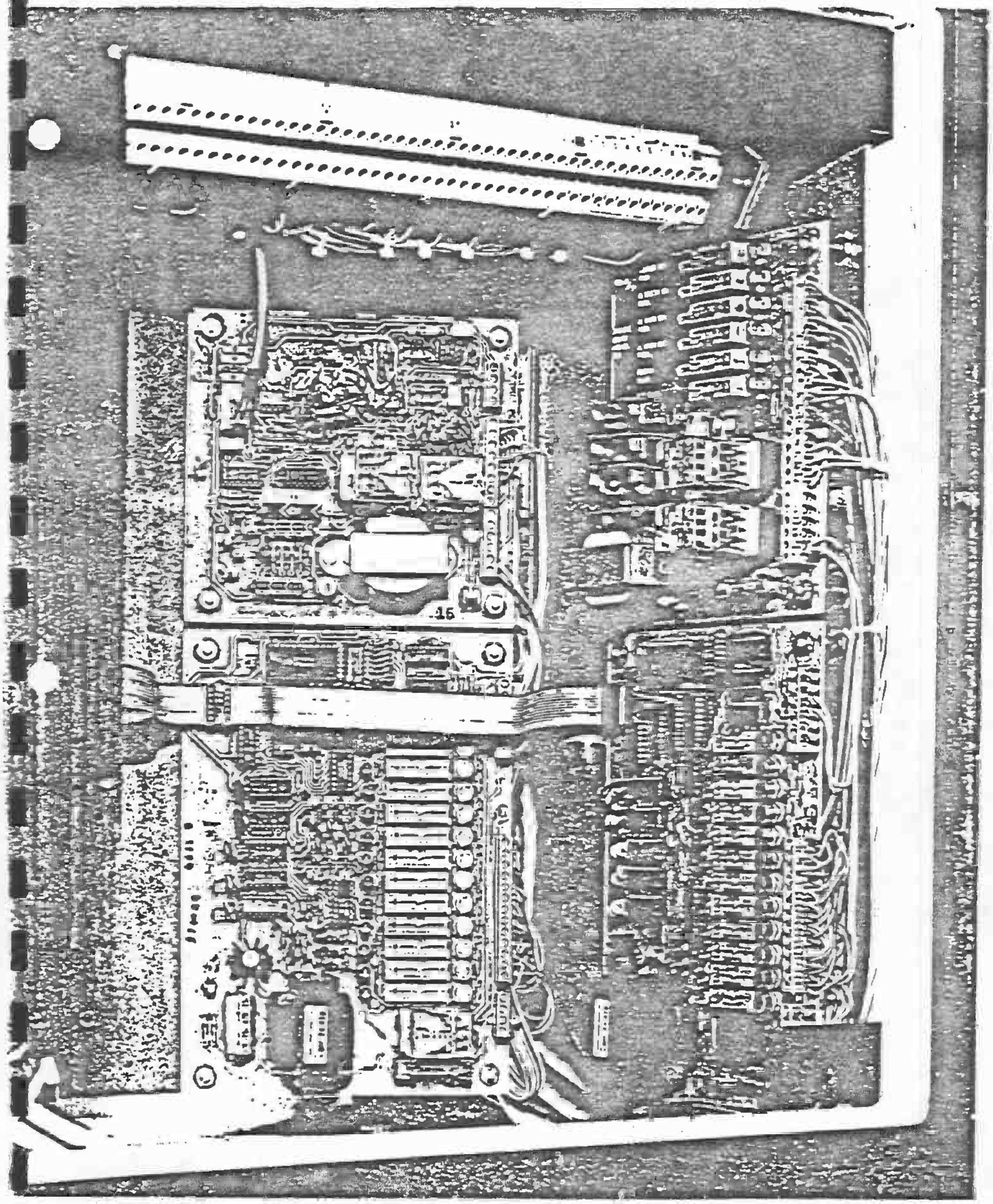


Figure 4
System Programmer
Inside View

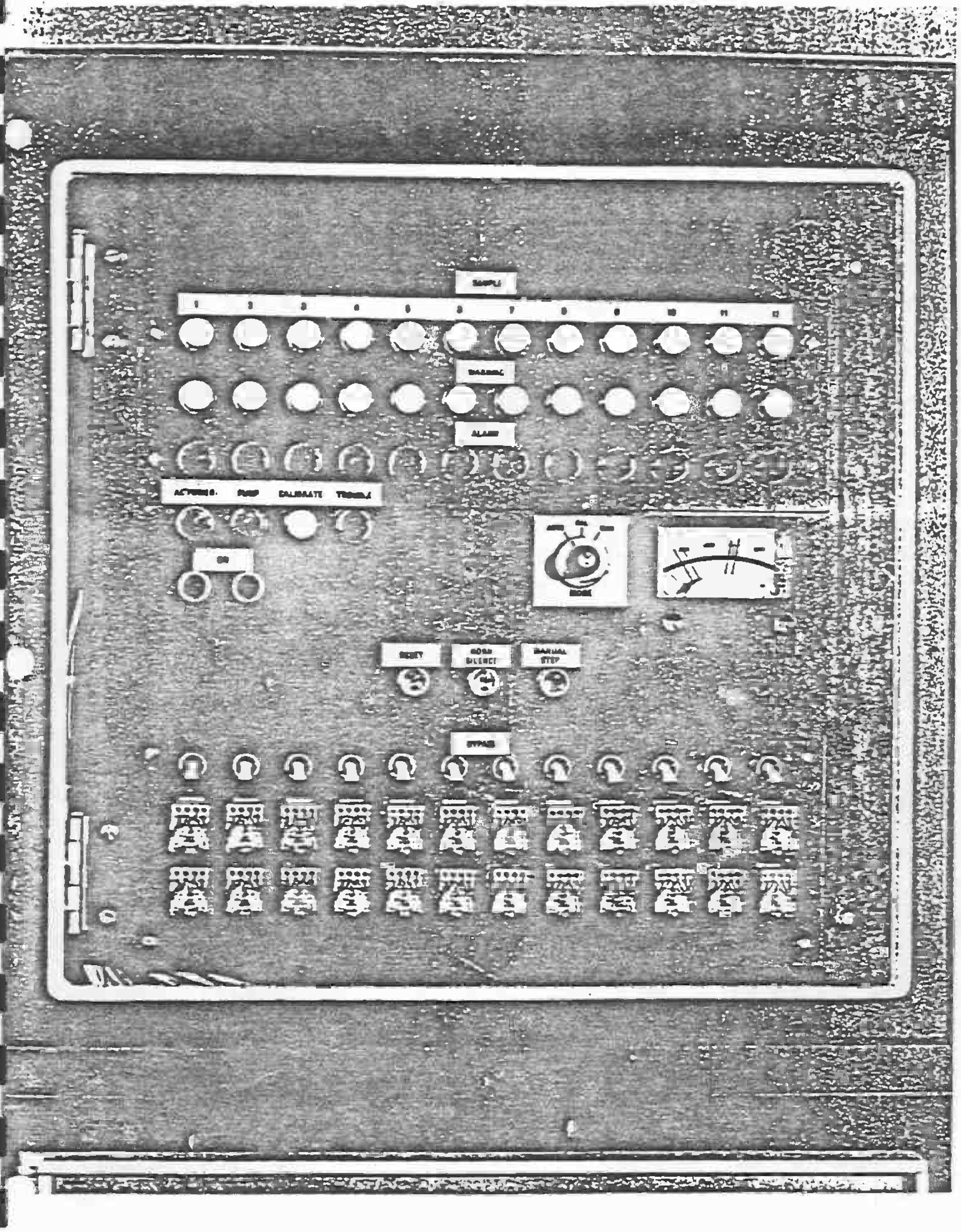


Figure 5
Front Panel
12 Point Programmer With All

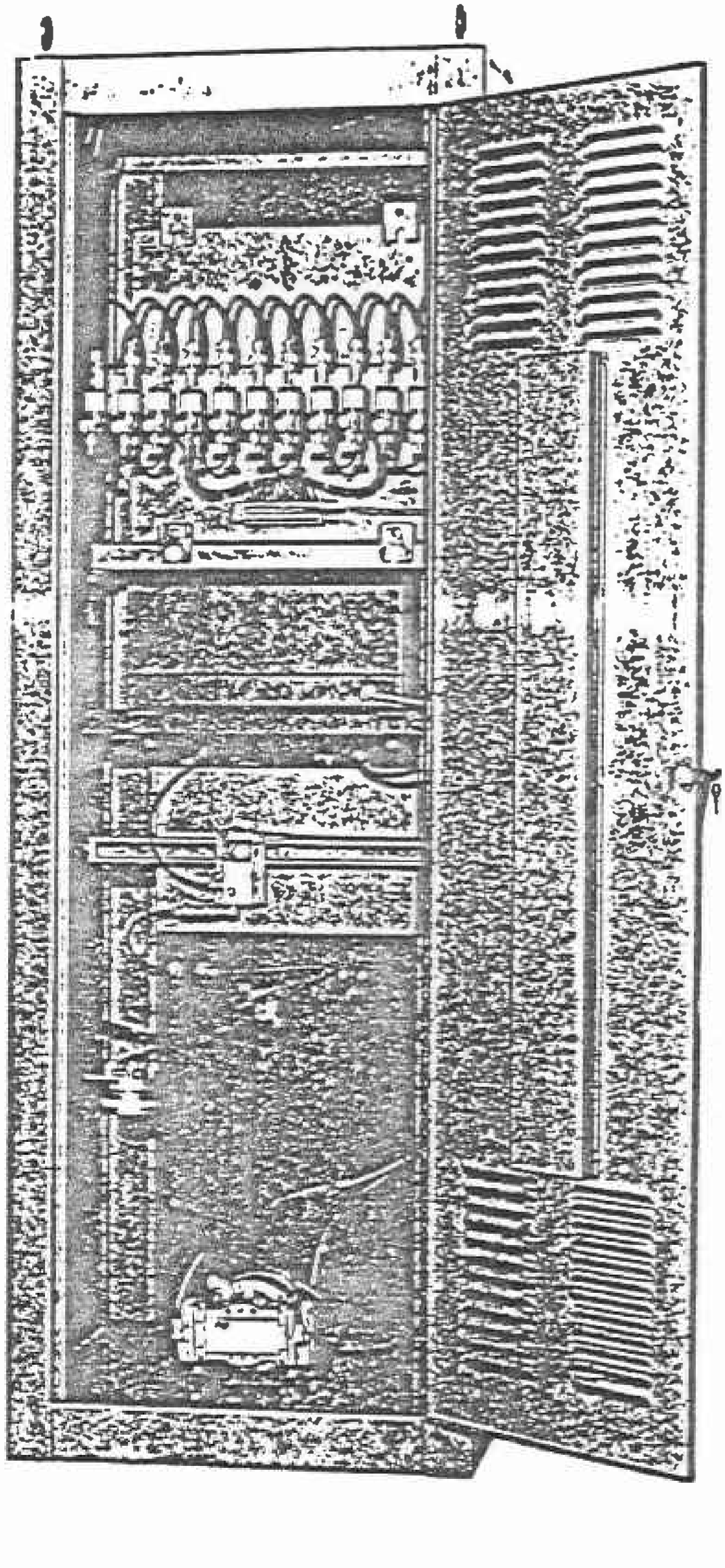


Figure 6
Rear View

12 Point Lira System
General Purpose

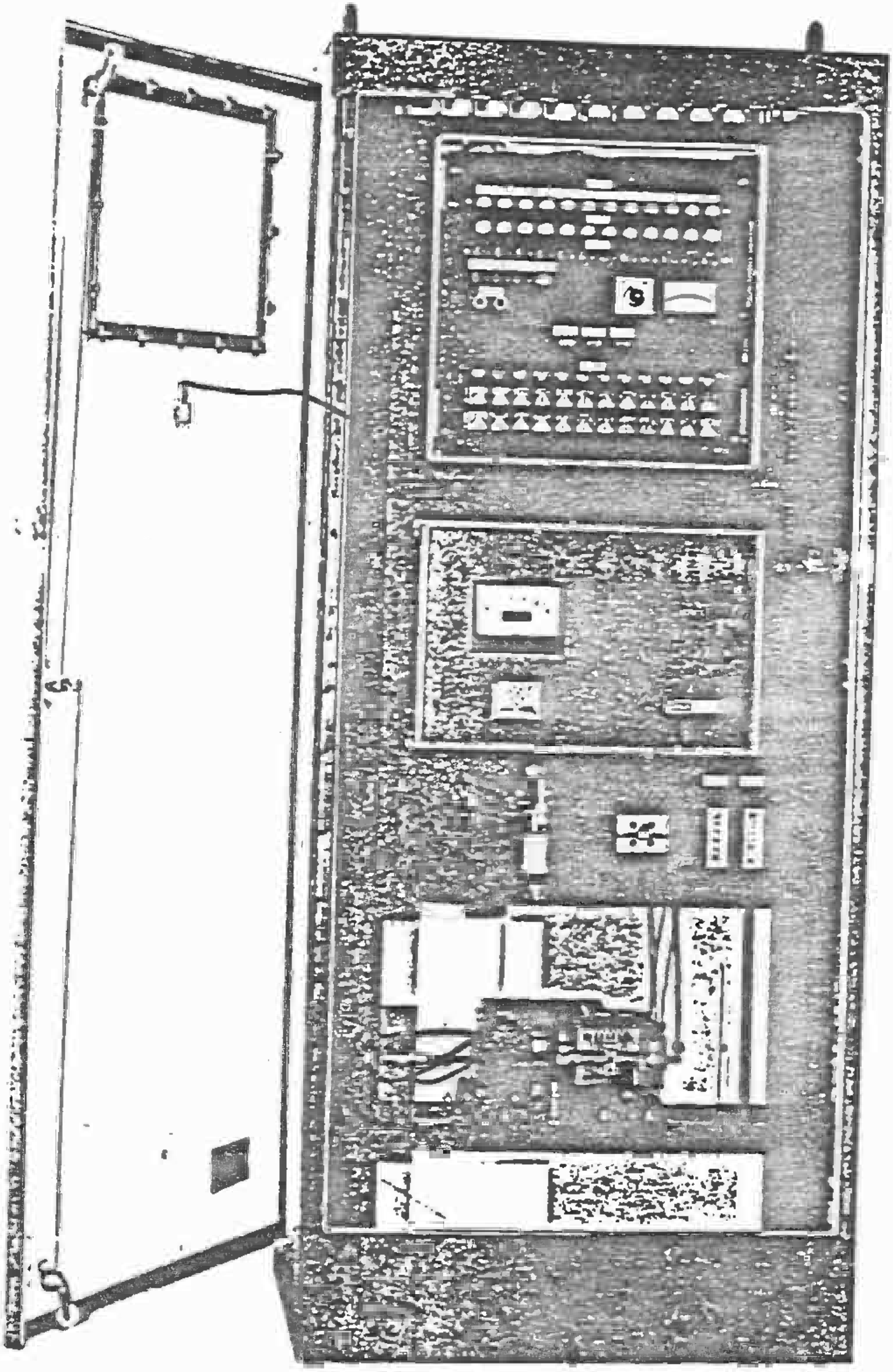
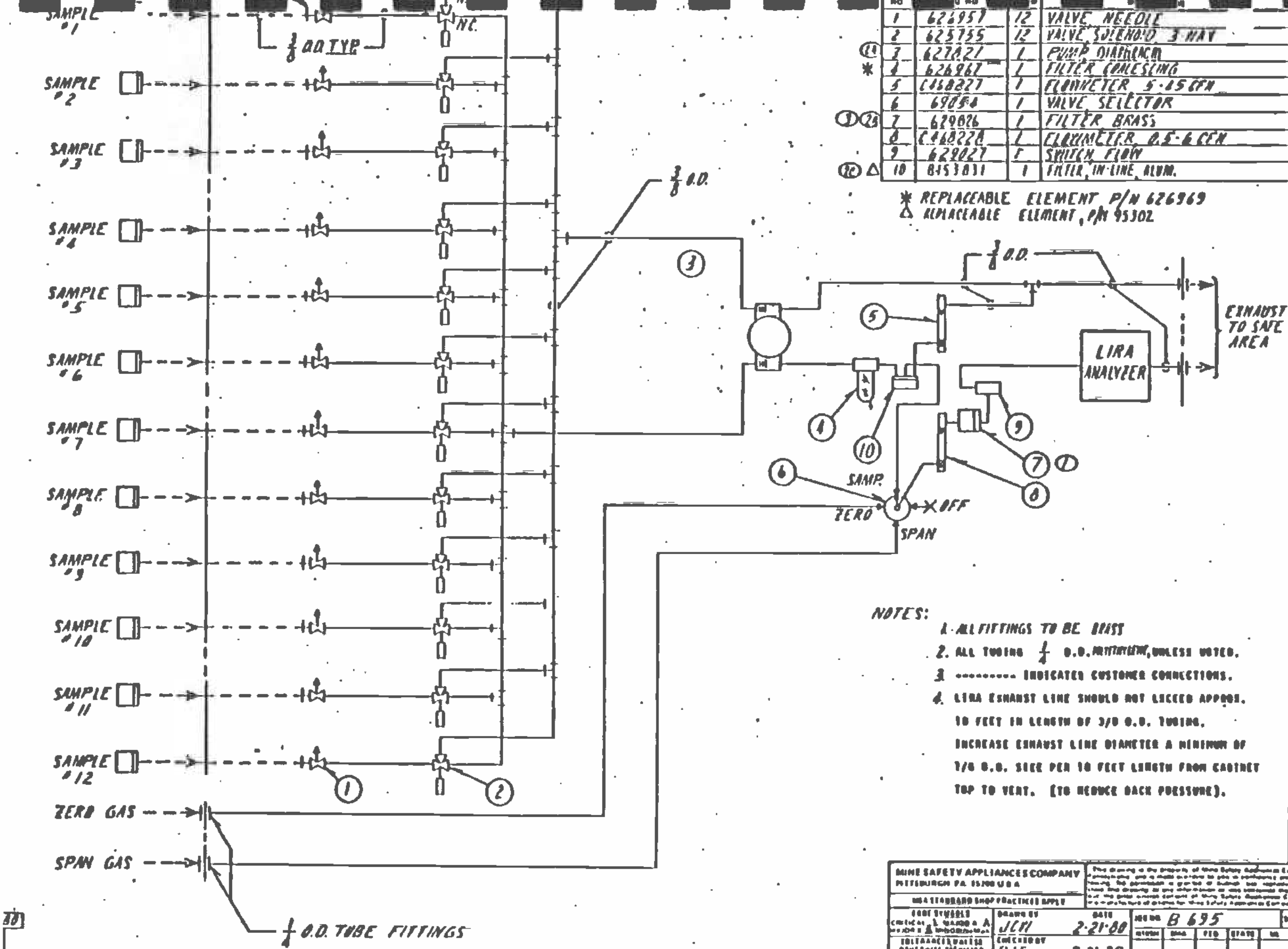


Figure 7
12 Point Lira System
Nema 12 Front View

[redacted]



	ITEM NO	[redacted]	[redacted]	[redacted]
	1	626957	12	VALVE NEEDLE
	2	625755	12	VALVE SOLENOID 3 WAY
(2A)	3	627821	1	PUMP DIAPHRAGM
*	4	626967	1	FILTER COALESCING
	5	C468227	1	FLOWMETER 5-45 CFH
	6	69054	1	VALVE SELECTOR
(3) (2B)	7	629826	1	FILTER BRASS
	8	C468228	1	FLOWMETER 0.5-6 CFH
	9	629027	1	SWITCH FLOW
(2C) △	10	8453031	1	FILTER, IN-LINE, ALUM.

* REPLACEABLE ELEMENT P/N 626969
△ REPLACEABLE ELEMENT, P/N 95302

[redacted] 8-25-[redacted] RELOCATED FILTER B695 RJS
(2) 10-10-8[illegible] A. 627821 W 627827 B YFO-027 ADDED TO M LIST C. ADDED P[illegible] 453031 B695 GJT
(3) 4-30-81 629826 W YFO-027 B695 GJT

NOTES:

1. ALL FITTINGS TO BE BRASS
2. ALL TUBING 1/4 O.D. POLYETHYLENE, UNLESS NOTED.
3. ---------- INDICATES CUSTOMER CONNECTIONS.
4. LIRA EXHAUST LINE SHOULD NOT EXCEED APPROX. 10 FEET IN LENGTH OF 3/8 O.D. TUBING. INCREASE EXHAUST LINE DIAMETER A MINIMUM OF 1/8 O.D. SIZE PER 10 FEET LENGTH FROM CABINET TOP TO VENT. (TO REDUCE BACK PRESSURE).

MINE SAFETY APPLIANCES COMPANY
PITTSBURGH PA 15208 U.S.A.
MSA STANDARD SHOP PRACTICES APPLY

DRAWN BY JCH 2-21-80
CHECKED BY RJS 2-21-80
PROJECT ENGINEER ALW 2-21-80

B 695

FLOW DIAGRAM

CSK3002-3780

Thermo Electron
CORPORATION
Instruments Division

Gas Filter Correlation CO Analyzer

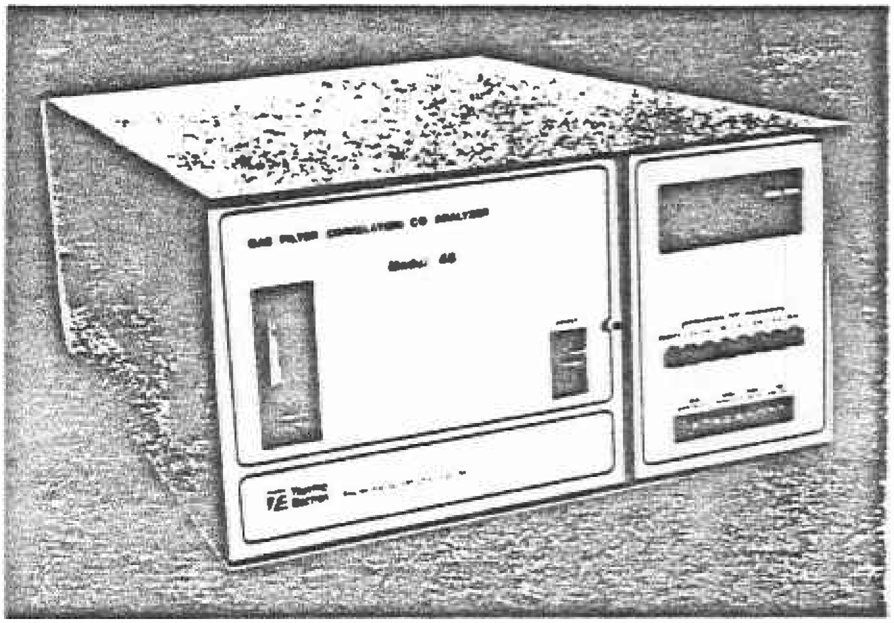
Model 48

For Continuous Ambient Air Monitoring

Thermo Electron's Microprocessor Based Model 48 Ambient CO Analyzer provides unequaled ease of operation, reliability, precision and specificity. The unique Gas Filter Correlation principle of operation offers the significant advantages of unequaled specificity and sensitivity and increased resistance to shock and vibration.

Key Features

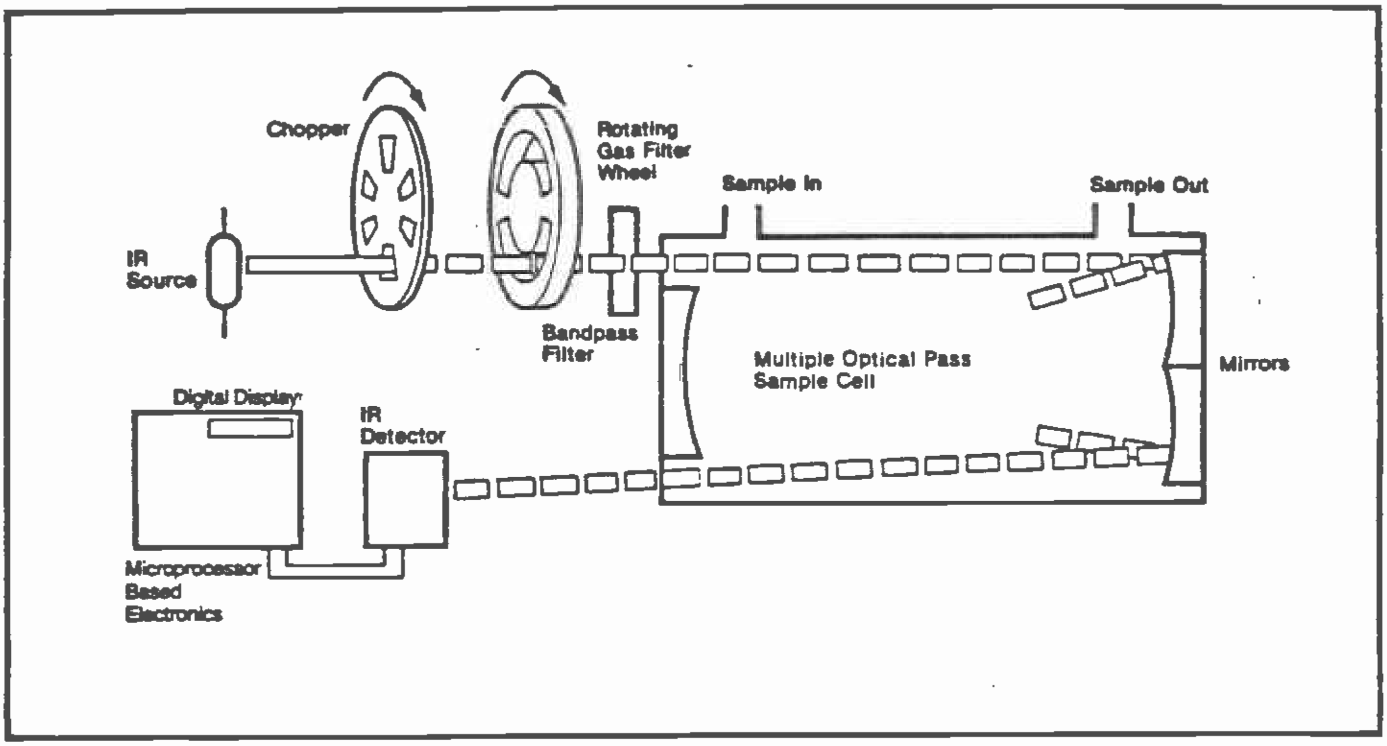
- Microprocessor Based
- Automatic pressure and temperature correction
- Dual fully independent outputs standard
- Hourly average output standard
- Lower ranges, wide dynamic range (suitable for both ambient and source)
- Highly specific to CO
- Long term zero and span stability
- Vibration and shock resistant
- Powerful diagnostics made possible by microprocessor
- Linear through all ranges
- Unaffected by changes in flow
- Self-aligning optics
- U.S.A.—EPA reference method RFCA-0981-054, range 0-50ppm time constant — 30 seconds



Model 48 Specifications

Ranges	0-1, 0-2, 0-5, 0-10, 0-20, 0-50*, 0-100, 0-200, 0-500, 0-1000 ppm
Zero Noise	0.05 ppm RMS — With time constant = 30 seconds
Minimum Detectable Limit	0.10 ppm
Zero Drift, 24 Hours	±0.2 ppm
Span Drift, 24 hours	±1% Full Scale
Rise/Fall Times (0-95%) (at 1ppm flow, 30 second integration time)	1 minute
Precision	±0.1 ppm
Linearity	±1%
Flow Rate	1 lpm standard
Rejection Ratio	Negligible interference from water and CO_2
Operating Temperature	Performance specifications maintained over the range 15–35° C (may be operated safely over the range 5–45° C)
Power Requirements	100 Watts; 105–125 VAC, 60Hz; 220-240VAC 50Hz
Physical Dimensions	17" wide × 8¾" high × 23" deep
Weight	45 lbs.
Dual Outputs (standard)	Selectable to 0-10mV, 0-100mV 0-1V, 0-5V, 0-10V; digital display: 1 hour integrated value. Other outputs available upon request (4-20ma, IEEE488)

* See Federal Register Tuesday February 18, 1975, Volume 40, Number 33, Part II for definitions and Federal specifications. Performance specifications over 15–35°C range.



Principle of Operation

The basic components of a Gas Correlation System are illustrated in the above diagram. Radiation from an infrared source is chopped and then passed through a gas filter which alternates between CO and N_2 due to Rotation of the filter wheel. The radiation then passes through a narrow bandpass filter and a multiple optical pass sample cell where absorption by the sample gas occurs. The IR radiation exits the sample cell and falls on a solid state IR detector.

The CO gas filter acts to produce a reference beam which cannot be further affected by CO in the sample chamber. The N_2 side of the filter wheel is transparent to IR radiation and therefore produces a measure beam which *can* be absorbed by CO. The chopped detector signal is modulated by the alternation between the two gas filters with an amplitude proportional to the concentration of CO in the sample chamber. Other gases do not cause modulation of the detector signal since they absorb the reference and measure beams equally. Thus, the Gas Filter Correlation System responds solely to CO.

Options

48–001 — Particulate Filter

48–002 — Rack Mounts

48–003 — Remote activation of zero and span solenoids.

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CORPORATION

Instruments Division

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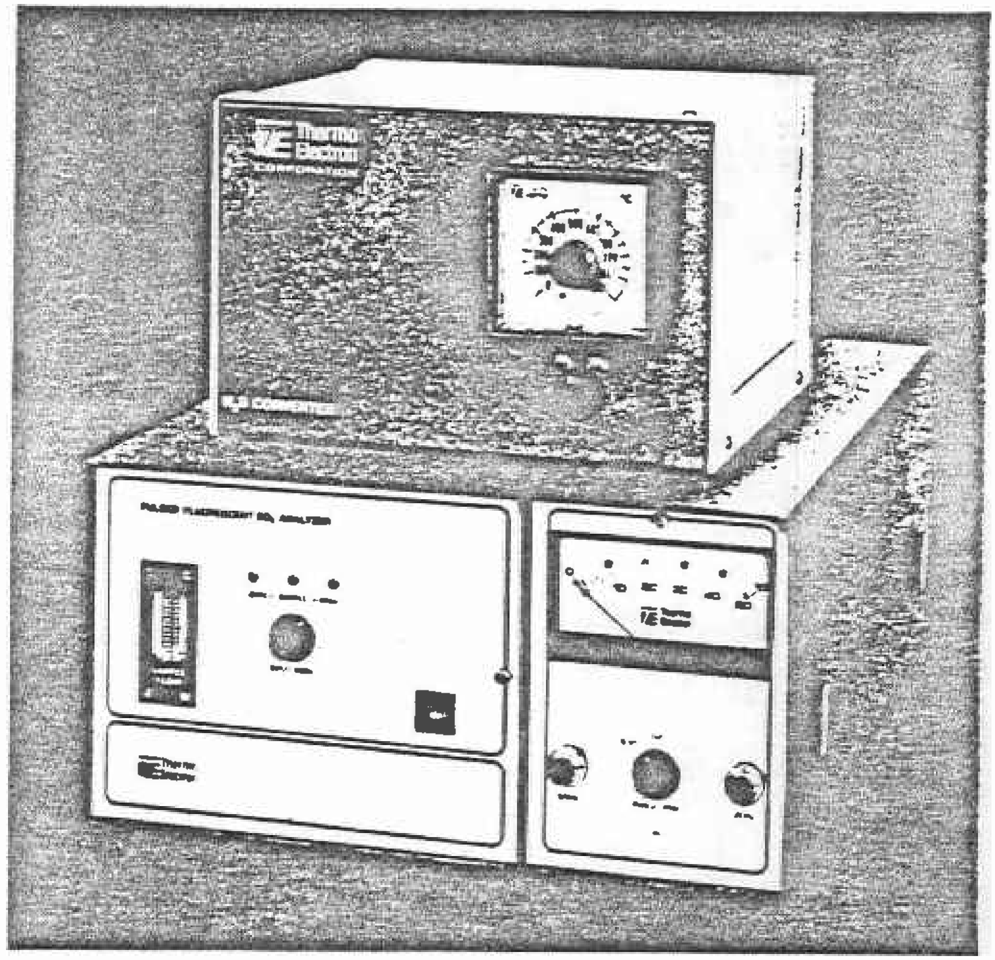
Telephone (617) 435-5321
Telex 948325

Printed in U.S.A. — 1/83 5M

Thermo Electron CORPORATION
Environmental Instruments Division

Pulsed Fluorescent H_2S Analyzer



Model 45

For Continuous H_2S Monitoring

Thermo Electron's *Model 45* consists of an H_2S-to-SO_2 Converter coupled to a *Pulsed Fluorescent* SO_2 Analyzer. Continuous H_2S monitoring is accomplished by converting the H_2S in the sample to SO_2 for its subsequent detection by the SO_2 Analyzer according to the following reaction:

$$H_2S + \frac{3}{2}O_2 \longrightarrow SO_2 + H_2O$$

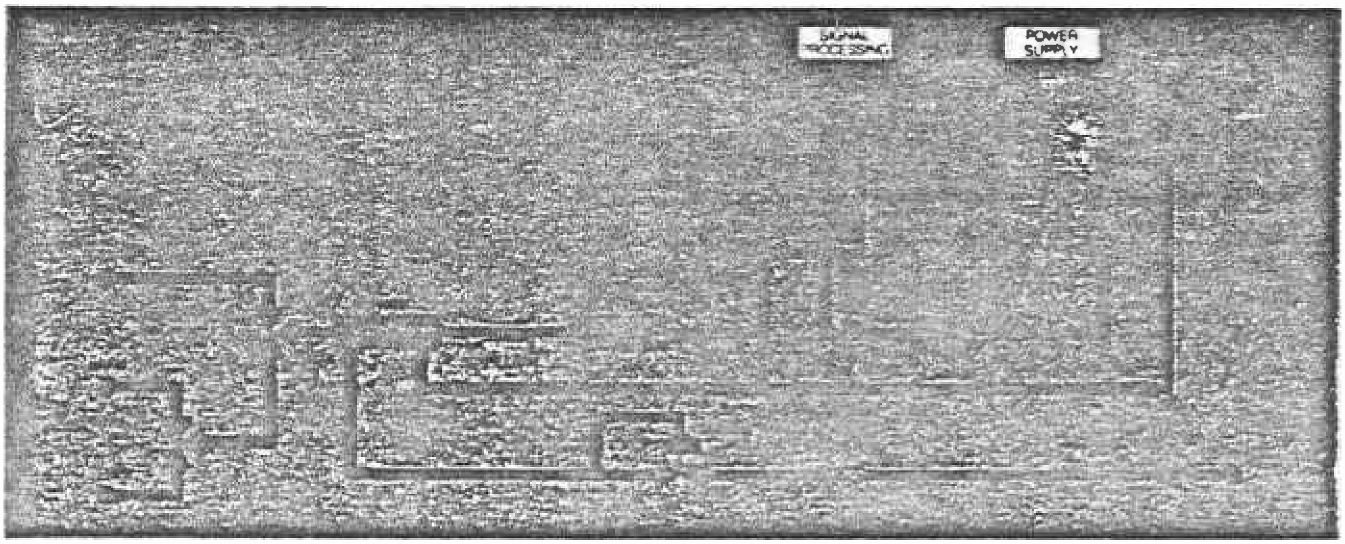
The Converter section of the *Model 45* catalytically converts each H_2S molecule to SO_2 so that the output of the SO_2 Analyzer is equal to the concentration of H_2S entering the Converter. Any SO_2 present in the original sample is scrubbed prior to its entrance into the Converter providing an instrument response specific to H_2S.

The SO_2 Analyzer section of the *Model 45* is based upon the principle of *Pulsed Fluorescence,* whereby pulsed ultraviolet light passes through a narrow bandpass filter to a measurement chamber where it excites SO_2 molecules. As these molecules return to the ground state they emit a characteristic fluorescence with intensity linearly proportional to the concentration of SO_2 molecules in the sample. The fluoresced light then passes through a second filter to illuminate the sensitive surface of a photomultiplier tube. Electronic amplification of the output of the photomultiplier tube provides a meter reading and an electronic analog signal for recorder output.

Key Features

- Specific response to H_2S
- No consumable gases or wet chemicals required
- Longterm zero and span stability
- Maintenance free
- Field-proven reliability
- Insensitive to changes in flow and temperature
- Linear through all ranges
- Longterm unattended operation

Gas Flow Schematic of Model 45



Options

45-001 External activation of zero/span solenoid valve

45R-1 19" Rack-mountable configuration (Ambient)

45R-2* 19" Rack-mountable configuration (Source)

*Also available in a NEMA configuration

Model 45 Specifications

Standard Ranges Model 45-1 (Ambient) Model 45-2 (Source)	 0–0.5, 0–1, 0–5 ppm (0–50 ppm optional) 0–50, 0–100, 0–500, 0–1000, 0–5000 ppm
Noise	0.001 ppm
Lower Detectable Limit	0.002 ppm
Zero Drift 24 hrs 7 days	± 0.003 ppm ± 0.005 ppm
Span Drift 24 hrs 7 days	± 1% ± 2%
Lag Time	15 sec
Rise Time (0-95%)	2 min
Fall Time (0-95%)	2 min
Precision	± 0.5%
Operating Temperature	5 to 45°C
Power Requirements	450 watts (total) 115V AC / 60 Hz; 115V AC / 50 Hz, 220V AC / 50 Hz
Physical Dimensions	Analyzer: 17" W x 8¾" H x 23" D Converter: 12" W x 9" H x 12" D
Weight	Analyzer: 55 lbs Converter: 25 lbs
Output	0–10V standard, also available, 0–5V, 0–1V, 0–100mV, 0–10mV, (field-selectable) Other outputs available on request (dual 4-20 ma, 1 hr integrated value, etc.)

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CORPORATION

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Printed in U.S.A
5M—BAI—882

Thermo Electron Corporation

NEW

GAS FILTER CORRELATION

CH_4 ANALYZER

(PRELIMINARY DATA SHEET)

NEW

Thermo Electron Instruments

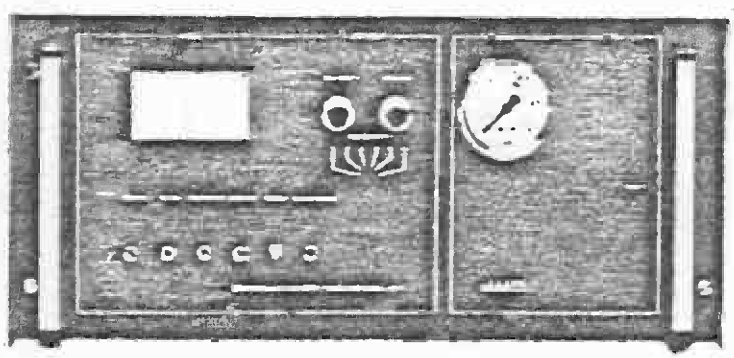
Model 18 Specifications

Ranges	0-5 ppm to 0-5000 ppm (10 Ranges)
Zero Noise	0.05 ppm RMS - With time constant = 30 seconds
Minimum Detectable Limit	0.10 ppm
Zero Drift, 24 Hours	± 0.2 ppm
Span Drift, 24 Hours	± 1% Full Scale
Rise/Fall Times (0-95%) (at 1 ppm flow, 30 second integration time)	1 minute
Precision	± 0.1 ppm
Linearity	± 1%
Flow Rate	1 lpm standard
Rejection Ratio	Negligible interference from water and CO
Operating Temperature	Performance specifications maintained over the range 15-35°C (may be operated safely over the range 5-45°C)
Power Requirements	100 Watts; 105-125VAC, 60Hz; 220-240VAC, 50Hz
Physical Dimensions	17" wide x 8 3/4" high x 23" deep
Weight	45 lbs.
Dual Outputs (standard)	Selectable to 0-10mV, 0-100mV, 0-1V, 0-5V, 0-10V; digital display; 1 hour integrated value. Other outputs available upon request (4-20ma, IEEE488)

J.U.M.®
ENGINEERING

HEATED TOTAL HYDROCARBON ANALYZER

MODEL VE7



- All heated components
- Integrated heated sample pump
- Permanent heated stainless steel 2 micron sample filter
- Built in burner air supply- no extra bottles needed
- Automatic fuel enrichment for ignition
- 19 inch relay rack mount
- 1% precision full scale
- Response time- 90% full scale within 1 second

The J.U.M. Engineering Model VE7 is a high accuracy Total Hydrocarbon Analyzer for the measurement and analysis of organic vapors.

The VE7 utilizes a Hydrogen Flame Ionization Detector (FID) in a thermostatically controlled oven to prevent the loss of high molecular weight hydrocarbons.

Options

Digital display with BCD output/without BCD output
Remote range control and range I.D.
Recorder output of oven temperature

More Features

- Two level alarms with contact closures for high Concentration Caution and high Concentration Alarm (optional)
- Modular construction, mechanical, electric, pneumatic sections
- Remote range and calibration gas control (optional)
- Multichannel capability for simultaneous sampling and analysis of multiple streams, when used in parallel with one analyzer for each sample stream.
- Direct reading in parts per million (ppm) or in percent lower explosive limit (LEL) — sensitive down to one ppm (as Methane).

MAJOR APPLICATIONS

- CONTROL OF SOLVENT RECOVERY SYSTEMS
- DIESEL RAW EXHAUST HYDROCARBONS ANALYSIS
- DIESEL PARTICULATE TUNNEL EPA SPECIFICATION HYDROCARBONS ANALYSIS SYSTEMS
- GASOLINE RAW EXHAUST ANALYSIS
- CATALYTIC CONVERTER TESTING
- CARBON ABSORPTION REGENERATION CONTROL
- STACK GAS HYDROCARBON EMISSIONS MONITORING
- STATIONARY ENGINE EXHAUST ANALYSIS
- LEL (LOWER EXPLOSIVE LIMIT) MONITOR OF SOLVENT-LADEN AIR

Principle of Flame Ionization Detector Operation

The flame ionization detector is based upon a burner in which a small flame is sustained by carefully regulated flows of air and fuel (normally either pure hydrogen or hydrogen/helium mixture). The burner jet is also used as an electrode and is connected to the negative side of a 300 v power supply. Also in the burner is a "collector" electrode which is connected to an electrical amplifier. These polarized electrodes establish an electrostatic field in the vicinity of the burner flame. When a sample of gas is passed into the burner it is ionized in the flame, and the electrostatic field causes the charged particles to migrate towards the electrodes. The positive ions are attracted to the burner jet and the negative ions (electrons) to the collector electrode. A small current now flows between the two electrodes and is used as an input signal to the electrometer amplifier. The current is measured by the amplifier and is displayed on the instrument meter as a percentage concentration.

If the sample gas used does not contain hydrocarbons, the ionization level is extremely small and only produces a very low background current. This background current, or "noise", can be completely eliminated by adjusting the ZERO control potentiometer when zeroing the instrument.

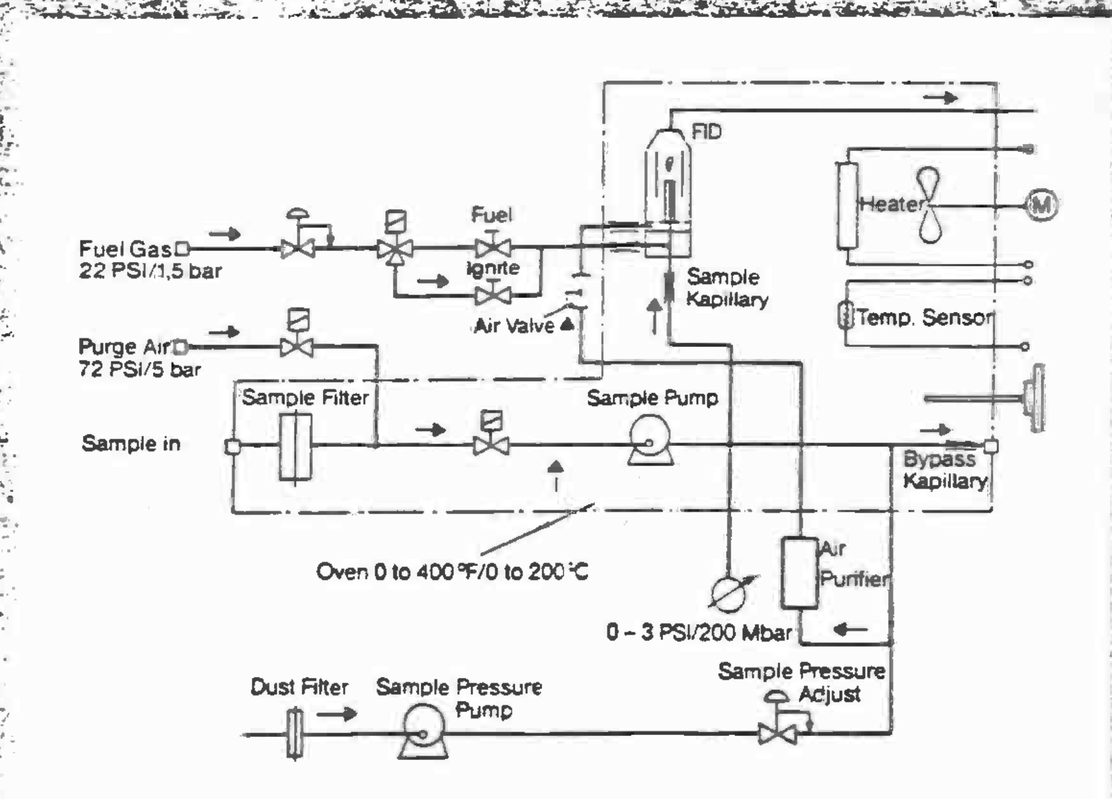
When, however, the sample gas contains hydrocarbons the ionization level is enormously increased, and is directly proportional to the number of carbon atoms in the sample. The analyser is therefore specific to hydrocarbons, with negligible interference from other species, it also has an output which is linear to the hydrocarbon concentration. As the analyser reading is proportional to the number of carbon atoms present, the GAIN potentiometer can be adjusted so that a direct reading can be given either as a specific hydrocarbon (e.g. ppm Propane, C_3H_8), or the methane equivalent (ppm CH_4 or C_1).

The proportional output of the analyser requires that the sample flow is carefully and consistenly regulated. Thus the function of the analyser flow system is to deliver consistent, regulated flows of fuel, air and sample gas into the detector. To prevent heavier hydrocarbons condensing in the system and causing "hydrocarbon retention", a thermostatically controlled heating system is employed, and can be set at any desired temperature from ambient to 200° C. The sample pump, fitted in the standard instrument, is also heated. A heated sample filter is also incorporated to prevent the ingress of foreign matter into the detector, and a special feature of the J.U.M. F.I.D. is a BACKPURGE system which allows this filter to be cleaned without dismantling.

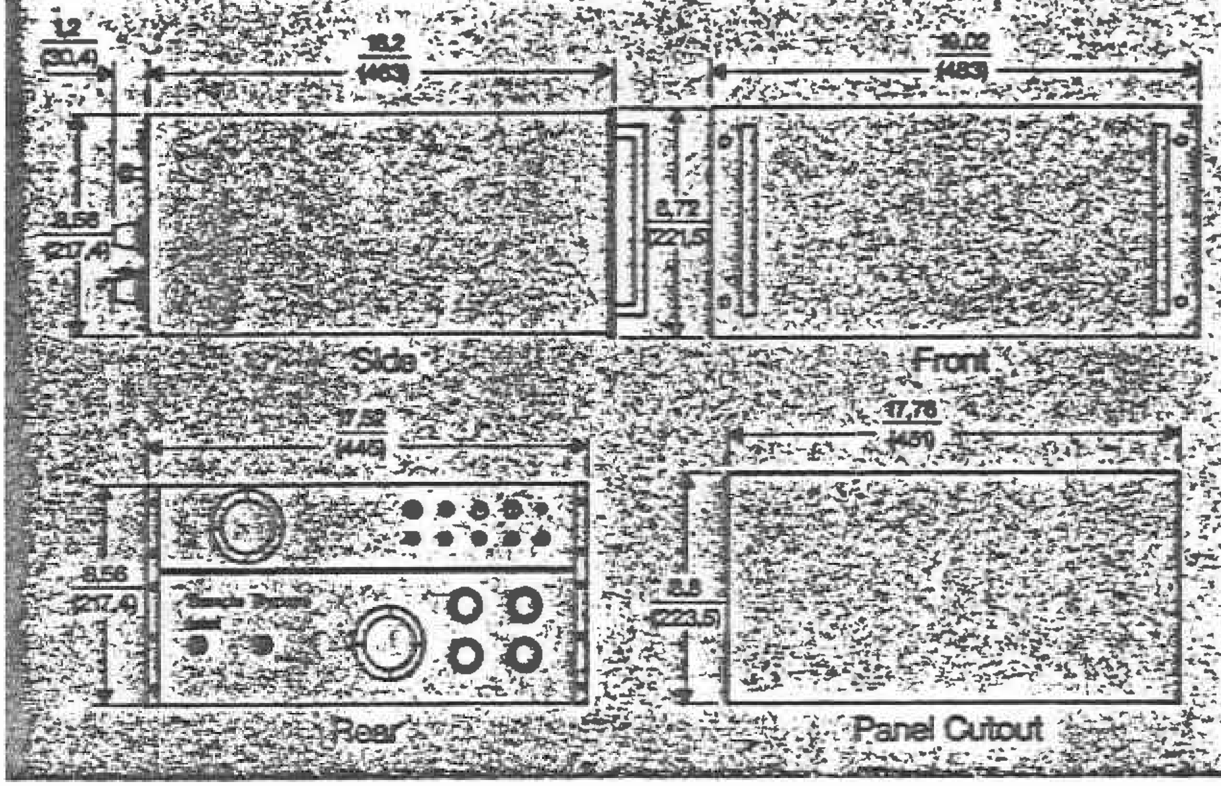
A RANGE switch gives up to 8 step changes which can be specified by the user. An ALARM can be set by the user to warn when a required hydrocarbon level is monitored. The instrument has been disigned with the users' needs very much in mind, and the options available enable the user to tailor the VE 7 to suit his exact requirements.

STANDARD SPECIFICATIONS:

Analysis Method:	Flame Ionization Detector (FID)
Sensitivity:	Max. 1 ppm CH_4 [illegible]
Response Time:	90% of full scale in less than one second
Zero Drift:	1% of full scale per 24 hours
Span Drift:	1% of full scale per 24 hours
Linearity:	Within 1%
Oxygen Synergism:	Less than 1% of selected range
Ranges:	Any three of the following: 0 – 10, 100, 1000, 10,000, 100,000 ppm
Outputs:	0 – 10 Volts D.C.
Display:	Analog Meter in ppm Hydrocarbon or in % LEL
Zero/Span Adjust:	Manual on front panel
Fuel Consumption:	Hydrogen: 20 cc/min. at 22 psig (1.5 Bar) Hydrogen/Helium 40/60 mix: 80 cc/min.
Air Consumption:	None; Integral Air generator
Zero & Span Gas:	3 psig (200 m Bar)
Sample Pump:	All Stainless Steel, heated, 3 liters per minute at operating temperature
Sample Pressure:	By Integral Pump 3 psig (200 m Bar)
Sample Filter:	Permanent all stainless steel, 2 micron back-purged for cleaning.
Analysis Temperature:	Adjustable 200 to 400°F (93 to 204°C)
Power Requirements:	110 Volts, 60 Hertz AC, 800 Watts (others on request)
Ambient Temperature:	32°F to 110°F (0 to 43°C)
Dimensions:	Width 483 mm (19 inches) Depth 460 mm (18 – 1/8 inches) Height 221 mm (8 – 3/4 inches)
Weight:	38,6 lbs. (17,5 kg)
Shipping Weight:	53 lbs. (24 kg)



OUTLINE AND MOUNTING DIMENSIONS



ORDERING INFORMATION:

Part Number	Description
1800007	Model VE7 All Heated Hydrocarbons Analyzer
	Ranges: 0 – 10, 100, 1000, 10,000, 100,000 ppm H.C. (three ranges)
1800017	Model VE7; Ranges; As specified
	Options:
30017	Digital Display 3½ digit
30007	Digital Display 3½ digit with BCD output
01007	Remote Range Control and Range I.D.
00707	Recorder Output of oven temperature

J.U.M. Engineering Ges. m. b. H.: reserves the right, at any time and without notice, to change specifications presented within this data sheet, and assumes no responsibility for the application or use of devices herein described.

Warranty

J.U.M. Engineering Ges. m. b. H.: warrants each new unit of its manufacture to be free of defects in material and workmanship for one year from the date of delivery.

(Assembled in Munich, West Germany)

J.U.M. ENGINEERING COMPANY
25 Cathy, Oakland, California 94619 USA
(415) 568-5753

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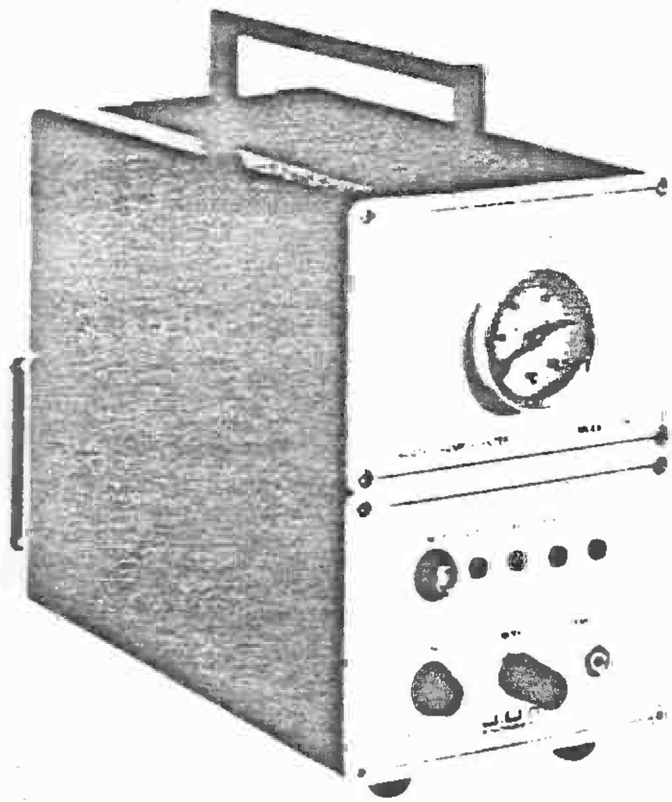
Detmoldstrasse 4
D-8000 Munich, West Germany
011-49-89-3519366

Represented By:

J.U.M.®
ENGINEERING

ALL HEATED SAMPLE FILTER

MODEL 1128



- All heated components
- All stainless steel
- Permanent heated 2 micron sample filter
- Backpurge system allows filter to be cleaned without dismantling
- Remote control for sample, calibrate and backpurge is standard
- Integrated heated sample pump (optional)
- Compact
- Portable

The JUM SAMPLE FILTER is an efficient, all heated and low pressure drop filter for removing solids from a gaseous sample. The Model 1128 utilizes a stainless steel filter and a stainless steel valve in a thermostatically controlled oven to prevent the loss of high molecular weight hydrocarbons or condensation of water.

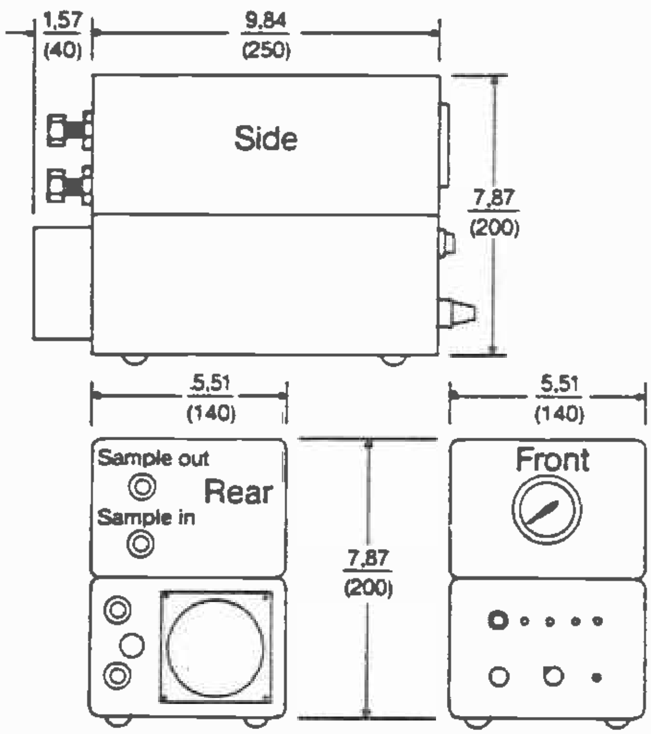
MAJOR APPLICATIONS

- **Removing particles from a gaseous sample where condensation of heavy hydrocarbons or water before analysis desirable**
- **Diesel raw exhaust analysis**
- **Gasoline raw exhaust analysis**
- **Stationary diesel engine exhaust analysis**
- **Stack gas emissions monitoring**

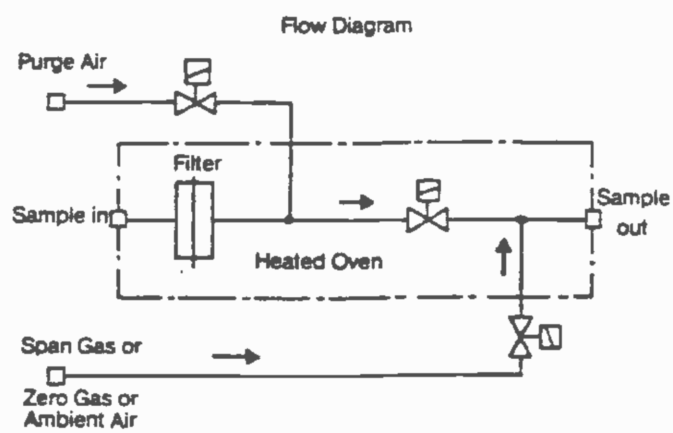
STANDARD SPECIFICATIONS:

Sample filter	All stainless steel
Filter pore size	2 micron
Filter surface area	512 square inches (13,000 mm²)
Sample valve	All stainless steel/Viton®
Purge air valve	All brass/Viton®
Calibration gas valve	All brass/Viton®, or to be specified
Oven temperature	Adjustable 200 to 400 °F (93 to 204 °C)
Ambient temperature	32 °F to 110 °F (0 to 43 °C)
Power requirements	110 Volt 60 Hertz AC, 500 Watt (other on request)
Dimensions	Width 5,5 inches (140 mm), Depth 9,84 inches (250 mm), Height 7,84 inches (200 mm)
Weight	16,5 lbs (7,5 kg)
Shipping weight	23,1 lbs (10,5 kg)

OUTLINE AND MOUNTING DIMENSIONS



FLOW DIAGRAM



J.U.M. Engineering Ges. m. b. H.: reserves the right, at any time and without notice, to change specifications presented within this data sheet, and assumes no responsibility for the application or use of devices herein described.

Warranty

J.U.M. Engineering Ges. m. b. H.: warrants each new unit of its manufacture to be free of defects in material and workmanship for one year from the date of delivery.

(Assembled in Munich, West Germany)

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25 Cathy, Oakland, California 94619 USA
(415) 568-5753

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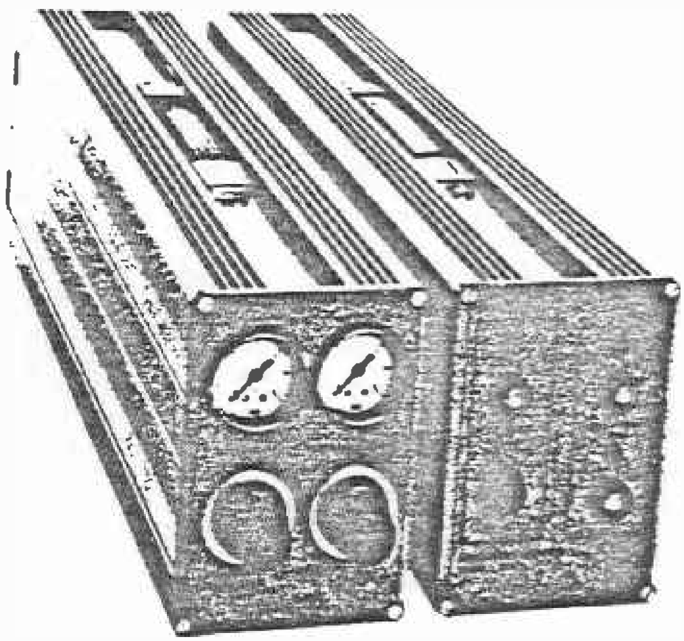
Detmoldstrasse 4
D-8000 Munich, West Germany
011-49-89-3519366

Represented By:

J.U.M.®
ENGINEERING

TJ SERIES FID-BURNER AIR SUPPLY



Model TJ 37

The type TJ Burner Air Supply is a highly efficient purification system for use in the production of ultra pure air, as required for gas chromatographs and other laboratory instruments. It consists of a two-stage compressor system and a dual filtration system, each in separate enclosures. The produced air is of exceptional purity, being at least as pure as cylinder "zero" air and having a very constant oxygen concentration. The regulated output pressure is continuously variable from 1.0 to 4.5 bar (14.5 to 65 psig).

ADVANTAGES

The major advantage of the burner air supply is its convenience and safety as compared to the use of cylinder air and the transportation & storage of the cylinders. High purity air is available at the touch of a switch and there is no moving in and out of heavy cylinders.

The Burner Air Supply is very cost effective when compared to the use of cylinder air. Its cost can be recovered rapidly from the savings of not having the continuing expense of purchasing and handling cylinder air. Investment and operating costs can be paid-off in less than one year when used to supply air for several chromatographs.

PURE AIR GENERATOR FOR:

- **Gaschromatographs with FID**
- **Continuous total hydrocarbon analyzers with FID**
- **Flame photometers**
- **Constant concentration of oxygen**
- **Constant output-pressure**
- **Low maintenance**
- **Silent in operation**
- **Low current consumption**
- **Lower costs (When compared to cylinder air)**
- **2 pressure ranges selectable by switch from frontpanel**
- **Compact**
- **Adjustable from 0 to 65 psig (± 0.5%)**
- **Flows of up to 4 liters/minute**
- **Economical and simple to expand for higher flow rates**

OPERATION

The Burner Air Supply takes in ambient air by means of a diaphragm pump and filters the air through a particulate filter (0.08 micron). Any condensation is collected in a water trap, by means of a cooling coil.

A combination of four fine filters provides filtering out of fine particulate. Two charcoal absorbers in series adsorp the organic impurities (hydrocarbons). The resultant output air has a purity that is equal to or better than that of high purity cylinder air.

The output pressure of the burner air supply is controlled by means of two integral pressure regulators; pressure gauges for interstage (pump) pressure and output pressure are located on the front panel. A relief valve in the compressor line prevents any stalling of the pump motors, which could otherwise be caused by short duration power failures.

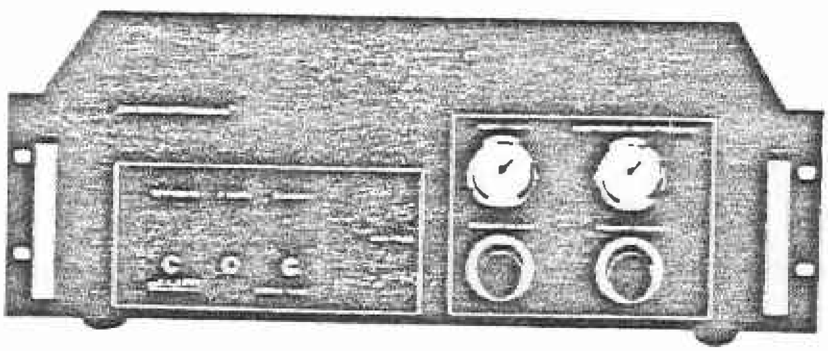
The operation of the type TJ Burner Air Supply is simple and without problems. Operation is silent and virtually maintenance free; maintenance requirements are limited to the occasional drainage of water collected in the water trap and replacement of the absorption cartridge (approximately once every two years).

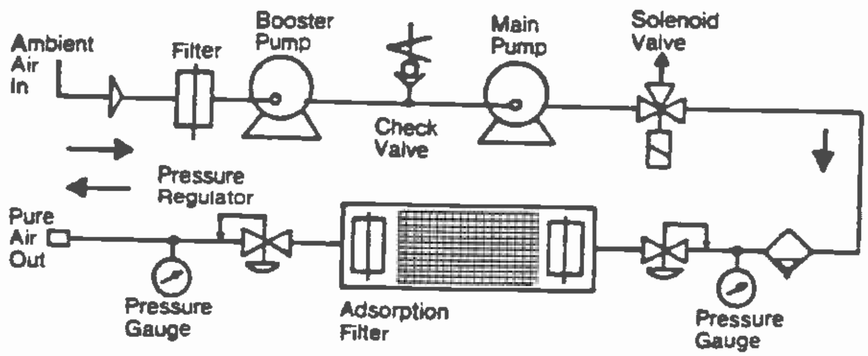
STANDARD SPECIFICATIONS

Dimensions:	**Model TJ 37** (Dual Enclosures) Compressor: 3,94 inch (100 mm) wide, 5,51 inch (140 mm) high 19,7 inch (500 mm) deep Filter section: 3,94 inch (100 mm) wide, 5,51 inch (140 mm) high, 19,7 inch (500 mm) deep **Model TJ 36** (Rack Mount) 19 inch (483 mm) wide, 5,2 (132 mm) high, 14,2 inch (360 mm) deep
Power requirements:	110 Volt, 60 Hertz 60 Watt, others on request.
Compressors:	Diaphragm type main pump and diaphragm type booster pump.
Pressure ranges:	Two electrically controlled ranges: 0 to 2 bar (30 psig) and 0 to 4.5 bar (65 psig)
Pressure regulation:	Adjustable interstage regulator and adjustable output regulator; pressure accuracy is $< \pm 0.5\%$. Maximum pressure is 4.5 bar at no flow, 0.8 bar at 4 liters/min.
Water trap:	5 micron filter
Particulate filter:	99.99% efficiency
Air filtration:	4-stage in-line filter with 2-stage adsorption cartridge; 99.99% efficiency.

MODEL TJ 36

Rack Mount





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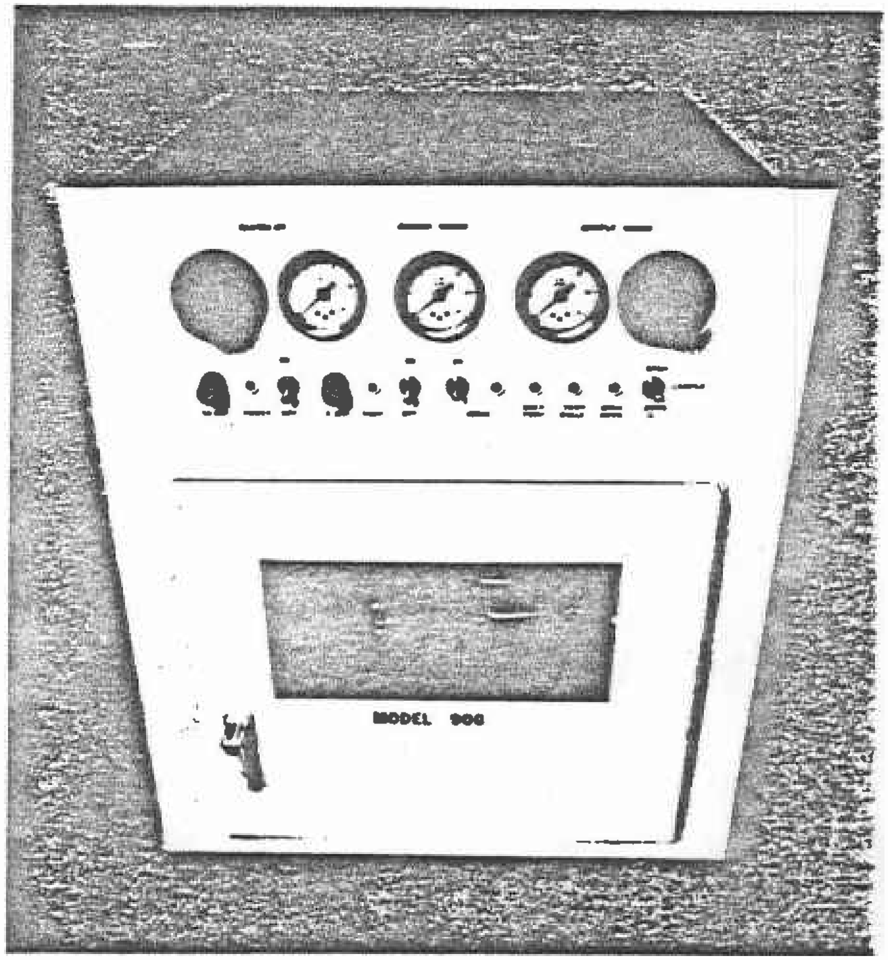
Represented By:

Thermo Electron CORPORATION
Environmental Instruments Division

Heated Sample Gas Conditioner



Model 900
For Conditioning Source Gas Samples

The Model 900 Heated Sample Gas Conditioner draws a raw stack sample through heated tubing and delivers a clean, dry measurement sample to several instruments. The Model 900 contains a large particulate filter and a stable flow blending network in a heated chamber. Within the heated chamber the raw sample is first filtered and then blended with clean dry air. This blending reduces the dew point temperature of the raw sample to below room ambient. Thus, when the sample exits the Model 900, the particles have been removed and the measurement sample is dry and is in a consistent air background. The formation of condensates or their removal is eliminated, therefore, the composition and ratio of the pollutants (NO, NO_2, SO_2, CO, and CO_2) are not altered.

Key Features

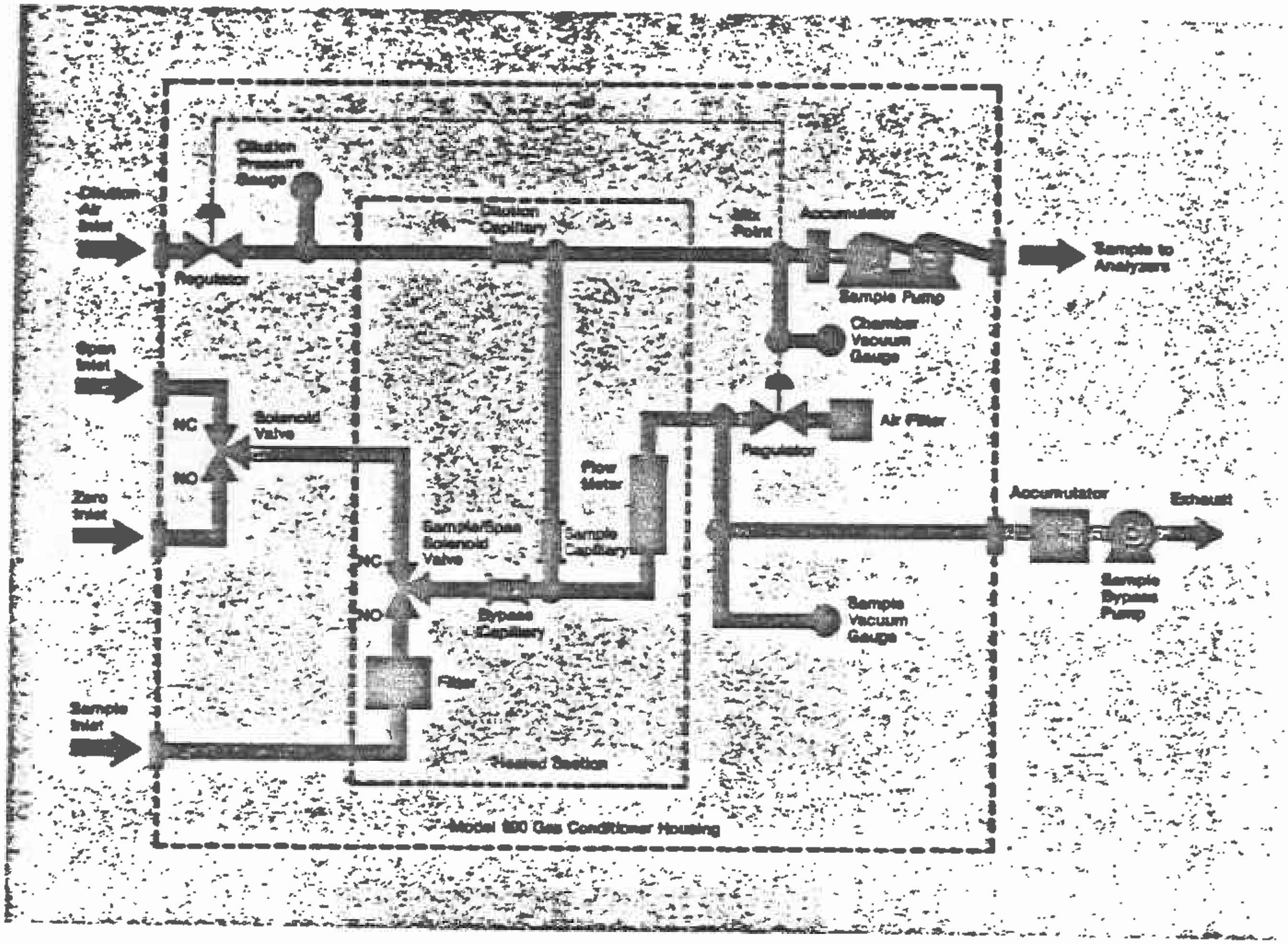
- Large visible particulate filter
- Safety features prevent condensate-laden sample from entering instruments
- Can be expanded to accept up to three separate continuous samples, with automatic sequencing.
- Bench top or rack mountable
- Designed for easy maintenance
- Designed for longterm unattended operation
- Blend ratios selectable
- Field proven reliability
- No corrosive condensates formed to absorb sample gas
- Provides conditioned sample for multiple analyzers

Model 900 Specifications*

Raw Sample Inlet Temperature	250°F (maximum)
Raw Sample Inlet Dew Point Temperature	150°F (maximum)
Sample Delivery Pressure	8 PSIG
Sample Flow (Blended Output)	3ℓ/min standard (larger flows available)
Raw Sample Flow (Input)	1ℓ/min (approximately)
Chamber Temperature	165 ± 10°F
Operating Temperature	60 to 100°F
Power Requirements	750 watts; 115V AC / 60 Hz; 220V AC / 50 Hz
Physical Dimensions	19" wide × 22¼" high × 15½" deep
Instrument Weight	72 lbs. (includes pumps)
Back Flush (optional)	20 cfm @ 100 PSIG for 20 seconds

*Specifications are typical and are subject to change without notice

Model 900 Flow Scheme



The sample enters via a heated sample line to the heated section of the Model 900. Sample passes through a sample filter to the Sample/Span solenoid valve. The sample then passes through the bypass capillary and is divided a small sample portion passes through the sample capillary, while the larger sample flow goes to the flow meter, through an accumulator (flow capacitor) to the sample pump and then to exhaust.

The sample regulator maintains the differential pressure across the sample capillary, thus maintaining constant flow.

The dilution air, regulated to 10 PSIG, passes through the dilution capillary and flows to the sample/air mix point, blending with the sample. The blended sample is pumped to the analyzers for analysis.

Options

900-004 Sample Probe Backflush
Includes valving, plumbing and internal timers which automatically control the timing and sequencing of the backflush operation on an hourly basis.

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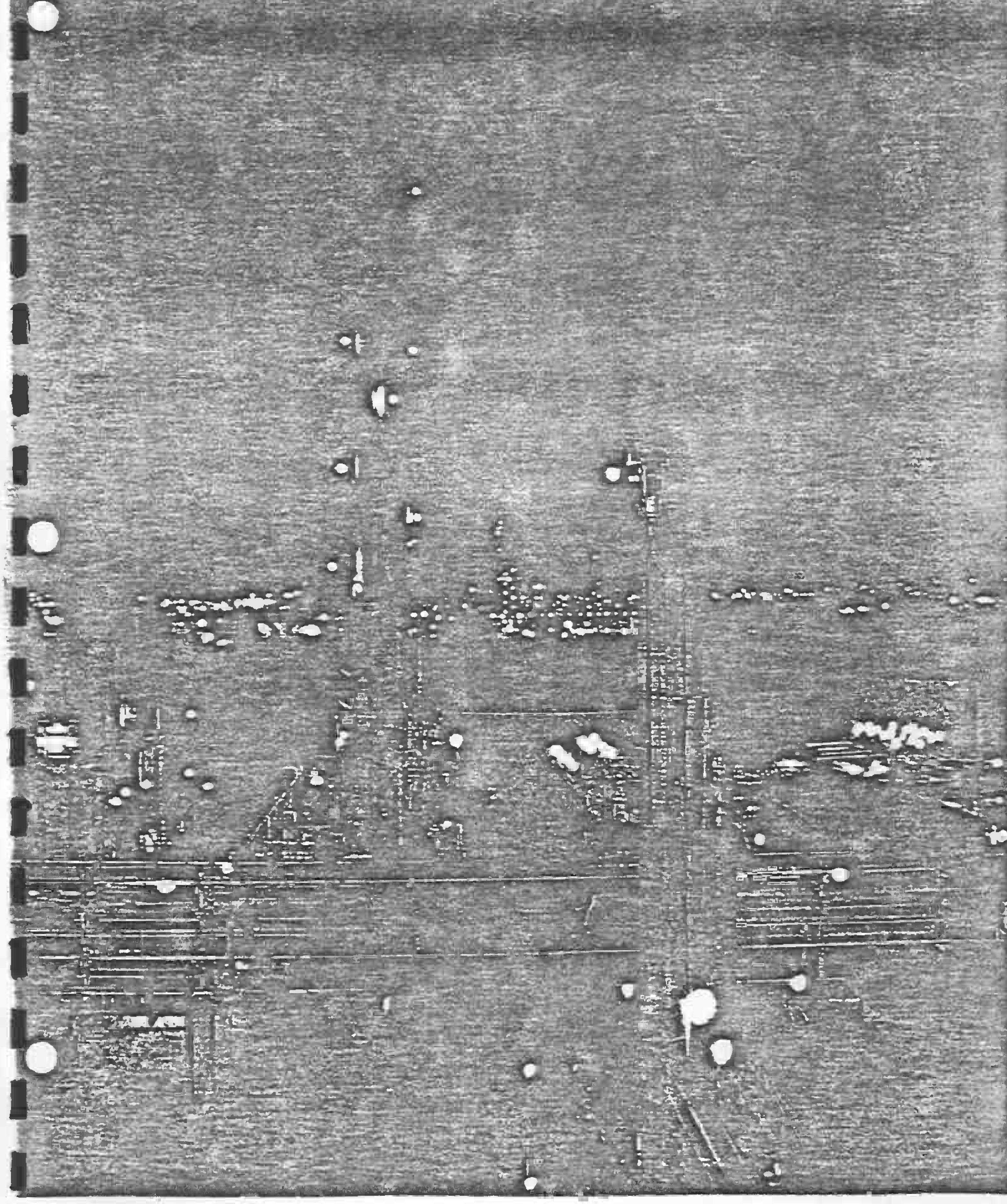
interscan corporation

TOXIC GAS MONITORING INSTRUMENTATION

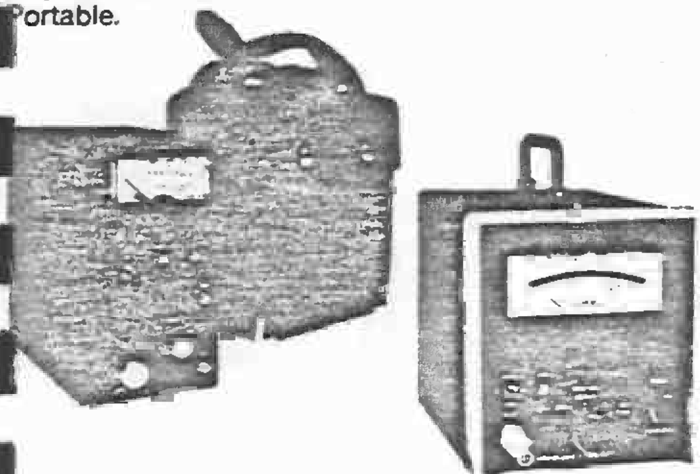


Interscan Corporation manufactures a complete line of instrumentation for monitoring CO, SO_2, H_2S, NO, NO_2, Cl_2 and other toxic gases. The company was founded in 1974 by people with broad experience in sensor technology, analog and digital electronics, pneumatic devices, and process instrument applications. Indeed, it is this combination of expertise as well as a **talent for listening** that has helped Interscan become the industry's primary source and top problem solver. Whether your needs be in the area of workplace monitoring, OEM instruments, or custom system packaging, we invite you to ... ***Discover Interscan!***

Although Interscan has supplied hundreds of specially designed instruments, we are, naturally, best known for our standard products, field-proven in thousands of installations in well over 30 countries.

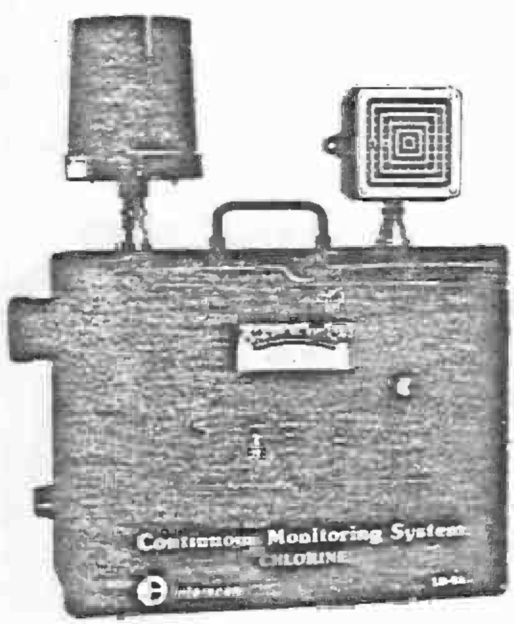
Portable Analyzers

Two types of portable analyzers are available . . . our original Standard Portable and the smaller Compact Portable.



Both types are intended for survey and occasional round-the-clock use, and operate off integral rechargeable batteries.

LD Series Continuous Monitoring Systems

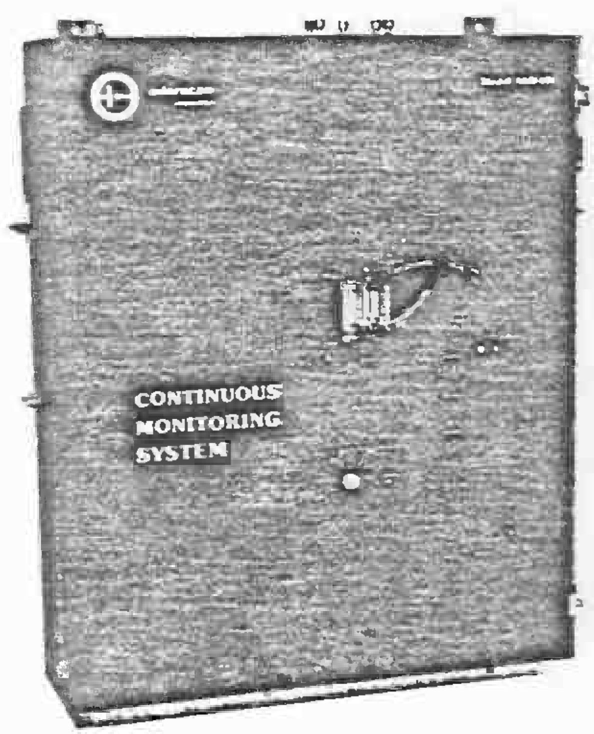


LD single point area monitors feature ultra-tough construction and process industry tested heavy-duty components throughout. Many options are available, including adjustable alarm contacts, opening up a whole spectrum of control possibilities.

Rack-Mounted Configured Analyzers

The Rack-Mounts are intended for those applications in which line power operation is desired, but the industrial type packaging of the LD Series is not required. Designed to be installed in a standard 19 inch (483 mm) rack, or to be used on the bench, their open frame construction and use of standard electrical and pneumatic components allow them to be easily incorporated into a system, if need be.

Multipoint Continuous Monitoring Systems



Intended for monitoring at several different locations within the same general area, Interscan's Multipoint systems feature either Stream-Switching operation, dedicated Continuous Monitoring channels, or a combination of the two approaches. Designed-in flexibility provides custom features at a standard equipment price.

Technical Data

APPLICABLE TO ALL INTERSCAN ANALYZERS

Principle Of Operation

The Interscan voltammetric sensor (U.S. Patent Number 4,017,373) is an electrochemical gas detector operating under diffusion controlled conditions.

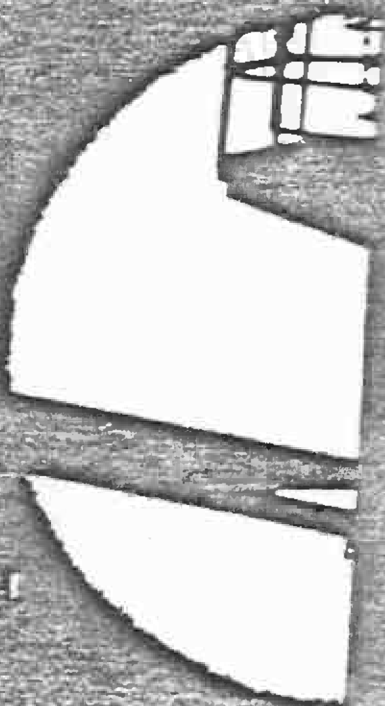
Gas molecules from the sample are adsorbed on an electrocatalytic sensing electrode, after passing through a diffusion medium, and are electrochemically reacted at an appropriate sensing electrode potential. This reaction generates an electric current directly proportional to the gas concentration. This current is converted to a voltage for meter or recorder readout.

The diffusion limited current, i_{lim}, is directly proportional to the gas concentration according to the simplified equation

$$i_{lim} = \frac{nFADC}{\delta}$$

where i_{lim} is the limiting diffusion current in amps, F is the Faraday constant (96,500 coulombs), A is the reaction interfacial area in cm^2, n is the number of electrons per mole reactant, δ is the diffusion path length, C is the gas concentration (moles/cm^3), and D is the gas diffusion constant, representing the product of the permeability and solubility coefficients of the gas in the diffusion medium.

An external voltage bias maintains a constant potential on the sensing electrode, relative to a nonpolarizable reference counterelectrode in the 2-electrode Interscan sensor. "Nonpolarizable" means that the counterelectrode can sustain a current flow without suffering a change in potential. Thus, the counterelectrode acts also as a reference electrode, thereby voiding the need for a third electrode and a feedback circuit, as would be required for sensors using a polarizable air counterelectrode.



Interference Guidelines

rt shows the approximate concentration (ppm) of interfering gas needed to cause a 1 ppm deflection in the chosen analyzer.

INTERFERING GAS

ANALYZERS	Cl_2	CO	COS	C_2H_5SH	H_2	SAT. HC	UNSAT. HC	H_2S	$(CH_3)_2S$	CH_3SH	NH_3	NO	NO_2 (N_2O_4)	N_2O	SO_2	SO_3
Cl_2	—	>500	>500	S	>500	>10^4	>500	S	>500	S	25	>500	S	>10^4	S	>10^4
CO	>500	—	>500	>500	125	>10^4	S	>500	>500	>500	5	>500	>500	>10^4	>500	>10^4
H_2S	>500	>500	>500	2	>10^4	>10^4	>500	—	>500	2	190	>500	S	>10^4	S	>10^4
MMH Hydrazine	7	>500	>500	8	>500	>10^4	>500	4	>500	8	200	>500	>500	>10^4	5	>10^4
NO	>500	>500	>500	>500	>500	>10^4	>500	>500	>500	S	40	—	>500	>10^4	S	>10^4
NO_2 (N_2O_4)	S	>500	>500	S	>500	>10^4	>500	S	>500	S	35	>500	—	>10^4	S	>10^4
SO_2	>500	>500	>500	S	>500	>10^4	>500	S	>500	S	45	>500	-10	>10^4	—	>10^4

NOTE: Interferences are not necessarily linear and may also exhibit time dependent characteristics. S = scrubber required.

Common Specifications

(Applicable to all analyzer configurations)

Specification parameters are defined per ISA's S5.1 Committee and SAMA's RC-20-11-1964 standard, and the numerical values are generalized in our attempt to describe operating characteristics of the entire product line. Performance of a particular model (for a specific gas or measuring range) may vary from the above, and may be further influenced by environmental factors. For further data, please consult the factory.

Accuracy: ±2.0% of full scale (limited to accuracy of calibration standard)
Repeatability: ±0.5% of f.s.
Minimum Detectability: 1.0% of f.s.
Linearity: ±1.0% of f.s.

The zero and span drift specifications assume that the analyzer is equilibrated, is at constant temperature, with a properly maintained sensor.

"Drift" is defined as an undesired change in output over a period of time, which change is unrelated to input, operating conditions, or load.

Zero Drift: ±1.0% f.s. (24 hours)
Span Drift: Less than ±2.0% of f.s. (24 hours)
Lag Time: Less than 1 second
Rise Time: 20 seconds to 90% of final value (or better)
Fall Time: 20 seconds to 10% of original value (or better)
Calibration: Against standard gas mixture

THE MOST OFTEN REQUESTED

Interfering Gas Scrubbers

Model Number	Use With This Analyzer	Removes
56	NO	NO_2, SO_2
100	CO	Alcohols, Aldehydes, Unsaturated Hydrocarbons
158	CO	NO, NO_2, SO_2, H_2S
170	SO_2, NO_2 Cl_2	H_2S
200	NO_2, Cl_2	SO_2

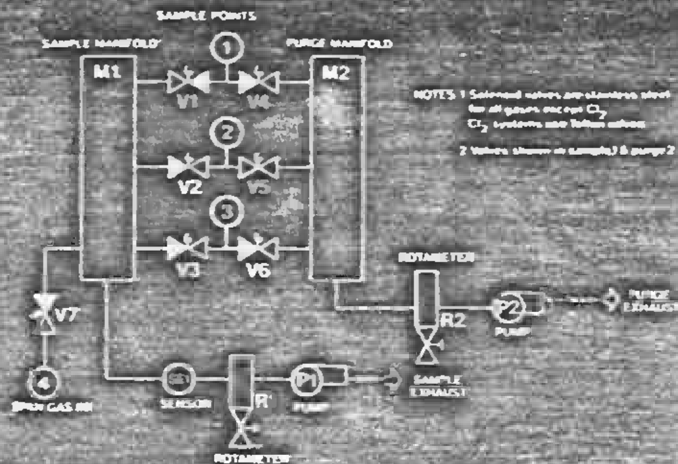
Many other scrubbers are available. Please consult the factory for further information.

Multipoint Continuous Monitoring Systems

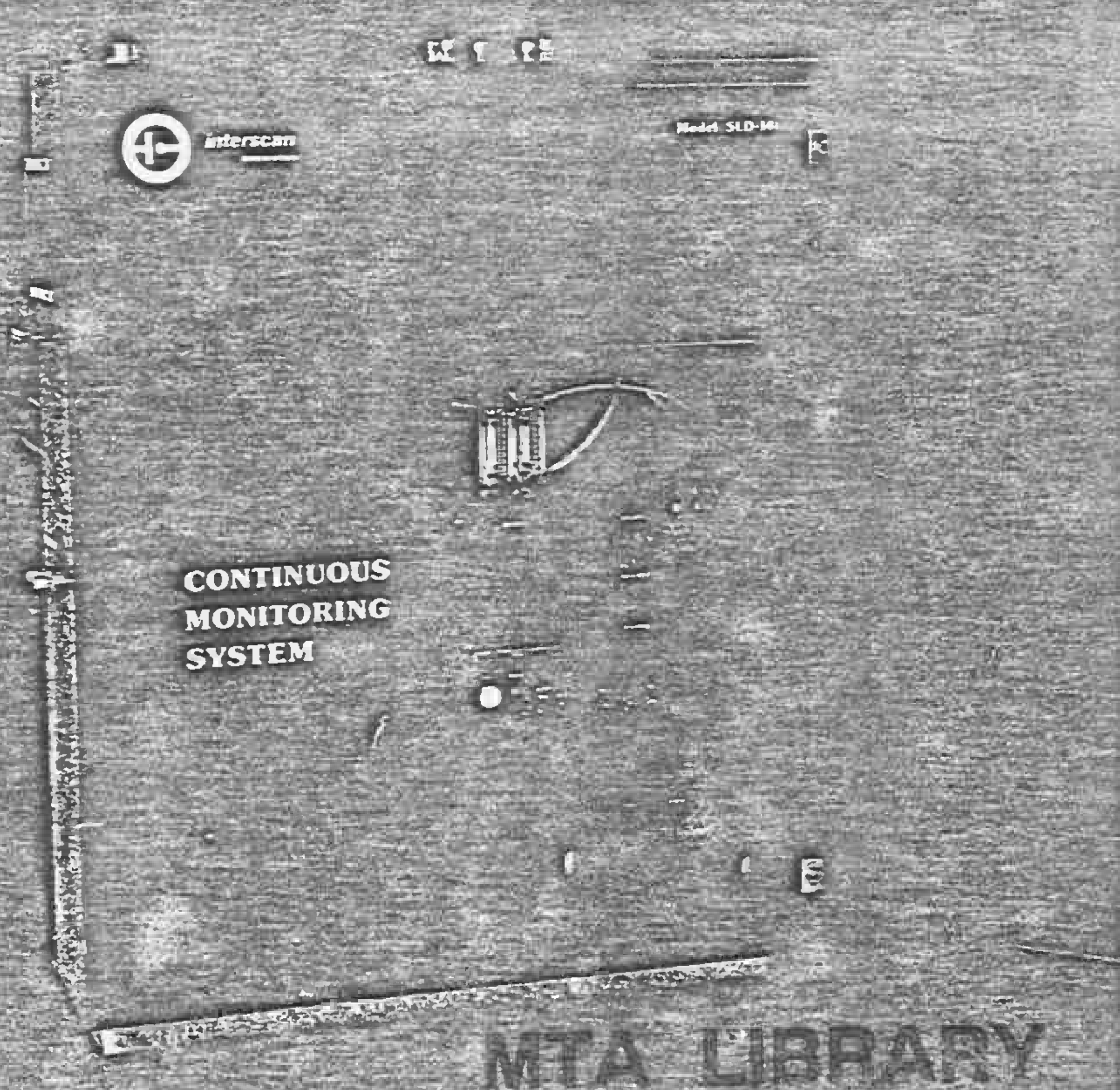
Although Interscan has been an innovator in many aspects of toxic gas detection, it has perhaps distinguished itself most in the area of Multipoint systems. Two basic approaches are offered: Stream-Switching and Continuous-On-Line Multipoint (COLM). Multipoint systems are, themselves, the subject of separate applications bulletins. Thus, only a rudimentary treatment is given herein. Please contact your representative or the factory for additional information.

STREAM-SWITCHING:

In a Stream-Switching installation, a single analyzer interrogates each of the sample point locations as a function of time. A typical flow schematic is shown below:



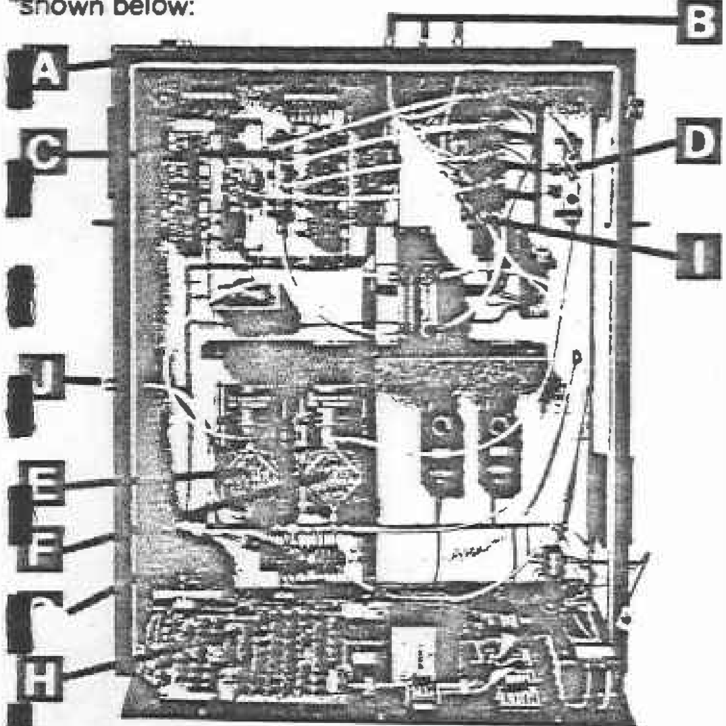
Consider gas analysis occurring sample point 1: V1 is energized open, allowing sample to flow through M1 to the sensor, R1, P1 and exhaust.



V5 is energized open allowing sample from SP2 to flow through its sample line, (and M2, R2, P2 and exhaust) thus assuring a fresh sample when analysis switches to this point. When stream-switching occurs, V2 and V6 ...rgize, providing sample analysis at SP2, and line refreshing (or "purging") at SP3.

Span gas is introduced at V7, which energizes open when the "span" mode is selected at the main panel.

A Stream-Switching system is usually packaged as shown below:



A Conduit hub—access to alarm contacts
B Sample inlet fittings
C Purge manifold
D Sample manifold
E Purge pump
F Sample pump
G Refillable sensor
H Master control board
I 3-way solenoid valves
J System exhaust

All pneumatic and analysis functions are contained in a single enclosure.

Method Of Sequencing
Sequencing (Stream-Switching) operation is controlled at an integral solid state clock, which actuates the solenoid valve drivers. Dwell time at each sample point is normally the same, and is user-selectable (60, 120, 180, or 240 seconds).

Alarm Functions (Alarm Delay)
When an alarm condition (high gas concentration) occurs, the set of contacts dedicated to the affected sample point does not immediately energize. Instead, a user-adjustable delay cycle (3, 15, 35 or 45 seconds) is initiated. Also included is a fixed delay (7 seconds) which begins upon switching to a new sample point. (This time is needed for the pneumatics and sensor to recover from possible alarm conditions at the previously interrogated sample point.) The adjustable delay begins after an alarm level is encountered. This delay is useful when monitoring in areas that can experience short term, inconsequential transient high concentrations. If an alarm level is encountered such that the delay elected exceeds the dwell time remaining, the sequencing clock stops until the delay times out, thus determining if a true alarm condition exists. If an alarm level is encountered at the beginning of the dwell time, the 7 second and user-adjustable delays run concurrently. If alarm levels persist beyond the delay period, the alarm functions are activated.

Low Flow (Filter Clog Indication)
Flow restrictions may occur from time to time. To detect such a condition, a vacuum switch is connected to the pump side of the purge manifold (M2). If a restriction is encountered, the system switches the purge to the next point in sequence. This point will then be skipped in the sampling mode, as well.

Panel Display Features
- Position Indication...showing the point presently being interrogated, via numerical LED's.
- Alarm Indication...showing the affected point(s) via numerical LED's.
- Low flow indication...showing the affected point(s), via numerical LED's.

CONTINUOUS-ON-LINE MULTIPOINT:
COLM is an installation in which several sample points are interrogated at dedicated sensors, all contained within a single enclosure. As such, a continuous readout for each sample point is provided.

Alarm Functions
Alarm levels are set by simulating an alarm condition with the zero control, and pushing a button, whereupon the value is stored in random access memory. Different levels can be set at each point, if desired. User-adjustable delays, identical to those in the Stream-Switching systems, are also included.

Low Flow (Filter Clog Indication)
Dedicated vacuum switches monitor each sample pump, turning them off in the event of a sufficient restriction.

Sensor/Electronics Check
Every 15 minutes, a particular signal is applied to each sensor, which should produce a characteristic output. An incorrect output latches a panel indicator, and can also trigger additional warning devices.

Panel Display Features
- Alarm, Low Flow and Sensor/Electronics failure indication, via numerical LED's.
- Digital meter concentration display:
  ...Dedicated meters.
  ...Manually switchable single meter.
  ...Auto-scanning single meter.

COLM is strongly recommended for applications in which:
...The off-time of stream-switching is unacceptable.
...Central control and display are desirable.
...Remote location of dedicated analyzers is inappropriate for maintenance or other reasons.

LD Series

Interscan's LD Series represents the ultimate in single point continuous monitoring systems. **Each and every component has** been chosen based on years of experience in some of the most demanding environments imaginable. What's more, the units are easy and inexpensive to maintain.

An impressive array of options allows the specifier to put together a system ideally suited to the application at hand. Safety, industrial hygiene, plant engineering, and maintenance will all agree... today's best bet is Interscan's LD Series.

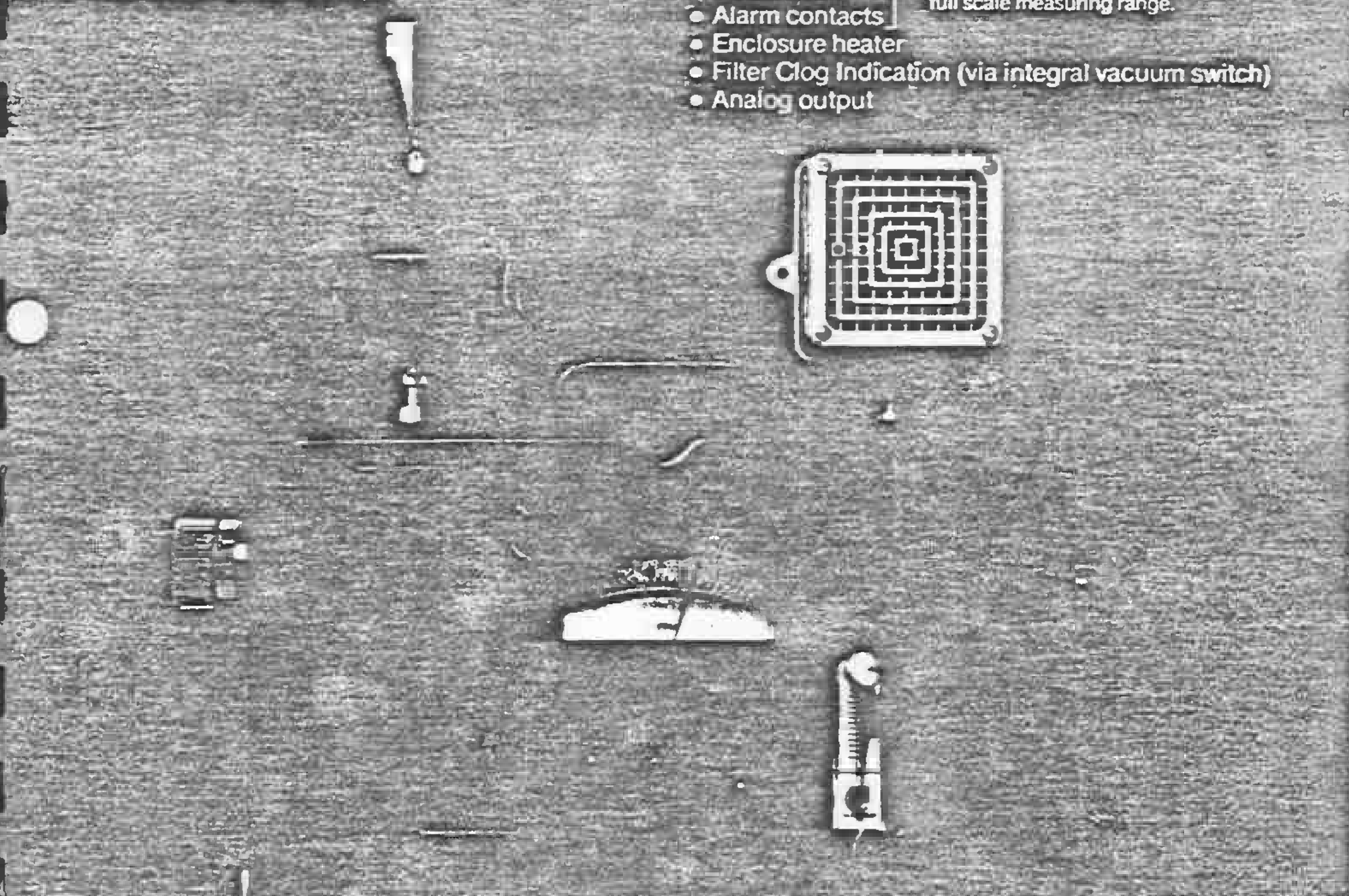
- Super-rugged NEMA Type 4X* fiberglass enclosure

*NEMA Type 4X enclosures have the same provisions as Type 4 enclosures and, in addition, are corrosion-resistant.
NEMA Type 4 enclosures are designed to meet the following hose test: Enclosures shall be tested by subjection to a stream of water. A hose with a one-inch nozzle shall be used and shall deliver at least 65 gallons per minute. The water shall be directed on the enclosure from a distance of not less than 10 feet and for a period of 5 minutes. During this period it may be directed in any one or more directions as desired. There shall be no leakage of water into the enclosure under these conditions.

- Integral diaphragm pump
- Rotameter
- Hinged interior panel for ease in service access
- Refillable sensor
- Supplied with appropriate inlet filter

- Alternative packaging, including Type X or Type Z purged enclosures.
  NOTE: If RFI is anticipated, a metallic or vacuum-metallized fiberglass enclosure must be specified.
- Audible alarm
- Visual alarm
- Alarm contacts

  (Audible alarm, Visual alarm, Alarm contacts:) continuously adjustable through the full scale measuring range.
- Enclosure heater
- Filter Clog Indication (via integral vacuum switch)
- Analog output



Continuous Monitoring System

CHLORINE

interscan

LD-34

- Dual alarm set points
- Triple alarm set points
- "Power-Off" (loss of power) alarm
- Aspirator (in lieu of pump)

ADDITIONAL SPECIFICATIONS:

Pump: Viton diaphragm, operating with a vibrating armature system. Maximum vacuum ...16.0 inHg (-54.2 kPa); maximum pressure...6.0 lb/in²g (41.4 kPa); free output ...4.5 l/min.

Aspirator: All Teflon body with Kel-F jet.

Inlet Filter:

Application	Filter Model Number and Description
CO, NO	Model 258-Gauze/finely divided activated charcoal filtration medium; zinc-plated cold rolled steel body, brass fittings.
H_2S, NO_2	Model 358-High-efficiency microfiber glass element; polycarbonate body.
SO_2, Cl_2	Model 458-Teflon element; Swinnex body.

All filters provide 99.9% removal of particles 0.5μm and larger.

Vacuum Switch: Capsule...Ni Span C, adjustable 1.20-30.0 inHg (-4.06 to -101.6 kPa).

Rotameter: Meter block...cast acrylic plastic; float-black glass; control valve...Type 316 stainless steel or brass, depending on application.
Accuracy: ±10% of f.s.

Internal Tubing: ¼" OD x ⅛" ID (6.35 x 3.18 mm) Viton; ¼" OD x ⅛" ID (6.35 x 3.18 mm) Teflon; ¼" OD x 0.170" ID (6.35 x 4.32 mm) polyallomer; depending on application.

Tube Fittings: Compression type...Brass, type 316 stainless steel, Kynar or polypropylene, depending on application.

Enclosure Heater: Vitreous enamel fixed resistor, 250 ohms, 50 W.

Thermostat: Liquid-filled sensing element specially treated to resist corrosion; equipped with knurled knob dial adjustment.

Meter: 0-50μA, taut band, provided with mirrored dial; 100 divisions full scale.

Handle: Aluminum, 90° folding type, provided with spring detent; black oxide finish.

Alarm Signals: **Audible**...Vibratory horn, 100 dB at 10 feet (3.05 m), volume adjustable. **Visual**...Rotating "beacon ray" type, with 25W lamp, and concentrating parabolic reflector.

Alarm Contacts: 2 sets of Form "C" contacts (DPDT); Ratings...5A resistive, 2.5A inductive. Interface at threaded, liquid-tight conduit hub.

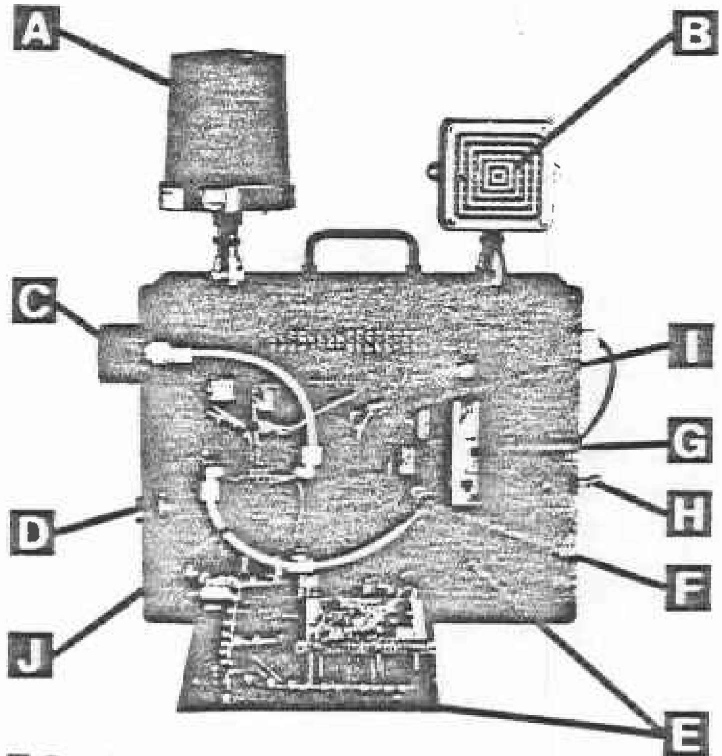
Analog Output: 0-100 mV or 4-20 mA f.s. Interface at phone jack/phone plug connection; phone jack provided with spring load dust/moisture cover; cable included.

"Power-Off" Alarm: Normally closed relay actuates piezo-electric type audible signal, 2.9 kHz, 90 dB at 2 feet (610 mm); operates off 15V C-Zn battery (NEDA Type 208)...supplied.

Dimensions: 20¾" H x 20½" W x 8¾" D (527 mm x 521 mm x 222 mm) (When provided with light and horn)

Weight: 27½ lb. (12.5 kg) (When provided with light and horn)

Power: 105-125 VAC, 50/60 Hz, 1.5A or 205-230 VAC, 50/60 Hz



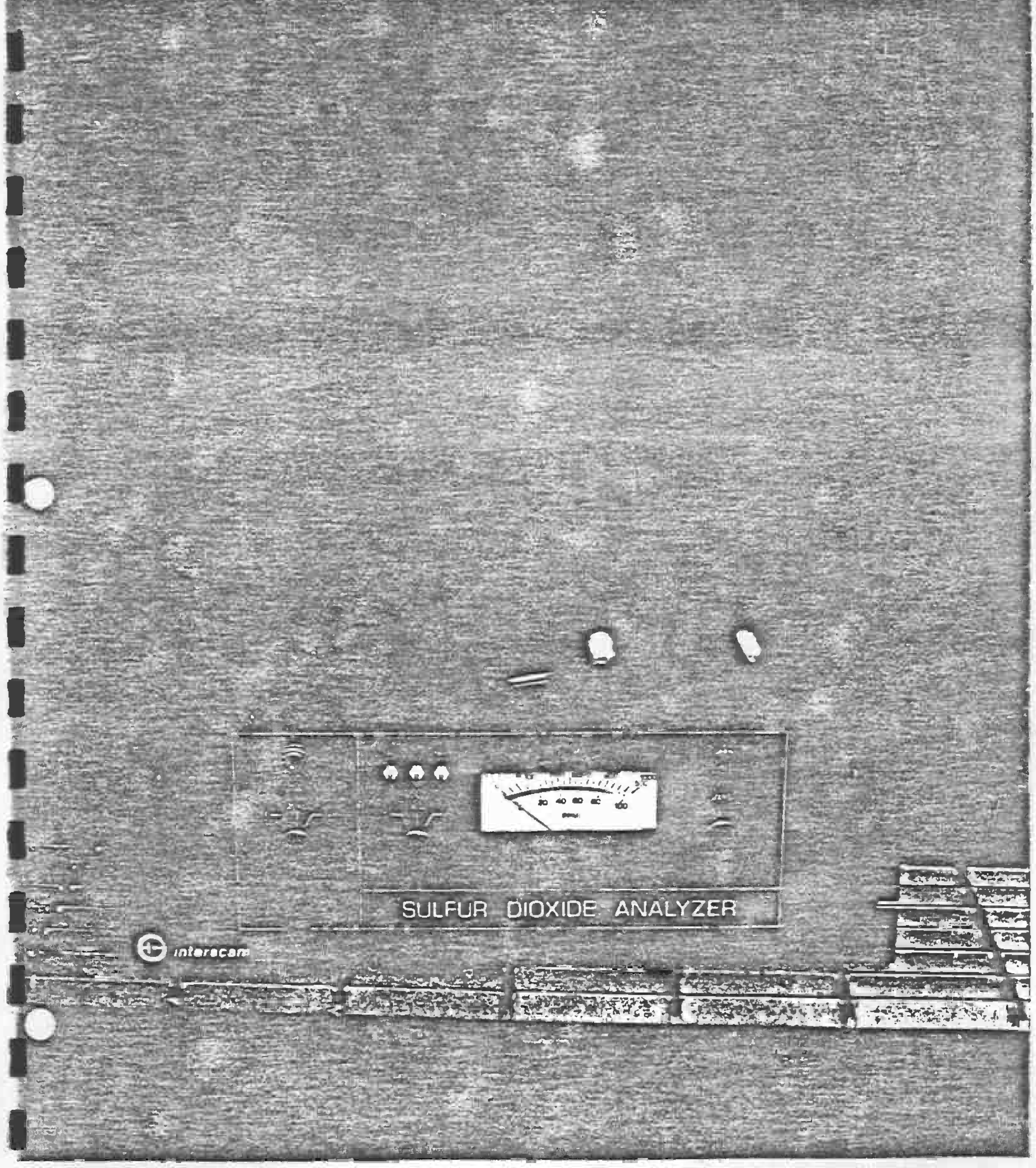
- **A** Rotating beacon-ray light
- **B** Vibratory horn
- **C** Sample inlet filter
- **D** Conduit hub — access to alarm contacts
- **E** Convenient hinged panels
- **F** Diaphragm pump
- **G** Rotameter
- **H** Sample exhaust
- **I** Thermostat
- **J** Refillable sensor

ORDERING INFORMATION:

Model Series	Full Scale Range(s) (ppm)	Model Series	Full Scale Range(s) (ppm)
LD-14 CARBON MONOXIDE ANALYZER (CO)	0-100 0-250 0-500 0-100/0-500 Special Ranges	LD-17 HYDROGEN SULFIDE ANALYZER (H_2S)	0-10 0-20 0-100 0-10/0-100 Special Ranges
LD-15 NITROGEN DIOXIDE ANALYZER (NO_2)	0-5 0-10 0-50 Special Ranges	LD-24 SULFUR DIOXIDE ANALYZER (SO_2)	0-5 0-10 0-50 0-10/0-50 Special Ranges
LD-54 NITRIC OXIDE ANALYZER (NO)	0-25 0-50 0-250 0-50/0-250 Special Ranges	LD-34 CHLORINE ANALYZER (Cl_2)	0-2 0-5 0-10 0-50 0-2/0-10 Special Ranges

Rack-Mount Configured Analyzers

The Rack-Mounts can be plain (provided with little more than a sensor, circuit board and readout) to fancy (incorporating many of the options of the LD Series). Either way, each Rack-Mount is fully loaded with Interscan reliability and performance.



FEATURES:

- Open frame chassis
- Pneumatic interface
- 0-100 mV analog output

OPTIONS:

- Integral pump and rotameter
- Integral rotameter, only
  NOTE: Analyzer requires sample flow of ca. 500 ml/min at a pressure of less than 2 lb/in²g (13.8 kPa). Sample inlet should be provided with suitable filter.
- Filter Clog Indication (via integral vacuum switch)
  NOTE: If this option is desired, integral pump and rotameter must also be ordered.
- Alarm contacts
- Dual alarm set points
- Triple alarm set points
- "Power-Off" (loss of power) alarm
- 4-20 mA analog output
- Aspirator
- Wrap-around cover

ADDITIONAL SPECIFICATIONS:

Pump: Viton diaphragm, operating with a vibrating armature system. Maximum vacuum ...16.0 inHg (-54.2 kPa); maximum pressure...6.0 lb/in²g (41.4 kPa); free output ...4.5 l/min.

Aspirator: All Teflon body with Kel-F jet.

Inlet Filter:

Application	Filter Model Number and Description
CO, NO	Model 258-Gauze, finely divided activated charcoal filtration medium; zinc-plated cold rolled steel body, brass fittings.
H_2S, NO_2	Model 358-High-efficiency microfiber glass element; polycarbonate body.
SO_2, Cl_2	Model 458-Teflon element; Swinnex body

All filters provide 99.9% removal of particles 0.5μm and larger.

Vacuum Switch: Capsule...Ni Span C, adjustable 1.20-30.0 inHg (-4.06 to -101.6 kPa).

Rotameter: Meter block...cast acrylic plastic; float-black glass; control valve...Type 316 stainless steel or brass, depending on application.
Accuracy: ±10% f.s.

Internal Tubing: ¼" OD x ⅛" ID (6.35 mm x 3.18 mm) Viton; ¼" OD x ⅛" ID (6.35 mm x 3.18 mm) Teflon; ¼" OD x 0.170" ID (6.35 mm x 4.32 mm) polyallomer; depending on application.

Tube Fittings: Compression type...Brass, type 316 stainless steel, Kynar or polypropylene, depending on application.

Meter: 0-50μA, taut band, provided with mirrored dial; 100 divisions full scale.

Handles: Aluminum, bow type, rectangular; black anodize finish.

Alarm Contacts: 2 sets of Form "C" contacts (DPDT); Ratings...5A resistive, 2.5A inductive. Interface at terminal strip.

Analog Output: 0-100 mV or 4-20 mA f.s. Interface at miniature insulated double binding posts (gold-flashed, and provided with captive thumb nuts).

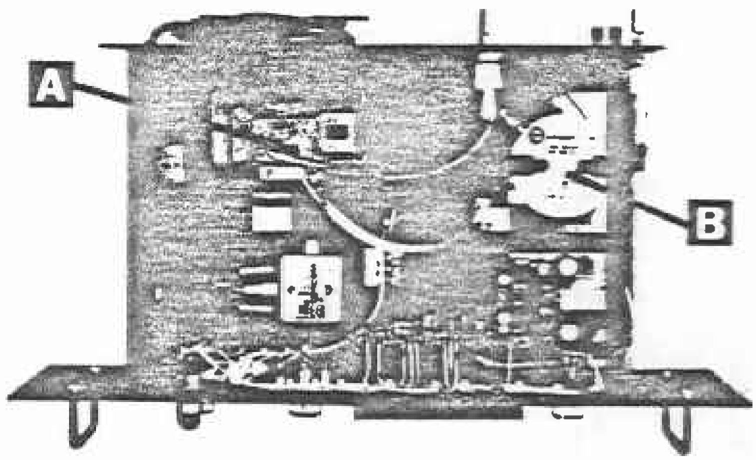
"Power-Off" Alarm: Normally closed relay actuates piezo-electric type audible signal, 2.9 kHz, 90 dB at 2 feet (610 mm); operates off 15V C-Zn battery (NEDA Type 208)...supplied.

Dimensions: 7" H x 19" W x 12" D (178 mm x 483 mm x 305 mm)

Weight: 11½ lb. (5.2 kg) (When provided with pump and rotameter)

Wrap-Around Cover: 0.090 inch (2.3 mm) aluminum, provided with rubber feet.

Power: 105-125 VAC, 50/60 Hz or 205-230 VAC, 50/60 Hz



A Diaphragm pump
B Refillable sensor

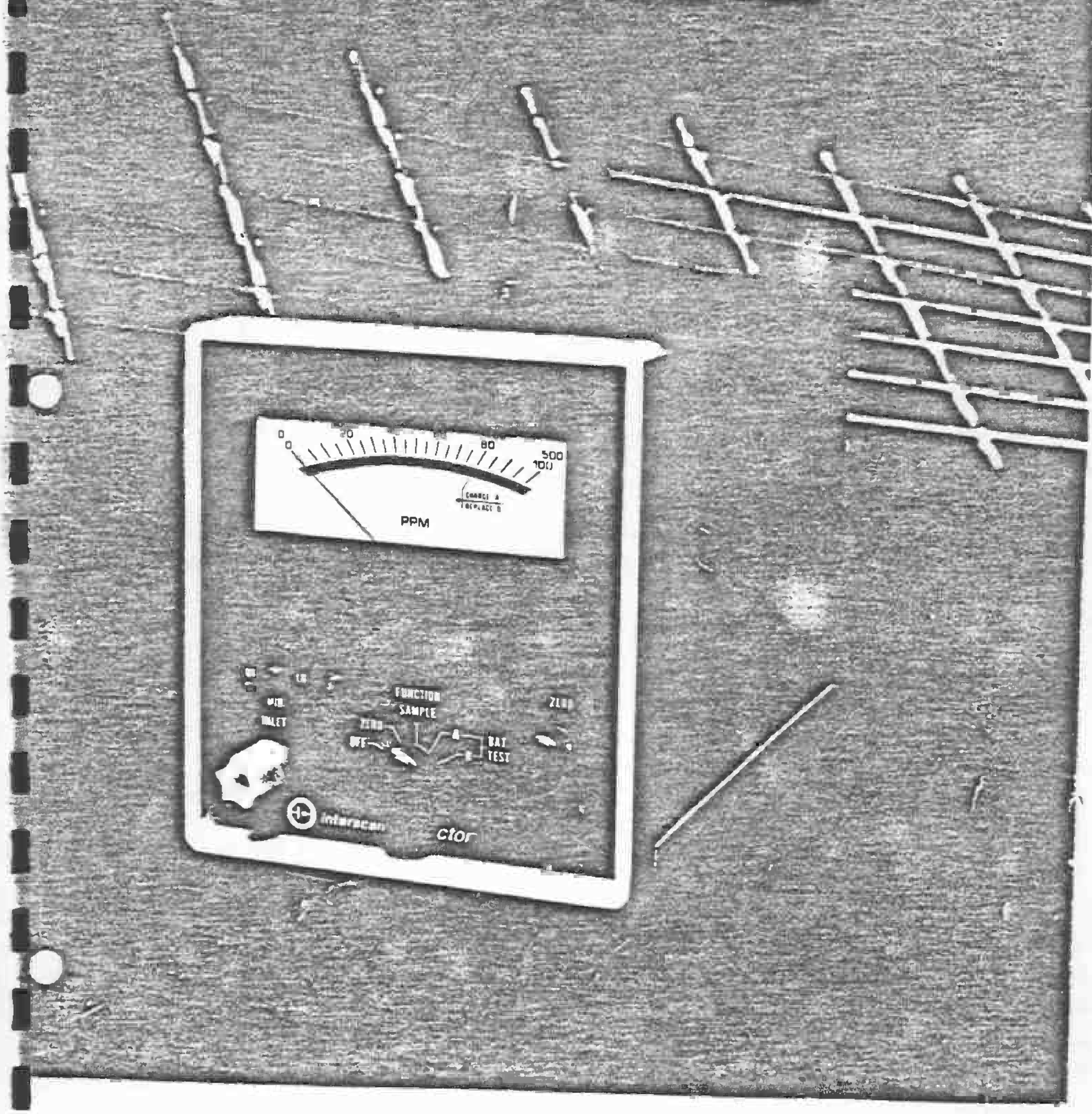
ORDERING INFORMATION:

Model Series	Full Scale Range(s) (ppm)	Model Series	Full Scale Range(s) (ppm)
RM-14 CARBON MONOXIDE ANALYZER (CO)	0-50 0-100 0-250 0-500 0-100/0-500 Special Ranges	RM-17 HYDROGEN SULFIDE ANALYZER (H_2S)	0-10 0-20 0-100 0-10/0-100 Special Ranges
RM-15 NITROGEN DIOXIDE ANALYZER (NO_2)	0-5 0-10 0-50 0-10/0-50 Special Ranges	RM-24 SULFUR DIOXIDE ANALYZER (SO_2)	0-5 0-10 0-50 0-10/0-50 Special Ranges
RM-54 NITRIC OXIDE ANALYZER (NO)	0-25 0-50 0-250 0-50/0-250 Special Ranges	RM-34 CHLORINE ANALYZER (Cl_2)	0-2 0-5 0-10 0-2/0-10 Special Ranges

Standard Portable

1000 Series "Standard" Portables have truly been the workhorse of the occupational safety and health field since 1975. When originally introduced, the units boasted a significant reduction in size from competitive models, beautifully simple circuitry, and rugged packaging.

Today, after delivering thousands of portable analyzers, as well as introducing several additional products, Interscan is still justifiably proud of the one that started it all ... the Standard Portable.



FEATURES:

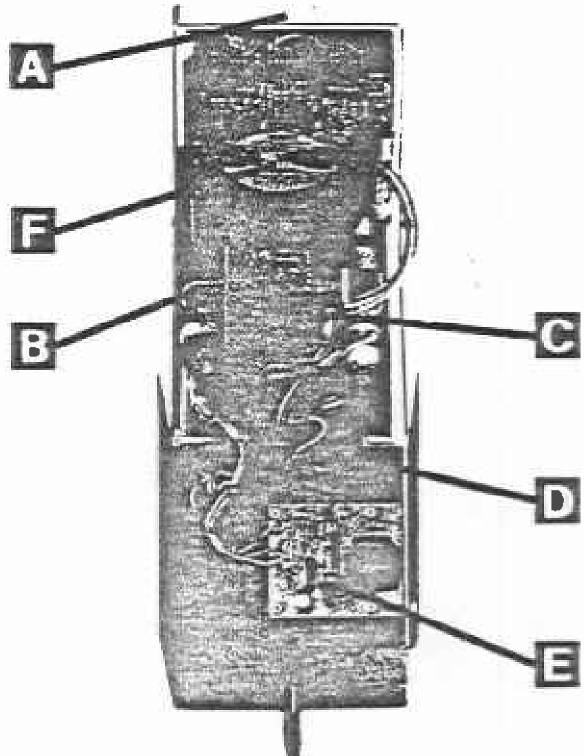
- An integral sample pump, powered by rechargeable Ni-Cd batteries (supplied), giving up to 10 hours of continuous service.
- Panel meter indication of battery condition... instantly
- Analog output
- Integral battery charger
- Available in an MSHA-approved version (Approval 2G-3129)

OPTIONS:

- Audible and visual alarms
- Special ranges
- Special packaging
- Digital panel meter
- Power and signal input to recorder via mating connector (allowing rechargeable battery operation of recorder as well as analyzer)
- Dual gas models

ADDITIONAL SPECIFICATIONS:

Pump:	Double diaphragm type, employing Scotch yoke design.
Internal Tubing:	$\frac{5}{16}$" OD x $\frac{3}{16}$" ID (7.94 x 4.76 mm) vinyl; ¼" OD x 0.170" ID (6.35 x 4.32 mm) polyallomer, depending on application.
Tube Fittings:	Compression type: Kynar or polypropylene, hose-barb type: polyethylene, depending on application.
Meter:	0-50μA, taut band, provided with mirrored dial, 100 divisions full scale.
Handle:	Aluminum, 90° folding type, provided with spring detent; black oxide finish.
Alarm:	**Audible**...Unijunction oscillator activating rear panel speaker. **Visual**...Incandescent, unitized construction, provided with red lens.
Analog Output:	0-100 mV f.s. **Standard:** Interface at miniature insulated double binding posts (gold-flashed, and provided with captive thumb nuts). **Recorder Power Option:** Interface at audio-type cord plug/receptacle arrangement; plug has captive coupler ring with threaded bushing.
Dimensions:	7¼" H x 6" W x 11½" D (184 mm x 152 mm x 292 mm)
Weight:	8 lb (3.6 kg)
Power:	a) Four primary alkaline MnO_2 batteries (NEDA Type 15A) for amplifier. b) Two (standard, for pump and power-on LED) or four (if provided with alarm or recorder power option) Ni-Cd batteries (NEDA Type 14 NC). **Charger:** Charge rate $\frac{C}{10}$. Accepts 105-125 VAC or 205-230 VAC input (field changeable). c) One HgO battery for bias amplifier (NEDA Type 1113 M). (NOTE: The separate amplifier power supply maintains a constant reference voltage to the sensor)



- A Rugged extruded aluminum frame
- B Double diaphragm pump
- C Purafil scrubber, standard in all CO models
- D Convenient hinged cover
- E Battery charger board
- F Electrochemical voltammetric sensor

ORDERING INFORMATION:

1140 SERIES CARBON MONOXIDE ANALYZERS (CO)

Model No.	Full Scale Range(s) (ppm)
1140	0-100
1142	0-100/0-500
1144	0-100/0-600
1146	0-50/0-100
1148	0-10/0-50
1149	0-3000
1140 sp	Special Ranges

1170 SERIES HYDROGEN SULFIDE ANALYZERS (H_2S)

Model No.	Full Scale Range(s) (ppm)
1170	0-1
1171	0-10
1173	0-20
1176	0-10/0-100
1170 sp	Special Ranges

1240 SERIES SULFUR DIOXIDE ANALYZERS (SO_2)

Model No.	Full Scale Range(s) (ppm)
1240	0-1
1245	0-5
1247	0-10
1248	0-10/0-25/0-50
1249	0-50
1240 sp	Special Ranges

1150 SERIES NITROGEN DIOXIDE ANALYZERS (NO_2)

Model No.	Full Scale Ranges (ppm)
1152	0-2/0-10
1154	0-10/0-50
1150 sp	Special Ranges

1540 SERIES NITRIC OXIDE ANALYZERS (NO)

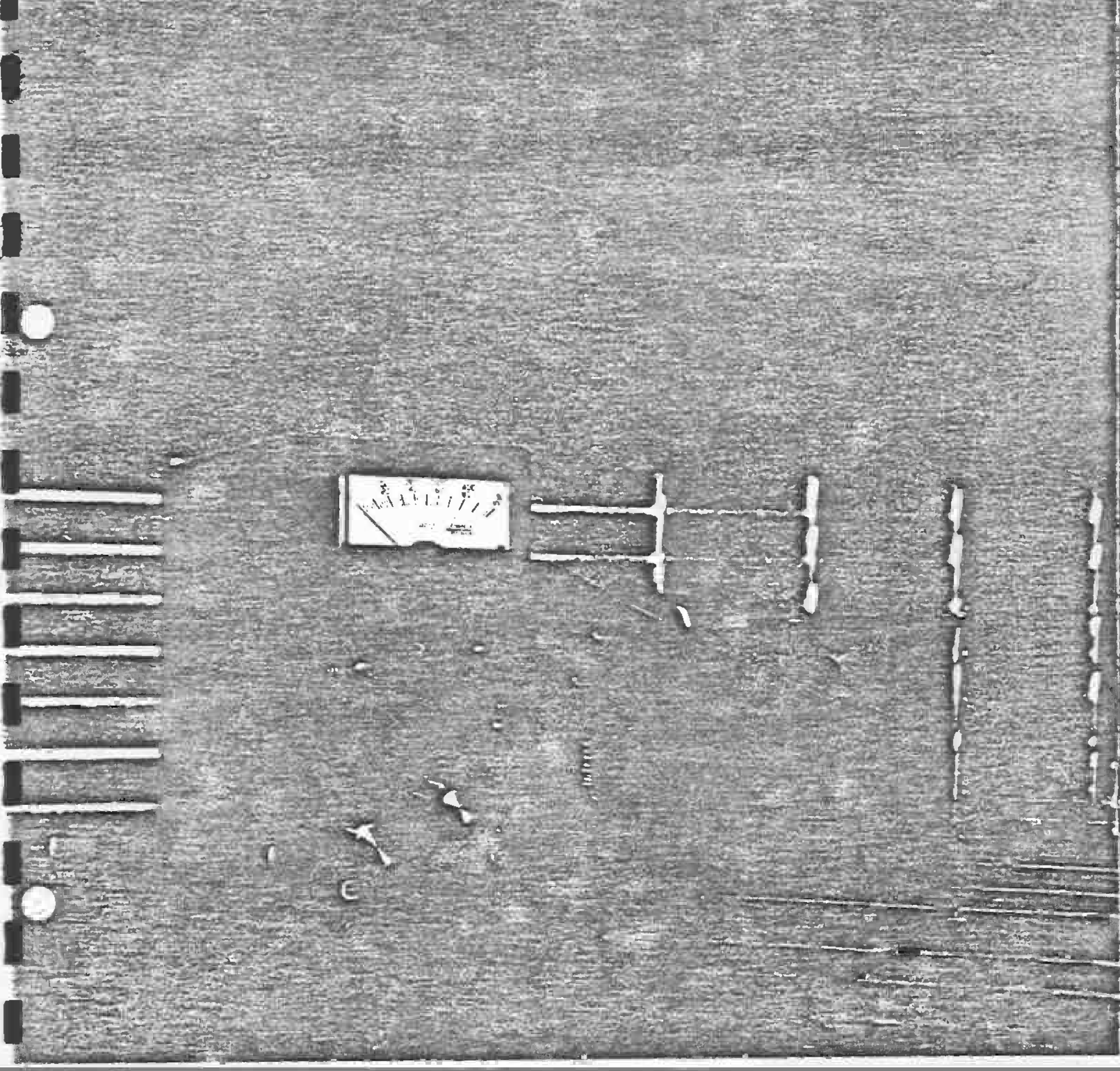
Model No.	Full Scale Range(s) (ppm)
1540	0-100
1542	0-250
1544	0-500
1545	0-10/0-50
1546	0-100/0-500
1548	0-250/0-500
1540 sp	Special Ranges

1340 SERIES CHLORINE ANALYZERS (Cl_2)

Model No.	Full Scale Range(s) (ppm)
1340	0-2/0-10
1341	0-2
1343	0-5
1345	0-10
1340 sp	Special Ranges

Compact Portable

Interscan's 4000 Series Compact Portables take advantage of the latest innovations in electronic design to bring the user an analyzer that is much reduced in size, but sacrifices nothing in performance to get there. The Compacts are provided with the identical sensor and pump as in our Standard Portables, and offer the same excellent ease of service access. Their small size and weight, along with their leather case, make them ideal for the over-burdened industrial hygiene and safety professional, who must carry many instruments to the job site.



...URES:

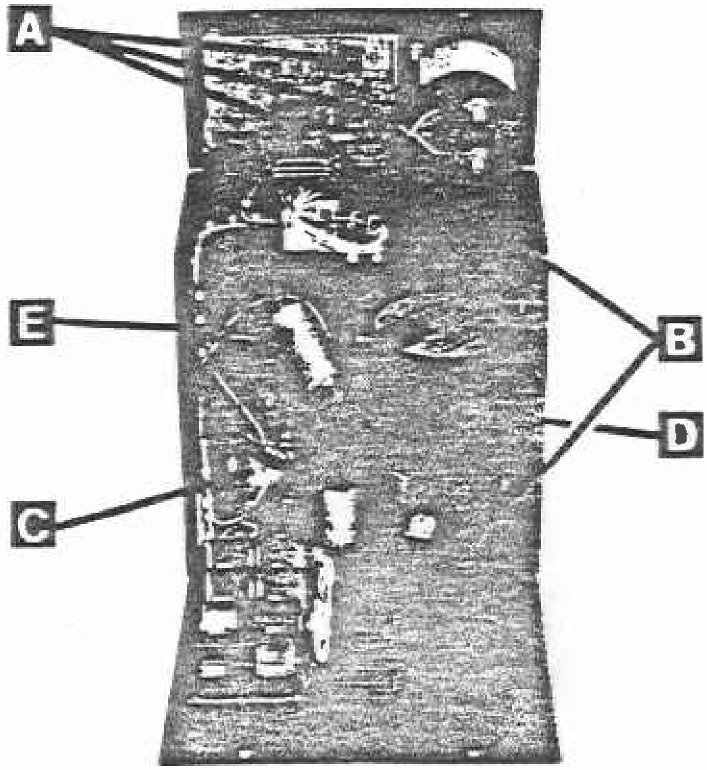
- ...ntegral sample pump, powered by rechargeable Ni-Cd batteries (supplied), giving up to 10 hours continuous service.
- Panel meter indication of battery condition... instantly
- Visual alarm
- Rugged leather carrying case

OPTIONS:

- Audible alarm
- Special ranges (triple range not available)
- Analog output
- Power and signal input to recorder via mating connector (allowing rechargeable battery operation of recorder as well as analyzer)

ADDITIONAL SPECIFICATIONS:

Pump:	Double diaphragm type, employing Scotch yoke design.
Internal Tubing:	¼" OD x ⅛" ID (6.35 x 3.18 mm) Viton
Tube Fittings:	Compression type: Kynar Hose-barb type: Polyethylene depending on application
Meter:	0-100μA, pivot and jewel, 50 divisions f.s.
Carrying Case:	10 oz. (283 g) moisture and mildew resistant chrome-tanned black latigo leather, provided with two Durable medium-pull snaps, chrome-plated steel corners and rivets, sewn 5 stitches/inch (2/cm). Nylon thread; belt provided with chrome plated steel buckle.
Alarm:	**Audible**... piezoelectric type 2.8 kHz, 85 dB at 10 feet (3.05 m). **Visual**... Red LED, peak wave length 660 nm, provided with lens.
Analog Output:	0-100 mV f.s. Interface at phone jack/phone plug connection; phone jack provided with spring load dust/moisture cover; cable included. **Recorder Power Option:** Interface at audio-type cord plug/receptacle arrangement; plug has captive coupler ring with threaded bushing.
Dimensions: (exclusive of case)	7" H x 4" W x 8⅞" D (178 mm x 102 mm x 225 mm)
Weight: (exclusive of case)	4½ lb. (2.0 kg)
Power:	a) Two primary alkaline MnO_2 batteries (NEDA Type 14A) for amplifier. b) Four Ni-Cd batteries (ANSI Type 1/2C, 750 mAh) for pump, alarms, and power-on LED. **Charger:** Wall plug-in type. **Input:** 117 VAC, 60 Hz or 220 VAC, 50 Hz. **Output:** 5.8 VDC, 70 mA (NOTE: The separate amplifier power supply maintains a constant reference voltage to the sensor.)



A All integrated circuits socket-mounted
B Convenient double-hinged cover
C Double diaphragm pump
D Sensor
E Purafil scrubber, standard in all CO models

ORDERING INFORMATION:

4140 SERIES CARBON MONOXIDE ANALYZERS (CO)

Model No.	Full Scale Range(s) (ppm)
4140	0-100
4142	0-100/0-500
4144	0-100/0-600
4146	0-50/0-100
4148	0-10/0-50
4149	0-3000
4140 sp	Special Ranges

4150 SERIES NITROGEN DIOXIDE ANALYZERS (NO_2)

Model No.	Full Scale Ranges (ppm)
4152	0-2/0-10
4154	0-10/0-50
4150 sp	Special Ranges

4240 SERIES SULFUR DIOXIDE ANALYZERS (SO_2)

Model No.	Full Scale Range(s) (ppm)
4240	0-1
4245	0-5
4247	0-10
4249	0-50
4240 sp	Special Ranges

4170 SERIES HYDROGEN SULFIDE ANALYZERS (H_2S)

Model No.	Full Scale Range(s) (ppm)
4170	0-1
4171	0-10
4173	0-20
4176	0-10/0-100
4170 sp	Special Ranges

4540 SERIES NITRIC OXIDE ANALYZERS (NO)

Model No.	Full Scale Range(s) (ppm)
4540	0-100
4542	0-250
4544	0-500
4545	0-10/0-50
4546	0-100/0-500
4548	0-250/0-500
4540 sp	Special Ranges

4340 SERIES CHLORINE ANALYZERS (Cl_2)

Model No.	Full Scale Range(s) (ppm)
4340	0-2/0-10
4341	0-2
4343	0-5
4345	0-10
4340 sp	Special Ranges

Other Products/ Special Applications

- CO Monitors for compressed breathing air (Basically a simplified LD-14)
- Hydrazine Analyzers (Available in all configurations)
- Dosimeters (Both time history and "single number" types)
- Personal Alarm Monitors
- Carboxyhemoglobin (via end-expired CO) Units
- Sample Conditioning Systems

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PROPOSAL FOR
HAZARDOUS GAS DETECTION SYSTEM

SUBMITTED FOR:
RAYMOND KAISER ENGINEERS, INC,.
OAKLAND, CALIFORNIA

SUBMITTED BY:
KVB, INC.
EQUIPMENT SYSTEMS DIVISION
OCTOBER 1984

KVB62 5951400

KVB
A Research Cottrell Company

TABLE OF CONTENTS

SECTION 1
INTRODUCTION

This proposal presents a description of the KVB Multipoint Gas Analysis System to warn of hazardous conditions in subway tunnels. Section 2 will provide a technical description, section 3 pricing and sections 4 and 5 will provide background information on KVB.

We have taken care in selecting the most appropriate components for each function and thus Kaiser can expect the highest performance and reliability. However, even more important to the project is the extensive experience in hazardous gas system design logic and custom microporcessor control systems that KVB possesses. After all wouldn't a propensity for false alarms, or undetected hazardous conditions present an onerous burden to operation of the subway. KVB should stand alone as uniquely qualified to design and manufacture such a system; the following points will elaborate.

1. KVB has designed and installed over 100 similar systems since 1978. In the process we have been able to define, and then refine techniques critical to success of a hazardous gas detection system, including human engineering.

2. KVB is a major manufacturer of Gas Analysis systems and is headquartered in Irvine, California. This geographic fact will assure prompt response to any of the projects needs and will guaranty the lowest possible long term costs of service.

3. The proposed system will utilize an advanced microprocessor to perform all required functions including automatic alarm verification, calibration, self-check and communication with the system mainframe computer.

4. The sample conditioning system will use multiple filtration and drying steps to assure that only clean dry samples will be presented to the analyticai sensors. This will provide the highest accuracy and reliability possible.

5. The analysis system is housed in an air conditioned, environmentally controlled enclosure to ensure consistant performance and dependability of all components.

6. High capacity positive displacement pumps are utilized to draw gaseous samples from great distances, yet allow fast cycling through the various points.

7. KVB guarantees to stock all parts and provide shipment within 48 hours of order. If we should fail to do so a 50% discount will be given on the purchase price. A similar guarantee on service will be given with a 100% discount if we fail to meet our promise.

By incorporating these and other features into our extractive monitoring systems, and selecting the best components available, KVB has supplied proven gas analysis systems for a variety of applications and uses, including emissions monitoring, performance monitoring, and hazardous gas detection. We currently have over 200 extractive systems installed, of which almost 100 have been certified to the emissions monitoring performance standards of the U.S. EPA.

A further description of the proposed system, KVB's background and experience, warranty, and terms and conditions are contained in the following sections.

SECTION 2.0

2.1 GENERAL

The KVB Hazardous Gas Detection System is a computer controlled, fully automatic gas analysis system that is designed to provide fast, reliable warning of hazardous gas concentrations at up to eight locations. In addition the system is equipped with a large number of self-check and verification features that preclude the possibility of false alarms while providing the highest reliability.

The system consists of three major parts:

1. The Sample Selection and Conditioning System
2. Analytical Instruments
3. Computer Control and Interface System

Each will be discussed in turn.

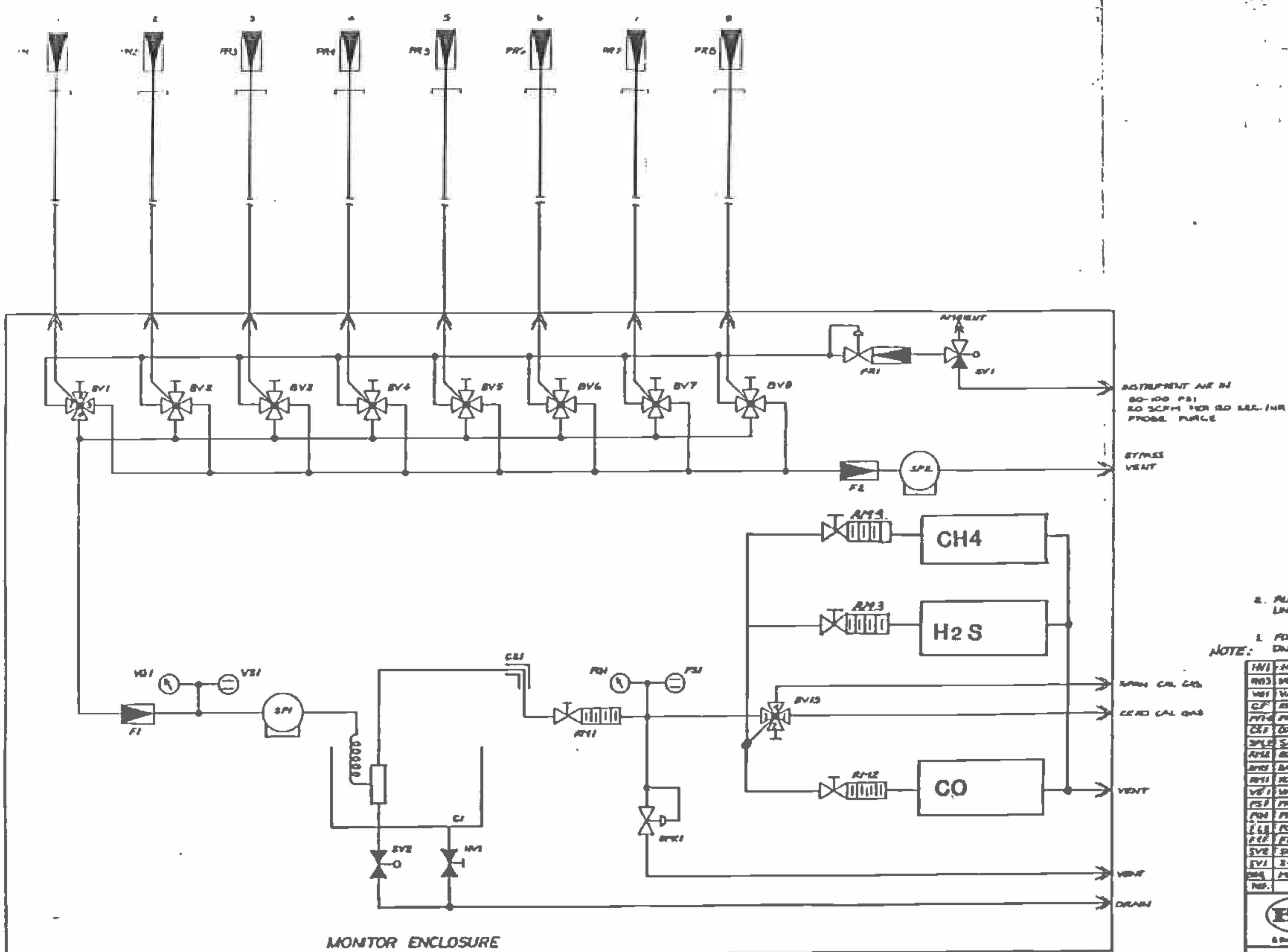
2.2 SAMPLE SELECTION AND CONDITIONING (Refer to Figure 1)

The Sample Selection and Conditioning System must be capable of time sharing up to eight sample locations and provide a clean, dry sample gas for presentation.

2.2.1 Sample Selection

The Sample Selection System performs a specialized sampling scheme that allows sample gases from distant locations to be analyzed quickly, thus providing fast warning of hazardous conditions.

Each sample line is connected to the common port of a five-way, multiport selector valve. Gas entering the valve may be directed as follows:



NOTE:
1. FOR MORE INFORMATION, REFERENCE DWG # EH -01,02,04,09
2. ALL PLUMBING BY KVB EXCEPT SAMPLE LINE INTERCONNECT TUBING

NO.	DESCRIPTION	QTY.	PART NO.
HV1	HAND VALVE - BRASS	1	[illegible]
MBS	MOTORIZED BALL VALVE	1	121248
VG1	VACUUM GAUGE	1	12711
CF	REFRIGERATION CONDENSER	1	12311
PF1-8	PROBE FILTER ASSY.	8	[illegible]
CS1	CONDUCTIVITY SENSOR	1	[illegible]
SP1-2	SAMPLE PUMP	2	[illegible]
RM2	ROTAMETER, LOW FLOW	1	[illegible]
BPR1	BACK PRESSURE REGULATOR	1	[illegible]
RM1	ROTAMETER, HIGH FLOW	1	[illegible]
VS1	VACUUM SWITCH	1	[illegible]
PS1	PRESSURE SWITCH	1	[illegible]
PG1	PRESSURE GAUGE	1	[illegible]
F1-2	POLYPROPYLENE FILTER	2	[illegible]
[illegible]	FILTER (REGULATOR)	1	[illegible]
SV2	SOLENOID VALVE, N.C.	1	[illegible]
SV1	3-WAY SOLENOID VALVE	1	[illegible]
BV	MOTORIZED BALL VALVE	8	[illegible]

KVB

SYSTEM SCHEMATIC

PROJECT COAL FIRE PROT. | SCALE NONE | SHEET 1 OF 1

DRN [illegible] DATE [illegible]
CKD DATE
APPVD DATE

FIGURE 1

NO	REVISION	DATE	BY	APPR	NO	REVISION	DATE	BY	APPR	NO	REVISION	DATE	BY	APPR	NO	REVISION	DATE	BY	APPR

To the Analyzer	SAMPLE
For Priming	BYPASS
For Backpurging Probe	Purge
Valve Closed	OFF

The sequence of operation for each selector valve is as follows:

a. Sample gas enters the selector valve through the common port. When the valve is in the SAMPLE position, gas will flow through the conditioning system to the analyzer

b. After an adjustable period of time in the sampling mode, the selector valve moves to the PURGE position. The microprocessor allows the instrument air into the selctor valve for probe blowback. The purge period lasts approximately ten seconds.

c. Following the purge mode, the selector valve is moved to the OFF position where it will remain until just before the next sampling mode.

d. One minute prior to its next sampling turn, the selector valve moves to the BYPASS position. This allows the bypass pump to draw fresh gas from the point about to be sampled, thus cleaning the stagnant gases from the sample line and achieving a steady-state stream of representative sample gases.

Each selector valve will be directed by the microprocessor control system to repeat the above process in turn. A similar selector valve is used to control zero and span gas flow to the analyzer.

2.2.2 **Sample Conditioning System**

The sample gas stream from the sample line and selector valve is drawn by the main sample pump through a filter and into a refrigerated condenser.

2.2.3 **Filters F-1 and F-2**

Filters F-1 and F-2 are replaceable-cartridge type filters designed to remove particulate matter down to 0.5 microns.

2.2.4 **Sample Pump SP-1 and Bypass Pump SP-2**

Both the sample pump SP-1 and the bypass pump SP-2 are identical, positive displacement type pumps using a moving diaphragm. All wetted parts are stainless steel, teflon, or viton. In normal operation the pressure at the pump outlet is set between 5 psi and 10 psi.

2.2.5 **Refigerated Condenser**

The condenser is located on the floor of the sample conditioning cabinet. Its purpose is to rapidly chill the sample gas, removing all condensable materials from the gas stream for a dry measurement. The condenser is a water bath type with teflon cooling coils and a thermo-plastic trap. The water bath will be maintained at a temperature of 35^{o}F to 40^{o}F by a thermostat mounted on the condenser. Condensate is collected in the trap at the bottom of the coil. The trap is drained automatically on a periodic basis by a control signal from the computer which energizes solenoid valve SV-2 . Expulsion pressure is provided by the sample pump and accumulated condensate is discharged to the drain.

2.2.6 Conductivity Sensor CS-1

The conductivity sensor CS-1 monitors the sample gas stream at the outlet of the condenser to detect any moisture remaining in the system which might damage the analyzers. A droplet of moisture across the conductivity sensor electrode closes a circuit which signals the computer to shut off the sample pump, and causes an alarm. When the sample pump stops, the moisture alarm is also energized to alert the operator of the need for maintenance.

2.2.7 Vacuum Switch VS-1 and Vacuum Gauge VG-1

The vacuum switch VS-1 is used to detect a high vacuum condition if any sample inlet becomes blocked. If the vacuum exceeds the preset level, it will notify the computer of this condition and activate an alarm. The vacuum gauge VG-1 is used for visual indication of the vacuum side of the sample system.

2.2.8 Pressure Switch PS-1 and Pressure Gauge PG-1

The pressure switch PS-1 is used to monitor sample pressure downstream of the sample pump. Pressure gauge PG-1 is used for visual indication. If the sample pressure drops below the preset level, its contact will cause an alarm (Loss of Sample).

2.2.9 Rotometers RM-1 & RM-2 and Backpressure Regulator BPR-1

Rotometer RM-1 is used to indicate total flow through the sampling system and the backpressure regulator BPR-1 is used to vent the sample gas flow that is in excess of that needed for analysis. This approach yields both minimum response time and higher analysis stability because of steady sample pressure. Rotometers RM-2, RM-3, and RM-4 are used to set and indicate flow through the gas analyzer.

2.2.10 Vents and Drains

All vented gases or drained fluids are piped overboard through bulkhead unions. They may be routed to sumps, but it is not usually necessary since the quantity of water discharged is small (teaspoons per hour), and the gases are not noxious.

2.3 ANALYTICAL INSTRUMENTS

KVB as a system supplier is unique in that we manufacture none of the analytical sensors. This allows us the independence and objectivity to select instruments on the basis of performance and value for each application. In this proposal various instruments are recommended and brochures on each are supplied under seperate cover.

2.3.1 Hydrogen Sulfide (H_2S) Monitor Labs #8780

The Monitor Labs #8780 Analyzer has been chosen to measure concentrations of H_2S. The instrument has been proven to be accurate andd reliable at over 1000 sites and has distinct advantages over other competitive instruments.

2.3.2 Carbon Monoxide (CO) Fuji Instruments #8310

A Fuji instruments #8310 Analyzer is chosen to monitor for carbon monoxide. This device offers a state of the art

N.D.I.R. microflow detector which translates into extreme stability at very sensitive ranges of analysis.

2.3.3 Hydrocarbons (CH_4 +) Horriba Instruments VIA 500

A Horriba Instruments VIA 500 has been selected to measure hydrocarbons. This N.D.I.R. technique is considerably more robust than any F.I.D. device and even though it is sensitive only to methane, it is believed that this instrument will provide the most reliable detection of hazardous conditions.

2.3.4 Other Analyzers

KVB will be willing to consider and evaluate inclusion of any other type of analytical sensor on request.

2.4 CONTROL SYSTEM

The KVB Hazardous Gas Monitoring System utilizes a state of the art microprocessor to control all bodily functions and assure the integrity of warnings. In addition the microprocessor will constantly check system status and provide an RS-422 interface with standard digital code for transmission to the main system computer.

2.4.1 Main Control Unit

The Main Control Unit issues control output commands for the following functions:

- o Sample Selection
- o Probe Blowback
- o Sample Line Priming
- o Condenser Draining
- o Automatic Calibration

- Alarm Verification

It in turn receives digital information and processes it for display. The following information is received by the Main Control Unit:

- Selector Valve Positions
- Inlet Blockage Alarm
- Loss of Sample Alarm
- Water Contamination Alarm
- Loss of Power Alarm

In addition, the Main Control Unit receives analog signals from each gas analyzer. Contact closures from the Main Control Unit are available for plant connection and can be used to indicate the following:

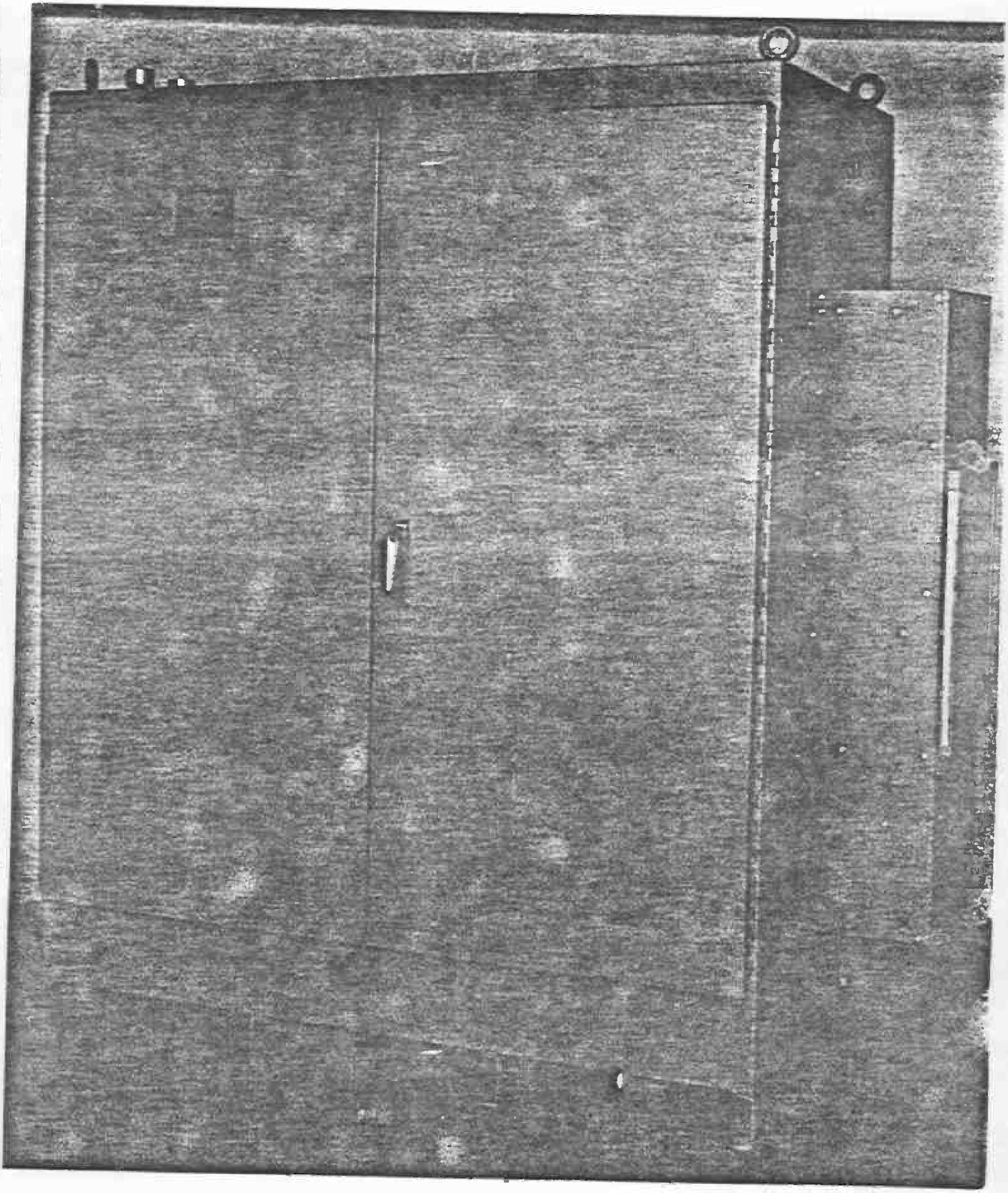
- System Failure
- High Level of Measured Gas

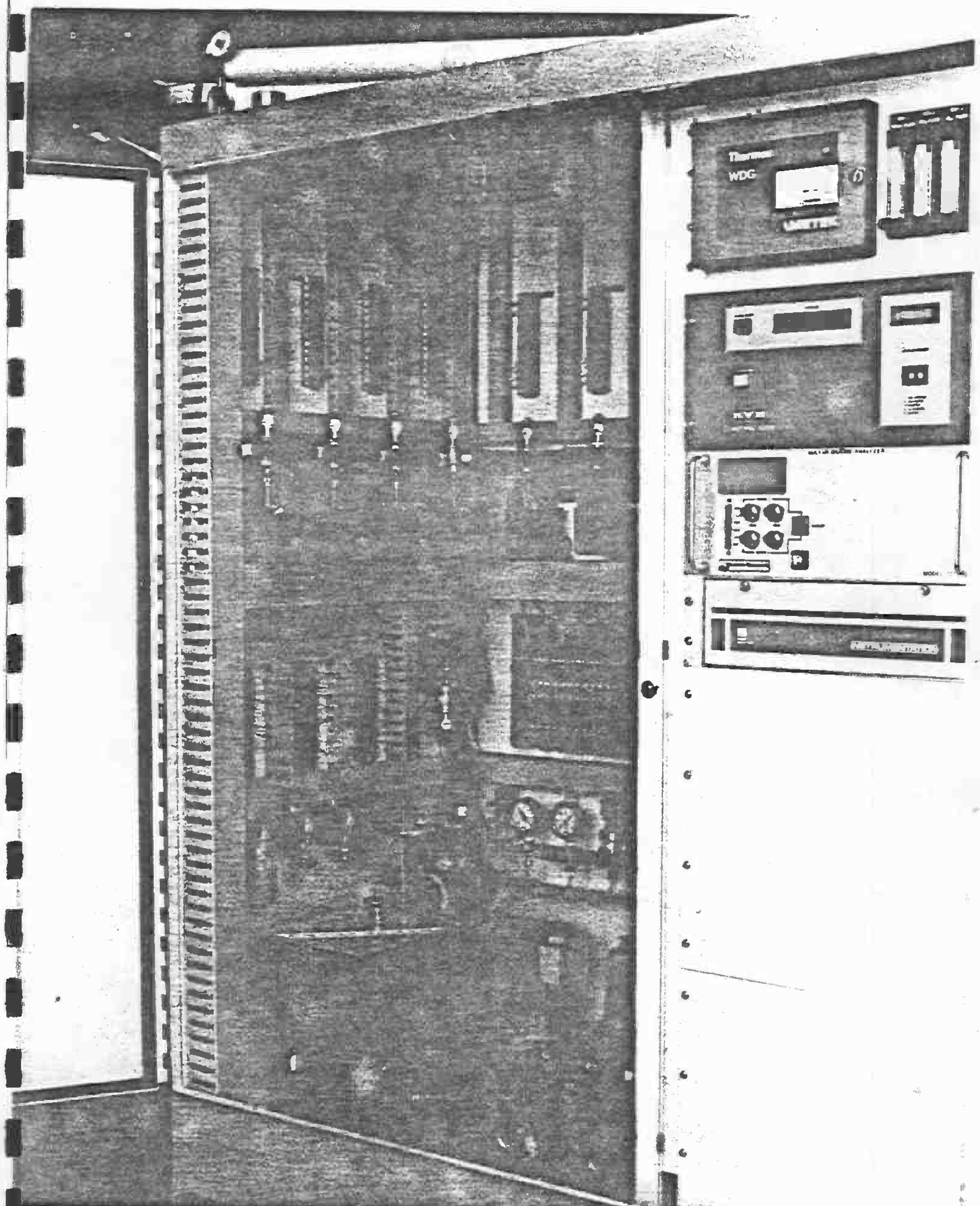
Other contacts can be made available as required. The Main Control Unit also provides a signal output (4-20 ma) for each measure gas.

The Main Control Unit contains a alpha-numeric display that constantly provides messages to keep the operator informed of system status and operation. In the event of any failure of the system, the display will indicate, in plain English, the cause. Aside from the analysis system self-check and diagnostics, the computer can also be used in a test mode to check 74 of the functions.

2.5 MAIN ANALYSIS ENCLOSURE

The Main Analysis Enclosure is a NEMA 12 enclosure that is 76" x 36" x 36" and is free-standing with doors front and rear. It houses the analytical instruments, sample conditioning equipment, and the Control System microprocessor. The Main Analysis Enclosure is temperature-controlled by a side mounted, hot bypass, valve type operation unit that will assure stable operation in an ambient temperature of $+32^{o}F$ to $110^{o}F$. The Main Analysis Enclosure is detailed in Figures 2 and 3.




WDG

SECTION 3.0

The cost for the proposed system as described in Section 2.0 will be based on supplying 20 identical systems but will be broken down on an individual basis for clarity.

1. One six point sampling system with micro processor control, environmentally controlled with recirculation air conditioning and provisions for three gas analyzers. Including complete software and hardware for automatic calibrations, alarm verification, and self check features. $38,000.00

2. Hydrogen Sulfide Analyzer $14,093.00

3. Methane Analyzer $8,250.00

4. Carbon Monoxide Analyzer $5,986.00

5. A service contract can be provided at an estimated $50,000 per year. Once system configuration is further defined a firm annual price can be quoted.

The above prices are valid for a period of 90 days and shipment of equipment can occur 180 days from order, F.O.B. Irvine, California and payment would be due on delivery.

SECTION 4.0

Warranty -- KVB, INC., a division of Research-Cottell Technologies, Inc., represents that, prior to shipping, the acceptability and performance of the gaseous monitoring equipment shall be verified. This shall be accomplished by conducting a 168 hour (seven day) burn-in and operational test at the KVB Manufacturing Facility.

KVB, INC. warrants that for a period of one year from the date of the monitoring system's first operation, or 18 months from shipment, whichever occurs first, it will correct any defects, either by repair or replacement, due to its use of defective material or faulty workmanship, provided that investigation by KVB, INC. discloses that such defects developed under normal and proper use. In addition, KVB, INC. agrees to pass on and assist the Purchaser with any warranty provided to KVB by suppliers of components that are in excess of the aforementioned warranties.

Notwithstanding other stipulations contained herein, KVB, INC. shall not, under any circumstances, be liable to the Purchaser in contract, tort, warranty or otherwise, for any special, indirect, incidental, or consequential damages occurring out of, or in connection with the delivery, use, or performance of the gaseous monitoring equipment provided to the Purchaser. In this regard, KVB, INC. shall not be liable for, nor shall the Purchaser assert any claims for, such damages as, but not limited to loss of profits or revenues, plant operating time, non-operating time, non-operation or increased expense of operation of other equipment, cost of purchased or replacement equipment, cost of replacement power, or claims of customers of the Purchaser for service interruptions. In the event that the Purchaser sells, leases, or otherwise transfer the gaseous monitoring equipment to a third party, the Purchaser shall obtain from such third party a written release from liability for damages described above in this paragraph. Such written release shall contain an Agreement by such third party to obtain similar releases from any subsequent user through the ultimate user. In the event the Purchaser cannot obtain such a release, the Purchaser and KVB, INC. shall confer on the course of action to be taken before such monitoring equipment is transferred or made available to a third party.

KVB, INC. makes no other warranties than those expressly set out herein. No grant is made of any other warranties, expressed or implied, including but not limited to the implied warranty for fitness for a particular purpose.

SECTION 5.0

BACKGROUND AND EXPERIENCE

KVB, INC. is a recognized consulting and research company providing engineering services and equipment for combustion performance monitoring and control. Since the early 1970's, KVB has been a leader in the development of new energy and emissions related technologies.

Utilizing this unique background and experience in the engineering and consulting services, The KVB Equipment Division has developed the most advanced Continuous Analysis Systems available today. Our product lines include Performance Monitors, Continuous Emissions Monitors, Continuous Gas Analysis Systems for FGD control, and Coal Fire Detection Systems.

A list of references is given in Table I. Please feel free to contact any of these references for information relative to KVB Gas Monitoring Systems. In many cases, the references listed will be able to directly compare the peformance of KVB extractive systems with both "in-situ" and "extractive" systems supplied by other equipment manufacturers. Such a comparative evaluation can be invaluable not only in providing performance data, but also in determing accurate lifetime costs of different systems when installation, maintenance, and parts costs are considered, as well as the initial capital cost investment. We are confident that the KVB systems will compare favorably in all respects with other monitoring systems available today.

An Installation List of KVB Extractive Monitoring Systems is given in Table II.

TABLE I. REFERENCE LIST

We feel that documented performance of equipment constitutes the only real criterion by which different systems can be evaluated, as maintenance costs for inadequate or improperly designed equipment can quickly surpass initial capital costs. We thus welcome the opportunity to provide the following list that presents a cross section of users that have first hand knowledge of the long term performance of KVB systems. In many cases they have had the opportunity to directly compare the KVB system with other approaches.

Public Service New Mexico New Mexico	-	Hank Taylor (505)598-6641
Southern California Edison California	-	Michael Schuck (213)572-1828
Indianapolis Power & Light Indiana	-	Gene DuPont (812)354-8801
Texas Cement Texas	-	Gerry Essl (512)295-6111
Wisconsin Electric Power Wisconsin	-	Wally Janus (414)694-8100
Houston Lighting & Power Texas	-	Don Butler (713)339-1551
San Diego Gas & Electric California	-	Al Ducey (619)134-7759
Allegeny Power Pennsylvania	-	Claude Frantz (412)838-6155
Public Service Coloado Colorado	-	Scott Diffendaffer (303)442-6556
Kerr-McGee Chemical California	-	Rolland Buchs (619)372-4311

Continued.....

West Texas Utilities Texas	-	Don Williams (915)672-9701
Utah Power & Light Wyoming	-	Rich McPherson (307)877-9071
Northern Indiana Public Service Indiana	-	Rick Ray (219)956-5249
Montana Power Montana	-	Dave Nation (406)748-2780

TABLE II. INSTALLATION LIST
KVB CONTINUOUS EMISSIONS MONITORING SYSTEMS
April 1984

Number	KVB S/N	Type of System	EPA Certified	Operating Since	Client and Location	A&E
1	EN 09	NO, CO, O_2, SO_2	N/A	March 1974	Public Service New Mexico Reeves Station, New Mexico	
2	EN 42	NO, CO, O_2	N/A	July 1972	Consolidated Edison Ravenswood Station, New York	
3	EN 43	NO, O_2	N/A	December 1972	Consolidated Edison 60th St. Steam Plant, New York	
4	EN 44	NOx, CO, O_2	N/A	November 1973	Portland General Electric Bethel Substation, Oregon	
5-6	EN 46	NO, CO	N/A	August 1974	Los Angeles Dept of Water & Power, Scattergood Plant California	
7-8	EN 49	NOx, CO, O_2	N/A	June 1974	Portland General Electric Harborton Station, Oregon	
9-14	EN 52	CO, O_2	N/A	June 1974	Houston Lighting & Power W. A. Parish Units 1 & 2, Texas	
15-16	EN 54	NOx, CO, O_2	Sep. 1980	February 1975	Houston Lighting & Power Cedar Bayou Units 1 & 2, Texas	
17-22*	EN 61	CO	N/A	December 1974	Niagara Mohawk Power Huntley Station, New York	
23-30*	EN 78 EN 85	CO CO	N/A N/A	December 1974	Niagara Mohawk Power Oswego & Albany Stations New York	
31	EN 84	NOx, CO, SO_2	Nov. 1978	Fall 1978	Houston Lighting & Power P. H. Robinson Unit 4, Texas	
32	EN 87	CO, O_2	N/A	Fall 1975	Houston Lighting & Power W. A. Parish Unit 3, Texas	
33	EN 90	NOx, CO, O_2, SO_2	N/A	April 1975	Wisconsin Electric Oak Creek Station, Wisconsin	
34	EN 63	NO, CO, O_2	N/A	April 1975	Power Authority Astoria Unit 6, New York	EBASCO
35	EN 98	NOx, CO, O_2	N/A	November 1976	U. S. Navy Port Hueneme, California	
36	EN 102	NOx, O_2	Nov. 1981	January 1977	City of Glendale, California	
37	EN 101	NOx, O_2, SO_2	Aug. 1977	May 1977	West Texas Utilities Fort Phantom Unit 2, Texas	Tippett & Gee
38	EN 105	NO, O_2	Sep. 1977	May 1977	Pasadena Dept of Water & Power Broadway Steam Plant, Calif.	
39	EN 112	NOx, O_2, SO_2	N/A	July 1978	Twin Cities Army Ammun. Plant Federal Cartridge Corporation Minnesota	
40	EN 107	CO, O_2	N/A	December 1977	Houston Lighting & Power W. A. Parish Unit 5, Texas	Brown & Root
41-42	EN 110	CO, O_2	N/A	January 1977	Houston Lighting & Power, Sam Bertron Units 2 and 4, Texas	
43*	EN 114	CO	N/A	May 1978	Public Service Co. of Indiana Indiana	
44	EN 108	CO, O_2	N/A	March 1978	Houston Lighting & Power W. A. Parish Unit 6, Texas	

*Coal Fire Protection System.

+Not yet on line.

Continued...

TABLE II (Cont.) - KVB Continuous Monitoring Systems Installation List

Number	KVB S/N	Type of System	EPA Certified	Operating Since	Client and Location	A&E
45-46*	EN 123	CO	N/A	June 1978	Public Service Co. of New Mexico San Juan Units 1 & 2, New Mexico	Brown & Root
47-50	EN 124	NOx, O_2, SO_2	Sep. 1978	August 1978	Arizona Public Service Four Corners Station Arizona	
51-52*	EN 134	CO	N/A	December 1978	Public Service Co. of New Mexico San Juan Units 3 & 4, New Mexico	Brown & Root
53-54	EN 143	NOx, O_2, SO_2	May 1978	April 1979	Public Service Co. of New Mexico San Juan Units 1 & 2, New Mexico	Brown & Root
55	EN 145	O_2, SO_2	Nov. 1979	May 1979	Pacific Power & Light Jim Bridger Station, Wyoming	Bechtel Power
56	EN 150	NO, CO, O_2	N/A	May 1979	Jacksonville Electric Authority Florida	
57	EN 140	CO, O_2	N/A	June 1979	Florida Power & Light, Florida	
58	EN 152	O_2, SO_2	Mar. 1980	November 1979	Santa Fe Energy/Chanslor Western Division, California	
59	EN 153	NOx, O_2, SO_2	May 1980	January 1980	Public Service Co. of New Mexico San Juan Unit 3, New Mexico	Brown & Root
60	EN 142	NO, O_2	Oct. 1979	August 1979	Southern California Edison Alamitos Units 5 & 6, California	
61	EN 160	NOx, O_2	Mar. 1981	December 1979	Libbey-Owens-Ford, Ohio	
62	EN 166	NO, NOx, NH_3	N/A	April 1980	Arapahoe Generating Station Colorado	Stearns-Roger
63	EN 162	NOx, O_2, SO_2/O_2, SO_2	N/A	February 1982	Sikeston Light & Power Power Station 1, Missouri	Burns & McDonnell
64-65*	EN 172 EN 176	CO	N/A	July 1980	Salt River Project Coronado Generating Station Arizona	Stearns-Roger
66	EN 163	NO, O_2, SO_2	May 1981	June 1980	Wisconsin Electric Power Pleasant Prairie Units 1 & 2 Wisconsin	Sargent & Lundy
67-68	EN 168	CO, O_2	N/A	June 1980	Wisconsin Electric Power Pleasant Prairie Units 1 & 2 Wisconsin	Sargent & Lundy
69-82	EN 171	NOx, O_2	Dec. 1980	June 1980	Los Angeles Dept. of Water & Power, Haynes/Scattergood/Valley Harbor Generating Stations California	
83-97	EN 173	NO, O_2	Dec. 1980	June 1980	Southern California Edison 30 Boilers at 9 Plants California	
98	EN 182	NO, CO, O_2	Oct. 1980	May 1980	San Diego Gas & Electric Encina Power Plant, California	
99*	EN 177	CO	N/A	August 1980	Kansas Power & Light Jeffrey Energy Center, Kansas	
100-103*	EN 164	CO	N/A	June 1980	Utah Power & Light Hunter Station Units 1 & 2 Huntington Station Units 1 & 2 Utah	

*Coal Fire Protection System.

+Not yet on line.

KVB #62-5951400

Continued...

TABLE II (Cont.) - KVB Continuous Monitoring Systems Installation List

Number	KVB S/N	Type of System	EPA Certified	Operating Since	Client and Location	A&E
104*	EN 174	CO	N/A	July 1980	Public Service Oklahoma Northeastern Station, Oklahoma	
105	EN 184	NO, CO, O_2	Oct. 1980	July 1980	San Diego Gas & Electric South Bay Power Plant, California	
106	EN 186	NO, SO_2, O_2	Nov. 1982	June 1982	Public Service Co. of New Mexico San Juan Unit 4, New Mexico	Brown & Root
107-108*	EN 161	CO	N/A	July 1980	Allegheny Power Service Harrison 1 & Fort Martin Stations West Virginia	
109*	EN 193	CO	N/A	December 1980	Utah Power & Light Naughton Station, Wyoming	
110-111*	EN 169	CO	N/A	July 1980	Cajun Electric Power Company Louisiana	Brown & Root
112-114	EN 179 EN 179 EN 180	CO, O_2	N/A	October 1980	Consolidated Edison Company New York	
115*	EN 181	CO	N/A	July 1981	Pennsylvania Power & Light Pennsylvania	
116	EN 190	NOx, SO_2, O_2	June 1981	March 1981	U.S.E., GCA Corporation, Ohio	
117*	EN 191	CO	N/A	March 1981	Genstar Cement, Calaveras Cement Division, California	Kaiser Engineering
118	EN 188	NOx, NO, O_2, SO_2	Sep. 1983	August 1983	Nevada Power Company Reid Gardner Unit 4, Nevada	Fluor Power Svcs
119	EN 197	Sample System	June 1981	December 1980	U.S. EPA	
120	EN 192	NOx, O_2, SO_2	Feb. 1981	September 1982	Associated Electric Cooperative Thomas Hill Power Station Unit 3 Missouri	Burns & McDonnell
121	EN 204	NOx, O_2	Mar. 1981	November 1981	City of Lubbock, Holly Avenue Station Unit 2, Texas	Tippett & Gee
123	EN 194	O_2, SO_2	Jun. 1982	September 1981	Utah Power & Light Naughton Station, Wyoming	Bechtel
124*	EN 199	CO	N/A	August 1981	Pacific Power & Light Wyodak Plant, Wyoming	
125*	EN 200	CO	N/A	January 1982	IBM Corporation, New York	
126*	EN 201	CO	N/A	August 1981	Lone Star Industries, Cape Giradeau Plant, Missouri	
127*	EN 202	CO	N/A	April 1982	Medusa Cement, Charlevoix Plant Michigan	
128-130*	EN 203 EN 214 EN 215	CO	N/A	January 1982	Arizona Public Service Co. Four Corners Power Plant Arizona	
131*	EN 205	CO	N/A	January 1982	Central Louisiana Electric Rodemacher Power Station 2 Louisiana	Sargent & Lundy
132*	EN 206	CO	N/A	November 1982	City of Grand Island Nebraska	Combustion Engineering
133	EN 208	NO, CO, SO_2, O_2	Oct. 1981	July 1981	U.S. EPA	
134	EN 209	SO_2	N/A	June 1982	United Power Association Stanton Station, North Dakota	Research-Cottrell

*Coal Fire Protection System.

**Not yet on line.

TABLE II (Cont.) - KVB Continuous Monitoring Systems Installation List

Number	KVB S/N	Type of System	EPA Certified	Operating Since	Client and Location	A&E
135	EN 210	NO, CO, O_2	N/A	September 1982	Independent Valley Energy Co. Bakersfield, California	Fluor Engineers & Constructors
136	EN 212	NOx	--	August 1981	Owens-Illinois, California	
137*	EN 212	CO	N/A	+	Colorado-Ute Electric Association Colorado	
138	EN 218	NOx, CO, O_2	N/A	April 1982	Niagara Mohawk Power Corporation Oswego Steam Station 6, New York	Stone & Webster
139*	EN 220	CO	N/A	+	Platte River Power Authority Rawhide Unit, Colorado	Combustion Engineering
140-147	EN 222	NO, CO, O_2	N/A	February 1982	San Diego Gas & Electric Encina & South Bay Power Plants California	
148-149*	EN 223 EN 224	CO	N/A	+	Houston Lighting & Power Limestone Plant, Texas	Combustion Engineering
150*	EN 230	CO	N/A	January 1982	Martin-Marietta Cement, Iowa	Kaiser Engineers
151*	EN 231	CO	N/A	February 1982	Cajun Electric Power Company Louisiana	Burns & Roe
152*	EN 233	CO	N/A	+	Santee-Cooper Cross Generating Station South Carolina	Burns & Roe
153*	EN 234	CO	N/A	+	Sunflower Electric Holcomb Station 1, Kansas	United Engineers
154*	EN 235	CO	N/A	March 1982	Wisconsin Power & Light Columbia Generating Station Wisconsin	
155*	EN 236	CO	N/A	+	Wisconsin Electric Power Company Unit 7, Wisconsin	
156*	EN 237	CO	N/A	March 1982	Giant Portland Cement Harleyville Plant, So. Carolina	Willis & Paul
157*	EN 238	CO	N/A	+	Wisconsin Electric Power Unit 8, Wisconsin	
158*	EN 239	CO	N/A	March 1982	Giant Portland & Masonry Cement Harleyville Plant, So. Carolina	Willis & Paul
159-163 165-168	EN 241 EN 251	NOx, O_2, SO_2	---	+	Montana Power Company Colstrip Units 3 & 4, Montana	Bechtel Power
169*	EN 242	CO	N/A	+	Portland General Electric Carty Reservoir, Oregon	
170*	EN 243	CO	N/A	+	Deseret Electric, Utah	Foster-Wheeler
171*	EN 244	CO	N/A	+	International Combustion, Lidell Power Station 3, Australia	
172	EN 245	NOx, CO, O_2, SO_2	---	+	Phillip Morris, USA, Virginia	United Engineers
173-178*	EN 246 EN 247	CO	N/A	+	Wisconsin Electric Power Pleasant Prairie Units 1 & 2 Wisconsin	
179	EN 248	NOx, O_2	N/A	June 1982	IBM San Jose, California	HMR, Inc.

*Coal Fire Protection System.

+Not yet on line.

Continued

TABLE II (Cont.) - KVB Continuous Monitoring Systems Installation List

Number	KVB S/N	Type of System	EPA Certified	Operating Since		Client and Location	A&E
180-181	EN 249 EN 250	NOx, O_2, SO_2	---	+		Northern Indiana Public Service R. M. Schahfer Units 17 & 18 Indiana	Sargent & Lundy
182*	EN 252	CO	N/A	+		Lone Star Industries, Davenport Plant, California	
183	EN 253	NOx, SO_2, O_2	July 1983	June	1983	Sunflower Electric Kansas	United Engineers
184	EN 254	CO_2, SO_2, NOx, CO	July 1983	March	1983	Houston Lighting & Power W. A. Parish Unit 8, Texas	Bechtel
185	EN 255	O_2, SO_2, NOx	Apr. 1982	February	1982	Karr-McGee, California	
186*	EN 256	CO	N/A	November	1982	Muscatine Power & Light, Iowa	
187	EN 257	SO_2, NOx, O_2	N/A	+		Plains Electric, New Mexico	Burns & McDonnell
188	EN 258	SO_2, NOx, O_2	---	+		Deseret Generating, Utah	Burns & McDonnell
189*	EN 259	CO	N/A	April	1983	Kansas Power & Light Jeffrey Unit 3, Kansas	
191*	EN 261	CO	N/A	June	1983	Wisconsin Power & Light Wisconsin	
192*	EN 266	CO	N/A	July	1983	Western Illinois University Illinois	Petersburg Plumbing & Heating
193*	EN 267	CO	N/A	August	1983	Kansas Power & Light Jeffrey Unit 2, Kansas	
194*	EN 268	CO	N/A	April	1983	Northern Indiana Public Service Indiana	
195	EN 269	Performance monitor	N/A	November	1983	Southern California Edison Co. Ormond Beach Station, California	
196	EN 270	SO_2, O_2	Apr. 1983	January	1983	Montaup Electric Company Somerset Station Units 5 & 6 Massachusetts	Stone & Webster
197*	EN 271	CO	N/A	+		Northern Indiana Public Service Indiana	
198*	EN 272	CO	N/A	+		Tampa Electric, Florida Engineering	Combustion
199	EN 273	SO_2, O_2 (FGD)	May 1983	April	1983	City of Springfield V. Y. Dallman Unit 33, Illinois	Burns & McDonnell
200*	EN 274	CO	N/A	+		Baltimore Gas & Electric Brandon Shores Units 1 & 2 Maryland	Gilbert Associates
201*	EN 275	CO	N/A	+		Foster-Wheeler, New Jersey	
202*	EN 276	CO	N/A	February	1983	Pretoria Portland Cement South Africa	International Combustion
203*	EN 277	CO	N/A	May	1983	CCM Energy, Florida	
204*	EN 278	CO	N/A	June	1983	Moran Construction Company Lehigh Portland Cement, Waco Plant, Texas	Willis & Paul
205	EN 280	CEM	---	+		Kelco, California	
206*	EN 282	CO	N/A	+		West Pennsylvania Power Hatfield P.S., Pennsylvania	Allegheny Power

*Coal Fire Protection System.

+Not yet on line.

Continued...

TABLE II (Cont.) - KVB Continuous Monitoring Systems Installation List

Number	KVB S/N	Type of System	EPA Certified	Operating Since	Client and Location	A&E
233	EN 307	NOx, SO_2, O_2, CO (CEM)	—	March 1984	Ashgrove Cement Louisville Plant, Nebraska	
234-237	EN 310-313	SO_2, O_2	—	+	Houston Lighting & Power Malakoff Electric Generating Station Unit 4	GE Environmental
238	EN 314	CO, O_2	N/A	+	Gifford-Hill, Riverside Cement Riverside, California	Combustion Engineering
239	EN 315	SO, O_2 (CEM)	—	+	Alberta Power, Sheerness Generating Station, Units 1 & 2, Edmonton, Alberta, Canada	
240	EN 316	CO	N/A	+	Northern Indiana Public Service D.H. Mitchell Station, Units 4, 5, and 6, Michigan City, IN	
241	EN 317	CO	N/A	+	Cleveland Electric Illuminating Avon Lake Plant, Avon Lake, Ohio	
242	EN 318-320	NOx, SO_2	—	+	Tosco Oil Company, Avon Refinery Martinez, California	
243	EN 321	CO	N/A	+	Scott Paper Company Mobile, Alabama	J. E. Sirrine Co
244	EN 322	CO	N/A	+	Intermountain Power Project Delta, Utah	Babcock & Wilcox
245	EN 323	SO_2, O_2 (FGD)	—	+	Pacific Power & Light Bridger Station, Wyoming	
246	EN 324	CO	N/A	+	New York Gas & Electric Somerset Station Unit 1 Buffalo, NY	Wormald Fire Systems

*Coal Fire Protection System.

+Not yet on line.