V

DIRECT-READING INSTRUMENTS FOR ANALYZING AIRBORNE GASES AND VAPORS

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Introduction

Direct-reading instruments for airborne gases and vapors make a quantitative analysis that is read directly on an indicating meter, recorder, or other display. The distinction between these direct-reading devices and nondirect-reading devices is primarily that in the latter, analysis and/or measurement of an air pollutant is conducted after collection and at another location.

In this chapter, the physical principles of detection are discussed and current instrument systems are categorized according to these principles. In general, direct-reading instruments have a sensor which generates an electrical signal proportional to the contaminant concentration. This sensor may or may not be immediate to the sampling process. A gas pollutant may be detected by infrared absorption immediately upon sampling. On the other hand, there may be an intermediate step between sampling and detection, e.g., colorimetric gas anlyzers in which the gas is collected in a chemical reagent, allowed to react, and then analyzed colorimetrically. In such instances, the principle of operation may be referred to as a chemicophysical method in order to indicate the intervening chemical process before physical analysis. The chemical treatment predisposes the sample to the analytical method. In this discussion, both physical and chemicophysical instrumentation are discussed, although methods are categorized explicitly in terms of physical detection and/or analysis techniques.

Principles of Detection

Several physical methods of detection and analysis are employed in direct-reading instruments, including electrical conductivity, potentiometry, coulometry, radioactive tracers, thermal conductivity, photometry, spectroscopy, colorimetry, chemiluminescence, mass spectroscopy, and gas chromatography. The basic principles of these detection methods and their capabilities are outlined below.

The limitations discussed may or may not be pertinent to all applications of a method. Electrical conductivity measurements, for instance, are nonspecific in the sense that anything that ionizes will affect the measurements. However, if the application is one in which the pollutant is at relatively high concentrations and has much greater conductivity than known interferences, then lack of specificity ceases to be a significant consideration. Sulfur dioxide in a stack effluent as a result

of combustion of high sulfur coal is an example. Knowledge of the measurement problem under consideration and related ramifications, such as environmental conditions and subsequent data handling and interpretation, allow selection of an instrument most appropriate for the specific situation.

Electrical Methods

This category includes the various methods by which chemical and/or physical properties of the gas pollutant introduce changes in the electrical parameters of a gas or solution. Sensor output is related to the concentration of the gas being measured.

Conductivity

Gases that form electrolytes in an aqueous solution cause a change in the solution's electrical conductivity. Conductivity detectors sense this change directly. However, because the electrical conductance of the solution is a summation of the effects of all ions present, the method is not specific. Only when the concentrations of all other electrolyzing gases are constant or relatively insignificant, can the observed conductance be related to the concentration of the gas being measured.

Temperature control is important in conductance measurements because, in electrolytic conduction, the temperature coefficient can be on the order of 2%/°C. Cabinets equipped with thermostats are sometimes used to maintain temperature equilibrium.

To obviate the need for temperature control, electrical compensation is sometimes used. Variations in test solution temperature are accounted for automatically by a thermistor immersed in the test solution. The thermistor is part of the electrical circuit and is selected to have a temperature coefficient of resistance that will permit satisfactory compensation over a range of temperature variations.

Potentiometry

Gases that react with reagents in solution to change the pH of the solution produce a potentiometric change that reflects the concentration of the reacting gas. The potentiometric change is sensed by a galvanic cell commonly referred to as a "pH electrode." The galvanic cell is basically a system in which energy associated with chemical reactions is converted into electrical energy in the form of an electromotive force (emf). In analytical applications, it depends primarily on concentrations of the substances involved in the electrode reactions.

To obtain a correct measure of the emf sensed by a pH electrode, a potentiometric measurement is required. This is defined as a measurement in which there is no flow of current into or out of the cell being measured. Null balance potentiometers meet this requirement. Other techniques in use, such as vacuum tube voltmeters and pH meters, result in observations with relatively negligible current flow ranging from 10^{-6} to 10^{-14} ampere.

In principle, pH change, or potentiometry, is nonspecific. In practice, a certain amount of specificity may be introduced by the choice of reagents that are most conducive to the desired reaction for the gas to be sampled. The carbon dioxide analyzer developed by Lodge[1] is an example of potentiometric measurement of equilibrium pH in the reaction of carbon dioxide with a suspension of insoluble carbonate in the form of marble chips. The hydrogen-ion activity gives a measure of the CO_2 concentration.

Coulometry

Coulometry is the measurement of the number of electrons (in terms of coulombs) transferred across an electrode–solution interface to carry to completion the reaction of a particular substance in a sample. In instrument applications, such as the Titrilog, the measurement involves an indirect determination of the number of coulombs required for the production of bromine that reacts with the sulfur dioxide being determined. The method is inherently sensitive since a microcoulomb equivalent corresponds to nanogram amounts and less of most simple substances.

In principle, there is no restriction in coulometry relating to the volume of the sample or to the concentration of the substance in the sample. Furthermore, since the method basically involves a measurement of the number of coulombs required for a particular reaction, it does not provide for determining the endpoint of the reaction. As a result, any of the known methods of endpoint detection may be utilized. The sensitivity of the endpoint detection technique, however, may become the limiting factor in the ability of the coulometric system to detect very low concentrations.

Ionization

Detection by ionization is based fundamentally upon making a gas conductive by the creation of electrically charged atoms, molecules, or free electrons and the collection of these charged particles under the influence of an applied electric field. Various ionizing reactions used for the measurement of gas concentrations have been discussed in considerable detail by Lovelock.[2] Ionization is actually a special case of electrical conductivity as a physical method of detection. Since prime consideration, however, is given to the ionizing reactions rather than the resulting conductivity, ionization is identified separately. As a conductivity measurement, the method in general is nonspecific. The nature of the ionizing reaction, however, may make the method more or less specific.

Flame ionization is a method that has been applied in commercial instruments (Figure V-1). The great increase in production of ions by introducing a volatile

carbon compound into a hydrogen flame burning in air provides a sensitive method of ionization detection. A satisfactory explanation of the process leading to production of ions in this manner remains to be made, although some explanations have been offered. This detector has a wide linear dynamic range and a response extending to a concentration of approximately 1.0%. It is insensitive to the presence of such contaminants as air or water vapor, but it responds to most organic compounds. Response is depressed with compounds having electronegative atoms such as oxygen, sulfur, and chlorine. Changes in geometry, flow rate, and composition of the gases supplied to the flame alter the relative response of the detector to different compounds.

Selective Sampling

An electrochemical technique may be combined with a selective sampling scheme to give better discrimination. Examples of this technique are some commercial instruments that sample through a gas-permeable membrane. The membrane is selected for its capability to be highly specific in the gas or gases that can pass through it.

Radioactive (Tracers) Techniques

Detection of very low levels of radioactive substances by well-developed physical methods, such as scintillation and Geiger counters, points to the use of a radioactive tracer in a clathrate reaction. In a device reported by Bersin,[3] SO_2 reacts with $NaClO_2$ to release ClO_2, which reacts with a clathrate in which ^{85}Kr is released. The released ^{85}Kr is detected by a Geiger counter, and the resulting count rate is related to the SO_2 concentration initiating the reaction. The method is sensitive to concentrations on the order of 1.0 ppm and specific only to the extent that the initial reaction is limited to the gas being studied. In the device cited, for example, NO and NO_2 may provide significant interference, depending upon their concentrations relative to SO_2.

Thermal Methods

Detection of various thermal properties of gases is a widely used method of gas analysis. Two thermal properties of gas contaminants, conductivity and combustion, have served as the basis of operation of instruments currently in use.

Conductivity

The thermal conductivity of a gas provides a physical method of quantitative measurement. The method is nonspecific. Where mixtures are resolved into components, as in a chromatographic column, thermal conductivity is used extensively. Nevertheless, for a mixture of a few components in which one gas has a significantly high coefficient of thermal conductivity and occurs at a relatively larger concentration, thermal

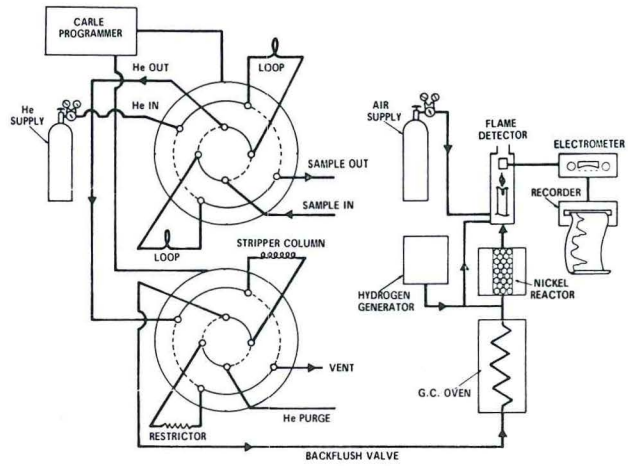

FIGURE V-1. Automated gas chromatographic–flame ionization detection system for CO and CH_4 analysis.

conductivity can be used with some success. Often, a differential measurement may be used to balance out the presence of other gases so that a change in concentration of the gas of interest can be detected. A combustible hydrocarbon in air, for example, is burned; the CO_2 is measured before and after combustion, and the change in CO_2 is related to the hydrocarbon content. In applying this technique, one must consider the increased water vapor as a product of combustion. It can be accounted for either by drying or saturating the sampled air stream before and after combustion. Although CO_2 has low solubility in water, at very low concentrations such a procedure may present additional problems.

Combustion

The heat released during combustion, a particular physical characteristic of combustible gases, is used for quantitative detection. Suffering the same limitation as thermal conductivity, this method is also nonspecific. Depending upon sampling and measurement conditions, it may or may not be used appropriately to give satisfactory results.

One type of thermal combustion cell involves a resistance bridge in which the arms of the bridge are heated filaments. The principle of operation consists of introducing the sample into the gas cell in which the combustible gas ignites upon contact with a heated filament. The resulting heat of combustion changes the resistance of the filament. The change in resistance is detected by conventional bridge measurement techniques and is related to the gas concentration on the basis of calibration standards.

Another combustion method uses catalytic heated filaments or oxidation catalysts, and detection is by change in resistance in a balanced bridge or by thermocouples, respectively. Combustion can be made more or less specific by operating specified filament

temperatures so as to ignite the gas of interest and/or by selection of an oxidation catalyst favoring a desired reaction such as "hopcalite" for carbon monoxide.

Spectroscopic and Photometric Techniques

Electromagnetic techniques are customarily used in absorption spectroscopy in which electromagnetic energy, in the form of ultraviolet (UV), visible, and infrared (IR) radiation, is absorbed by a pollutant medium. Recent advances in spectroscopy have introduced a number of techniques that are being adapted to gas analyses.[4] These include microwave radiation, correlation spectroscopy, Raman radiation, laser sources, solid-state detectors, derivative spectroscopy, and Fourier spectroscopy. Some of these techniques are being applied to emission and scattering of electromagnetic waves by pollutant gases in addition to the absorption phenomena.

These electro-optical techniques offer a broad range of applications, some of which cannot be achieved by any other methods. For example, long-path, *in situ* gas analyses as well as remote sensing can be conducted by electro-optic methods only. These methods are applicable to point sampling as well.

For this discussion, it is appropriate to consider first the three basic molecular phenomena under which these methods fall, namely, absorption, emission, and scattering. Subsequently, there follows a discussion on the various spectroscopic schemes by which these phenomena are detected and analyzed.

Molecular phenomena. Molecules characteristically absorb, scatter, and emit electromagnetic radiation. The unique relationship of the radiation involved with the molecular structure permits qualitative identification and quantitative concentration measurements to be made of material composition.

Absorption. Gas molecules absorb incident electromagnetic energy at wavelengths corresponding to the change in energy states of a given molecule.

Emission. Gas molecules emit at wavelengths corresponding to the change in energy states of a given molecule. Absorbing wavelengths are identical to emitting wavelengths for a specific change in the energy state of a molecule. Absorption constitutes an increase in energy; emission, a decrease in energy. In emission, the source of energy can be internal, such as thermal emission, or it can be external such as chemiluminescence by chemical interaction.

Scatter. Incident radiation can be scattered as well as absorbed, or it may be absorbed and re-emitted at a different wavelength. Energy scattered by molecules at the same wavelength as the incident wavelength is referred to as Rayleigh scatter. Energy absorbed at absorbing wavelengths to raise the energy state of the absorbing molecules and re-emitted at new wavelengths is referred to as fluorescence. The shift in wavelength, indicating some loss in energy, is toward longer wavelengths.

In Raman scattering, the incident radiation causes a virtual transition in the molecular energy states with re-emission of radiation at both longer and shorter wavelengths than that of the incident radiation. Raman scattering does not require the incident radiation to be at or near the absorbing wavelength of the gas and can thus take place at any wavelength. The intensity of Raman scattering, however, increases inversely as the fourth power of the wavelength of the incident radiation. Consequently, the UV region is the more attractive region for Raman scattering than the IR portion of the spectrum. Raman scattering is further enhanced by a factor of 100 or more when the incident radiation is near the absorbing wavelength of the gas. This is referred to specifically as resonance Raman scatter.

Infrared Photometry

Nondispersive methods. Many pollutant gases have characteristic absorption lines in the infrared region of the electromagnetic spectrum. The nondispersive method avoids the use of dispersive optics, e.g., prisms or gratings. Selectivity in sensing the pollutant at its absorbing wavelength is achieved in one of several ways: by selective light sources (lasers), by selective detectors, by selective filtering of light sources, or by combinations of these.

IR gas analyzers are available for measurement of CO, CO_2, and various hydrocarbons (e.g., methane) by selective detection using gas filters.[5] In a typical analyzer, IR radiation from two hot filament sources passes through parallel tubes, one a "reference" cell (containing clean air) and the other the "analysis" or "sample" cell (containing the pollutant gas, i.e., CO in air). Some of the radiation is removed by the CO in the sample cell at its absorbing wavelengths, and the remainder passes on to the detector. The detector is made selective only to the absorbing wavelengths of CO by filling it with pure CO. The detector generates an electrical signal output based on the difference in absorption between the reference and sample cells. This output becomes a quantitative measure of the concentration of CO in the sample cell based on calibration of the output readout.

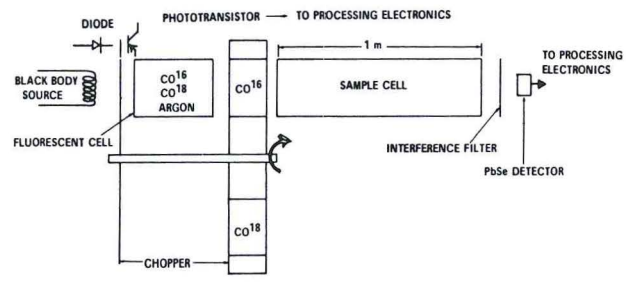

FIGURE V-2. Argon fluorescent NDIR CO analyzer.

A nondispersive, fluorescent IR CO analyzer using a novel approach has been developed.[6] The technique consists of absorption spectroscopy in which the source of energy is fluorescence from a gas cell matching the pollutant gas under analysis. In principle, this gives the perfect wavelength correlation, high signal-to-noise ratio, and excellent discrimination.

In the instrument developed for CO (Figure V-2), IR radiation from the black body source stimulates the CO molecules in the sealed fluorescent cell that in turn provides the fluorescent radiation as the source of energy for the absorption measurement. The chopper cells containing $C^{16}O$ and $C^{18}O$ are part of the analytical scheme whereby the measurement is uniquely sensitive to the presence of CO in the sample tube. Briefly, if the $C^{16}O$ and $C^{18}O$ signals are defined as the "A" and "B" signals, respectively, only the "A" signal will be attenuated by the presence of CO gas in the sample tube since the natural isotopic abundance of $C^{18}O$ is only 0.2% of $C^{16}O$. The processing electronics generate an output proportional to the quantity [B–A]/B. This expression shows sensitivity to differential absorption of the two signals. In addition, maintenance of the "B" signal at fixed amplitude by automatic gain control allows the measurement to be independent of variations in source power of detector response.

The arrival of laser sources, offering monochromatic wavelengths and high beam intensities, is a significant development. The technique of selecting a laser line that coincides with an absorption line of a gas as a means of specific and sensitive gas analysis has been demonstrated.[7,8] Current developments in tunable dye lasers[9] in the UV and visible, and tunable solid-state diode lasers in the IR,[10] offer great potential for a range of specific and sensitive gas analyzers with direct readout.

Selective filtering of light in nondispersive techniques can be achieved anywhere between the light source and the detector as another means of sensing a pollutant at its absorbing wavelength. It is done most effectively with filters at the detector. Optical filters are available with various specifications on transmission, bandwidth, and location of center wavelength of transmission. Interference filters provide very narrow transmission bandwidths, but they do not approach the wavelength resolution capability of dispersive techniques. Prototype long-path spectroscopic instrumentation has been developed using interference filters for detection of ozone.[11]

Resolution of filtering techniques in the infrared range is on the order of 10 cm^{-1} as compared to absorption linewidths that may be on the order of 0.1 cm^{-1} at atmospheric conditions. Consequently, interferences are possible because of overlapping absorption lines from other pollutant gases within the transmission band of the filter. This necessitates correction for interferences by additional measurements in adjacent spectral regions and introduces more complexity in the analytical scheme and instrumentation.

In comparison, the use of lasers as a selective light source offers the advantage of a very narrow line (on the order of 0.001 cm^{-1}) to give high discrimination against interferences. On the other hand, selective light filtering and detection by gas filters offers the resolution of the absorbing gas itself and deletion of all the lines of the absorbing gas. This method is also referred to as gas correlation spectroscopy as compared to optical correlation spectroscopy, which will be discussed later.

Dispersive methods. Dispersive methods are used in spectrophotometers having optical elements such as prisms or gratings. These elements spatially disperse the light from a broadband source so that wavelength selection may be achieved by means of proper physical placement of mechanical slit openings. Resolution is related primarily to the slit width, the dispersive power of the optical element, and the optical configuration of the instrument. The limiting factor on resolution is the dispersive optical element. Gratings are available that permit resolution in the infrared on the order of 0.1 cm^{-1} and less.

The dispersive technique permits continuous scanning of the spectrum within the wavelength region of the dispersive element. This is an advantage over fixed optical filter techniques. In the infrared region, for example, a grating can cover the region from 7 to 14 μm. Lasers fall in between since they can have a single wavelength or, as in the case of an isotopic CO_2 gas laser, have as many as 150 discrete lines. These lines fall within a narrow range of the spectrum, however, and being discrete, they do not really permit a continuous scan.

Ultraviolet Photometers

Ultraviolet photometers operate on the characteristic of certain gases to absorb UV radiation. An appropriate wavelength is selected for the detector based on the absorption characteristics of the pollutant of interest. Mercury, for instance, has a strong absorption at 254 nm. The reduction of energy received at the photometer as a result of absorption by vapors in the gas samples is a measure of mercury vapor concentration. Other spectroscopic techniques, such as correlation and derivative techniques (discussed below), are also applied to UV detectors.

Other Photometric Techniques

Fourier interferometry. The interferometer-spectrometer is a dispersive-type instrument that permits an examination of a large portion of the spectrum, which eventually can be displayed as a function of wavelength. Unlike the grating-type dispersive technique, inter-

ferometry first generates a frequency spectrum by light interference in an optical system. The frequency spectrum is converted mathematically into the conventional wavelength spectrum by Fourier transforms. A conventional scanning dispersive spectrometer generates a spectrum by serially scanning the spatially dispersed wavelengths as a function of time. The interferometer has multiplexing capability, whereby all the wavelengths are scanned concurrently in time and are measured directly as a frequency spectrum.

The Block Engineering interferometer-spectrometer is a commercial example of the Michelson interferometer design. In principle, this design (Figure V-3) consists of two plane mirrors, M_1 and M_2, one of which is fixed, and two plane-parallel plates, G_1 and G_2. Light from an extended source is incident at 45° on plate G_1, partially silvered on the rear surface, and is divided into reflected (path A) and transmitted (path B) beams of equal intensity. The light reflected from M_1 passes through plate G_1 a third time before it reaches the detector. The light reflected from mirror M_2 passes back through G_2 a second time, is reflected from the surface of plate G_2, and into the detector. The two beams have a phase difference governed by the difference in the two paths. As incoming radiation is received by the interferometer, a fringe pattern is produced by interference in the two beams. When one of the mirrors is moved back and forth at a slow constant velocity, the motion is manifested as an alternate brightening and darkening of the central fringe. The detector records these signal changes. Incident radiation containing many wavelengths would generate a composite signal of all the sine waves that corresponds to all the wavelengths in the source. A Fourier wave analysis of the signal produces a wavelength spectrum.

The maximum resolution of this interferometer depends upon the maximum travel of the moveable mirror and is equal to the maximum travel distance divided by one-half the wavelength. Commercial interferometers are available with resolution approaching 0.5 cm^{-1} in the IR wavelengths. Throughput and multiplexing capabilities of the interferometer offer an advantage over the conventional dispersive spectrometer in the speed with which a spectrum can be obtained. The Fourier transformation, however, is an involved procedure and adds to the complexity and cost of the instrumentation.

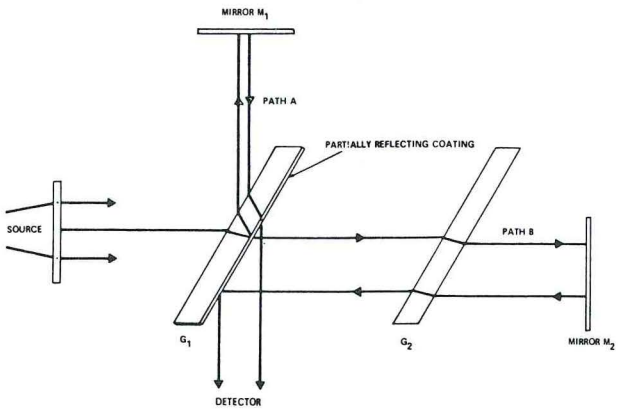

FIGURE V-3. Michelson interferometer.

Correlation. Correlation techniques consist of matching a reference spectrum of the gas to be measured against the spectrum of the sampled gas to be analyzed, or what might be referred to as the sample spectrum. The reference spectrum may be generated by a photographic mask or by a gas cell whereby the techniques are referred to as optical correlation spectroscopy or gas correlation spectroscopy, respectively. The latter is also referred to as a matched filter technique or a gas filter technique and was discussed earlier under "Nondispersive Methods." The sample spectrum may be generated by dispersive optics or by nondispersive gas filters.

A commercial instrument has been developed in which a photographic mask provides the reference spectrum and correlation spectroscopy is the analytical scheme.[12] This instrument may be descriptively referred to as an optical-correlation dispersive-type device and also has been described in "Other Instrument Developments."[13]

Derivative technique. The derivative technique simply involves processing the transmission versus wavelength function of an ordinary spectrometer into a signal proportional to the first, second, or n^{th} derivative of this function. The derivative signal improves the detectability of overlapping spectral lines and bands, and it suppresses the effects of a fluctuating light source. Thus, it enhances the signal-to-noise ratio, the resolution of the data, and the sensitivity. Instrument designs have involved different approaches in executing the derivative output. These include sinusoidal modulation and a difference measurement of flux at two adjacent wavelengths. Theoretical work has been conducted to evaluate the accuracy with which various approaches represent the derivatives.[14] A detrimental effect found in using higher derivatives is the decrease in signal.

Hadamard transform technique. The Hadamard transform technique[15] is an analytical technique developed to overcome the energy limitations of frequency-scanned spectrophotometers. Thus, it offers the advantages of the Michelson interferometer with its high-energy input and multiplexing capability, but it does not involve the usual Fourier transforms. This method consists of optically encoding the spectral output of a multislit spectrometer. The encoding involves sequential measurements of the total light intensity in combinations of selected spectral bands. The resulting

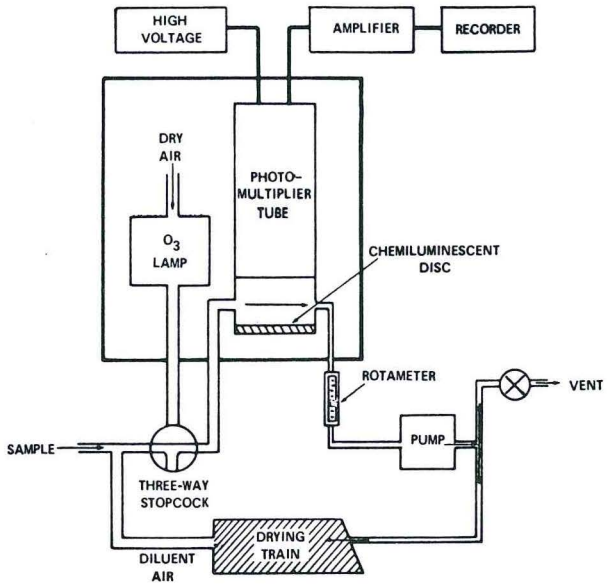

FIGURE V-4. Ozone analysis by ozone-organic-dye chemiluminescent reaction and photometric detection.

encoded optical information is obtained as a set of simultaneous linear algebraic equations, and the spectral reconstruction is accomplished through the use of matrix inversion techniques.

Chemi-Electromagnetic Methods

Chemi-electromagnetic techniques of gas analysis employ a chemical reaction followed by a measurement of electromagnetic radiation. They include two classes depending on whether radiation absorption or emission is used to detect the reaction product.

Colorimetry

Colorimetry is a method wherein the pollutant gas is sampled and reacted with a reagent. With selection of the proper reagent, the reaction is specific to the pollutant gas of interest and a unique color is formed. The electromagnetic-absorptive capacity in the visible wavelengths of the reacted reagent is utilized to give a quantitative analysis. In addition, the intensity distribution of a range of transmitted wavelengths (referred to as the spectral characteristic of the absorbing medium) is unique to the absorbing medium and provides a qualitative analysis.

The measurement system consists of a source of radiant energy, the sample solution to be measured, and a detector for the unabsorbed or transmitted radiation. The usual radiant energy source in the visible range is the electric bulb with an incandescent tungsten filament.

Special sources are used for UV and IR to provide sufficient energy at these wavelengths. Photocells are used as detectors and include three types: 1) photoconductive, 2) photovoltaic, and 3) photoemissive. The important point to consider with respect to the detector and source combination is that each has its own spectral characteristic; therefore, the optimum combination to obtain maximum sensitivity is one in which both have maximum response in the wavelength range of interest.

An important aspect of the instrument design is the provision for operation in a given spectral region. This may be done in a number of ways, extending from the simple fixed-band filter to the relatively complex monochromator with an adjustable bandwidth and a wavelength drive to scan the entire spectrum. It is necessary that the instrument operator determine the calibration curves for the instrument in use under present working conditions.

These chemicophysical systems do not have the relatively instantaneous response time of the purely physical devices because there is a certain time delay involved in the gas-scrubbing process, the chemical reaction time, and the reagent flow system. Consequently, the 90% response times are on the order of 5 to 30 minutes versus 5 to 30 seconds for the physical systems.

Photometric (Chemiluminescent) Methods

These methods[16] involve detection of emissive radiation by photometric techniques. The emission of radiation is stimulated either chemically by a gas-solid or gas-gas chemiluminescent interaction or thermal-chemically by a gas/hydrogen-flame chemiluminescent interaction.

An ozone analyzer, based on the chemiluminescent reaction of O_3 with Rhodamine B absorbed on silica gel and on photometric detection of the resultant emission, gives a measure directly related to the mass of ozone flowing over the dye per unit of time (Figure V-4). Emission is at 585 nm, and sensitivity of the method is 1.0 to 10 ppb.

The gas-gas chemiluminescent reaction utilizes a similar approach in the photometric detection of the resultant emission. Ethylene-ozone and ozone-NO are reactions that have been developed for ozone and nitric oxide analyses, respectively. Sensitivities are in the 1.0 to 10 ppb range, and interferences appear to be negligible.

Flame photometric detection (FPD), based on strong luminescent emissions between 300- and 423-nm wavelengths, has been applied to sulfur compounds introduced into hydrogen-rich flames (Figure V-5). Use of a narrow-band optical filter with transmission at 394 nm (± 5 nm) gives a specificity ratio of sulfur to nonsulfur compounds on the order of 10^4. The method has a sensitivity for sulfur compounds (SO_2, H_2S, CS_2, CH_3SH) on the order of 1.0 to 10 ppb. Response of the method for compounds with sulfur contents in excess of 50% by weight is linear for concentrations in the

range from 5 ppm to about 1.0 ppm.

Although the FPD method primarily gives a measure of total sulfur, this method combined with gas chromatography provides the capability to separate and measure each sulfur compound in a mixture of sulfur compounds. Since the system response to the various sulfur compounds is the same for equal concentrations (Figure V-6), calibration of the system for each compound of interest is not necessary.

Magnetic Methods

Paramagnetic Analyzers

The paramagnetism of oxygen, a conspicuously distinctive physical property of oxygen compared to other gases, provides a method by which it may be detected under the influence of a magnetic field. In practice, an air sample is introduced into an electrically heated cross tube of an annular chamber, half of which is exposed to the field of a strong magnet. As the oxygen molecules are attracted to the region of higher field strength, the resultant air flow partially cools the heating coil. The difference in the electrical resistances of both parts of the heating coil constitutes a measure of the oxygen concentration.

Mass Spectroscopy

In principle, mass spectroscopy consists of the deflection of ionized molecules subjected to a magnetic field and their classification in accordance with their mass and charge. The current intensity detected is proportional to the number of particles in each class. The sample size required is very small, on the order of 1.0 μL of gas. Specificity is high because individual particle classes are detected with instruments having high resolution. The detection limit for SO_2, for example, has been reported on the order of 0.001 μL. Mass spectrometry has been combined with gas chromatography for the identification of chromatographic fractions and peaks.

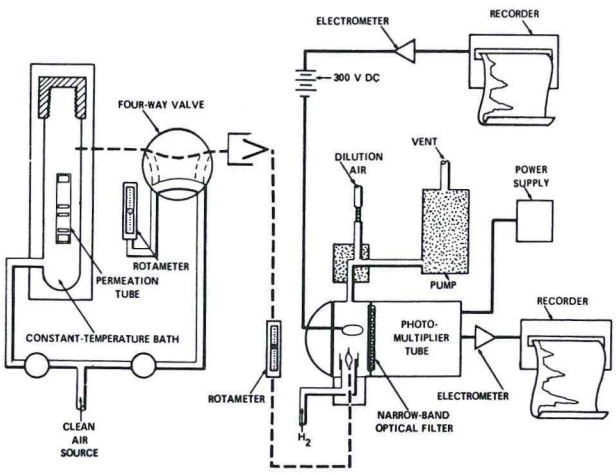

FIGURE V-5. Flame photometric detector sulfur compounds.

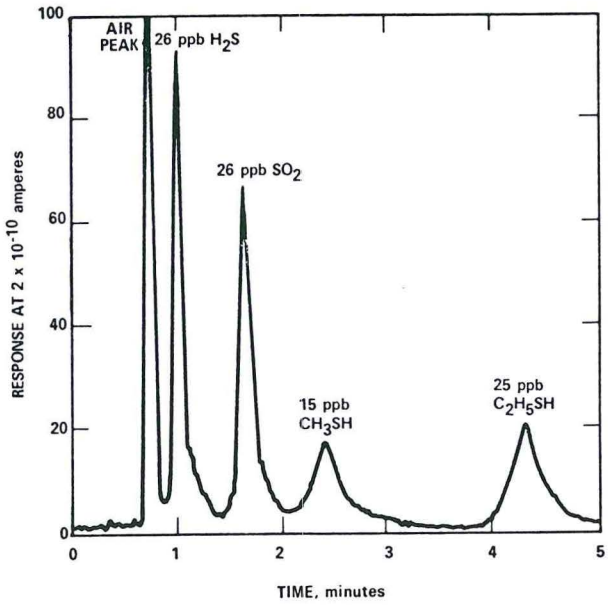

FIGURE V-6. Gas-chromatographic/flame photometric detection system response to mixtures of SO_2, H_2S, CH_3SH, C_2H_5SH in air.

Special Case-Gas Chromatography

In gas absorption chromatography, the components of a mixture migrate differentially in a porous sorptive medium. The method does not serve directly for the detection of substances nor does it provide an estimate in the absolute sense. Chromatography is primarily a method of resolving complex mixtures, and this depends upon the differential migration of the components through the porous medium. This differential migration is carried out so that each component separates as a discrete substance. The separated substances appear in a carrier gas as a function of time as the carrier gas passes through the absorption column. Detection of the separated components takes place as the carrier gas emerges from the column.

As an analytical system, gas chromatography utilizes various sensitive detection techniques. The detection methods are not necessarily specific because the chromatographic method itself is highly specific. Early detection was based on thermal conductivity cells. Methods are now used to measure trace components on the order of 1.0 to 10^3 ppb. These include the flame-ionization method (Figure V-1) and the flame photometric method (Figure V-5) described earlier.

A chromatographic system consisting of an absorption column and a detection unit is selected with the following considerations: 1) the nature and concentration of the associated components in the mixture from which the separation is to be made; 2) the nature and concentration of the component to be measured; 3) the resolving ability of the absorbing column, its stability,

contaminants, and temperature characteristics; and 4) the sensitivity of the detection cell, its reproducibility, stability, and response time.

Analysis for a specific component requires a method, either specific or nonspecific, for the detection and identification of the isolated components of a mixture. The use of particular reference substances and the sorption time sequence technique are suitable methods. In addition, under standardized conditions, the relative migration of carrier gas and components can be used.

Sampling Schemes

A gas pollutant measurement with a direct readout instrument involves some sampling scheme that is inherent in the measurement technique. The two basic parameters that define the sample are time and space. This is to say a valid interpretation of the analytical measurement requires information on the environmental sample with respect to time and the space it occupied during this time. A measurement that is made in real time and on a continuous basis, as in many monitoring devices, is considered instantaneous in time. The actual sample volume represented by the analysis depends upon the air flow rate and the response time of the analytical system. The response time may be in excess of a minute or two, or the analytical results may be integrated electronically to give an average concentration measurement over a period of time. Thus, a gas measurement can be integrated over a period of time by the sampling technique itself prior to analysis. For example, the gas may be absorbed in a reagent in a bubbler for several minutes and subsequently analyzed with the cycle repeated for each measurement.

Traditionally, gas measurement involves sampling at a point or through an inlet opening at the end of a probe or tube. This constitutes point or probe sampling and represents a measurement of gas concentration of a small volume of the environment in the vicinity of the probe inlet. On the other hand, long-path sampling usually consisting of an electro-optical method, involves a large spatial sample of meters to kilometers in length over a single path length. In this case, the measurement represents the instantaneous concentration over the spatial path. If point sampling is executed from a moving vehicle or over a prescribed path length, one can also arrive at an average spatial concentration. Strictly speaking, however, it is not identical to the instantaneous spatial average achieved by the electro-optical method, although under certain conditions one can closely approach the same end result.

Summary

A brief discussion has been presented on the principles of detection and measurement of gases by direct-reading instruments. These techniques range from traditional methods involving well-known physical principles of conductivity, coulometry, and colorimetry, to advanced methods of Raman scattering and chemiluminescence; from the traditional point sampling methods to the latest long-path, electro-optical schemes. The merits of any particular measurement technique have to be judged both by the performance specifications of the instrument and the conditions under which the application of the instrument is to be made.

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Instrument Descriptions

This section contains tables and short descriptions of the commercially available direct-reading instruments for gases and vapors. The tables are designed to provide an overview of the instrument features, size, and capabilities while the descriptions give more detailed information and photographs. Each description is numbered and is cross referenced in the tables which appear at the end of the chapter. The descriptions are grouped by the operating principle upon which the measurement is based. The instrument tables are as follow:

Table VI-1. Electrical Conductivity Analyzers
Table VI-2. Potentiometric Analyzers
Table VI-3. Coulometric Analyzers
Table VI-4. Flame Ionization Detectors
Table VI-5. Thermal Conductivity Detectors
Table VI-6. Heat of Combustion Detectors
Table VI-7. Colorimetric Analyzers
Table VI-8. Infrared Photometers
Table VI-9. Ultraviolet and Visible Light Photometers
Table VI-10. Photometric Analyzers
Table VI-11. Photometric Analyzers of Surface Deposits
Table VI-12. Paramagnetic Analyzers
Table VI-13. Aerosol Formation and Detection Systems
Table VI-14. Electron Capture Detectors
Table VI-15. Photoionization Detectors
Table VI-16. Gas Chromatographic Analyzers
Table VI-17. Conductivity Analyzers
Table VI-18. Infrared Photoacoustic Analyzers

These tables reference instrument manufacturers by code letters; complete names, addresses, and telephone numbers are given in Table VI-19.

Electrical Conductivity Analyzers

V-1.1 J-W Toxic Gas Alarms for NH_3, H_2S, and SO_2
Bacharach, Inc.

The Model MHO is used to continuously detect the presence of small concentrations of ammonia, H_2S, and SO_2 in the toxic range. Air is sampled by means of a vibratory pump, and H_2S in the sample is oxidized to SO_2. In the detection cell, the sample contacts a flowing stream of distilled water. Ammonia or SO_2 in the sample dissolves in the water, which increases the conductivity of the water. This conductivity change triggers a thyratron tube to turn on a relay and alarm signal. The complete analyzer is housed in a small, wall-mounted case containing the detection cell, power supply, vibratory pump, flowmeter, alarm circuit, and all other required components. A constant flow of distilled water

is fed by gravity from a one-gallon plastic bottle mounted on the wall above the analyzer.

V-1.2 UltraGas-U3S Sulfur Dioxide Analyzer
Calibrated Instruments, Inc.

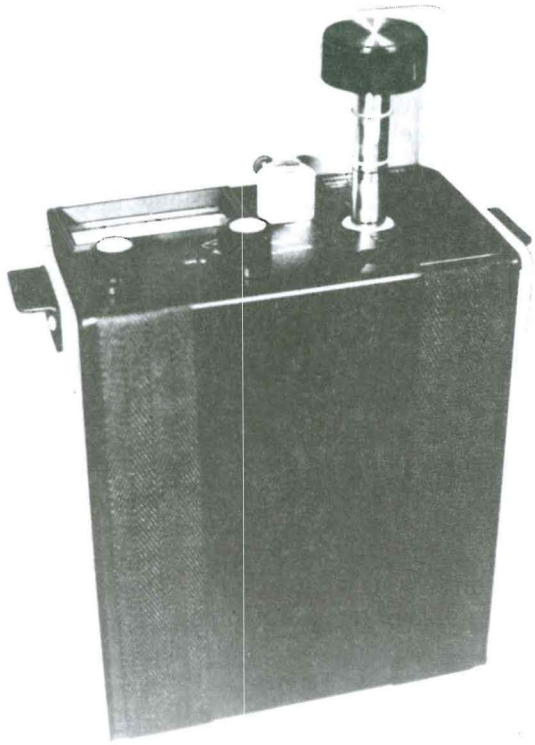
The UltraGas-U3S is a sampling and analysis device for measuring the concentration of SO_2 in air by the conductivity method. Existing interference components can be eliminated in most cases through suitable absorption traps so that measurement is selective. In the instrument, a constant and continuous stream of air and reagent mix in a reaction chamber. The conductivity of the solution changes in proportion to the concentration of SO_2. The conductivity change is determined in the detector by two electrode sections. The conductivity of the reagent is measured first in one section, and after reaction with SO_2, the conductivity is measured in the second section. The difference in the two alternating currents flowing through the two electrode sections is selected electronically by the recorder. A temperature-dependent resistance compensates for temperature changes.

V-1.3 SO_2 Sampler
Casella London, Ltd.

This instrument is used to measure airborne SO_2 and was designed for portable use in ambient air. It measures the change in conductivity of an electrolyte through which air with SO_2 has been bubbled. Absorption of SO_2 and its production of H_2SO_4 produces a change in conductivity directly proportional to the amount of SO_2 present in the volume of air drawn through. Temperature compensation from 0°C to 40°C is provided, and the sampling period can be varied from a few minutes up to 24 hours from rechargeable batteries. Aspiration rate is 1.0 L/min. There is a matching battery-operated programmer/recorder that is connected to the sampler by a multipin socket on the front panel. This programs the sampler to operate unattended at preset intervals of 1, 2, 4, and 8 times per hour. Running time is 30 hours when set for 8 recordings/hour; chart capacity is 62 hours at this recording rate.

V-1.4 SO_2 Ultra Portable Analyzer, Model U2-D5
CEA Instruments, Inc.

The U2-D5 portable analzyer measures the electrical conductivity resulting from the reaction of SO_2 and H_2O_2. It can be used for industrial hygiene and air pollution measurements. Buffering effects from CO_2 are eliminated because the analyzer operates on an acidified peroxide solution. The peroxide oxidizes SO_2 into sulfuric acid. Chassis and case are made of aluminum, thermoplastics, stainless steel, Viton®, buna-n, and carbon. Initial response time: one second, complete; integrated readout, approximately three minutes. Operating temperature range: 2°C to 49°C. Sample cell volume: 0.3 ml. Reservoir volume: approximately 150 ml. Air sample volume: 100 cc. Readout: 2.5 in. tautband, 1 mA DC meter.

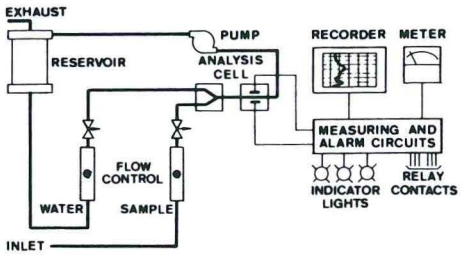


INSTRUMENT V-1.4. Model U2-D5 portable SO_2 analyzer.

V-1.5 Gas Analyzer System, Series 9000
Devco Engineering, Inc.

The Devco Engineering Series 9000 is designed specifically for the continuous monitoring of toxic gases or vapors in the atmosphere or of trace concentrations of contaminants in process streams. Typical applications include monitoring for CO_2, Freon®, or ammonia in refrigeration plants; continuous monitoring for SO_2 in air pollution studies; automatic bed cycling by continuously monitoring the effluent in solvent recovery systems; measuring H_2S in air and hydrocarbon streams in petroleum refineries or sewage treatment plants. Analysis is based on measurement of electrical conductance in water due to ionization of the gas or vapor being monitored.

Prior to analysis, certain gases, such as H_2S or the halogenated hydrocarbons, are treated by thermal decomposition or oxidation in a pyrolysis train; the

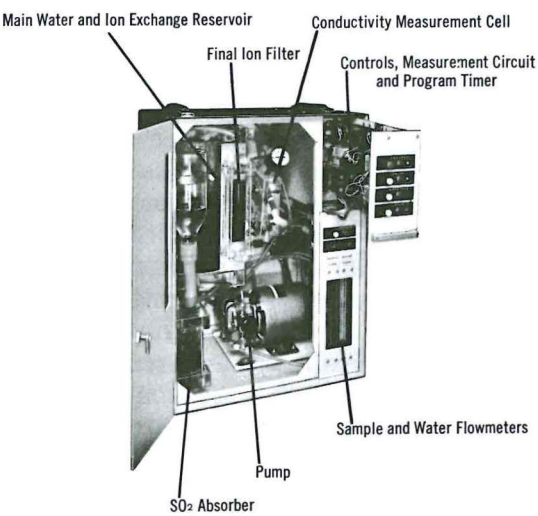


INSTRUMENT V-1.5. Component and flow schematic for the Devco Series 9000 gas analyzer.

emanating combustion products are then passed on to the analysis cell. This system is furnished in wall-mounting, in NEMA type 12 enclosures, in free standing relay rack-type housings, in portable packages (115 VAC, 60 Hz operated), or in fully explosion-proof construction. No special reagents are required; two quarts water are required approximately every 30 days. Multipoint, sequential sampling systems are available to monitor up to eight points on a single instrument by means of a sample program assembly.

V-1.6 Davis Electro-Conductivity Analyzers
Scott Aviation

The Davis Electro-Conductivity Analyzer is designed for the continuous measurement of atmospheric concentrations of contaminants such as SO_2, Cl_2, CCl_4, H_2S, NO_x, hydrazine, and methyl chloride. In general, it will respond to gases or vapors that will ionize in water, either directly or after decomposition or oxidation by a pyrolyzing furnace. These units are available as permanently installed units or in compact versions that are suited to mobile applications such as air pollution survey work. The measuring principle utilized is the measurement of conductivity after a gas sample ionizes in water. Certain gases will not ionize directly in water; these require a pyrolyzing furnace to oxidize or decompose into components that will ionize in water. Typical of such gases are H_2S and phosgene.



INSTRUMENT V-1.6. Model 11-7010-RP, portable Recording Electro-Conductivity Analyzer.

The system components are completely housed in a self-supporting cubicle, which is finished in a grey Hammertone enamel. The Portable Recording Electro-Conductivity Analyzer, Model 11-7010-RP, is intended for air pollution survey work. Systems are available as single or multiple point systems that will periodically check several locations for presence of the particular gas being detected.

Potentiometric Analyzers

V-2.1 Series 7 Portable Toxic Gas Monitors
CEA Instruments, Inc.

Self-contained and intrinsically safe, Series 7 monitors are applicable to a wide range of industries. These monitors utilize electrochemical sensors with a built-in sample pump, digital LCD, and microprocessor control. Besides the digital readouts, the dot-matrix display gives instruction and caution information. Response time: 90% within 30 seconds; HCl, within 60 seconds. Operating temperature: -10°C to +40°C below 90% relative humidity. In addition to a visual display, a continuous, audible tone is produced to indicate low battery or sensor fault.

V-2.2 Series U Toxic Gas Detectors
CEA Instruments, Inc.

The Series U instruments are dedicated gas detectors in portable, wall-mounted, or multipoint configurations for a variety of contaminants. All instruments in this series utilize electrochemical-type sensors. The diffusion-type sensors are guaranteed for two years, provide rapid response, are solid-state, and UL approved. Other features include low battery warning lights; built-in battery charger; high poison resistance to sulfur, lead, silicon, and halogenated compounds; and rugged, compact, leather carrying case. Operating temperature: -20°C to +65°C.

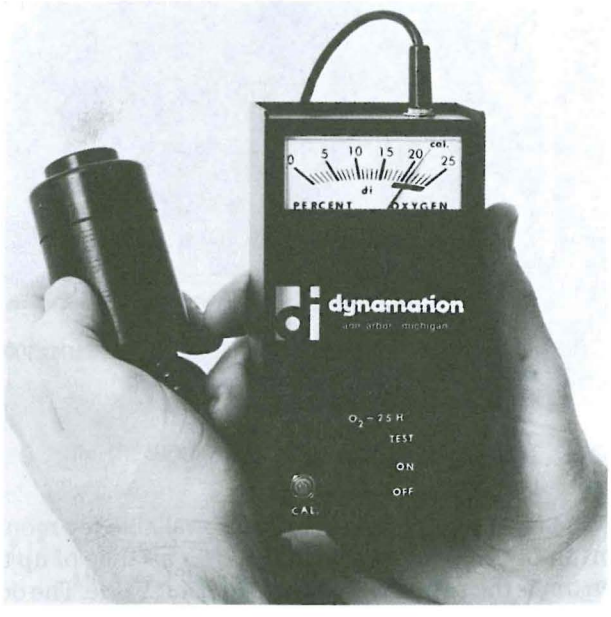
V-2.3 TGA Series Portable Toxic Gas Analyzers
CEA Instruments, Inc.

The TGA Series Analyzers utilize a dedicated gas membrane, galvanic cell (electrochemical) sensor. The analyzer is comprised of a sensor unit, vacuum pump, and an amplifier unit. The gas permeates the membrane causing a reduction in current at the surface of the working electrode. Response time: typically ⅓ of full

scale is achieved in less than 30 seconds. Alarm point: ⅓ of full scale (adjustable) with flashing red lamp (latching) and audible buzzer. Sampling distance: up to 30 feet. Sample flow rate: 0.5 L/min (adjustable). Recorder output: 0 to 10 mV (option 4 to 20 mA). Alarm contact closures: NO/NC, 250 VAC, 1A capacity. Operating temperature: 0°C to 40°C

V-2.4 O_2–25H Oxygen Meter
Dynamation, Inc.

The Dynamation oxygen sensor is a microfuel cell which has a life expectancy of one year before replacement is required. Cell replacement requires less than one minute. The O_2–25H has low maintenance requirements since no chemicals or electrolyte needs to be changed or added. The only control is a calibration adjustment which is used to set the meter at 20.9% O_2 before testing. Standard equipment includes a flexible cord and remote cable. This cable can be extended up to 8 feet for remote sampling; a 25-foot extension cord is an available option. Response time: 90% in less than 10 seconds. Temperature range: 0°C to 52°C.



INSTRUMENT V-2.4. Dynamation oxygen meter, Model O_2–25H.

V-2.5 MONOGARD and dynaMite Personal Monitors
Dynamation, Inc.

The MONOGARD and dynaMite Series of pocket-sized instruments combines digital LCD and diffusion chemical cell sensing for CO, H_2S, O_2, SO_2, and NO. The units feature an audible, pulsating alarm and a visual flashing light when unsafe atmospheres are encountered. Each unit has a low battery alarm, test switch, and illuminated display switch for reading in dark areas. All alarm points are factory set and customer adjustable. MONOGARDS are enclosed in rugged aluminum cases with leatherette carrying cases. The dynaMite gives more than 250 hours of continuous operation from its replaceable lithium battery. Operating temperature for the monitors ranges from 0°C to 41°C or to 52°C. Response time is 90% of full reading in 30 seconds. Monitors warm up in less than 10 seconds. The expected sensor life is 1.5 years (6-month warranty).

V-2.6 Series 300 Air Pollution Analyzers
Eitel Manufacturing, Inc.

These analyzers are designed to provide drift-free performance and reliability for continuous, unattended monitoring. Systems for single or multigas determinations are available in ranges covering source emissions, occupational exposures, or ambient air concentrations. The gas sample flows across a membrane during its passage through the Faristor. Some gas molecules diffuse through the membrane and dissolve in a thin liquid film where they undergo electro-oxidation or reduction. An opposite reaction occurs at the reference, resulting in current flow in the load circuit proportional to the pollutant concentration. The Faristor is plugged into the slot in the rear panel of the instrument and gas connection is made through polypropylene fittings on the outside of the module.

Linearity: ± 0.5%. Zero drift: ± 0.5%/24 hours. Span drift: ± 1%/week. Response time: 5–15 seconds to 95%. Ambient temperature: 32°C to 39°C. Temperature compensation: 4°C to 52°C. Sample pressure: not greater than 15 psig. Sample flow: 0.5 to 2 L/min. Recorder output: 100 mV.

INSTRUMENT V-2.6. Eitel Manufacturing's SO_2/NO_x analyzer. Left to right: front view; Faristor modules; rear view, showing plug-in slots for Faristors.

V-2.7 Microtox® and Microco® Personal Monitors
GfG Gas Electronics, Inc.

The G3000 series toxic monitors are hand-held,

lightweight monitors available for CO (Microco®) and H_2S (Microtox®). Both the Microco and Microtox utilize diffusion input electrochemical cells. The cells are designed to last 1 to 2 years with little maintenance. A steel mesh diffusion screen and a Teflon® membrane protect the unit from dust and splash water. The rechargeable, sintered metal Ni-Cd battery pack powers the unit for over 100 hours of continuous operation on one charge. Both units utilize a three-chamber, 8-mm high digital display. Operating temperature for both units is 0°C to 53°C; response time is 15 seconds (T_{90}).

V-2.8 Polytector Personal Multigas Monitor
GfG Gas Electronics, Inc.

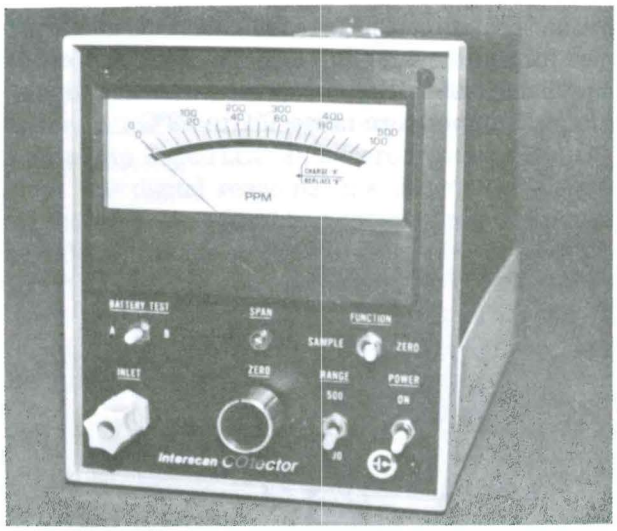
The Polytector combines three sensors into one hand-held, personal monitor. The monitor offers the option of diffusion sampling or the use of a continuous diaphragm pump. Several standard versions are available ranging from a three-channel gas detector to an atmospheric monitor and datalogger. The detection principle varies with the application requested, e.g., electrochemical for O_2, H_2S, and CO; catalytic combustion for methane or combustibles; N-type thermocouple sensor for temperature; and a thin film polymer for humidity. A variety of features are available including automatic datalogging capabilities with 8K of RAM, automatic calibration and zeroing, clock and alarm functions, automatic operating mode, interfaceable with IBM PC, backup power supply, and continuous update of software capabilities. All units are housed in polyamid 12, crack-resistant plastic. Operating temperature for all units is 0°C to 53°C. Optical/acoustic alarm system featuring four-character, 8-mm, digital display. Response times vary from 1 second (CH_4) to 15 seconds (CO).

V-2.9 Model CO260 Carbon Monoxide Monitor
Industrial Scientific Corporation

The CO260 Carbon Monoxide Monitor carries Mine Safety and Health Administration approval and is suitable for any work environment in which CO is a potential hazard. When equipped with an optional sampling pump and a length of flexible tubing, the CO260 also can take remote air samples of enclosed or confined areas prior to entry. The CO260 utilizes a diffusion-type electrochemical sensor. The digital LCD indicates CO concentrations over the range of 1 to 1999 ppm. Other features include audible and visual alarms for CO and low battery condition, replaceable alkaline batteries that provide 2400 hours of continuous (nonalarm) operation, backlighting of display for low-light operation, a dust-tight stainless steel case, and many flexible accessories. Operating temperature range is -10°C to +40°C.

V-2.10 Portable Gas Analyzers, Series 1000
Interscan Corporation

The Series 1000 operates on the electrochemical voltammetric sensor principle and is designed for ambient portable survey analysis or fixed round-the-clock use. The Interscan sensor is a leak-proof, two-electrode sensor, with a gel matrix inside the sensor that emits a free-floating electrolyte. Linearity: ± 1% of full scale. Zero drift: ± 1% of full scale (in 24 hours, this is equilibrated and at a constant temperature with sensor properly maintained). Span drift: less than ± 2% of full scale (24 hours, equilibrated and at a constant temperature with sensor properly maintained). Lag time: less than one second. Rise time: 20 seconds to 90% of final value or better. Fall time: 20 seconds to 10% of original value or better.



INSTRUMENT V-2.10. Interscan Portable Gas Analyzer, Series 1000.

V-2.11 Toxic Gas Dosimeters
Interscan Corporation

The Series 5000 dosimeters are available for monitoring CO, NO_2, H_2S, SO_2, and Cl_2 over a range of up to ten times the respective Threshold Limit Value. The dosimeters provide alarm features and stored one-minute average concentrations values. The dosimeters utilize a diffusion electrochemical voltammetric sensor. The sensor is a leak-proof, two-electrode sensor, with a gel matrix inside the sensor that emits a free-floating electrolyte. The sample diffuses across a membrane into the sensor where the analog signal is converted to a digital format. One-minute averages are computed and stored in random access memory. Nondestructive readout of the data is accomplished by plugging the dosimeter into a Metrosonics Metroreader where a variety of data is printed out. Rise time: 20 seconds to

90% of final value (or better). Fall time: 20 seconds to 10% of original value. Zero drift: ± 1.0% of full scale (24 hours). Span drift: ± 1.0% of full scale (24 hours).

V-2.12 Model 681 Formaldemeter
MDA Scientific, Inc.

The Model 681 is a portable, pocket-sized monitor for formaldehyde. The instrument uses an electrochemical fuel cell detector, consisting of two platinum electrodes that measure atmospheric formaldehyde vapor concentration by electrochemical reaction. Interferences: additive readings in presence of methanol, ethanol, formic acid, phenol, resorcinol, and furfuryl alcohol under certain conditions. Response time: 20 seconds. Stability: 2.5% drift over 6 months. Adjustments: zero and span potentiometers.

INSTRUMENT V-2.12. Model 681 Formaldemeter.

V-2.13 Monitox Personal Alarms
MDA Scientific, Inc.

The Monitox Personal Alarms are pocket-sized monitors that are available for a variety of toxic contaminants. The units are available in digital readout/alarm and alarm only modes. The alarms can be coupled with the Chronotox Data Acquisition System to provide exposure documentation over time. The Monitox utilizes a diffusion gel-type electrochemical sensor. Sophisticated circuitry allows enhanced stability, sensitivity, and reproducibility while minimizing zero drift. Many features are available with the Monitox system including a variety of alarm configurations, battery level indicator, easy calibration with the gas generator system, and long sensor life. Operating temperature range is 0°C to 45°C; low temperature option for operation down to -30°C is available. Gas generator's power source is a 9-volt alkaline battery, whose life is 800 functional checks.

V-2.14 MiniCO™ Carbon Monoxide Indicators
Mine Safety Appliances Company

The MSA MiniCO™ Carbon Monoxide Indicators are pocket-sized devices for measuring CO concentrations in ambient air. They operate on the principle of an electrochemical polarographic sensor cell. In operation, air samples diffuse through a gas porous membrane and a sintered metal disc to enter a chamber within the cell. The cell electro-oxidizes CO to CO_2 in proportion to the partial pressure in the chamber, and the resulting signal is amplified and temperature compensated to drive the meter. An adapter with aspirator bulb, using standard MSA sampling lines is available for remote sampling. The units are battery powered. The alarm set point is adjustable over the range of 25 to 500 ppm. All models have ± 2% precision and accuracy, 90% response time in 30 seconds, a span drift less than 2% full scale/day, and zero drift less than 1% full scale/day. MiniCO Indicators can be field-calibrated using the MSA Calibration Check Kit, Model R. Common interferents include SO_2, H_2S, NO_2, ethyl alcohol, and H_2.

INSTRUMENT V-2.14. MiniCo™ Carbon Monoxide Indicator.

V-2.15 Portable CO, H_2S, and Cl_2 Indicators
Mine Safety Appliances Company

The Model 70 for CO, Model 80 for H_2S, and Model 90 for Cl_2 are portable instruments designed for the detec-

tion of low concentrations of these gases in air. The instruments operate on the principle of an electrochemical polargraphic-type cell. In operation, the contaminant gas is reduced (Cl_2) or oxidized (CO and H_2S) in proportion to the partial pressure of the gas. The resulting electrical signal is monitored, temperature compensated, and amplified to drive a meter. Sampling rate: approximately 1.5 L/min. Response time: 90% of final reading in less than 30 seconds. Span and drift: less than 1% full scale/day. Calibration and zero adjustments are made with "lift-to-adjust" knobs. Unit is calibrated for use with an external 1-V, 1000-ohm impedance recorder. The MSA Calibration Check Kit, Model R, provides a convenient method of checking the response of the instrument.

V-2.16 ECOLYZER Portable Carbon Monoxide Monitor
National Draeger, Inc.

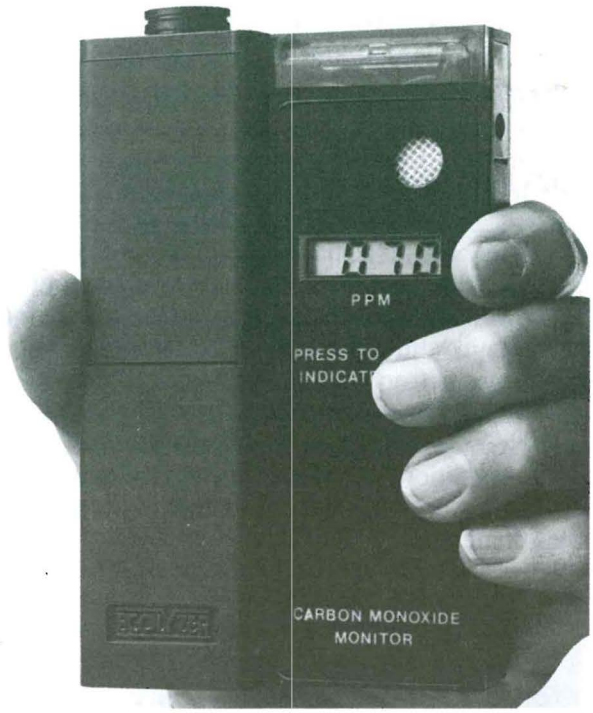
The Series 2000 ECOLYZER Portable Carbon Monoxide Monitor utilizes electrochemical oxidation at a potential-controlled, Teflon-bonded diffusion electrode for detection. Its stability is as follows: noncontinuous (spot checking) — typical spot checking operation during a work day, signal decay < 1%/24 hours over the life of instrument; continuous — signal decays by <1.5%/24 hours over the first 25 days and < 1%/24 hours subsequently. Response time: 25 seconds. Precision and accuracy: 1.0% full scale. Sampling rate: 700 cc/min. Readout mode: meter (110 div. full scale) and recorder.

V-2.17 Personal Carbon Monoxide Monitor
National Draeger, Inc.

The pocket-sized ECOLYZER Personal Carbon Monoxide Monitor for continuous monitoring of CO is designed for the personal protection of workers entering areas where there may be significant accumulations and sudden release of high concentrations of gas. The monitor features an adjustable stroboscopic visual alarm as well as an audible alarm. The unit employs a diffusion sensor utilizing a three-electrode, electrochemical detection principle. Rise time: < 60 seconds to 90% of signal. Accuracy: 5% of reading or ± 1.0 ppm. Span drift: 2% of reading per day or 2 ppm. Zero drift: < 5 ppm/day. Operating temperature range: 0°C to 40°C. Relative humidity range: 5% to 90%.

V-2.18 ENOLYZER Model 7100
National Draeger, Inc.

The ENOLYZER Model 7100 is a portable, direct-reading instrument for simultaneous and separate determination of NO and NO_2. The unit may be operated by rechargeable Ni-Cd batteries or line current. The instrument sensor utilizes an electrochemical reaction



INSTRUMENT V-2.17. Model 210 personal CO monitor.

at potential-controlled, Teflon-bonded diffusion electrodes. Response time: 90% NO, < 5 seconds; 90% NO_2, < 30 seconds. Precision and accuracy: ± 1% full scale for NO; ± 2% full scale for NO_2. Stability: noncontinuous (spot checking) — typical operation of spot checking during a work day, NO and NO_2 signal decay < 1%/24 hours.

V-2.19 EXOTOX Triple Gas Monitor
Neotronics

The EXOTOX Monitor offers the capability of monitoring O_2, combustible gases, and CO or H_2S in a single portable monitor. This monitor is especially designed for gas monitoring prior to entry into confined spaces and to give continuous protection to the individual while in the confined space. The EXOTOX utilizes electrochemical sensors for O_2, CO, and H_2S and low power pellisters for combustible gases. The sample enters the instrument by diffusion or can be aspirated from a confined source to the instrument. Sensor response can be read from a LCD display or via audible or visual alarms. Features include a built-in elapsed time display, computed time-weighted averages and short-term exposure limits, full RF protection, fast sensor response, minimal drift, small size, and lightweight. Operating temperatures: -15°C to +50°C. Storage temperature: -20°C to +55°C. Humidity: 0% to 100% (noncondensing). Drift: 0.6% to 1.5% over 200 days. Digital LCD readout: 20 mm × 38 mm. Battery life: approximately 10 hours per charge.

V-2.20 NEOTOX Pocket Personal Monitors
Neotronics

The NEOTOX monitors offer individual, lightweight, pocket-sized protection against the hazards of O_2 deficiency and enrichment, CO, and H_2S. The monitor incorporates a visual LCD display and lockable alarms in an intrinsically safe unit that fits in the pocket. The NEOTOX line utilizes the same electrochemical sensors incorporated in the EXOTOX for O_2, CO, and H_2S. Features include a three-digit, top-mounted LCD; water-tight membrane switches; visual and audible alarms; low battery indication; full RF protection; belt clip for easy carrying; water- and dust-proof design; and fast sensor response; units meet all international intrinsic safety standards. All monitors provide a 6-mm LCD digital display. Total drift for 200 days is between 0.06% and 1.5%. All are powered by 9-volt dry batteries which have a life span of 200 to 300 hours, depending upon the monitor used.

V-2.21 Ozone Recorder, Model 03T
Ozone Research and Equipment Corporation

This recorder is designed for atmospheric ozone measurement and ozone measurement in control rooms, laboratories, production plants, warehouses, etc. Ozone measurement is based upon the iodometric principle incorporated into an electronic loop feedback servo system that allows continuous measurement of ozone concentrations to as low as 3 pphm. The Model 03T samples at the rate of 4000 cc/min, allowing greater unit accuracy and less dependence on slight changes in sample air flow. The instrument will operate for three-day intervals without change in operation solution, allowing unattended operation over weekends and at night. Response time: normal atmospheric change, 90% of true value in 2 minutes. Chart speed: 1 in./hour. Chart period: 31 days. Options: alarm circuit and meter for remote signal.

V-2.22 Ozone Measurement Instrument, Model MSA-3
Ozone Research & Equipment Corporation

This portable instrument is used to determine ozone in air or O_2 for applications such as in ozone test chambers, other confined sources, process streams, and in the atmosphere. The principle of measurement is based upon the quantitative release of iodine from a buffered solution of potassium iodine in the titration with sodium thiosulfate of the released iodine. The Model MSA-3 employs the electrometric endpoint method, whereby the endpoint of the titration is indicated on a meter. In operation, the instrument is supplied with potassium iodide and sodium thiosulfate solution. With this method, there is no iodine volatilization factor since there is a fixed quantity of thiosulfate, and time (3 to 5 min) is the only variable. The measurement period ends upon the appearance of iodine which is sensed electrometrically. Other features include a dry vane vacuum pump and Pyrex-unitized construction of the reaction assembly with integral platinum electrodes and spray jet. Sampling rate: 3000 cc/min.

V-2.23 Sulfur Dioxide Analyzer/Recorder
Process Analyzers, Inc.

The Titrilog II is an automatic instrument for the determination of oxidizable sulfur compounds such as H_2S, SO_2, mercaptans, thiophene, and organic sulfides and disulfides. This instrument can be used for measurement in the atmosphere, in gas streams, and in stack gases. The measurement cell consists of an electrolyte containing potassium bromide from which free bromine is being generated electrolytically. In addition to the generating electrodes, there is a set of electrodes sensitive to free bromine. The potential of these electrodes varies with the concentration of free bromine in the solution. In order to distinguish between some of the different sulfur compounds, liquid absorptive filters are furnished as an accessory. These filters absorb one or more of the compounds of interest, enabling their concentration to be determined by difference. A programming system will route the sample through either of the filters, bypass the filters, and establish a zero level on an automatic repetitive cycle.

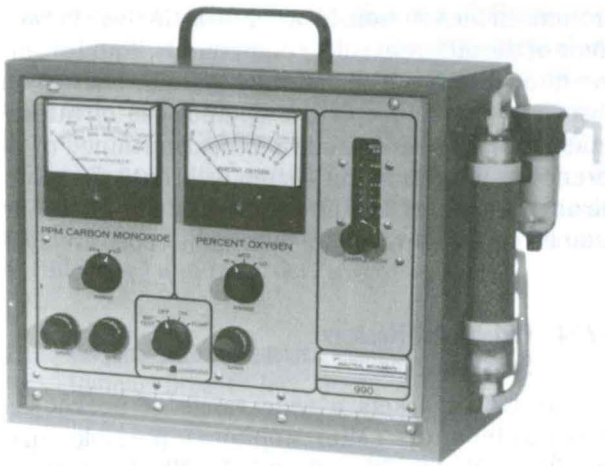
V-2.24 Portable Gas Monitors
Sensidyne, Inc.

Sensidyne markets a wide range of pocket-sized personal monitors (Mini Monitors), portable survey monitors (Series SS2000 and SS4000 for semiconductor gases), and a variety of fixed gas detection systems. The Mini Monitors and Series SS2000 monitors utilize diffusion electrochemical cells specifically designed for each gas to be detected. The lightweight (7 oz), pocket-sized Mini Monitors feature a continuous LED light-illuminated digital display, dual alarm set points, intrinsically safe design, replaceable batteries, RFI/EMI protection, and easy calibration. Additional features on the hand-held Series SS2000 include long-life sensors (3 years expected life), rechargeable batteries, optional continuous operation from AC power, triple alarm system, and ability to withstand temperature extremes. Response time: $<$ 20 seconds for Mini Monitors, 10 to 15 seconds for SS2000, $<$ 30 seconds for SS4000. Battery life: over 100 hours for Mini Monitors, 20 hours for SS2000, $<$ 35 hours for SS4000. Humidity range: 5% to 95% for Mini Monitors and SS2000; 20% to 90% for SS4000. Temperature range: 0°C to 40°C for all monitors.

V-2.25 Portable Flue Gas Analyzer
Teledyne Analytical Instruments

The Model 990 is a completely portable, battery-powered flue gas analyzer designed to rapidly monitor the O_2 and CO content of a combustion process. When these two measurements are combined for the purpose of maximizing fuel-burning efficiencies, boilers and heaters can be fine-tuned for optimum air/fuel ratios.

The CO trace measurement is accomplished by an electrochemical sensor (6-month warranty). The sensor output is directly proportional to the CO concentration. Zero and span drifts are less than 2% in 24 hours. A 90% of full-scale response is attained in 30 seconds or less. Operating temperature: 0°C to 50°C. O_2 analysis is accomplished with Teledyne's Micro-Fuel Cell (one-year warranty) which produces an electrical signal that is directly proportional and specific to the O_2 concentration in the flue gas. A 90% of full-scale response is attained in 13 seconds or less.



INSTRUMENT V-2.25. Portable Flue Gas Analyzer, Model 990.

Coulometric Analyzers

V-3.1 EA-1 Gas Analyzer
Adsistor Technology, Inc.

The EA-1 Gas Aanalyzer is a portable instrument for detection of flammable and nonflammable gases in the ppm and percent LEL ranges. The EA-1 utilizes the Cold Sensor™ element which does not burn vapor to detect gas. The Cold Sensor element operates on the principle of adsorption, the phenomenon which attracts and holds a molecule to the surface of a solid. The measure of this attractive force is known as the van der Waals' constant for the specific molecule. Gaseous diffusion carries the traces of toxic or explosive gas into contact with the adsorptive material in the sensor changing the sensor's electrical characteristics. The sensor's monitoring system is adjustable to the level of detection desired from small concentrations on the ppm scale (toxic gases) to a percent of the lower explosive limit (combustible gases). The system can transfer data to terminals or computers. Monitoring or alarm systems can be used to trigger corrective control systems.

INSTRUMENT V-3.1. EA-1 Gas Analyzer.

V-3.2 H_2S Sentox
Bacharach, Inc.

This instrument is a diffusion instrument used to detect H_2S gas in the range of 0 to 50 ppm. The H_2S Sentox operates on the oxidation-reduction principle. When exposed to H_2S gas, the metal oxide sensor is reduced and then returns to its normal oxide state when returned to an O_2 atmosphere. This change alters its ability to conduct electricity which is proportional to the concentration of H_2S.

V-3.3 J-W Oxygen Indicators
Bacharach, Inc.

The K Series of O_2 indicators are available in various models and ranges designed to meet the need for portable, fast response, indicating devices measuring in the low and medium O_2 percentage ranges. The Model GPK is a combined O_2/combustible gas indicating detector. Model HPK is a combination O_2/combustible gas indicator similar to the Model GPK except that it has two combustible gas ranges. Both of the combination detectors are also available in Bureau of Mines-approved versions. In the Model K O_2 indicators, the sample of the atmosphere to be tested is drawn into a self-generating electrolytic cell by means of an aspirator bulb. The current produced is directly proportional to the amount of O_2. Detector cell life for all models is 6

months and may be reactivated. The cell plugs into the instrument and may be replaced or reactivated in a matter of minutes. In the combination instruments, the combustible gas detector components are the same as those described under J-W Combustible Gas Indicators.

V-3.4 SNIFFER® 103 Portable Oxygen Deficiency Monitor
Bacharach, Inc.

The SNIFFER® 103 O_2 deficiency monitor is a lightweight, compact unit for use in entering into confined areas such as vessels, tanks, manholes, silos, pits, tunnels, shafts, or any other possible O_2 deficient areas. The SNIFFER 103 utilizes a diffusion electrochemical cell for O_2. The combustible model utilizes a catalytic (platinum bead) sensor. The sensor response is read on a LCD or can trigger an audible or visual (LED) alarm. Other features include continuous operation for 10 hours, low battery indicator, continuous safety (no on/off switch), intrinsically safe, utilizes 9-volt alkaline battery operation, and a convenient belt/pocket clip.

Continuous operating time: 10 hours at 25°C. Charging time: 14 to 16 hours. RFI Rejection: no alarms will trigger with 5W radio at 2 feet. Audible alarms include 1 Hz pulse rate for high combustibles, 3 Hz pulse rate for low O_2, and a steady tone for low battery or sensor failure. Visual displays include an alarm symbol for both high combustibles and low O_2, a broken battery symbol indicating low battery, a 100% LEL display, and a 0% O_2 display.

V-3.5 Model 946 Trace Acid/Base Monitoring System
Beckman Instruments, Inc.

The Beckman Model 946 Trace Acid/Base Monitoring System continuously measures trace acid or base concentrations in a variety of process streams. Applications include 1) HCl in vinyl chloride monomer product, 2) HCl in catalytic reformer recycle hydrogen, 3) trace acids in various hydrocarbon streams, and 4) trace ammonia leakage. The system combines the gas or vaporized liquid sample with a metered flow of demineralized water using precise flow control. The gas/liquid mixture flows to a separator where the gas phase is exhausted at the top, and the liquid phase is drained out the bottom into a stainless steel pH flow chamber that measures the pH of the water. The system measures any pH shifts and correlates them to ppm to continuously monitor trace quantities of acids or bases in process streams.

Response: 90% in 3 minutes. Sample flow rate: liquid from 10 to 25 cc/min to vaporizer; gas from 5 to 10 L/min; demineralized water flow rate from 100 to 200 cc/min. Quality of water from 1 to 10 megaohm/cc specific resistance (1 to 0.1 microohm/cm specific conductivity). Materials in contact with sample: stainless steel, glass, Teflon, Viton, PVC. Sample temperature compensation: automatic, from 0°C to 100°C. Ambient humidity limits: up to 99% RH. Ambient temperature limits: 0°C to 50°C.

V-3.6 Model OM-11EA/OM-11 Oxygen Analyzers
Beckman Instruments, Inc.

The Beckman Models OM-11EA and OM-11 are designed for monitoring vehicle emissions and other applications requiring precise measurement of rapid changes in the concentration of gaseous O_2. They are frequently used in emission measurement consoles and other multiparameter analytical systems. The analyzers use electrochemical technology for polargraphic O_2 analysis. The Models OM-11EA/OM-11 utilize a factory-charged, factory-sealed disposable O_2 sensor. The sensor has automatic temperature compensation at both normal and high temperatures. Designed principally for engine exhaust analysis, the Model OM-11EA is suited for console mounting. For applications requiring a remote sensor, the Model OM-11 has a 15-foot interconnection cable that allows the small, compact pick-up head to be remotely located in the most advantageous position.

Speed of response: 100 ms for fast mode (90%). Zero drift: ± 0.5% over 24 hours. Span drift: ± 1.0% over 24 hours. Noise: < 0.2% peak-to-peak. Linearity: ± 0.2%. Outputs: 10 mV, 100 mV, or 5 VDC. Sample flow rate: 0.14 to 0.28 m^3/hr (2.36 to 4.7 L/min). Sensor control temperature: 40°C ± 1°C. Ambient temperature limits: 4.4°C to 35°C. Ambient humidity limits: 0% to 95% RH.

INSTRUMENT V-3.6. OM-11 Oxygen Analyzer.

V-3.7 Ozone Analyzer, Model 950
Beckman Instruments, Inc.

The Beckman Ozone Analyzer is designed for continuous monitoring of photochemical oxidants. The

chemiluminescent method used is based on the principle that ozone reacts with ethylene to produce a light emission. Selectable recorder outputs of 10 mV, 100 mV, 1 V, and 5 V are available by means of a selector switch. During operation, ethylene is directed to the detector at a flow rate of 10 to 20 cc/min. A safety valve is incorporated on the ethylene flow and is designed to shut off the ethylene flow in the event of power failure.

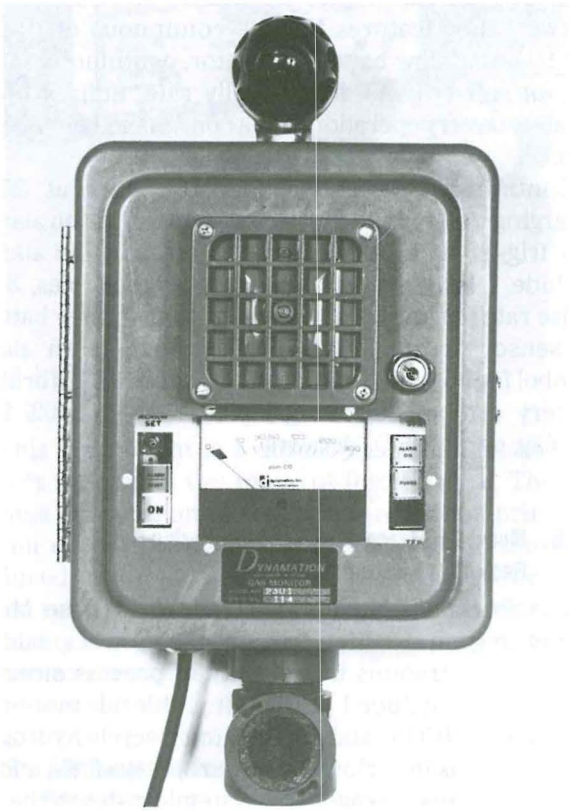
Air samples are introduced at a constant flow rate to the detector by an internal pump and flow control system. A standard for zero calibration is obtained by passing ambient air over a chemical scrubber to remove all traces of ozone. An optional ozone generator is offered which provides a convenient means of providing span checks. The air flow across the ozone generator provides a known level of ozone to the detector, plus the auxiliary flow permits correlations with the wet chemical KI method. Response time: 90% in 3 seconds. Zero and span drift: less than 1% per day. Operating period: 7 days or more. Noise: 0.5%. Operating temperature: 4°C to 38°C.

V-3.8 NO, NO_2, NO_x Monitor, Model 952
Beckman Instruments, Inc.

The Beckman NO, NO_2, NO_x Monitor is used to monitor the ambient atmosphere where the oxides of nitrogen concentration range between 0.1 and 10 ppm. The chemiluminescent detection principle incorporated in the Model 952 is based upon the reaction of NO with O_3 to produce NO_2, about 10% of which is electronically excited to a higher energy state. Return of the NO_2 molecule to its ground state results in emission of ultraviolet light. This light energy is measured by means of a photomultiplier and electronic circuitry and is directly proportional to the concentration of NO present in the sample. NO_x is determined by converting the NO_2 to NO, free of interference from other atmospheric compounds, and subsequent determination of the chemiluminescent reaction. NO_2 is determined by the electronic subtraction of NO from NO_x. Continuous outputs of 10 mV, 100 mV, 1 V, and 5 V are available for recording, telemetry, etc., of each parameter, i.e., NO, NO_x, and NO_2. In the flow control system, ambient air is employed for ozone generation by means of a pump and a UV lamp. Response time: 90% in 3 seconds. Zero and span drift: less than 1% per day. Operating period: 7 days or more. Noise: 0.5%. Operating temperature: 4°C to 38°C.

V-3.9 CO-Monitor
Dynamation, Inc.

The CO-Monitor, Model CO-2300 Carbon Monoxide Monitor/Alarm, is a fixed location monitor which will continuously indicate the level of CO in ppm on its meter. The Dynamation catalytic, semiconductor sensor system monitors the air by natural air diffusion and convection. The Model CO-2300's twin sensor system automatically compensates for humidity changes. Natural air diffusion and automatic humidity compensation eliminates the maintenance that is required in using other CO detection units. The catalytic, semiconductor sensors have a life expectancy of up to 5 years under normal use. Response: 90% of maximum reading within 20 seconds with 200 ppm CO concentration. Meter scale size: 3.5 in. Alarm: internally adjustable 10 to 300 ppm CO; factory set at 200 ppm, standard. Recorder output: available on terminal strip inside 0 to 1 mA current recorder standard.



INSTRUMENT V-3.9. Dynamation CO-Monitor, Model CO-2300.

V-3.10 Oxygen Analyzer, Model 60-620
Edmont-Wilson

Edmont Oxygen Meters are used to measure O_2 sufficiency for entry into confined spaces and residual O_2 in food packaging operations and in petrochemical processing; to monitor inert gas atmospheres used in welding operations, refrigeration systems, over vats and tanks; to check O_2 levels during catalyst regeneration; and to monitor combustion efficiency in boilers, annealing furnaces, and heat treatment processes. These

meters are available in four models which vary in size and options. Most units offer built-in warning light and sound alarm that signal when O_2 content drops below 19.5% or exceeds 22.5%.

Readout mode: % O_2 indicated on 6-cm meter. Interferences: concentrations higher than 0.25% (2500 ppm) of SO_2, halides, and the oxides of nitrogen read as O_2; mercaptans and H_2S in concentrations of 1% or more. Response time: 90% in 10 seconds. Stability: less than 1% drift during the first 2 weeks of operation when corrected for atmospheric pressure changes. Accuracy: $\pm$ 0.2 O_2 in calibration range and temperature. Temperature from 15°C to 50°C.

INSTRUMENT V-3.10 Edmont Oxygen Analyzer, Model 60-620.

V-3.11 Sulfur Dioxide Sensor
Ericson Instruments

The Ericson Sulfur Dioxide Sensor measures SO_2 down to the sub ppm level in gases and liquids; it also measures total content of sulfite and H_2S in solutions. Areas of application include analysis of SO_2 in air pollution, water pollution, pharmaceutical solutions, beverages, and chemical process streams. The sensor consists of an electrochemical cell covered with a membrane having a high permeability for SO_2. The SO_2 diffusion through the membrane causes an electrochemical reaction, giving rise to an electric current flowing through the sensor in accordance with Faraday's law. The membrane is impermeable for ions and large molecules. The electrochemical cell does not respond to gases such as O_2, CO_2, CO, NO_2, O_3, or Cl_2. In liquids, the sensor responds directly to the concentration of dissolved SO_2. To determine total dissolved sulfites, the pH of the solution must be considered. Analysis of total sulfite in a sample of unknown pH consists of mixing the sample with a pH buffer solution to fix the pH value, measuring the free SO_2 concentration with the sensor, and reading total sulfite concentration from the calibration curve taken in an identical pH buffer solution. Response time: 90% in 2 to 3 minutes. Background current: 1–2 $\times$ 10^{-9} amp. Temperature coefficient: about 3%/°C. Temperature range: 15° to 35°C. Unlimited lifetime; electrode needs solution refill every 2 months.

V-3.12 Personal Oxygen Monitor, Model OX-80
GasTech, Inc.

The GasTech Model OX-80 Personal Oxygen Monitor is a pocket-sized, lightweight instrument designed to continuously monitor O_2 and sound an alarm at a preset level of 19.5%. A pushbutton activates a digital readout. The top-mounted sensor may also be used remotely for tank entry testing. The OX-80 O_2 sensor is a diffusion electrochemical cell in which O_2 produces a chemical reaction directly proportional to the sampled atmosphere. The electrochemical cell is guaranteed for 6 months of operation before reactivation. Standard accessories include a plug-in battery charger, belt clip, and wrist strap; 15-in. and 30-in. O_2 cell extension cables and lapel-mount repeater buzzer are optional.

V-3.13 Microox® Personal Oxygen Deficiency Monitor
GfG Gas Electronics, Inc.

The Microox® is a pocket-sized monitor with an easy-to-read digital display and optical/acoustical alarm to warn of O_2 deficient conditions. It is Model 3012 in the G3000 Series which are in small, stainless steel cases and operate over 100 hours continuously between battery charges. The Microox uses a fuel cell sensor and is available with a remote 25-foot sensor, an adjustable alarm, rechargeable batteries, and a stainless steel case that is dust and waterproof. Temperature: 0°C to 53.3°C. Response time: T_{90} = 10 seconds. Cross sensitivity: partial pressure chlorine. Lifespan of sensor: 9 to 14 months. Display: 3-character digital, 8 mm high. Gas transport: diffusion.

V-3.14 Model OX231 Oxygen Monitor
Industrial Scientific Corporation

The OX231 Oxygen Monitor is designed to be intrinsically safe and carries MSHA approval. It is suitable for any work environment in which deficient O_2 levels are a potential hazard. This battery-operated, diffusion-type instrument is recommended for use in confined spaces such as manholes, tunnels, ships' holds, storage tanks, deep vats, closed compartments, and underground installations. The OX231 utilizes a diffusion electrochemical cell that can be replaced in the field without disassembling the case. Percent O_2 is displayed on a liquid crystal readout in increments of 0.1% O_2. Replaceable alkaline batteries provide 2400 hours of continuous operation. Other features include audible and

visual alarms of low O_2 levels and low battery condition, adjustable alarm level, backlighted display for low light situations, on–off switch to prevent accidental shutoff, and dust-tight stainless steel case. Temperature range: -15°C to +45°C.

V-3.15 Scen-Trio
Lumidor Safety Products

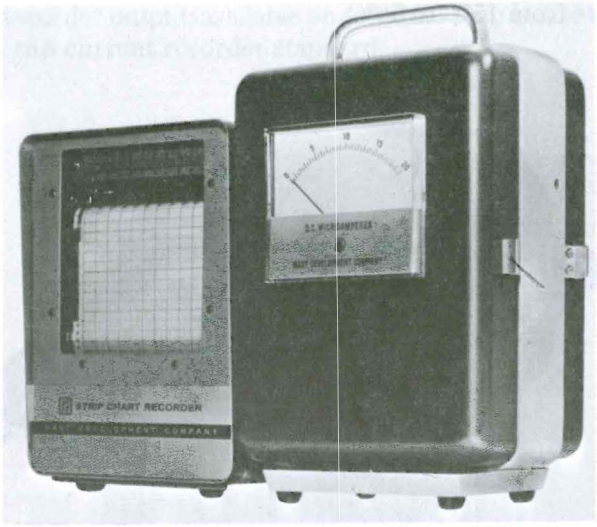
Scen-Trio is a continuous sensing device for three different categories of gases: explosives, toxic, and O_2. Both visual and audible alarms are activated when preset threshold levels have been exceeded. This portable, battery-powered, multigas detector/alarm has a rechargeable Ni-Cd battery pack and self-powered O_2 fuel cell. It is rated intrinsically safe for Class I, Division I, Groups A, B, C, and D. Scen-Trio operates with reasonable accuracy of alarm settings within the temperature range of -5°C to +45°C. Humidity range 15% to 100% RH when calibrated in 50% RH atmosphere and will operate at lower RH (5% to 20% RH) with good accuracy if calibrated in a dry atmosphere accordingly.

V-3.16 LP-COM-19GR Oxygen Monitor
Lumidor Safety Products/e.s.p. Inc.

The LP-COM-19GR is a hand-held O_2 deficiency monitor which features a detachable probe for remote monitoring. The monitor is suitable as a personal warning device or as a pre-entry monitor for confined spaces. The LP-COM-19GR utilizes a diffusion galvanic cell for measuring percent O_2 over the range of 0% to 50%. The cell should last for one year (warranted for 8 months). Other features include visual and audible alarm for low O_2 concentration and low battery, battery test switch, replaceable alkaline batteries, various length probe cords, easy sensor replacement, and a belt clip. Temperature range: -5 C to +40°C.

V-3.17 Portable Ozone and Oxidant Recorders
Mast Development Company

The Model 724-2 Ozone Meter, Model 725-11 Nitrogen Dioxide Meter, and Model 725-21 Microcoulomb Detector are portable, nonspecific electrochemical instruments that are used for the detection of O_3, NO_2, NO, Cl_2, I_2, F_2, and other strong oxidant vapors in low air concentrations. The microcoulomb sensor is used in all three instruments. Selectivity for specific oxidants is related to the concentration, pH, and composition of the electrolyte used. In the Model 724-2 Ozone Meter, the sensing of ozone in the air sample is accomplished by the oxidation-reduction of potassium iodide contained in the sensing solution. High concentrations of SO_2 negatively interfere with ozone determinations, but this interference can be eliminated by using the Model 725-30 SO_2 Filter Kit to trap the SO_2 before it enters the sensor. The microampmeters used on the Model 724-2 Ozone Meter and the Model 725-11 Nitrogen Dioxide Meter are calibrated directly in concentration units. Sampling rate: 140 cc/min. Rise and fall time: 1 minute. Operating temperature range: 0°C to 44°C. Unattended operating time: 3 days (except 30 days for Model 724-2L large reservoir ozone recorder).



INSTRUMENT V-3.17. Mast Model 725-21 Microcoulomb Recorder, with Model 725-3C strip chart recorder.

V-3.18 Model 3300 Oxygen Monitor
MDA Scientific, Inc.

The Model 3300 is designed for the detection and measurement of percent O_2 in a variety of work environments. Typical applications include pre-entry monitoring, personal monitoring, and O_2 therapy monitoring. The Model 3300 utilizes a diffusion electrochemical cell that is stable over a wide range of temperatures and humidities. The monitor is internally compensated for temperatures over the range of 0°C to 50°C. A variety of features are available including a choice of ranges (0% to 25% or 0% to 100%), replaceable 9-volt batteries, and alarm setting. Sensor charge life: approximately 1 month. Response time: 10 seconds (90% response). Battery life: approximately 300 hours.

V-3.19 Portable Oxygen Indicator, Models E & S
Mine Safety Appliances Company

The MSA Portable Oxygen Indicator measures O_2 concentration in gaseous mixtures. Model E operates in the range of 0% to 25% O_2 by volume; Model S has a

range of 5% to 40%. Both models are designed for ambient portable use in the testing of manholes, tunnels, tanks, and other enclosed spaces before entry. They can also provide O_2 measurement for combustion control, flue-gas testing, and similar process uses. The detection of O_2 by the Portable Oxygen Indicator is based on the principle of a primary galvanic cell. It consists of a negative zinc electrode and a positive carbon electrode in a special electrolyte called "Oxylite," which generates electricity in much the same manner as a dry cell battery. These battery-powered instruments include a line trap assembly feature that prevents liquids from being drawn into the instrument (the trap can also be filled with a Gasorbent to remove acid gases from the sample stream) and a sampling line that can be attached to a solid 4-foot probe rod for additional safety in testing enclosed spaces before entry.

INSTRUMENT V-3.19. MSA Portable Oxygen Indicator.

V-3.20 Oxygen Indicator Models 245, 245R, and 245RA
Mine Safety Appliances Company

MSA Oxygen Indicators are hand-held devices for measuring atmospheric concentrations of O_2 over a range of 0% to 25%. Model 245 is designed primarily for checking O_2 content in mines and the sensor is contained in the instrument case. Models 245R and 245RA house the sensor cell in a separate plastic holder at the end of a sampling cable. These models find broader application in industrial areas where remote sampling is frequently required. The Oxygen Indicator detects O_2 by a galvanic sensor cell containing a gold cathode and lead anode in a basic electrolyte. In operation, O_2 diffuses through the cell face to initiate redox reactions which, in turn, generate a minute current proportional to the O_2 partial pressure. External accessories: Model 245 — adapter for tube sampling, sampling line (5 feet, with couplings) with other lengths available; Models 245R and 245RA — replacement sensor with 10-foot cable, extension cables, 50-foot lengths. Safety provisions: Model 245RA is equipped with audio alarm which is factory set to activate when the O_2 concentration falls below 19.5%. (Alarm setpoint is adjustable internally.) Once activated, the alarm will sound continuously for up to 24 hours until manually deactivated or until the O_2 concentration rises above alarm setpoint. Response time: 90% in less than 20 seconds. All models can be calibrated quickly with uncontaminated fresh air, 20.8% O_2.

INSTRUMENT V-3.20. MSA Oxygen Indicator Model 245.

V-3.21 Toxgard® Monitor
Mine Safety Appliances Company

The MSA Toxgard® is an area monitoring instrument for measuring HCN, H_2S, and Cl_2. An amperometric-type instrument, the Toxgard Monitor contains two electrodes bathed in an electrolyte that flows into a porous glass cell. The center electrode is the reference; the outer electrode measures the gas concentration. As the sample gas diffuses into the cell, it contacts the "measuring" electrode and a current is generated proportional to its concentration. When there are no gases present, a zero shift of less than 1% full scale is typical.

V-3.22 Toxgard® Indicator, Model C
Mine Safety Appliances Company

The MSA Toxgard® Indicator, Model C, is a con-

tinuous monitoring instrument for use in the detection of H_2S, HCN, and CO. The instrument operates on the principle of an electrochemical polargraphic cell that oxidizes the gas of interest in proportion to its partial pressure in the sample atmosphere. Safety provisions: tamper-resistant controls; audible and visual alarms. Response time: 50% in 30 seconds, typically 90% in 120 seconds. Span and zero drift: 1%, 1 day maximum.

INSTRUMENT V-3.22. MSA Toxgard® Indicator, Model C.

V-3.23 Multi-Component Monitoring System For Air Pollution
Philips Electronic Instruments

This series of instruments allows continuous, automatic field monitoring of ambient air quality. Five of the measuring modules (SO_2, NO_2, NO, CO, H_2S) use the principle of coulometry, as used for the Model PW 9700. The gas of interest is bubbled through an electrolyte and, as a result, the concentration of one of the components of the electrolyte will change. CO is measured indirectly by the iodine released when CO is passed through heated iodine pentoxide. NO is measured as NO_2 after oxidation. Selective filters ensure that each module is specific for the pollutant it is to measure. Chemiluminescence was chosen for O_3 measurements. This is specific for O_3 and depends on the emission of light by Rhodamine B when exposed to ozone.

The modules are contained in a standard steel-framed, glass-reinforced plastic case for wall or panel mounting. One telemetering module provides up to 19 channels for control and data transmission. Span drift: $< 2\%$ in 24 hours after a stabilization period; 5% for O_3. Calibration: span and zero checks can be performed remotely, controlled with built-in standard source and zero filter. Interference error: negligible for all interfering gases in the concentrations occurring in the atmosphere. Climatological influence: the specifications are given for a temperature range of 0°C to 30°C. Output signal (before telemetry): 0–20 mA into 0–500 ohm. Maintenance: 3 months continuous operation without the need for service and/or maintenance.

V-3.24 Scott-Alert Model S103 Oxygen Indicator
Scott Aviation

The Scott-Alert Oxygen Indicator can be obtained in a single hand-held unit or combined with other sensors for combustibles, CO, or H_2S. Applications include entry to confined spaces, chemical plants, or occupational hazard surveys. The Model S103 utilizes a diffusion-type electrochemical cell which is capable of 20 hours of continuous operation. The percent O_2 readout is in large LCD digits that can be illuminated for low-light conditions. Other features include UL- and FM- Approved for Class I, Division I, Groups A, B, C, and D; memory capability that retains the lowest O_2 measurement taken; visual and audible alarms for low battery life, end of use, low or high concentration, and sensor failure; and sealed corrosion-resistant tactile feel and tactile location function switches. Display contains status legends for gas concentrations being measured and indicated. Speed of response: 20 seconds to 63% of O_2 change. Temperature limits: storage, -3°C to +60°C; operating, 0°C to 40°C.

V-3.25 Series 330 Personal Safety Oxygen Monitors
Teledyne Analytical Instruments

The Series 330 uses a disposable electrochemical cell which, in the presence of O_2, produces an output signal linear with and specific to O_2. This instrument has an integral meter readout and is applicable for use in confined space entry and occupational surveys.

V-3.26 Portable Gas Monitors, Joy Series 44000
Western Precipitation Division, Joy Manufacturing

Joy 44000 Series portable gas monitors are used to measure ambient air for compliance with OSHA requirements for NO_2, SO_2, H_2S, and CO. Models for stack sampling of SO_2, O_2, and NO_x are also available. A built-in pump draws a sample through a preconditioner and over an electrochemical sensor. The sensor generates a current proportional to the gas concentration which is amplified by a solid-state electronic pack and displayed on a meter. Output jacks for recorder input are provided, and an optional dosimeter (for 8-hour OSHA conformance checks) is available. A filter/scrubber cartridge is used to satisfy the requirements for stack gas conditioning. The cartridge is rated at 99.95% removal efficiency for particles of 0.6 μm or larger using the disposable filter tubes. Water con-

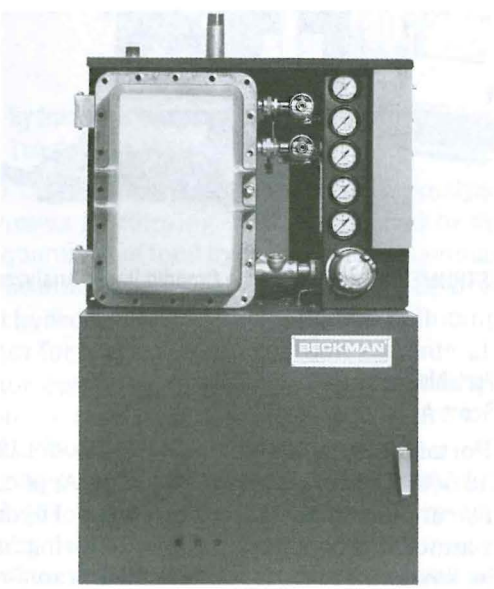
densate is also trapped in the filter cartridge and is easily removed. Interfering gases, if present, are removed in the scrubber portion of the cartridge using the scrubbing solution provided.

Flame Ionization Detectors

V-4.1 Model 6710 Analyzer
Beckman Instruments, Inc.

The Model 6710 Analyzer unit contains the chromatographic columns, detector system, sample injection, and column switching valves all in a temperature-controlled enclosure. The analyzer unit is designed for field location in hazardous areas with the electronics enclosed in an approved explosion-proof housing. Being self-sufficient, the analyzer may function on a "stand alone" basis for direct operation by a computer or Model 6710 Programmer. The analyzer may be provided with thermal conductivity (TC) or flame ionization detectors (FIDs). Four-element TC detectors are employed for most applications and provide a wide dynamic range from several hundred ppm to 100% full scale. The FID is specified for trace hydrocarbon analysis.

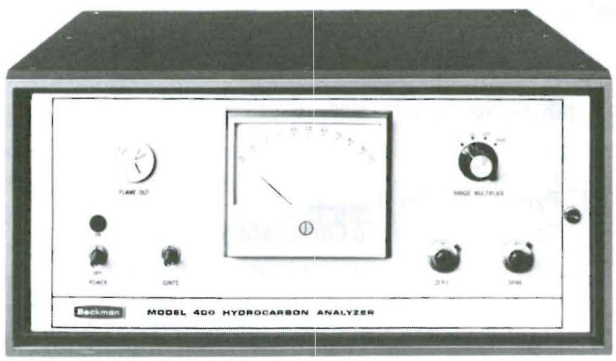
Ambient temperature limits for the analyzer are -29°C to +50°C and 0°C to 37.7°C for the programmer. Air requirements: 2 to 5 scfm (0.94-2.36 L/min) at 40 psig (207 kPa). Carrier gas requirements: 50 to 100 cc/min normal, varies with application. Sample flow: approximately 10 cc/min liquid or 100 cc/min vapor through analyzer (bypass as required). Operating temperature: 55°C to 225°C as required. Temperature control: ± 0.05°C. Location: up to 304.8 m (1000 ft) from analyzer maximum.



INSTRUMENT V-4.1. The Beckman Model 6710 Analyzer.

V-4.2 Model 400 Hydrocarbon Analyzer
Beckman Instruments, Inc.

The Model 400 employs the flame ionization detection method for use in a variety of engine exhaust applications. Its single-unit case is designed for panel, rack, or bench mounting. Case design permits front, top, and rear access to simplify maintenance. Noise: < than ± 0.5% of full scale. Zero and span drift: ± 1% of full scale per 24 hours. Response time: 90% of full scale in 0.5 seconds at bypass flow rate of 3000 cc/min. Output: 10 mV-, 100 mV-, 1 V-, or 5 VDC-selectable is standard; 40 to 20 mA, 10 to 50 mA DC, optional. Fuel gas requirement: hydrocarbon-free air. Sample requirements: 500 to 3000 cc/min at 5 to 10 psig, input, depending upon desired response time. Ambient temperature limits: 0°C to 43°C. Ambient humidity limits: 95% RH. Safety features: flame-out indicator, integral flame arrestor, and automatic fuel shut-off

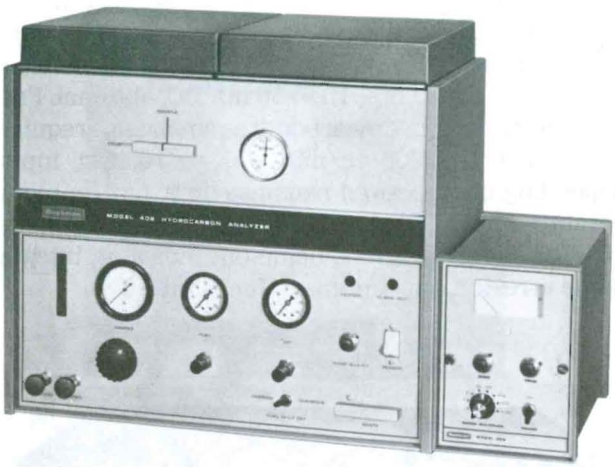


INSTRUMENT V-4.2. Beckman Model 400 Hydrocarbon Analyzer.

V-4.3 Model 402 Hydrocarbon Analyzer
Beckman Instruments, Inc.

The Beckman Model 402 Hydrocarbon Analyzer has been designed for direct analysis of raw exhaust from turbine engines, heavy-duty gasoline and diesel engines, and light-duty diesel engines. The Model 402 accurately measures hydrocarbons over a wide selection of eight full scale ranges using a flame ionization detector. During operation of the Model 4302, the sample is admitted to the analyzer at a flow rate of 6 ft^3/hour. Hydrogen/helium fuel and air flow rate to the burner are determined by regulating the gas pressure against controlled porosity restrictors. The admission of sample, fuel, and air to the burner results in the ionization current. Electronic range: 90% in less than one

second (with CH_4 from analyzer input without sample probe). Analysis temperature: 93°C to 204°C, adjustable. Ambient temperature limits: 0°C to 43°C. Electronic stability: ± 1% full scale/24 hours, with less than -12.2°C ambient temperature change. Ambient humidity limits: 95% RH. Output: 10 mV, 100 mV, 1 VDC, option. Temperature-controlled probe is available in 10- or 20-foot lengths; Teflon® surface in contact with sample (proportional temperature controlled and adjusted from 93°C to 204°C).



INSTRUMENT V-4.3. Model 402 Hydrocarbon Analyzer.

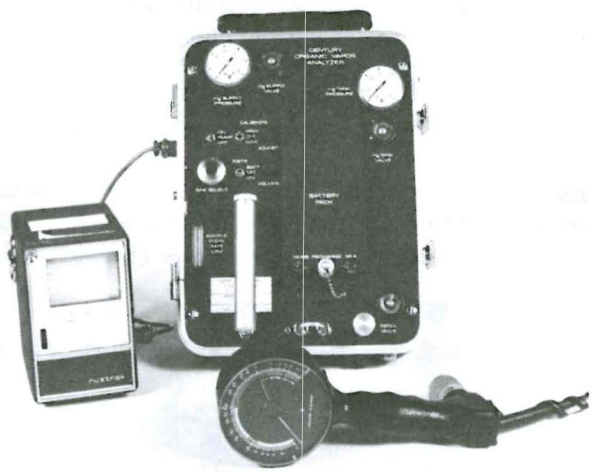
V-4.4 Hydrocarbon Gas Analyzer
Columbia Scientific Corporation

The HC5000 performs real time and continuous dry analysis of hydrocarbon gases utilizing a flame ionization detector (FID). Emphasis is focused on stable and reliable performance without a source of clean combustion air required. Thermal control of sample air, hydrogen, and exhaust gas is controlled to within ± 1% over 10°C to 40°C ambient temperature range. It closely approximates ppm hydrocarbon molecules rather than approximate methane equivalents as provided by FIDs operating in the gas chromatograph (GC) mode. Noise: ± 0.05 ppm CH_4. Lag time: < 15 seconds. Rise and fall time to 90%: < 30 seconds. Zero and span drift: ± 0.2 ppm/day; ± 0.3 ppm/3 days. Linearity: ± 0.1 ppm CH_4. Selectable time constant: 1 second or 10 seconds. Operational specifications: unattended operation (no adjustment of flow or electrical systems), 7 days. Sample flow rate: approximately 200 ml/min; hydrogen flow rate: approximately 140 ml/min.

V-4.5 Organic Vapor Analyzer
Foxboro Company

The Organic Vapor Analyzer (OVA) is designed to measure trace quantities of organic materials in air using a hydrogen flame ionization detection system. It has a single logarithmically scaled readout from 1 ppm to 100,000 ppm or with a lower maximum level, if desired. Designed for use as a portable survey instrument, it can also be readily adapted to fixed remote monitoring or mobile installations. The instrument response is read on a hand-held meter assembly or can be read utilizing the external monitor signal. An audible detection alarm is provided; it can be preset to any desired level and has a frequency modulated tone that varies as a function of the signal level. The standard instrument includes an audible flame-out alarm, battery test indicator, and internal electronic calibration.

Standard accessories include instrument carrying and storage case, high pressure fuel filling hose assembly, and AC battery charger. Response time: < 2 seconds. Sample flow rate: nominally 2 L/min. Fuel supply: 75-cc tank of pure hydrogen at maximum pressure of 2300 psig, fillable while in case. Service life: hydrogen supply and battery power — 8 hours operating time, minimum. The umbilical cord is 5 feet long with connectors for electrical cable and sample hose. In-line disposable and permanent particle filters are standard; activated charcoal filters are optional.

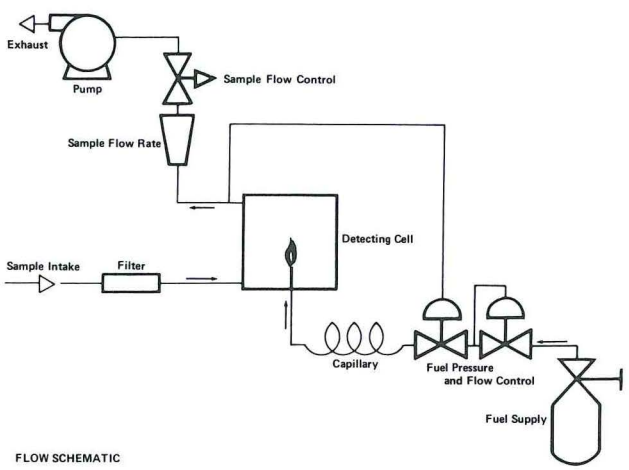


INSTRUMENT V-4.5. Foxboro Organic Vapor Analyzer.

V-4.6 Portable Flame Ionization Meter
Scott Aviation

The Portable Flame Ionization Meter, Model 11-654, is used to detect trace hydrocarbons in air. Applications of the instrument include 1) measurement of hydrocarbons as atmospheric pollutants; 2) montoring for fuel leaks in storage areas or during fuel transfer and loading operations; 3) measurement of hydrocarbons in liquid oxygen or inert purge gas; 4) monitoring for

toxic concentrations of solvents or process chemicals in manufacturing areas, ventilating systems, or storage areas; or 5) monitoring of manholes, sewers, and drains for accumulations of toxic or explosive gases. The basic principle of operation of this detector is ionization of hydrocarbon molecules in a hydrogen flame. Sample flow is obtained by an internal diaphragm-type pump. The fuel flow (40% hydrogen; 60% nitrogen) is controlled in two stages by a pressure regulator followed by a constant differential-type control. All controls necessary for operation of the system are mounted on the front panel. Recorder ouput terminals are available on the rear panel as are the fuses, sample inlet and exhaust connections, fuel supply controls, and electrical power input. Speed of response: varies directly with sample flow rate; 2 to 3 seconds, exclusive of external sample transport.



INSTRUMENT V-4.6. Schematic of Davis Flame Ionization Meter.

V-4.7 Hydrocarbon Analyzers, 400 Series
Teledyne Analytical Instruments

The TAI Series 400 flame ionization analyzers are continuous monitoring devices designed to measure trace quantities of total hydrocarbon contaminants in a gaseous atmosphere. The analyzer may be used 1) to detect hydrocarbons and atmospheric pollutants; 2) to monitor for fuel leakage or for toxic solvents; and 3) to monitor combustion efficiency by measuring hydro carbon emissions. In the Series 400, there are three models: Model 402 for positive pressure sampling; Model 403 for portable atmospheric sampling; and Model 404 for portable high temperature sampling. Constant temperature is maintained by a solid-state, thermistor temperature controller. Gas flows are regulated by maintaining a constant pressure across a sintered stainless steel restrictor in lieu of capillary tubing. An integral, self-purging manifold for introduction of span, zero, and sample gas is provided, allowing all operations to be performed at the front panel of the instrument.

The low-volume sample path, in conjunction with a variable sample bypass system, provides a fast response to process changes. Only one second is required for 90% response to a change from 10 ppm to 1000 ppm. Noise: $< \pm 0.5\%$ full scale. Drift: $< 1\%$ full scale per day. Output: linear signal meter readout provisions for 0 to 5 mV DC recorder. Ambient temperature: 4°C to 38°C. Flow rate: 100 ml to 400 ml/min of sample 40 ml to 50 ml of fuel (200 ft^3 cylinder lasts 3 months); fuel mixture of 40% hydrogen and 60% nitrogen. Pressure rating up to 100 psi.

V-4.8 AID Models 580 and 585 Portable Organic Vapor Analyzers
Thermo Electron Instruments

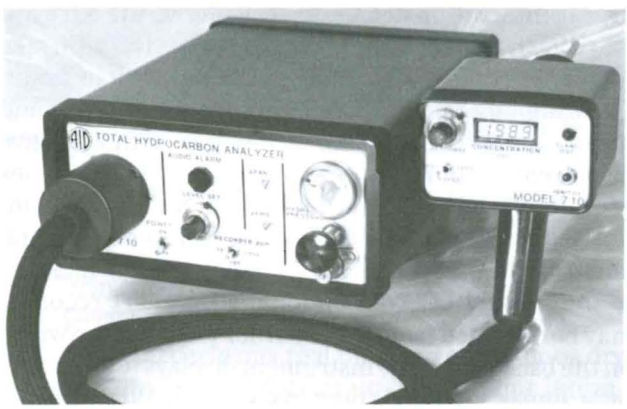
The AID 580 and 585 are portable monitors that use a photoionization detector (PID). The PID utilizes a high-energy ultraviolet lamp to ionize a sample that is drawn into the instrument. In general, the PID will respond to most organic compounds. It is insensitive to methane, ethane, and most of the permanent gases. The sampling rate is 500 ml/min for the AID 580 and 50 ml/min for the AID 585, each regulated by a positive displacement pump. Internal, rechargeable batteries provide 8 hours of continuous use. No fuel or compressed gases are required. The AID features an integral audio alarm that can be preset to any level. In addition to the normal LCD, an optional strip chart recorder may be operated from the recorder terminals provided on the back panel. The instrument displays information by a linear digital display. As with all PIDs, limited specificity is available by changing the energy of the photoionization lamp. Both instruments are equipped with a 10-eV lamp; an optional 11.8-eV lamp is available. Response time for the AID 580 is 2 seconds at 500 ml/min and 5 seconds for the AID 585 at 50 ml/min. A span and zero calibration control is provided on the front panel of the unit.

INSTRUMENT V-4.8. AID Model 580 Portable Organic Vapor Analyzer.

V-4.9 AID Models 710 and 712 Portable Total Hydrocarbon Analyzers

Thermo Electron Instruments

The AID 710 and 712 are designed as portable ambient monitors for use in the detection of fugitive emissions and other types of leaks using flame ionization detectors. The AID 710 and 712 are comprised of two units: the side pack and a gun. Samples are drawn in by a positive displacement pump at the rate of 1.5 L/min. The unit requires the availability of an external source of hydrogen to recharge the internal hydrogen supply. The AID 710 and 712 operate off an internal, rechargeable battery pack which supplies a minimum of 8 hours of power. The unit is provided with a high level audio alarm and a flame-out indication to determine when the operations are interrupted. An optional recorder may be connected to the instrument through the terminal jacks on the back of the unit. The response time of the unit is 5 seconds, 90% full scale. A zero and span potentiometer is provided on the front panel of each unit.

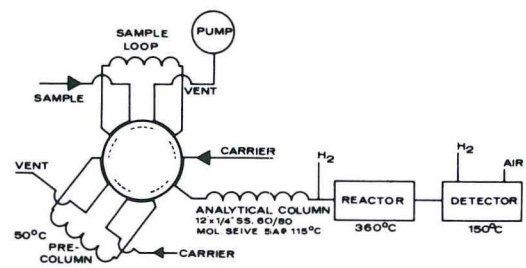


INSTRUMENT V-4.9. AID Model 710 Portable Total Hydrocarbon Analyzer.

V-4.10 350F Analyzer for CO/CH_4 and Total Hydrocarbons

Tracor, Inc.

The Tracor 350F Analyzer combines a gas chromatographic column with a flame ionization detector (FID) and can be used to measure concentrations of CO, methane, and total hydrocarbons. CO reacts with hydrogen in the presence of reduced nickel catalyst to quantitatively produce methane. The FID is coupled to the reactor for the measurement of the methane reactant. Selectivity is attained by using a precolumn prior to the analytical column that removes all interferents, passing only CO and CH_4. The analytical column then permits separate identification and quantification of both the CO and CH_4. Total hydrocarbons can be analyzed by introducing an ambient air sample directly to the flame during each analytical cycle. An integral flame-out H_2 cutoff is incorporated. The analytical column is housed in a heated mandrel oven. Temperature control is within 0.05°C, assuring reproducibility of analytical time. A panel-mounted pyrometer with a four-position selector switch enables the operator to monitor temperatures of all analytical parameters: valve oven, column oven, reactor, and detector. Fast-response thermocouples permit a full temperature/area profile within seconds.



INSTRUMENT V-4.10. Schematic of Tractor 350F for CO and CH_4.

Thermal Conductivity Detectors

V-5.1 Model 7-C Thermal Conductivity Analyzers

Beckman Instruments, Inc.

The Beckman 7-C Series Analyzers utilize the thermal conductivity (TC) principle of measurement to analyze the concentration of one component in a mixture of gases. These analyzers may be used in 1) power generating plants to detect hydrogen in generator cooling systems; 2) ammonia plants to measure

INSTRUMENT V-5.1. Model 7-C Thermal Conductivity Analyzer.

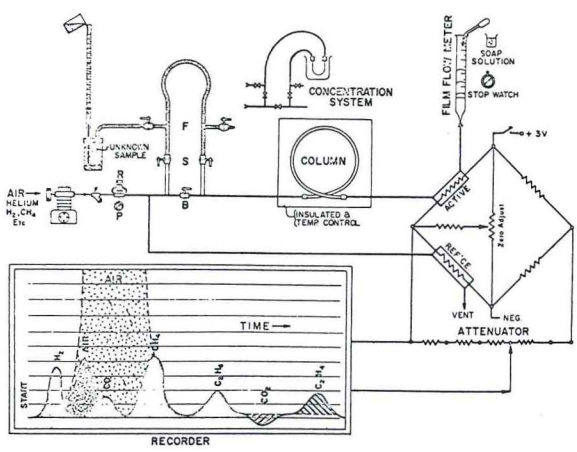
hydrogen in NO, ammonia, argon, CO, or O_2; 3) petroleum refineries to measure hydrogen in C through C_6 hydrocarbons; or 4) air liquefaction plants to measure argon in O_2 and NO, or measuring O_2 with argon impurities. The Beckman instruments use heated TC filaments in a Wheatstone bridge to detect gases. Cell response time: 95% of change in 30 seconds at a sample flow rate of 250 cc/min. Sample flow rate: nominally 50 to 350 cc/min. Reference gas flow rate: 5 to 10 cc/min; at these flow rates, a cylinder containing 200 ft^3 of gas will last over one year. Sample pressure is 0 to 50 psig (69 to 345 kPa). An indicating meter is available for most ranges. Ambient temperature limits: 4.4°C to 38°C. Explosion-proof enclosures are available for use in Class 1, Division 1, Group D, hazardous locations.

V-5.2 Analograph and Servocorder
Deutsch Engineering & Testing Services

The Analograph uses an air or helium carrier for determinations of selected compounds in air pollution analysis, flue gas analysis, utility gas identification, toxic gases, and breath gas analysis. The Analograph is a chromatograph which uses either catalytic combustion or thermal conductivity (TC) detection. A fully transistorized Servocorder is used to handle the detector signal and has full scale response of ⅛ second, zener reference voltage, multirange switch with an octave span from 1 mV to 1024 mV full scale response. Optional dual-column hot–cold detector in a top-opening metal case permits sharp peaks for fixed gases to C_{15} components.

The Analograph has recorder outlet terminals, fine and coarse zero adjust, and bridge voltmeter. It is supplied with partition column, carrier gas regulator, flow meter, operating manual, and technical papers complete with built-in TC and catalytic combustion detector, three sample tubes, zener diode power supply, and silica gel columns. Optional accessories include AC or DC sampling pumps, plastic sampling jars, special columns, and liquid injection syringes.

The Servocorder is portable in a two-tone black and gray case with carrying handle. Scale: 0–100 Chart: 26059-x with 0–100 range and 10/50 chart ruling, with a #206 synchronous motor rated for 110 V, 60 cycle providing a speed of ¾ in./min (chart speed selector optional). Maximum source impedance: 100,000 ohms. Zero adjust: full scale.



INSTRUMENT V-5.2. Schematic of chromatograph.

V-5.3 Leak Hunter Model 8065
Matheson Gas Products

The Matheson Model 8065 Leak Hunter is a portable, hand-held unit designed for leak detection of nonflammable gases. Leak detection is achieved by a microvolume, thermisterized, thermal conductivity (TC) detector cell mounted in the front end of the hand unit. Self-diagnostics are included to determine the status of the detection circuitry, current, and low battery conditions (displayed as visual and audible warnings). For noisy environments, earphones are supplied. Gases detected: any gas with a different TC to reference ambient air. Response time: < 1 second. Recovery time: 1 second. Audio: fixed volume, variable frequency audio generator mounted in gun housing. Diagnostics: low battery indication, detector cell failure alarm. Operating time: maximum 14 hours from rechargeable batteries. Operating temperature: 0°C to 50°C. Storage temperature: -20°C to +70°C.

Heat of Combustion Detectors

V-6.1 Gastron Combustible Gas Detectors
Bacharach, Inc.

The Gastron is a portable instrument used to detect and locate combustible gas leaks. The Model 310 is identical to the Model 282 except that it will detect hydrogen. A continuous sample of air is drawn through a sensing element where controlled catalytic combustion occurs, causing a signal to be generated which feeds both a visual and an audio indicating circuit. When gas is detected, an audio signal is momentarily interrupted and a visual indication is presented on a visual readout meter. The Gastron contains a pump, detector element, filters, control circuit, audio circuit, indicator, switch, and zero-adjust. A quick-disconnect cable leads to a battery pack. The probe contains a humidity controlling filter. Response time: < 2 seconds. Warm-up time: 2 minutes. Dust discrimination: filters down to 1 μm. Temperature: operating -34°C to +54°C; storage -51°C to +66°C. Drift rate: 100% of scale/hour in "Search" range (approximate). Detector cell life: 40 hours (normal operation) average.

V-6.2 SNIFFER® 500 Series Portable Area Monitors
Bacharach, Inc.

The SNIFFER® 500 Series Portable Area Monitors are instruments designed to alert personnel to the hazards of O_2 deficiency and the presence of dangerous concentrations of combustible gases, CO, and H_2S. The SNIFFER 500 Series combines sensors for two or three different contaminants. The sensors include a heated catalytic bead for combustible gases and electrochemical cells for O_2, H_2S, and CO. Any combination of these contaminants, up to three, is available. Various visual (steady or pulsing LEDs) and audible alarms (using steady, alternating, or pulsed tones) are used for different instruments. In addition to the various alarm options, the 500 Series includes an integral sampling pump, a variety of concentration ranges for combustibles, analog displays, low flow and battery alarms, and use in hazardous areas. Operating temperature: -20°C to +50°C. Response time: variable from 5 seconds to 60 seconds (90% response). Operating time: 10 hours.

V-6.3 Super Sensitive Indicator
Bacharach, Inc.

The Super Sensitive Indicator uses a catalytic combustion sensor comprised of two identical platinum elements incorporated as opposite arms of a Wheatstone bridge circuit. One element serves as a reference; the other element, exposed to the sample, reacts catalytically in the presence of low concentrations of combustible gas. Batteries provide up to 8 hours of continuous operation. Sampling rate: approximately 1.0 L/min. Readout mode: meter. Response time: initial response within 1-2 seconds of exposure. Instrument stability is in keeping with battery-operated instruments of this general design.

INSTRUMENT V-6.3. Super Sensitive Indicator.

V-6.4 TLV SNIFFER®
Bacharach, Inc.

This instrument operates on the principle of catalytic combustion (a process of oxidizing a combustible gas/air mixture on the surface of a heated catalytic bead element). Eight-hour continuous operation is possible with six, size D, Ni-Cd batteries or approximately 3 hours with six, size D, carbon-zinc batteries. Sampling rate: 1.65 L/min, nominal. Readout mode: meter, audible alarm, earphone output, recorder output. Response time: initial response within 1-2 seconds of exposure. Its stability is in keeping with instruments of similar sensitivity and construction.

INSTRUMENT V-6.4 TLV SNIFFER®.

V-6.5 Ultra I and Ultra II
Bacharach, Inc.

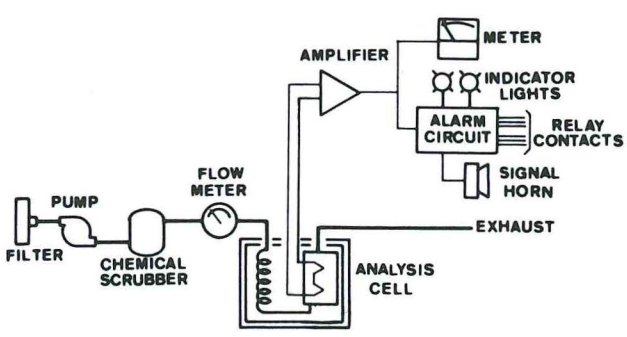
The Ultra I measures the degree of flammability of any combustible gas or vapor mixture in air. The Ultra II is a dual-scale instrument which indicates both percent LEL and the actual quantity of combustible gas in the sample. Ultra I and Ultra II measure the flammability of gas in the LEL range using the catalytic combustion principle. Each instrument has two scales: 0% to 20% LEL and 0% to 100% LEL. When concentration exceeds 20% LEL, the indicator switches automatically from the lower to the upper scale. The Ultra II also can switch to a thermal conductivity circuit to indicate the actual quantity of combustible gas; in the sample. Both units use methane as the calibration gas; have span and zero adjustments through holes in the lower housing; are powered by four, size D batteries; and have temperature ranges from -10°C to +50°C (limited by battery specifications).

V-6.6 Model 12 Combustible Gas Detector
Chestec, Inc.

The Model 12 is a solid-state detector for all combustible gases. The unit can be worn as a safety monitor for gas meter readers, gas appliance servicemen, petroleum workers, and laboratory workers. The Model 12 utilizes a solid-state semiconductor detector. The detector is silenced by nulling (zeroing) using the sensitivity knob. Any additional combustible gas will start the instrument clicking within seconds. Like a Geiger counter, the click rate increases with combustible gas concentration. The detector can be nulled to silence for gas concentrations up to about 1000 ppm. Any additional gas concentration will cause the instrument to start clicking. The knob pointer and dial scale indicates the approximate concentration in ppm at null. Other features include 12 VDC to 6 VDC charger, belt clip, earphone for noisy operations, and rechargeable Ni-Cd batteries. Temperature range: -29°C to +66°C. Operating time: 10 hours.

V-6.7 Carbon Monoxide Detection System
Devco Engineering, Inc.

The Devco Engineering Carbon Monoxide Detection System is used to detect the presence of CO in parking garages, vehicle tunnels, steel mills, industrial plants and warehouses, and in air pollution monitoring. Devco Series 1000 Carbon Monoxide Detection Systems utilize the "Heat of Reaction" method for the measurement of CO in air. A schematic of the flow system is shown in Instrument V-6.7. The air sample is passed through a heated chamber containing a catalyst bed which promotes the oxidation of CO. Heat generated by this reaction is proportional to the concentration of CO in the air sample. A solid-state, time-proportioning temperature controller maintains the constant temperature within the analysis cell and cell chamber. All Series 1000 instruments include a "Trouble Alarm" relay circuit. This relay, controlled by instrument failure alarm circuits, illuminates a blue "Trouble" light and provides for external or remote alarm actuation on sample flow failure or low analysis cell temperature. Zero drift: $< \pm$ 2% with voltage fluctuations of $\pm$ 15%. Response to reading: 30 seconds. Error: none due to hydrogen or hydrocarbon gases. Catalyst life: 1 to 2 years average. Calibration drift: due to relative humidity, error < 2% of full scale reading for relative humidity 50% $\pm$ 20%.



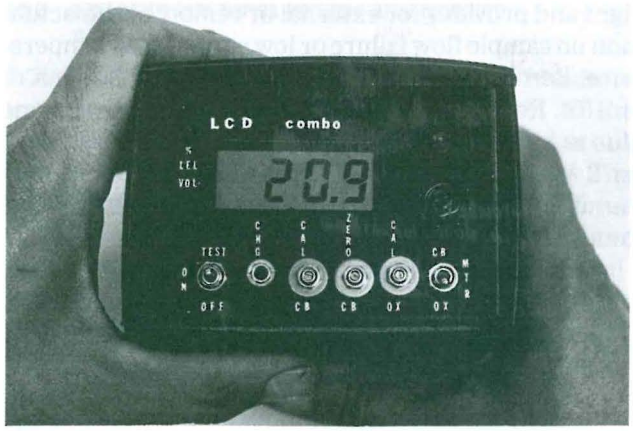
INSTRUMENT V-6.7. Schematic of the Devco Series 1000 Carbon Monoxide Detection System.

V-6.8 Combustible Gas/Vapor Detection System
Devco Engineering, Inc.

Devco Engineering Series 5000 Combustible Gas and Vapor Detection Systems are designed for continuous monitoring of combustible gases. This system employs a pair of catalytic hot wire elements forming two legs of a balanced Wheatstone bridge. Single point or multiple point units are available for either continuous monitoring of each sample area or for sequential sampling via a single detection system. Two types of remote detector heads are available. The Diffusion Detector Head samples by means of diffusion and convection of the combustion gas in air. The Continuous Flow Detector Head makes use of a suction pump to maintain a continuous flow of the sample through the analysis cell. Speed of response: < 1.0 second. Analog signal output for recorders, controllers, or digital display. Solid-state single and dual alarm circuits available with S.P.D.T. relay contact output. Ambient temperature limits: instrument, 0°C to 57°C; detector head, to 93°C standard; to 121°C for high temperature head.

V-6.9 LCD Combo Monitor
Dynamation, Inc.

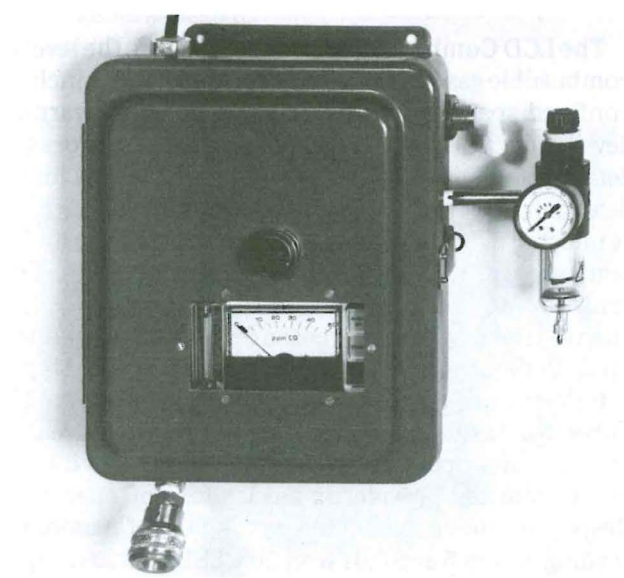
The LCD Combo may be used to measure the level of combustible gas and O_2 deficiency. Applications include confined space entry and use as a personal warning device. The unit utilizes catalytic hot wire sensors for detection of combustible gas and a chemical cell for O_2 detection. The twin combustible sensors are electrically connected in a bridge configuration to compensate for temperature, humidity, and electronic changes. The sensors output is linear from 0% to 100% LEL. The chemical electrolytic cell measures the O_2 level and has up to 18 months of life before replacement. The O_2 cell is temperature compensated with a thermistor that is imbedded inside the sensor. The cell can be easily changed and operated from 9°C to 49°C. The instrument batteries provide up to 9 hours of operation. Response time: combustible gas — 90% of maximum reading within 5 seconds with 20% LEL methane; O_2 — 90% of maximum reading within 30 seconds. Warm-up time: 3 seconds for combustible gas; 10 seconds for O_2.



INSTRUMENT V-6.9. Dynamation LCD Combo.

V-6.10 Respiratory Air line CO Monitor/Alarm
Dynamation, Inc.

The Model ABL-50 is a CO monitor/alarm specifically designed for respiratory airline breathing applications. It will continuously indicate the level of CO in ppm on its built-in meter and activate external alarms if the concentration exceeds the preset alarm threshold. The Model ABL-50 is connected to a tee fitting in the air line which bleeds off a small, continuous sample of air flowing between the compressor and the user. This sample is filtered for particulate matter, has the oil mist removed, and is regulated to 10 psig before passing over the solid-state catalytic semiconductor sensor. Enclosure: polyester fiberglass NEMA 4 with cover latch. Controls: calibration and alarm threshold internal.



INSTRUMENT V-6.10. Dynamation Respiratory Airline CO Monitor/Alarm, Model ABL-50.

Meter size: 2.5 in. Response: 90% of maximum reading within 2 minutes with 20 ppm CO concentration; faster at higher concentrations. Alarm adjustment range: 2 ppm to 50 ppm CO. Recorder output: 0 to 1 mA. Interferences: other types of organic vapors will be detected if present in high concentrations or at their TLV. Sensor purge period: 1 minute nominal. Sensor stabilization period: 10 minutes nominal.

V-6.11 Combustible Gas/Vapor Detectors
ERDCO Engineering Corporation

The ERDCO Engineering Corporation line of TOX-EX portable combustion gas/vapor indicators are used in safety checks for the presence of combustible gases or vapors. They are used for plant and personnel safety when inspecting, cleaning, or repairing tanks; manholes; ships' holds; and sewage treatment plants. They are widely used in utilities, refineries, laboratories, and combustible storage areas. TOX-EX gas/vapor indicators operate on the basic principle of the catalytic reaction of flammable gases and vapors on an electrically-heated platinum filament in a Wheatstone bridge circuit. Accessories available for most models include hose sampling attachment with a 5-foot hose or additional lengths optional; 30-inch semirigid nylon tubing probe; calibrator; adapter and tank with 25% LEL methane. All models have a response time of less than 3 seconds using 25 feet of sample hose; approximately 5 seconds with 50 feet of hose. All models differentiate methane from petroleum vapor electrically, without adding an absorption filter. In addition, the filament in each model is designed to prevent burnout even when repeatedly exposed to high gas. It is also highly resistant to mechanical shock.

V-6.12 Portable Dual Range Combination Combustibles/Oxygen Deficiency Detector and Alarm
GasTech, Inc.

The GX-3A detects combustible gas and O_2 deficiency simultaneously and gives both an audible and a visual alarm whenever either hazardous condition is encountered. It uses a resistive catalytic combustion sensor for combustible gases and an electrochemical cell to measure O_2. The sample is drawn into the instrument by means of an integral pump, and continuous operation of up to 6 hours is assured by the use of Ni-Cd rechargeable batteries. Solid-state alarm circuits for O_2 and combustibles actuate independent alarm lights and a common audible signal which continues until manually reset. Standard calibration is based on methane. In the ppm range, the detector is calibrated to read directly in ppm of a specific hydrocarbon vapor,

normally calibrated on toluene. Calibration curves can be supplied for interpretation of readings of other vapors of interest. Detection limits for O_2 are direct readings from 0% to 25% O_2. Alarm can be set at OSHA limit of 19.5%. The response time is within 3 seconds when using standard sampling hose. Its stability is ±2% full scale per 4-hour period.

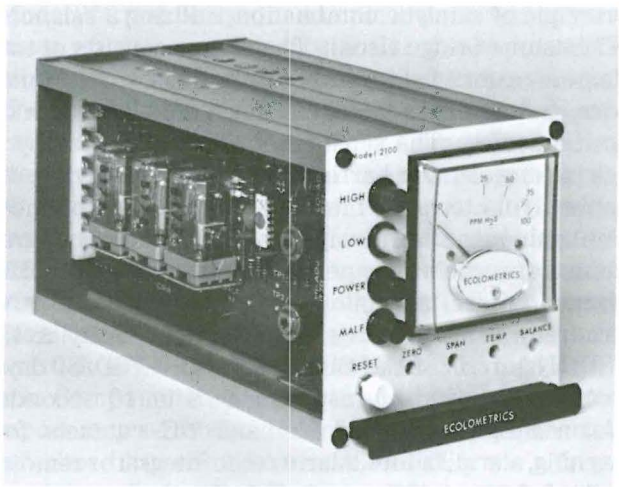
INSTRUMENT V-6.12. GasTech Gas Detector/Alarm, Model GX-3A.

V-6.13 Combustible Gas Monitor and Detector
General Monitors, Inc.

The General Monitors, Inc., Model 170 Combustible Gas Detector is a small, lightweight instrument that detects all hydrocarbon gases, including methane, in addition to alcohols, ketones, ethers, etc. It can be used individually or as a multichannel system. The Model 110E combustible gas monitor serves as a personal gas alarm system for anyone who must work underground or in potentially explosive atmospheres. It can be employed as a temporary fixed system or for gas leak searching. Extension probes for inserting the diffusion sensor into tanks or through manhole covers are provided. The operation of all monitors is based upon a low temperature version of the diffusion catalytic principle. Elements are available for specific detection of hydrogen. In general, other elements are not specific but will have varying responses to different combustible gases. Response time is 1 second to 2 seconds. Stability varies with the application, but generally, recalibration should be performed every 1 or 2 months.

V-6.14 Hydrogen Sulfide Monitor
General Monitors, Inc.

This monitor is designed to protect personnel who may be exposed to H_2S gas. Two alarm levels are provided that can be set and changed easily in the field. The sensor is a continuous diffusion type with a semiconductor sensing element. When exposed to H_2S, the sensing element's electrical resistance characteristics are changed, thus altering the current flowing through it. This change in sensor current produces a signal proportional to the amount of H_2S present. The Model 2100 is an all solid-state controller. It is a single-channel device which has three printed circuit boards that carry all the electronics and alarm relays. Temperature range: -18°C to +66°C.



INSTRUMENT V-6.14. Hydrogen Sulfide Monitor, Model 2100.

V-6.15 Exotector® Combustible Gas Meter
GfG Gas Electronics, Inc.

The Exotector® series of combustible gas meters covers three models for confined space entry, gas survey work, and leak detection. The Exotector has two modes of operation: pump operation for sampling from confined spaces and diffusion operation for continuous operation in combustible atmospheres. The different models offer ranges of combustible/methane detection from 0% to 10% LEL for leak detection to 0% to 100% LEL for full range monitoring. The Exotector utilizes two sensors: catalytic combustion for 0% to 100% LEL and a hybrid thermal conductivity cell for 0% to 100% by volume detection even in the absence of O_2. Both sensors are mounted in a voltage- and temperature-balanced bridge configuration. Standard features include an analog display, an optical/acoustical alarm, a

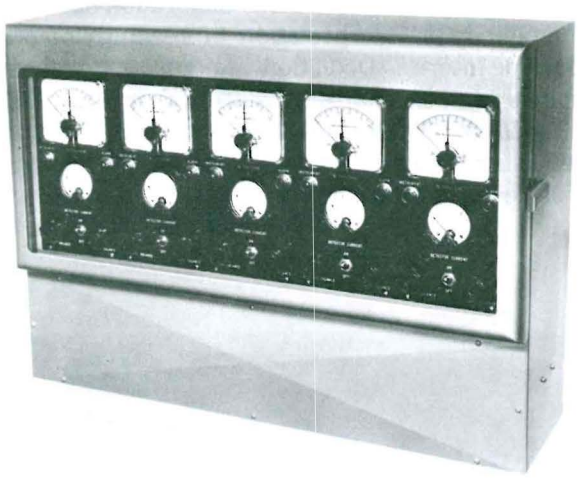
dual operation mode, 16 hours of operation on one battery charge, sensor life of 1 to 3 years, and intrinsically safe design. The three models (G614/G615, G624/G625, and G634/G635) are housed in antistatic, high-impact Polyamid 12. Response time: T_{90} = 10 seconds; warm-up time < 15 seconds.

V-6.16 Combustibles Analyzer, Model 647
Hays-Republic Division Corp.

The Hays-Republic Model 647 Heavy-duty Industrial Combustibles Analyzer effectively monitors combustibles levels in flue gases. Other applications include coating ovens and dyers, controlled-atmosphere furnaces, crude oil handling facilities, distilling operations, engine test cells, electrolytic generators, explosives and fumigant manufacturing, sewage treatment plants, and combustion processes. The Model 647 operates on the principle of catalytic combustion, utilizing a balanced Wheatstone bridge circuit. The sensor consists of two flame arrestors, five layers of fine mesh of woven Monel wire, and a porous metal cup for a double margin of ignition safety. The sensor is further protected by a selective, molecular barrier that reduces catalytic poisoning from tetraethyl lead and silicone compounds. Contaminants: silicone vapors, tetraethyl lead. Integral indications: meter for percent combustibles or LEL; alarms, failure, and pilot lights. Output: 0–100 mV. Accuracy: ± 5% full scale/day (FSD). Linearity: ± 4% FSD. Hysteresis: < 1% FSD. Zero drift: 1% FSD/30 days maximum. Speed of response: 90% in 10 seconds. Alarm outputs: isolated NO and NC contacts for warning, alarm, failure. Alarm reset: integral or remote. Fail safe features: failures alarm indicating open, short, or low voltage at detector, negative zero drift in excess of 10% FSD, loss of power. Temperature range: 0°C to 66°C.

V-6.17 Combustible Gas Detectors
Houston Atlas, Inc.

All of these instruments are capable of detecting the presence of any gas or vapor which, when combined with O_2 in free air, presents a potential explosion hazard. These instruments use the hot wire platinum element for detection. Model 510: portable type in aluminum case with batteries and built-in charger. Its probe is on a 2-m cable. Model 520: a multiunit instrument composed of two to six channels, each similar in operation to the Model 510 above. Either rack- or panel-type mountings. The sensing element is housed in a probe and safety shielded by a Monel metal screen. Up to 100 feet of extension cable may be used with this probe. Response: full scale in 4 seconds.



INSTRUMENT V-6.17. Atlas Multitector Model 520.

V-6.18 Model CD212 Methane Gas Monitor
Industrial Scientific Corporation

The CD212 Methane Gas Monitor is designed for use in mines and other work environments to assure optimum protection against hazardous levels of methane gas (CH_4). This monitor is suitable for use by face bosses and equipment operators where continuous monitoring of CH_4 is essential. It also is ideal for maintenance crews performing welding or cutting operations by the last open crosscut. The CD212 and CD210 (High Sensitivity) Methane Monitors utilize diffusion-type catalytic bead sensors in a Wheatstone bridge. The sensor detects methane over the range of 0% to 5% (by volume) and can run continuously for up to 9 hours on a charge. Other features include an audible alarm for rising methane levels, low battery condition, and malfunction in the sensor; on–off switch that prevents accidental shutoff; digital LCD with illumination; and a rugged stainless steel case. Temperature range: -10°C to +50°C.

V-6.19 GASPONDER® Multiple Gas Monitors
Lumidor Safety Products

The GASPONDER® Models (I–IV) offer the capability of monitoring combustibles, percent O_2, CO, and H_2S in any desired combination or all together. These monitors are designed for a wide variety of applications including telecommunications, industrial processes, water and waste treatment plants, sewer and manhole areas, construction, and oil and gas refineries. The GASPONDERs employ a wide variety of sensors including a poison resistant catalytic sensor for combustibles, galvanic cell for O_2, and electrochemical cell for CO and H_2S. The monitors use an internal pump at flows of up to 375

cc/min for fast instrument response. The monitors also incorporate audible and visual alarms for high or low concentrations, low battery condition, and low flow; charge indicator; automatic battery cutoff circuit; and back-lighted LCD. MSHA approved for mining and methane atmospheres. Temperature range: -5 C to +45°C. Operating time: 10 to 12 hours per charge.

V-6.20 Rechargeable RCM/REM Carbon Monoxide and Ethylene Oxide (EtO) Meters

Macurco, Inc.

The RCM and REM are miniature (shirt pocket-sized) meters specific to CO and EtO, respectively, that are powered by rechargeable Ni-Cd batteries. The units may be plugged into 120 VAC for continuous use or operated on batteries as a portable meter. The RCM and REM utilize low maintenance, solid-state semiconductor sensors. The readouts are composed of 10 LEDs for display of the concentrations. Other features include special warm-up circuits, low voltage battery protection, simple operation, and interference-free measurements. Accuracy: continuous use, 10%; intermittent use, 25%. Warranty: 1 year including batteries.

V-6.21 RGM Flammable Gas Meter

Macurco, Inc.

The RGM is a miniature (shirt pocket-sized) flammable gas (CH_x) meter that is powered by Ni-Cd rechargeable batteries. The CH_x semiconductor sensor features low maintenance and long life. An electronic meter, composed of 10 LEDs, displays the 0% to 1% or 0% to 5% range of methane gas in air. Other features include special warm-up circuits, low voltage battery protection, easy calibration, and simple operation. Accuracy: in normal use, 25%; after calibration, 10%. Warranty: 1 year including batteries.

V-6.22 Model 8957 Hazardous Gas Leak Detector

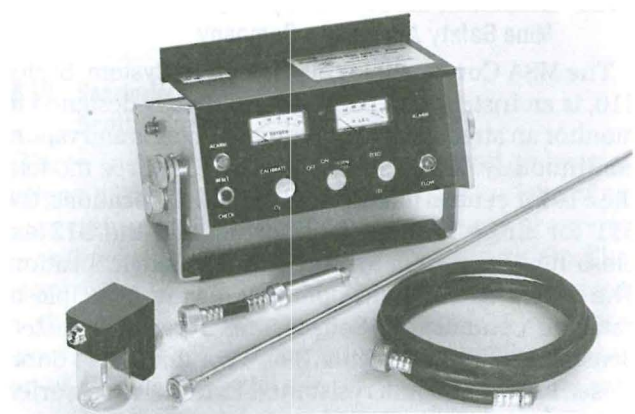
Matheson Gas Products

The Model 8057 Hazardous Gas Leak Detector monitors laboratory, plant, and process areas; instrumentation; tubing; fittings; storage containers; and production equipment for potentially dangerous leaks of gases and vapors at TLV levels. The Model 8057 uses a solid-state gas sensor with a sintered metallic block. An air sample from the suspected leak-source area is drawn into the unit and over the sensors by the internal, low power-drain micro pump. At intermittent tone sounds, a LED lamp flashes if a gas leak is detected. The tone frequency is proportional to the detected gas concentration; i.e., slow beep for low concentration and a faster beep for higher gas concentrations. The alarm can be silenced by means of a switch on the back of the unit. In this mode, the LED continues to flash in the event of gas detection. Detection time: 10 to 20 seconds depending on gas and sensitivity setting. Approximately 6-hour continuous operating time with full charge (charger included). Operating temperature: 0°C to 40°C. Warranty: 1 year from date of purchase.

V-6.23 Portable Combustible Gas and Oxygen Alarm, Models 260 and 100

Mine Safety Appliances Company

The Portable Combustible Gas and Oxygen Alarm, Model 260, is a dual-purpose instrument designed to monitor areas for combustible gases and/or O_2 deficiency. Although primarily a portable instrument, Model 260 may be used as a semicontinuous monitor in areas where an audible/visual alarm is required. The Model 100 contains the combustible gas monitor only. The combustible gas portion of the instrument uses a catalytically activated Pelement™ filament in a Wheatstone bridge. The O_2 portion of the instrument operates by means of a diffusion galvanic sensor cell. Sampling rate is 1.6 L/min. Other accessories include standard MSA probe rods, tubes, carrying harness, and sampling lines when used for remote sampling. The combustible gas alarm is factory set to trigger at 50% LEL and the O_2 alarm at 19.5% O_2. Both alarm points are field adjustable. Compounds containing silicon and leaded gasoline vapors may seriously impair instrument response. An inhibitor filter should be used to nullify the effect of leaded gasoline vapors. Response: 90% in $<$ 20 seconds. Accuracy: $\pm$ 5% of full scale for combustible and $\pm$ 2% for O_2.



INSTRUMENT V-6.23. MSA Portable Combustible Gas and Oxygen Alarm, Model 260.

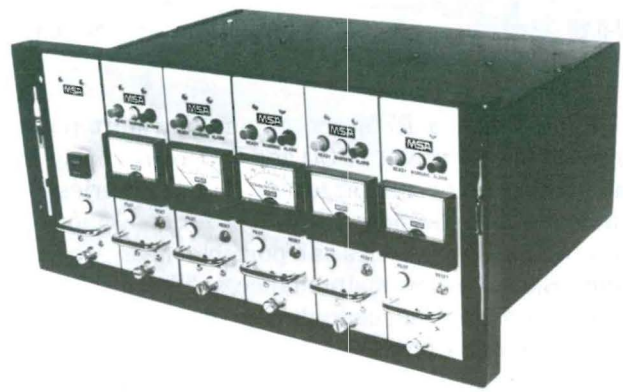
V-6.24 Explosimeter® Combustible Gas Indicator, Model 2A
Mine Safety Appliances Company

The MSA Explosimeter®, Model 2A, measures combustible gases and vapors in concentrations up to 100% of LEL. The instrument operates by the catalytic action of a heated platinum filament in contact with combustible gases. External accessories: sampling line available in length multiples of 5 feet for remote testing; hollow, 3-foot rigid probe tube for sampling from bar holes or manholes; solid, 4-foot probe rod for use in testing tanks that may contain liquids; charcoal filter in external cartridge holder for use as an aid in distinguishing between gases and condensable vapors in sample. Response time: 10 to 15 seconds. Model 2A is factory-calibrated on pentane in air. Pentane calibration is used because it is representative of petroleum vapors. When testing other combustible gases, readings are generally on the high or safe side.

INSTRUMENT V-6.24. MSA Explosimeter Combustible Gas Indicator, Model 2A.

V-6.25 Combustible Gas Detection System, Series 510
Mine Safety Appliances Company

The MSA Combustible Gas Detection System, Series 510, is an instrument package specifically designed to monitor an atmosphere for flammable gases and vapors continuously. The System is available in three models: the 510 for central monitoring of multiple locations; the 511 for single-location monitoring; and the 512 explosion-proof system for monitoring a single location. The Series 510 System operates on the principle of catalytic combustion. Sensor life: 3 years expected. Sensor cable requirements: 3 or 4 conductor, 14 ohms closed loop, maximum resistance. External accessories: diffusion head including sensor and assemblies. Safety provisions: tamper-resistant controls; malfunction light and relay which deactivates in the event of lost power, open sensor, or severed or shorted cable; built-in short-circuit protection; built-in warning lights and alarm circuitry. Accuracy: ± 2% with control unit and sensor -18°C to +54°C; ± 4% with sensor -40°C to +28°C. Response time: typically less than 5 seconds to alarm at a preset level of 40% with an input of 50% LEL. Zero drift: ± 0.5% FS/week.



INSTRUMENT V-6.25. MSA Combustible Gas Detection System, Series 510.

V-6.26 Spotter™ LEL Combustible Gas Detector, Model QII
Mine Safety Appliances Company

The Spotter™ LEL Combustible Gas Detector, Model QII, is designed for ambient portable use in the measurement of combustible gases and vapors. The Spotter uses a catalytically treated Pelement detector in a Wheatstone bridge. Battery supplies approximately 175 readings on a single charge. External accessories: instrument comes supplied with soft leather carrying case; single-unit and 10-unit battery chargers are also available. Safety provisions: out-of-range LED lights when combustible gas exceeds instrument range. Calibration: factory calibrated on pentane in air.

INSTRUMENT V-6.26. MSA Spotter™ LEL Combustible Gas Detector, Model QII.

V-6.27 Gascope® Combustible Gas Indicator, Models 60 and 62
Mine Safety Appliances Company

MSA Combustible Gas Indicators are portable instruments for use in detecting, measuring, and pinpointing leaks of combustible gases or vapors. Model 60 is calibrated on methane in air by volume in a low range of 0% to 5% and a high range of 0% to 100%. Model 62 is calibrated on pentane in air in a low range of 0% to 100% LEL and a high range of 0% to 100% by volume. MSA Combustible Gas Indicators use two different types of filaments: a catalytic combustion filament for low range operations and a thermal conductivity filament for high range. Sampling rate: 1.5 L/min. The Gascope may be used with MSA 3-foot probe tubes and rods. An external holder for charcoal cartridges attaches to sample line connection of the instrument. Gascope indicators can operate continuously for over 8 hours on batteries. Silicon compounds may seriously impair response of the instruments. Leaded gasoline vapors can also poison the catalytic combustion filament; an inhibitor filter should be used to nullify this effect. Constant voltage power supply to filaments minimizes zero drift. Calibration: separate adjustment knobs for each measuring circuit of the changings of zero settings.

INSTRUMENT V-6.27. MSA Gascope Combustible Gas Indicator, Model 60.

V-6.28 Methanometer
National Mine Service Company

The G-2000 Methanometer is a pocket-sized, hand-held instrument for measuring the concentration of methane in air. The G-2000 is a diffusion-type methanometer. Gas is admitted to the sensor through two screened ports in the top of the instrument. A LED chain is activated by holding a pushbutton on the side of the case. An additional LED on the front of the instrument gives a constant indication of battery condition while the instrument is in use. The G-2000 is housed in a stainless steel case. MSHA certification: 8C-43. Display: LED chain (0% to 2% CH_4) with underrange and overrange indicators. Detector: catalytic bead on platinum wire. Charging: 50 mA constant current. Approximately 300 readings with fully charged battery.

V-6.29 Scott-Alert Model S101 Combustible Gas Indicator
Scott Aviation

The Scott-Alert Combustible Gas Indicator can be obtained in a single, hand-held unit or combined with other sensors for O_2, CO, or H_2S. The Model S101 indicator can be used in petroleum refineries, petrochemical plants, in gas transmission and distribution pipelines, in the fire and police service, occupational hazard surveys, in the maritime industry, the military, telephone and radio communications, or mines. The monitor utilizes a diffusion-type, catalytic bead sensor which is capable of 10 hours of continuous operation. The percent LEL readout is in large LCD digits which can be illuminated for low-light conditions. Other features include memory capability that retains the highest percent LEL measurement taken; visual and audible alarms for low battery life, end of use, high concentration, and sensor failure; and sealed, corrosion-resistant, tactile feel and tactile location function switches. Case: molded, high impact-resistant, flame-retardant ABS plastic. Display contains status legends for gas concentrations being measured and indicated. Combustible response: 10 seconds to 63% of step change of applied gas concentration. Temperature limits storage: -40°C to +60°C; operating, -10°C to +60°C. O_2 response: 20 seconds to 63% of O_2 change with temperature limits of -3°C to +60°C, operating at 0°C to 40°C. H_2S response: 45 seconds to 63% of step change of applied gas concentration with temperature limits of 3°C to +60°C, operating at 0°C to 40°C.

V-6.30 Vapotesters
Scott Aviation

These instruments are used in general industrial hygiene surveys and safety inspections to determine the presence or absence of combustible gas or vapors in confined spaces, storage areas, work spaces, etc. The measurement of combustible gases and vapors is based on the principle of catalytic combustion of these vapors. A flashback arrestor is used to prevent propagation of a flame from the sensor. The components are housed in a die-cast aluminum case and plastic battery holder. Battery life is approximately 8 hours, continuous duty. An aspirator bulb furnishes the suction necessary for sampling. The Model D-11 Vapotester No.

11-325 is a two-filament instrument designed for general use, suitable for detecting the presence of any combustible gas or vapor in air. The Model D-2 Vapotester No. 11-410 is a single-filament, single-control instrument designed for general use for detecting the presence of any combustible gas or vapor in air. The D-16 Vapotester No. 11-660 is a two-filament, two-range instrument designed to detect combustible gases or vapors in the ppm range, in addition to the zero to LEL.

INSTRUMENT V-6.30. D-16 Vapotester No. 11-660.

V-6.31 Combustible Gas Alarm System
Scott Aviation

The 3800 Series Combustible Gas Alarm System is suitable for monitoring process work, utility areas, industrial sewers, and storage areas where an explosive condition may arise through combustible gas accumulation. The 3800 Series sensor consists of a pair of catalytic filaments that oxidize the combustible gas at concentrations lower than usually required for combustion. The sensor employs inner and outer stainless steel, sintered metal flame arrestors. Preferred installations utilize one sensor per module for distances up to 2000 feet. Alternate installation utilizing two sensors per module are limited to total distances for both sensors of 1000 feet. Units are designed for rack or panel mounting. Speed of response: 1 second for 1 cycle (hydrogen). Zero drift: ± 3% in 30 days of constant ambient conditions. Sensor temperature limit: -18°C to +121°C. Module temperature limit: 0°C to 66°C. Alarm setting: adjustable from 5% to 95% LEL.

V-6.32 Hydrogen Sulfide Monitor, Model 10HS
Sierra Monitor Corporation

The Sierra Model 10HS monitor continuously measures the concentration of H_2S in the ambient air. Incorporated in the Model 10HS is a solid-state H_2S sensor, microprocessor, concentration display, operating controls, audible alarm, and rechargeable battery or AC power supply. Displays include present concentration, time-weighted average value for exposure on a single shift, or maximum concentration value sensed during a work period. Accessories supplied: earphone for high noise area, instruction manual, and instrument case. Battery gives 8- to 10-hour operation per charge. Device and alarm are intrinsically safe for use in hazardous locations. Operating temperature range: -20°C to +40°C. Response time: 80% of full scale in 2 minutes. Zero drift: < 3% of full scale in 8 hours. Warm-up time: < 5 minutes. Operating controls: on/off switch; display concentration switches for 1) present concentration sensed, 2) time-weighted average value for exposure, 3) maximum concentration value sensed, 4) time unit has been in operation, 5) test for checking operation function and audible alarm, 6) zero screw is adjusted to display zero present concentration in fresh air (interior adjustment), and 7) calibration screw is adjusted to display 25 ppm present concentration (interior adjustment) when exposed to 25 ppm calibration gas. Alarm levels are factory preset for ceiling concentration level of 20 ppm, time-weighted average value alarm at 10 ppm, evacuation alarm at 50 ppm, and when battery condition is low.

V-6.33 Model 2000 Portable Combustible Gas Detectors
Sierra Monitor Corporation

The Series 2000 detectors are ideal for gas detection in mines, manholes, tanks, natural gas fields, garages and vehicle maintenance facilities, utilities, testing of gas cylinder and new piping connections, etc. The units utilize solid-state, metal oxide sensors and operate in three different modes: 1) proportional mode — a continuous audible "tick" increases logarithmically as gas concentration rises, 2) low alarm mode — 250 ppm H_2 and 500 ppm CH_4, and 3) high alarm mode — 2500 ppm H_2 and 5000 ppm CH_4. Other features include an alarm for the upper range of gas concentration, an earphone for noisy operation, a 15-foot 120 VAC power cable, an 18-inch flexible probe, replaceable batteries, and intrinsically safe for use in Class 1, Division 1, Groups B, C, and D. Warm-up time: 30 seconds. Response time: < 1 second. Temperature range: -5°C to +50°C. Battery life: 8-hour continuous.

V-6.34 Model 102 Combustible Gas Analyzer
Teledyne Analytical Instruments

The Model 102 uses a catalytic bead sensor. Combustible gases present in the air burn in the presence of O_2, producing a signal proportional to the concentration of the combustible gases. Sample rate: diffusion when

placed in air. Readout mode: integral meter with recorder output signal. Detection limits: 100% of LEL of most combustible gases. Specificity: must be calibrated in "equivalent" of a designated combustible gas. Response time: 90% of full scale in < 20 seconds. Accuracy: meter ± 0.5% of full scale.

INSTRUMENT V-6.34. Teledyne Model 102 Combustible Gas Analyzer.

Colorimetric Analyzers

V-7.1 CEA 555 Continuous Colorimetric Analyzer
CEA Instruments, Inc.

The CEA 555 is a portable, ambient air monitor that can be used for continuous colorimetric analysis of numerous compounds. The CEA 555 contains a rechargeable DC power source and a constant-volume adjustable air pump. An air sample is continuously drawn into the unit and scrubbed with an absorbing reagent that removes a trace pollutant from the air stream and transfers it into the liquid reagent system. The subsequent color formation is read by a colorimeter and displayed on a built-in meter or on the optional digital readout shown in Instrument V-7.1. A recorder output is also provided.

Operating period: 20 hours, fully charged internal batteries. Signal output: 0 to 1.0 V at 0 to 2.0 mA. Calibration: < 1% drift/72 hours. Sensitivity: 1% of full scale. Nonlinearity: < 2%. Zero and span drive: < 2%/72 hours. Air flow drift: < 1%/72 hours. Noise: 0.75% of full scale. Lag time: 4 minutes. Rise time to 90%: 4 minutes. Fall time 90%: 2.5 minutes. Temperature range: 4.5°C to 49°C. Temperature drift: at laboratory conditions ± 3°C, ± 1%; from 15°C to 30°C, ±2%; from 30°C to 50°C, ± 4%; from 14°C to 50°C, ± 8%. Relative humidity range: 5% to 95%. Reagent requirements: SO_2, 3.4 L/week modified West and Gaeke; 3.4 L/week demineralized water; NO_2, 3.4 L/week modified Saltzman (Lyshkow).

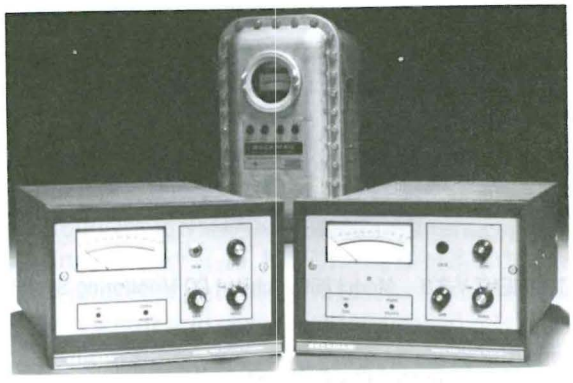
Infrared Photometers

V-8.1 Open Cell Nondispersive Infrared (NDIR) Gas Detector, Model 5600
Astro International Corporation

The Model 5600 is designed for fixed station monitoring of combustible gases in chemical plants, ships, well-logging, refineries, drying ovens, drilling platforms, sewage digesters, mines, and tunnels. Infrared (IR) energy from the IR source passes alternatively through two narrow band interference filters and the sample gas; it is then reflected by a spherical mirror to the solid-state detector. The sample filter wavelength is selected for line spectra absorbed by gases analyzed. Synchronous detection, dual wavelength ratioing, and processing of reference and sample signals are then performed to eliminate drift associated with alternate IR detectors. The Model 5600 has compensating circuitry for IR source and detector aging. It employs automatic gain control in the detection process and has a "dirty window" alarm with relay output that activates when insufficient energy reaches the detector. The system verifies "Zero" once each second providing an active detection device. Fail-safe operation and system status are automatic. Output: 0 to 1 VDC, 0 to 10 VDC, 4 to 20 mA DC fault alarm (relay); two independent settable alarms. Response time: 8 seconds. Zero and span drift: ± 2% (nonaccumulative).

V-8.2 Models 864/865 Nondispersive Infrared Analyzers
Beckman Instruments, Inc.

The Beckman Models 864/865 Nondispersive Infrared Analyzers are designed for precise determination of a given chemical component concentration in vehicle emissions. Applications include: 1) vehicle emissions, 2) automotive research and development, and 3) automotive certification testing. The Models 864/865 utilize NDIR radiation absorption which is produced from two separate energy sources. The infrared beams pass through two cells: a reference cell containing a nonabsorbing background gas, the other a sample cell containing a continuous flowing sample. Noise: 1% of full scale. Zero and span drift: 1% of full scale per 24 hours. Response time (electronic): variable, 90% in 0.5



INSTRUMENT V-8.2. Beckman Nondispersive Infrared Analyzers; left: Model 864; right: Model 865.

seconds to 26 seconds (15 field-selectable speeds). Sample cell length: 4 to 38.1 mm. Sample flow rate: nominal 500 to 1000 cc/min. Sample pressure: 15 psig. Maximum ambient temperature range: -1°C to +49°C. Output (field selectable): 0 to 10 mV, 0 to 100 mV, 0 to 1 V, 0 to 5 VDC. Nonlinear output standard; plug-in linear output optional.

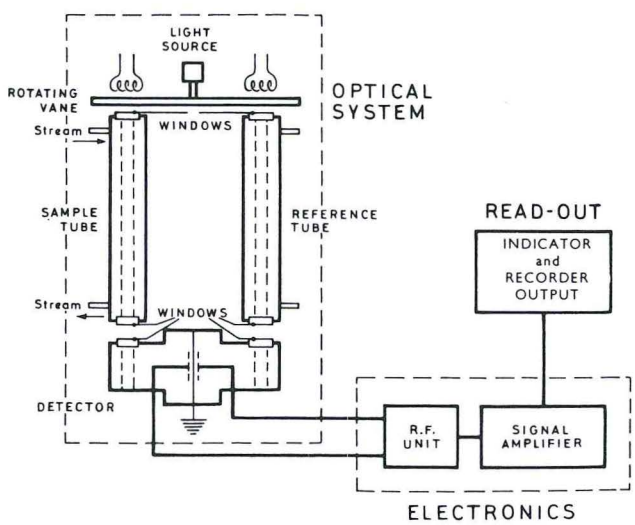
V-8.3 Model 866 Ambient CO Monitoring System
Beckman Instruments, Inc.

The Model 866 is designated as a reference method for ambient CO monitoring. Also, Model 867 is available for CO in vehicle exhaust monitoring. The Model 866 monitoring system combines the Model 865-17 NDIR analyzer, the Automatic Zero/Span Module, a Beckman-developed Automatic Flowing Reference Panel, and a Pump/Sample Handling Module into a self-contained system. Model 866 utilizes NDIR radiation absorption. The infrared beam passes through two cells: a reference cell containing a nonabsorbing background gas, the other cell containing a continuous flowing sample. Noise: < 0.2 P/10^6. Total interference equivalent: less than 1.5 P/10^6 per EPA specifications. Zero drift: $\pm$ 0.5 P/10^6 per 12 and 24 hours. Span drift: $\pm$ 1% per 24 hours. Electronic response time: 0.5 to 26 seconds, field selectable, EPA designated at 13 seconds. Ambient temperature limits: 0°C to 50°C; EPA designated at 20°C to 30°C. Outputs: 10 mV, 100 mV, 1 V, 5 VDC available from auto zero/span module; 4–20 mA DC optional.

INSTRUMENT V-8.3. Model 866 Ambient CO Monitoring System.

V-8.4 SC/LC Infrared Gas Analyzer
Calibrated Instruments, Inc.

The SC/LC Infrared Gas Analyzer applications include the measurement of CO in the atmosphere, in exhaust gases in internal combustion engines, and measurement of flue gases; the determination of gas distribution in model furnaces, study of air flow and ventilation systems; determining gas-to-air ratios; and as a leak detector. A schematic of the Infrared Gas Analyzer is shown in Instrument V-8.4. Radiation from the nickel-chromium wire sources is chopped at 7 Hz by the rotating vane and projected in a double beam through the analysis tubes to the detector. Radiation is absorbed in the sample tube in proportion to the concentration in the measured gas, but it passes unattenuated through the reference tube and the detector reacts to the different levels of radiation received. Ambient temperature: 0°C to 40°C. Pressure: normal atmospheric pressure. Bell volume: depends on range of concentration; the approximate volume for the most sensitive instrument is 150 cc. Sample volume: 250 cc minimum. Flow rate: up to 2 L/min. Discrimination: 1% of full scale reading. Modulation: 7 Hz nominal. Standard output: 50 to 550 mA through loads up to 200 or 1500 ohms. Standard response: on the order of 15 seconds depending on flow rate and range.



INSTRUMENT V-8.4. Schematic of Infrared Gas Analyzer.

V-8.5 Riken RI-411 Portable CO_2 Indicator
CEA Instruments, Inc.

The Riken RI-411 is a lightweight CO_2 infrared gas monitor with digital readout and audible alarm. The unit is applicable to food related industries, brewers, mushroom growers, greenhouse horticulture, welding, office ventilation systems, cooling systems, hazardous environments, laboratory and research projects, etc. The Riken RI-411 utilizes NDIR absorption to measure CO_2 in air. The unit is Ni-Cd battery operated and microprocessor controlled. The readings of CO_2 con-

centrations can be continuous or averaged over 1, 3, or 15 minutes. Averaged readings are held on the display until needed by the user. The RI-411 has a solid-state detector, an illuminated dot-matrix digital display, a recorder output, and can operate on AC using an optional DC power supply. Audible alarms: high CO_2 5000 ppm (short pulse, optional 25%), averaging period (long tone), and low battery (continuous tone). Response time: 10 seconds to 90% indication. Calibration: zero, calibration using nitrogen or air cylinder (zero gas); span, calibration using cylinder of CO_2 in air. Ambient temperature range: -10°C to +40°C. Ambient humidity range: 10% to 90% RH. Recorder output: 0 to 10 mv DC (linear). Auxiliary charger available for charging or continuous operation on 115 VAC adaptor. Operating hours: about 6 hours continuous.

V-8.6 Riken RI-550A Gas Analyzer
CEA Instruments, Inc.

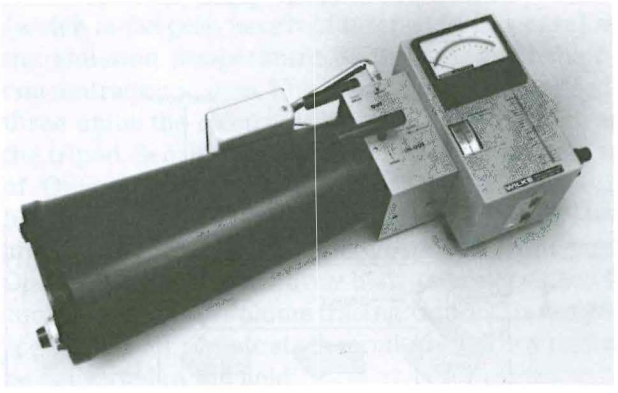
The Riken Infrared Gas Analyzer Model RI-550A is a single gas, lightweight, infrared analyzer designed to measure CO, CO_2, methane, ethylene, ethane, propane, or butane levels. This instrument operates on the NDIR absorption principle. The gas stream to be analyzed is drawn into the unit through a sampling probe and sampling line by means of an internal vacuum pump. The sample gas passes through an optical system, and the concentration of the constituent to be measured is read out directly on a meter. Response time: $<$ 10 seconds to 90% response. Zero and span drive: $<\pm$ 2%/8 hour of full scale. Sample flow rate: 6 L/min, normal, variable. Calibration is by internal span gas canister and/or built-in mechanical reference filter. Ambient temperature range: 0°C to 40°C. Ambient humidity range: 0% to 90% RH. Warm-up time: 30 minutes after power switch ON (usable after 3 minutes).

INSTRUMENT V-8.6. Riken Infrared Gas Analyzer, Model RI-550A.

Recorder output: 0 to 10 mV DC (internal resistance 100 ohms).

V-8.7 Miran Gas Analyzers
Foxboro Company

The Miran Gas Analyzers utilize NDIR absorption. Both the optical path of the gas cell and the wavelength can be varied to give specificity and sensitivity. The instruments are primarily used with a wavelength set for a characteristic absorption band. Ambient air is continuously sampled and either absorbance or percent transmittance measured. The Miran-I Variable Filter Gas Analyzer can be used to scan through the infrared spectrum (2.5 to 14.5 μm). The Miran 101 is a lighter weight analyzer that reads directly in concentration and is used when a limited number of vapors are to be analyzed. The Miran-II Gas Analyzers are designed for continuous monitoring applications in field installations. Miran-I Variable Filter Gas Analyzer: sampling rate, 28 L/min; readout mode, full scale ranges — 0 to 0.025, 0 to 0.1, 0 to 0.25, 0 to 1; absorbance units: 0–100% transmittance. Miran 101 Specific Vapor Analyzer: sampling rate, approximately 15 L/min (cell volume, 2.25 L); readout mode, direct reading in concentrations. Response and averaging time: $<$ 1 minute. Stability: drift $<$ 0.004 absorbance units at 23.25°C, 3.5 M.



INSTRUMENT V-8.7. Miran I Variable Filter Gas Analyzer.

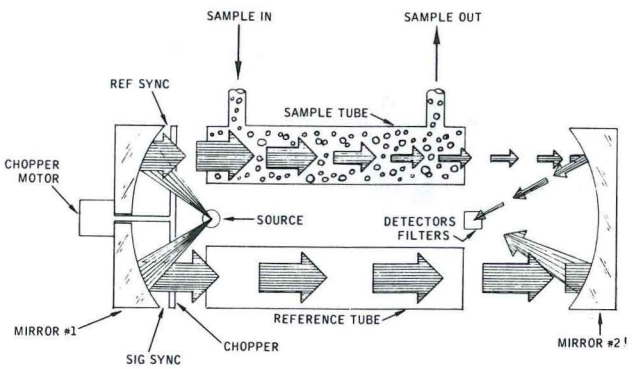
V-8.8 Model RI-413 Portable Freon® Monitor
GasTech, Inc.

The Model RI-413 is a portable instrument capable of measuring Freons® R-11, R-12, R-22, R-113, R-114, and R-502 in ppm concentrations. This instrument is ideal as a leak detector and survey meter around refrigerant or cleaning systems where Freons are typically used. The instrument can be used to obtain continuous output or average readings for 1, 3, or 15 minutes. The Model RI-413 utilizes NDIR absorption for detection.

The Model RI-413 contains a microprocessor for control operations and a durable miniature diaphragm pump to draw in the samples. Other features include a choice of alkaline or Ni-Cd batteries, an adaptor for 115 VAC operation, low battery and high gas level alarms, six detection ranges, self-illuminating digital display, and a 3-foot sampling probe. Response time: 10 seconds to 90%. Operating time: 4 hours.

V-8.9 IR-702 Infrared Analyzer
Infrared Industries, Inc.

The IR-702 Infrared Analyzer has the capability of detecting two gases simultaneously. Its internal standardization eliminates need for span gases, and solid-state circuitry allow fast response with low vibration sensitivity. In general, the system compares the optical (infrared) transmittance of two identical optical paths. One optical path passes through the sample of unknown gas, the other optical path passes through the reference path. The difference in optical transmittance between these paths then is a measure of the optical absorption. Speed of response: 90% of reading in 1 second. Accuracy: (specification dependent upon certified calibrations gas) ± 1% of full scale. Noise level: < 1% of full scale. Zero and span drift: < 1%/24 hours. Temperature range: 0°C to 20°C. Detector type: solid-state (PbSe). Output: 1 to 100 mV or 0 to 1 V. Warm-up time: 15 minutes. The sampling system is constructed of 316 stainless steel, windows of silicon, and tubing of Teflon®. Calibration: internal optical attenuator.



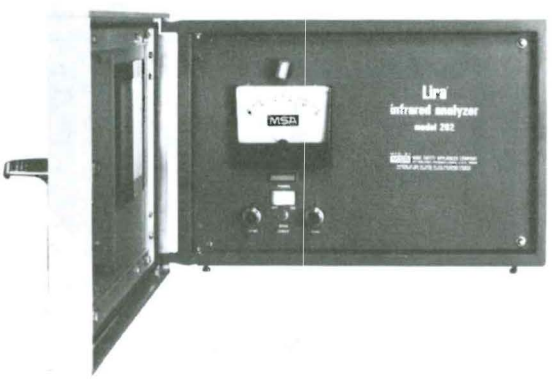
INSTRUMENT V-8.9. Model IR-702 detector diagram.

V-8.10 IR-711 Portable Hydrocarbon Analyzer
Infrared Industries, Inc.

The IR-711 Portable Hydrocarbon Analyzer is used for the instantaneous detection and measurement of percent LEL and ppm levels of the alkane family of hydrocarbons in and around fuel tanks and other enclosures. Because of its design, the IR-711 is particularly useful in the monitoring of JP-5 and other kerosene type fuels. This instrument is a NDIR analyzer for continuously monitoring the concentration of a specific gas in a gas sample stream. Standard recorder outputs (0 to 100 mV) are provided. The analyzer features a single infrared energy source which eliminates the complex alignment problems associated with dual infrared energy sources. Dual beam optical systems minimize drift effects due to changes in ambient temperature, spectral emission of the source, and power line variations. Reflective coatings are not required on the inside of the sample or reference cells reducing maintenance, cleaning, and replacement costs. Calibration gas: propane. Accuracy: 5%. Resolution: high range, 2.5% LEL; low range, 25 ppm JP-5. Drift: 1 hour — high range, < 2.5% LEL; low range, < 25 ppm; 8 hour — high range, < 5% LEL; low range, < 50 ppm. Warm-up time: 5 minutes. Response time for temperature compensation: 2 minutes.

V-8.11 LIRA Model 202 Nondispersive Infrared Analyzer
Mine Safety Appliances Company

The LIRA Model 202 Nondispersive Infrared Analyzer is designed for fixed station use in the detection of any component of interest that absorbs infrared energy. The sample cells are of aluminum block construction with a stainless steel insert, internally gold plated; length up to 8 in. standard; up to 20 in. with the high sensitivity optional. The windows are of sapphire, quartz, calcium fluoride, barium fluoride, etc. The tubing is flexible and corrosion resistant; solid type available. External accessories: explosion-proof or non-explosion-proof design; optional recorder. Precision and accuracy: ± 1% full scale. Response time: Model 202, 90% in 5 seconds; Model 202FR, 90% in 0.4 to 1.5 seconds (field adjustable); 4-position switch. Zero and span drift: < 1% full scale/day. Calibration curve is determined and provided for each instrument. Calibration is accomplished by using known gas on liquid samples for zero and span at instrument. Span check:

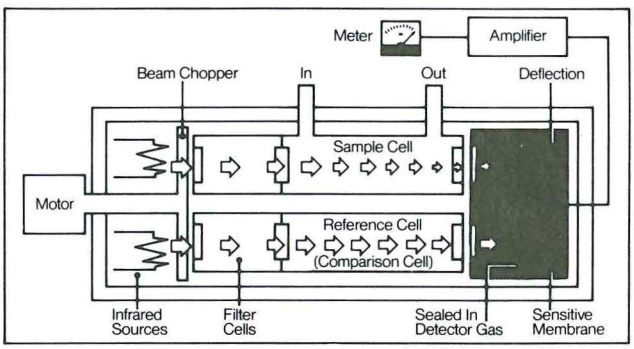


INSTRUMENT V-8.11. MSA LIRA NDIR Analyzer, Model 202.

precision resistor in source circuit simulates gas presence in LIRA cell, actuated by push-button on front panel.

V-8.12 LIRA Model 3000 Nondispersive Infrared Analyzer
Mine Safety Appliances Company

The LIRA Model 3000 Nondispersive Infrared Analyzer is designed for fixed station use in the detection of any gas or vapor that absorbs infrared energy. Its sample cells and windows are application dependent. Inlet, outlet, and purge fittings are ⅛-in. NPT, and the tubing is made of nylon. Least detectable quantity, sensitivity, and specificity are all application dependent. Response time: 90% in 5 seconds; optional 90% in 3 seconds. Zero and span drift: < 1% full scale (FS)/day, typically < 2% FS/week. Span check: electrical circuit simulates presence of sample gas when activated by push-button on front panel.



INSTRUMENT V-8.12. MSA LIRA NDIR Analyzer, Model 3000.

Ultraviolet (UV) and Visible Light Photometers

V-9.1 J-W Mercury Vapor SNIFFER®
Bacharach, Inc.

The J-W Model MV-2 Mercury Vapor SNIFFER® is a dual-range, hand-held instrument for the detection and measurement of mercury vapors in working areas. The sample is drawn into the detector and through the ultraviolet absorption chamber by a small motor-driven suction fan powered by a battery. To operate the detector, the user turns the control knob to the bias position, adjusts the zero, sets the air knob to sampling position, and reads the vapor concentration on the meter. The vapors of some organic compounds, such as benzene and its compounds, halogenated hydrocarbons, and particulates, absorb ultraviolet light at the lamp frequency. Normally, this slight interference does not present a problem. The detector has an efficient built-in filter that permits the meter to be zeroed in a contaminated atmosphere and then switched immediately to read the vapor concentration. The Model MV-2 is a self-contained, battery-powered instrument housed in a lightweight steel case. The indicating meter is calibrated in mg/m^3 of air. All controls and the carrying handle are mounted in the top of the case. The case itself houses the batteries, the 2537 Angstrom UV source lamp, the atomic absorption chamber, the photoelectric cell, and all other operating components. A slip-on connection is provided in the end of the case for an extension probe when used.

V-9.2 AISI Sulfur Dioxide Monitor
Barringer Research, Ltd.

The Barringer AISI Sulfur Dioxide Monitor is used to quantitatively determine the amount of SO_2 emitted by a source such as a stack without physically procuring a sample of the gas. Operation is based upon correlation with the absorption spectra of SO_2 in the ultraviolet. Hence, normal skylight may be used as the ultraviolet source and measurement obtained with the instrument located several hundred feet from the source. In operation, the viewing unit is first sighted on the target plume near the stack mouth. The vertical aperture is then adjusted so that only a small area in the center of the plume fills the field of view. The viewing unit is then moved to one side of the plume to zero out the background SO_2 level, and readings are obtained with the self-contained calibration cells. Finally, the viewing unit is again centered on the plume and the reading noted. These readings, together with the stack diameter (which is the path length of interest in this case) and the emission temperature of the gas, yield the SO_2 concentration in ppm. The instrument is comprised of three units: the electronic unit, the viewing unit, and the tripod. Sensitivity of Option 1 is 2 ppm-meters and of Option 2, 40 ppm-meters. Field of view: 0.15° horizontal; vertical is adjustable from 0° to 1.5°. Meter and chart recorder are located on the front panel. Option 1 is a high-sensitivity instrument designed for such applications as plume tracing. Option 2 is designed specifically for remote stack monitoring. They may not be converted in the field.

V-9.3 Model K-23B Mercury Vapor Meter
Beckman Instruments, Inc.

The Beckman Model K-23B Mercury Vapor Meter is designed to provide an instantaneous reading of mercury vapor in an enclosed environment. Areas where this instrument finds application include: OSHA compliance monitoring, chlorine and caustic plants, mines, chemical laboratories, hospitals, wind tunnels, dry battery manufacturing facilities, thermometer manufacturing facilities, and dental laboratories. The Beckman Model K-23B is a portable, ultraviolet filter

photometer tuned to a wavelength of 253.7 nm; the wavelength at which mercury vapor absorbs light. To ensure optimum accuracy at all times, a calibration filter assembly is built into the meter. Filters, having known absorption factors, can be switched into the optical path of the meter to provide standard references for calibration. Output: 0 to 100 mV plus meter. Noise: 0 to 0.1 scale; ± 1.5% full scale; 0 to 1.0 scale, ± 0.5% full scale.

V-9.4 Model 1003 Ozone Monitor
Dasibi Environmental Corporation

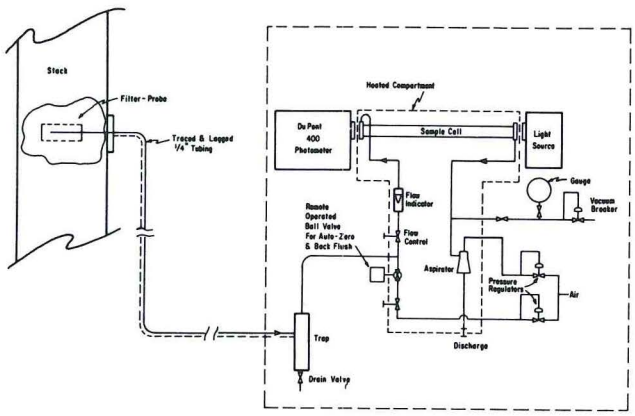
The Model 1003 Ozone Monitor continuously monitors the concentration of ozone in the air in ppm. An analog output is available for continuous strip-chart recording, and a binary-coded-decimal (BCD) output enables direct interfacing with a computer or a printer. Ozone concentration is measured by detecting the absorption level of ultraviolet light within a sample volume of air. Accuracy: ± 3%. Scale factor: adjustable to any standard. Drift: < 0.001 ppm/week noncumulative. Zero span: ± 0.4%/°C, corresponding to much less than 0.001 ppm. Interval: 8 or 30 seconds. Flow rate: 7 L/min at 8-second intervals; 1.0 L/min at 30-second intervals. Zero return: 1 interval from 1.0 ppm. Temperature: 0°C to 49°C. Meets vibration and shock constraints typically encountered in shipping, aircraft, and mobile vans; maintenance, 1000 hour mean time between maintenance (MTBM) under typical conditions.

INSTRUMENT V-9.4. Dasibi Model-1003 Ozone Monitor.

V-9.5 Stack Gas Analyzers for SO_2, NO_2, and NO_x
DuPont Company

The DuPont 460 Gas Analyzer Systems are designed for the continuous monitoring of SO_2 and NO_2 in stack emissions at power generating stations and industrial plants. The 461 Analyzer system is designed for source monitoring of nitrogen oxides. It measures NO_2 and analyzes for NO by converting it to NO_2.

The analyses are based on the strong ultraviolet absorption of SO_2 and the visible absorption of NO_2. The DuPont 460 Photometric Analyzer, using a split beam configuration, measures the difference in light absorption at two different wavelengths. Either manual- or automatic-operated filter switching mechanisms can be provided to allow one analyzer to be used for both SO_2 and NO_2 measurements. Since NO is essentially transparent in the visible and ultraviolet, quantitative conversion to NO_2 is required for its measurement. Speed of response: 15 seconds or less (5-minute cycle for Model 461). Analyzer output: linear, 0 to 10 mV standard; 4 to 20 mA and 10 to 50 mA available. Integrally mounted recorder optional. Accuracy: ± 2% of full scale. Linearity: better than 2%. An optional calibration filter corresponding to a fixed SO_2 concentration is provided. Compressed air at 30 to 80 psig.

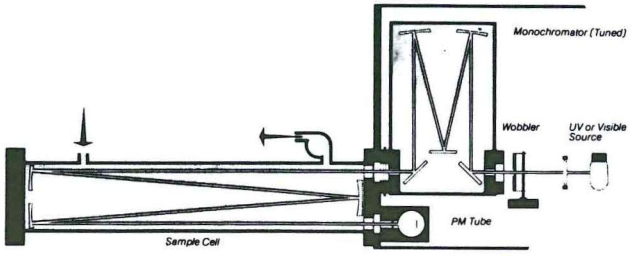


INSTRUMENT V-9.5. DuPont 460 Gas Analyzer System (SO_2/NO_2) flow diagram.

V-9.6 SM1000 Air Monitoring Systems
Lear Siegler

The SM1000 Monitoring Systems are tuned, second-derivative spectrometers that measure trace concentrations of NO_2, NO, SO_2, NH_3, or various other compounds in ambient-air mixtures. These instruments directly measure the narrow-band absorption of visible or UV radiation which is characteristic of the molecules of the compound being measured. The direct monitoring of this physical property is performed in real time, without sample alteration, without sample conditioning, and without secondary reactions. Instrument may be tuned to monitor any compound that exhibits narrow-band absorption of ultraviolet or visible light radiation. Sampling rate: single-component compound measurement is continuous. The Read mode output is ppm concentration, and the Test mode output is one of several selectable test voltages; both modes are select-

able from the front panel. Instrument is equipped with a panel meter for direct readout and with connections for an analog recorder. Interference equivalence for all substances is < 0.005 ppm. The performance of the SM1000 Air Monitoring Systems meets all federal Equivalent and Reference Method specifications and are summarized as follows for the compounds NO, NO_2, and SO_2; noise: 0.005 ppm; zero drift, ± 0.015 for 12 and 24 hours; span drift, < 5%/24 hours; rise and fall time (95%), 300 seconds. A span cell, containing a relatively high concentration of the actual compound, is provided for each instrument.



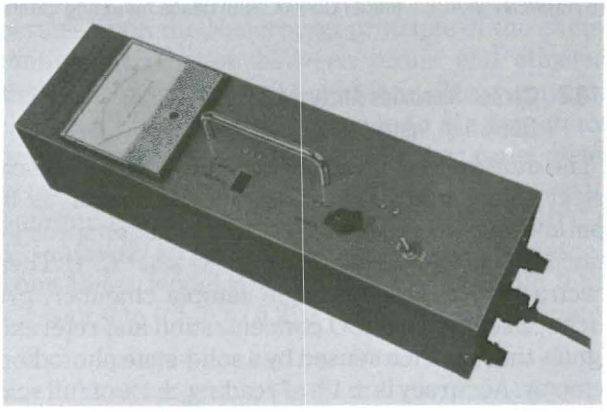
INSTRUMENT V-9.6. Schematic diagram of the Lear Siegler SM1000 Optical system.

V-9.7 Model 727-3 UV Ozone Monitor
Mast Development Company

The Model 727-3 UV Ozone Monitor utilizes the technique of UV absorption for fast and specific ozone detection. The monitor is suitable for use in ozone chamber work, environmental chamber work, safety monitoring near ozone generators in industrial or waste water treatment operations, OSHA-regulated monitoring, quality control for ozone producing appliances, and plant pathology studies. No expendable reagents of any kind are required. The instrument is portable and designed for both long-term, unattended use and intermittent operation. Off-the-shelf warm-up is less than 20 minutes. Flow rate: 2 L/min. Ambient temperature range: 0°C to 50°C. Relative humidity range: 5% to 95%. Unattended period: up to 30 days. Digital display: 0.00 to 9.99 ppm. Analog: 1V per 10 ppm. Accuracy: ± 4% (based on Beer's law). Lag time: 5 seconds. Rise time: 1 measurement cycle. Fall time: 1 measurement cycle. Zero drift: none. Span drift: 1% of calibration level/24 hour. Measurement cycle: 20 seconds.

V-9.8 Instantaneous Vapor Detector
Sunshine Scientific Instruments

The Instantaneous Vapor Detector is intended primarily for the detection of mercury vapor but can be used for the detection of other vapors in specified ranges of concentration. Applications include the manufacture of electric apparatus, instruments, bulbs, glassware, fur, and salt; in the chemical, metal mining, and smelting industries; and by insurance companies and laboratories. Operation of the detector is based on UV light absorption by mercury vapor. This same principle is also used for the detection of certain other vapors which have selective absorption characteristics for UV radiation. For this reason, the identity of the vapor under test must be known and the vapor must be free from other substances which will absorb or obstruct UV light. In addition, the vapor should be relatively uncontaminated by extraneous substances such as fog, dust, or smoke. Features: warm-up time < 15 minutes; < 1% change in reading for 10% line voltage variation. Low power consumption permits operation from a battery-powered inverter for complete portability. Special options include: explosion-resistant Model 38E, recorder output, single or dual set point meter (Model 38F), panel or rack mounting, audible/visible alarms, and systems for monitoring multiple locations.



INSTRUMENT V-9.8. Instantaneous Vapor Detector, Model 38D.

Photometric Analyzers

V-10.1 Model US400 Carbon Monoxide Analyzer
Bacharach, Inc.

The Model US400 is designed for the continuous measurement of low CO concentrations in the field of pollution monitoring and control, monitoring of work areas, garages, ventilation systems, and industrial process streams. Determination of CO is based upon the direct measurement of mercury vapor reduced from a heated, solid-state mercury oxide pellet by oxidation of the CO in the sample. The mercury vapor produced is the analog of the CO in the sample stream and permits the readout to be calibrated in terms of CO. The mercury vapor is measured by means of an UV filter

photometer. The US400 can be furnished suitable for bench mounting or installed in a standard 19-in. panel, suitable for rack or panel mounting. The sample-drawing pump and remotely operated flow control valves are enclosed in a separate housing. Ambient temperatures: 4°C to 43°C. Altitude range: sea level to 1500 m. Warm-up time: 15 minutes. Sample flow rate: 4.7 L/min. Span drift: ± 2% of full scale/day (FSD). Lag time: 5 seconds. Response time: < 10 seconds for 90% FSD. Sensitivity: 0.1 ppm/mV. Recorder outputs: floating or ground reference.

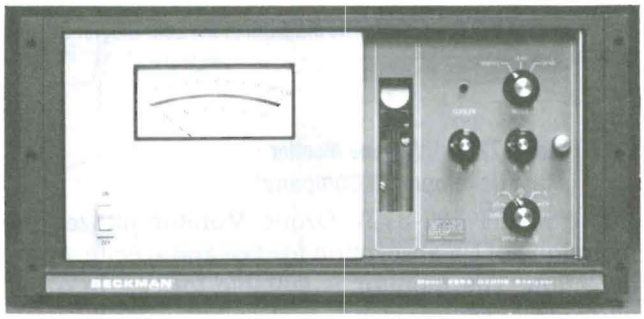
INSTRUMENT V-10.1. Model US400L with bench mounting cabinet.

V-10.2 Carbon Monoxide Analyzer DIF 7000
Beckman Instruments, Inc.

The dual-isotope fluorescence (DIF) technique can detect changes in CO concentrations as small as 0.1 ppm and involves producing infrared radiation spectra to match that of two CO isotopes, $^{12}C^{16}O$ and $^{13}C^{16}O$. These spectra "time-share" a single sample chamber, producing a sequence of CO concentration and reference signals that are then sensed by a solid-state photodiode detector. Accuracy is ± 1% of reading, ± 1% of full scale (accuracy is relative to calibration source), and linearity is ± 1%, 0 to 200 ppm. Specificity: interferent H_2O, rejection — 10,000:1; CO_2, rejection — 20,000:1. The error resulting from all other common interferents is less than 0.5% of range. Opacity tolerance: no degradation of accuracy when measuring in a medium of up to 50% opacity. Noise: 0.5 ppm peak-to-peak on 20-ppm range, increasing to 1.0 ppm on 200 ppm range. Span drift: 1% of reading/month (at constant temp.) Zero drift: 1 ppm/week (at constant temp.) Span and zero temperature coefficient: 0.2% of reading/°C change in ambient temperature. Response time: (90% of final reading) 8 seconds on 200-ppm range; 25 seconds on 20-ppm range. Output: 100 mV (other outputs up to 10 V available on special order). Impedance: < 400 ohms. Warm-up time: 30 minutes to full accuracy. Ambient temperature: 0°C to 50°C. Ambient relative humidity: 90%

V-10.3 Model 950A Ozone Analyzer
Beckman Instruments, Inc.

The Model 950A provides ozone analysis over a wide selection of full scale ranges for ambient air monitoring. The Model 950A utilizes a nonhazardous 90% CO_2/10% C_2H_4 mixture as the reactant gas, instead of pure ethylene typically required for chemiluminescent analysis. The chemiluminescent detection method is based on the principle that ozone mixes with ethylene, resulting in a chemiluminescent reaction which provides a light emission directly proportional to the ozone (O_3) concentration in the ambient air sample. Noise: 0% 0.000 P/10^6; 80% of span, 0.002 P/10^6. Total interference equivalent: < 0.005 P/10^6. Zero drift: < 0.005 P/10^6 per 12 hours; 0.001 P/10^6 per 24 hours. Span drift: ± 2% of full scale per 24 hours. Lag time: < 20 seconds. Rise and fall time: < 90 seconds. Ambient temperature: 4°C to 43°C; EPA designated at 20°C to 30°C. Outputs: 10 mV, 100 mV, 1 V, 5 VDC.

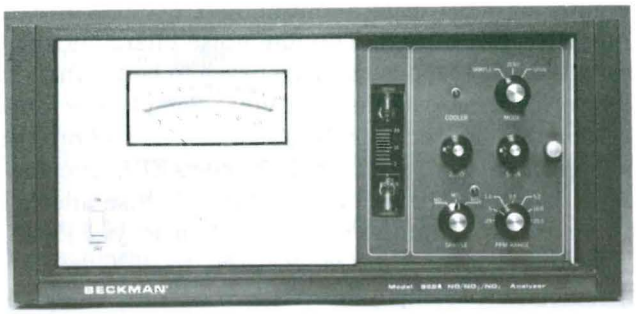


INSTRUMENT V-10.3. Model 950A Ozone Analyzer.

V-10.4 Model 952A NO/NO_x/NO_2 Analyzer
Beckman Instruments, Inc.

The Model 952A ambient NO_2 monitor is designed for field operation. The Model 952A chemiluminescent detector is based on the principle that NO reacts with ozone to produce NO_2, 10% electronically excited NO_2, and O_2. Following the NO–O_3 reaction, the NO_2 molecules immediately revert to NO_2. This process emits photons that produce a light emission directly proportional to the NO concentration in the ambient air sample. For NO detection, the sample gas and the ozone are introduced directly into the reaction chamber for analysis. To determine NO_x (NO + NO_2) concentration, the sample is first routed through the converter where the NO_2 is converted to NO and then routed to the reaction chamber for analysis. Noise: 0%, 0.002 P/10^6; 80% of span, 0.003 P/10^6. Total interference equivalent: 0.01 P/10^6. Zero drift: < 0.02 P/10^6 per 12 hours; <

0.005 P/10^6 per 24 hours. Span drift: ± 2% of full scale per 24 hours. Lag time: 0.5 minutes. Rise and fall time: 1.5 minutes and 1.0 minutes, respectively. Ambient temperature: 4°C to 43°C; EPA designated at 20°C to 30°C. Outputs: a) individual memory outputs for $NO/NO_x/NO_2$, switch selectable for 10 mV, 100 mV, 1 V, or 5 VDC; b) primary output signal, switch selectable for 10 mV, 100 mV, 1 V, or 5 VDC.



INSTRUMENT V-10.4. Model 952A $NO/NO_x/NO_2$ Analyzer.

V-10.5 Model 953 Fluorescent Ambient SO_2 Analyzer
Beckman Instruments, Inc.

Utilizing the fluorescent measurement technique, the Model 953 requires no support gases and reagents typically used with flame photometric or coulometric SO_2 analyzers. An internal zero gas scrubber permits ambient air to be used as the zero gas, eliminating the need for zero air cylinders. An added feature is an interferent reactor that eliminates interference due to polynuclear aromatics (PNAs) typically found in samples where dense automotive traffic prevails. Beckman's fluorescent monitoring methodology is based on the principle that SO_2 molecules fluoresce when irradiated by UV light in the 1900–3900 Angstrom wave band. While the phenomenon does occur over this broad spectrum, the optimum excitation wavelength takes place in the narrow 2100–2300 Angstrom band. The Model 953 transmits a broad UV light band via a quartz deuterium lamp, and a narrow UV light band via a light-collimator assembly. The narrow UV light band passes through the sample reaction chamber where a blue sensitive photomultiplier tube then measures the resulting SO_2 fluorescence.

Noise: 0.5 P/10^6 range, 0.001 P/10^6. Lower detectable limit: 0.5 P/10^6 range, 0.004 P/10^6. Zero drift: 0.5 P/10^6 range, $<\pm$ 0.005 P/10^6 per 24 hours. Span drift: 0.5 P/10^6 range, $<\pm$ 0.006 P/10^6 per 24 hours. Total interference equivalent: 0.5 P/10^6 range, $<$ 0.025 P/10^6. Lag time: 7 seconds. Fall time: 3 minutes. Ambient temperature: 20°C to 30°C. Output: 10 mV, 100 mV, 1V, 5 VDC.

INSTRUMENT V-10.5. Model 953 Fluorescent Ambient SO_2 Analyzer.

V-10.6 Model 1100 Ozone Meter
Columbia Scientific Industries Corporation

The Model 1100 Ozone Meter is used for ambient air monitoring and other applications where a specific determination for ozone in the presence of other oxidants is required. The Model 1100 Ozone Meter operates upon the Nederbragt principle of the chemiluminescent reaction between ozone and ethylene. Ethylene consumption: 15 cm^3/min. Time constant: selectable 1.0 second or 10 seconds. Known atmospheric interferences: none. Data display: panel meter, mirrored 4.5-in. scale. Electronic: solid-state except for photomultiplier tube. Operating temperature: 10°C to 45°C ambient. An optional portable Chemiluminescent Ozone Meter, Model MEC 2000, is also available. It has ranges of 0 to 0.1, 0 to 0.2, 0 to 0.5, and 0 to 1.0 ppm.

V-10.7 Nitrogen Oxides Analyzer
Columbia Scientific Industries Corporation

The Model NA530R Nitrogen Oxides Analyzer is designed for both research investigations and environmental monitoring for NO, NO_2, and NO_x. It uses the chemiluminescence reaction of ozone with NO in two independent and simultaneous photometric measurement systems to monitor for NO and NO_x. One system contains direct sample air and ozone, and the other contains sample air where all the NO_x has been converted to NO. The signals are subtracted for the (NO_2) signal. The chemiluminescence reaction is temperature sensitive causing several percent error if allowed to follow ambient temperature. High sensitivity and accuracy are obtained by controlling the temperature of the reaction chamber. Noise (RMS): 0% URL, 0.002 ppm; 80% URL, 0.004 ppm. Interference equivalent: 0.005 ppm each interferent; 0.015 ppm total interferent.

Zero drift: ± 0.007 ppm per 24 hours; ± 0.01 ppm per 7 days. Span drift: ± 0.013 ppm per 24 hours; ± 0.020 ppm per 7 days. Lag time: < 5 seconds. Rise and fall time (95%): 0.5 to 6 minutes depending on range and TC position. Linearity: ± 1%. Unattended operations: 7 days (no adjustment of flow or electrical systems). Sample air flow rate: 1.2 L/min (max). Dry air flow rate: ozone generator, approximately 200 ml/min. Outputs: meter, with selector switch to read NO, NO_2 or NO_x; recorder, each channel has separate outputs 0 to 10 V and 0 to 5 V adjustable to 0 to 100 mV. Relative humidity range: 0% to 95%. Ambient temperature range: 10°C to 40°C.

V-10.8 Ozone Analyzers
Columbia Scientific Industries Corporation

The Model OA 325-2R and OA 350-2R Ozone Analyzers have been designed to provide real time, continuous monitoring of ozone in ambient air. The Ozone Analyzers' operation is based on the gas phase chemiluminescent reaction between ozone and ethylene molecules which produces light energy in the 300- to 600-nm region. In the presence of excess ethylene, the intensity of light produced is proportional to the concentration of ozone. This reaction has been found to be free of interferences from other gases present in ambient air. The analyzers are identical except the OA350-2R has an internal UV ozone source to produce a span point and also a zero air source. Noise: 0% URL, 0.003 ppm; 80% URL, 0.002 ppm. A) each interferent ± 0.002 ppm or better or B) total interferents, 0.002 ppm or better. Zero drift: ± 0.002 ppm, 12 or 24 hours. Span drift: (% of reading): 20% URL, ± 1.5; 80% URL, ± 2.5. Lag time: 0.1 minute. Rise and fall time: 0.05 minute. Precision: 20% and 80% URL, 0.001 ppm. Temperature range: 20°C to 30°C.

V-10.9 Sulfur Analyzer Model SA285
Columbia Scientific Industries Corporation

The Model SA285 Sulfur Analyzer provides continuous, real time monitoring of sulfur compounds in the ppb range. It utilizes the Meloy-patented Flame Photometric Detector (FPD) to provide dry analysis of sulfur in air samples. The operating principle of the FPD utilizes the photometric detection of the 394-nm centered band emitted by sulfur-containing compounds in a hydrogen rich air flame. Its specificity arises from a geometric arrangement that optically shields the photomultiplier tube from the primary flame and the employment of a narrow band-pass interference filter. Noise (RMS): ± 0.5% of full scale (FS) maximum. Zero drift: ± 1% FS/24 hours. Span drift: ± 2% FS/24 hours. Lag time: 10 seconds maximum. Rise and fall time: 90%, 25 seconds maximum. Linearity in ppb: ± 1% of FS. Available outputs: a) meter, b) 10 VDC FS, c) 100 mVDC FS (adjustable from 10 mV to 5 V FS). Unattended operation: 14 to 28 days (no adjustment of flow or electrical system). Sample flow rate: approximately 200 ml/min. Hydrogen flow rate: approximately 140 ml/min. Ambient operating temperature range: 10°C to 40°C.

V-10.10 Fluorescence SO_2 Analyzer
Columbia Scientific Industries Corp.

The Model SA700 is built for direct ambient air monitoring of SO_2 using a continuous UV source of high intensity and stability. The low noise characteristics provide rapid response and accuracy to better than ± 2% even on the most sensitive ranges. Sample flow rates are less than 500 cc/min. Noise (RMS): ± 0.5% on 0 to 500 ppb scale. Zero and span drift: meets EPA specifications. Lag time: 10 seconds maximum. Rise and fall times: to 95%, 2 minutes maximum. Linearity: ± 1% FS. Operating temperature range: 20°C to 30°C to EPA specifications. Sample flow: < 500 cc/min. Interferences: meets EPA specifications. Output: a) 0 to 10 volts; b) 0 to 100 mV, adjustable to 0 to 5 volts. This instrument is suitable for bench mounting; rack mounting available.

V-10.11 Phosphorus Gas Detectors/Analyzers
Columbia Scientific Industries Corporation

Columbia Scientific offers monitoring of phosphorus by flame photometric detection as a companion or replacement capability in its sulfur analyzers. The capability is now available in Models PA 460 (integral log-linear amplifier) and PA 465 a portable, lightweight unit with 12-volt battery supply. Rise time for Model PA 460 is 2 to 3 seconds (nominal), < 10 seconds maximum; for the PA 465, it is 10 seconds to 90% of full response. Fall time: < 7 seconds for the PA460 and 3 seconds for the PA 465.

V-10.12 Halide Detector
GasTech, Inc.

The GasTech Halide Detector utilizes the phenomenon of increased spectral intensity of an AC spark in the presence of halogens in the atmosphere. The brightness of the spark in the UV region is directly proportional to the halogen content of the gas sampled. Its primary field of application is by industrial hygienists in industrial solvent cleaning and fine chemical production facilities. It has also proven useful as a process monitor. Interpretation of this reading is made by relating the meter reading to a calibration curve based on the specific gas being tested. Sampling rate: continuous. Readout mode: panel meter. Recorder output adjustable from 0 to 10 to 0 to 50 mV. Detection limits: threshold limit concentra-

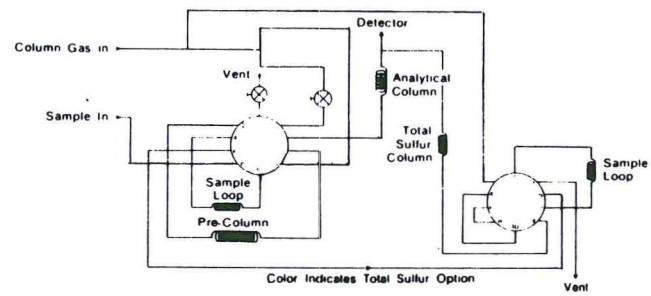
tions of most halogen-containing compounds. The instrument also has a range adjust in arithmetic ratios of 1, 3, and 10 permitting expanded readings up to 10,000 ppm. The instrument is generally not subject to interference from nonhalogenated substances, but it is affected by the presence of sulfur and cyanogen compounds. Sensitivity to these compounds is an order of magnitude less than sensitivity to halides. Response time is 3 to 5 seconds with an accuracy of ± 5%. Line voltage changes will have an effect on readings; otherwise stability is in the neighborhood of ± 5% per day.

V-10.13 Halide Meter
Scott Aviation

The Halide Meter is a portable instrument designed for field determinations of halogenated hydrocarbons in air. The Halide Meter is most often used for determining perchloroethylene, trichloroethylene, carbon tetrachloride, methylene chloride, and similar chlorinated hydrocarbons in air. Air containing halogenated hydrocarbons is passed through a chamber containing an AC electric arc between a copper electrode and a platinum electrode. A bright line spectrum of copper is produced when the air surrounding the arc contains halide vapors. The intensity of this copper spectrum is proportional to the concentration of halide vapors present. The meter readings are converted to ppm using calibration curves. A 20-ft Tygon® sampling hose is also provided with the instrument. Any halogenated material in the air being sampled will cause the instrument to give a reading and, in this sense, the instrument is nonspecific. It cannot, for example, differentiate carbon tetrachloride from trichloroethylene when the vapors are mixed. Nonhalogenated materials, such as hydrocarbons, do not interfere, however, and mixtures of halogenated vapors with other vapors may be evaluated.

V-10.14 Model 271HA Sulfur Analyzer
Tracor, Inc.

The Model 271HA was designed primarily as an automated monitor for low level H_2S and SO_2 (the two common sulfur air pollutants); however, the 270 HA can be used in a variety of other analytical applications simply by changing the column, sample loop size, and/or operating conditions. Operating on GC principles and utilizing the Tracor sulfur-specific flame photometric detector, the 270HA chromatographically separates and independently quantitates vapor-state sulfur compounds in gaseous media. Precise sample volumes, reproducible to within ± 0.2 cc, are injected via fixed F.E.P. Teflon® sample loops (9 cc standard). The 6-ft analytical column quantitatively separates the low molecular weight sulfur pollutants normally measured in air quality monitoring. Tracor's sulfur selective FPD detects and measures sulfur pollutants as low as 1 ppb (9-cc sample loop) without interference. Sampling rate: cyclic (225 seconds). Readout mode: dual output 0 to 10 mVFS (chromatographic) and 0 to 5 VFS (computer or datalogger) for each of two ranges (0 to 100 ppb and 0 to 1 ppm). Specificity: sulfur compound specific; possible interferences high concentrations of CO_2 and/or hydrocarbons (1000 ppm). Response time: sampling is cyclic, maximum response time 225 seconds. Stability: 1% per 24 hours; 2% per week.



INSTRUMENT V-10.14. Flow schematic for Model 270HA.

Photometric Analyzers of Surface Deposit

V-11.1 Hydrogen Sulphide Monitor
Fleming Instruments, Ltd.

The Fleming Hydrogen Sulphide Monitor was developed to meet requirements of underground sewer testing or in areas where there is a possibility of encountering toxic gases. The basic principle used in the Type 533 Monitor is the continuous evaluation, by a sensitive phototransistor, of the intensity of the brown stain produced by the action of H_2S gas on a lead acetate-treated filter paper. Small concentrations of H_2S (as low as 0.1 ppm) result in a staining of the paper, and the degree of stain is continuously evaluated by a stable and sensitive detector circuit. Paper tape: Whatman B.D.H. No. 1 lead acetate filter paper, 1 cm wide × 5 m long (at least 6 working days supply). Paper tape drive mechanism: clockwork motor with drive mechanism which also indicates the remaining operating time. Pump: miniature axial flow. Distilled water is the "wetting" agent. Sampling period to initiate warning signals is approximately 2 minutes (i.e., when set to 10 ppm sensitivity the device will trigger after 2 minutes sampling in a 10 ppm atmosphere).

V-11.2 Model 722AEX-A Gas and Vapor Analyzer
Houston Atlas, Inc.

The 722AEX-A is a fixed monitor which measures airborne H_2S either on the close range or on a limitless wide range when equipped with the System 400 orifice/

manifold kit accessory. The 722AEX-A operates by the photometric method. The air sample enters the instrument through its louvered hood where it is exposed to a lead acetate-impregnated tape. The H_2S content changes the tape from white to a darker color. A photoelectric cell measures the color change and provides a meter deflection proportional to the H_2S content of the sample. This principle is specific to H_2S. It is accurate to ± 2%. Accurate sample readings are ready in 3 minutes. Zero drift is 5% of full scale calibration.

V-11.3 Miniguard Personal Alarm Dosimeter
MDA Scientific, Inc.

The Miniguard is designed to function as a personal dosimeter for toxic chemical gases and vapors. The Miniguard uses a dry, chemically impregnated, paper-tape system, specifically sensitive to the substance being sampled. A piece of tape is inserted into the dosimeter, then the dosimeter is put in shirt pocket or worn on belt, etc. The tape is exposed either by diffusion or aspiration, depending on the system involved. The exposed tape section and an unexposed reference section of the tape are continually evaluated by two balanced Cd-S photocells. When a preset stain density equivalent to a dose in ppm/hours is reached, an audio alarm sounds. At the end of the exposure period, the tape can be removed and inserted into the readout device to provide a direct numerical reading of dose in ppm/hours. The sampling rate is by diffusion or 0 to 250 cc/min, depending on system and range. Readout is directly in ppm/hours. Specificity: no significant interference. Response time: variable, dependent on alarm setting.

INSTRUMENT V-11.3. MDA Miniguard Dosimeter for H_2S and readout device.

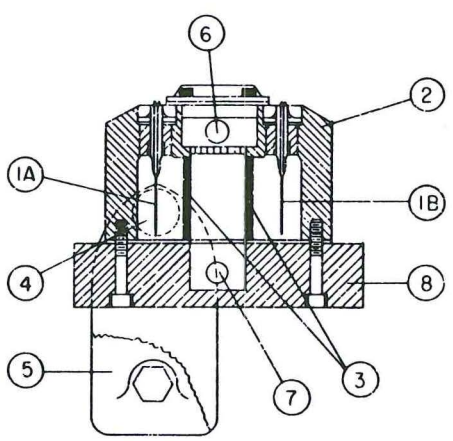
Paramagnetic Analyzers

V-12.1 Oxygen Analyzers
Hays-Republic Division Corporation

Model 633-II Suppressed Oxygen Analyzer and Model 635-II Magno-Therm Oxygen Analyzer are used to determine the O_2 content of gas mixtures where higher accuracy and repeatability are required than are possible with zero-based analyzers. *Model 633-II.* Oxygen is paramagnetic, i.e., it is attracted to a magnetic field. All other gases except NO and NO_2 are diamagnetic, i.e., are repelled slightly from a magnetic field. Paramagnetism diminishes with increasing temperature. The paramagnetic properties of O_2 are employed in the Model 633-II analyzer to produce a "magnetic wind," which is proportional to the concentration of O_2. Measurement of the cooling effect of this "magnetic wind" provides a measure of the O_2 concentration. Since NO and NO_2 are seldom encountered in significant amounts, they generally do not interfere with the O_2 measurement.

Model 635-II. In this model, operation of the measuring cell is based upon a physical phenomenon, magnetic wind, which is due to the unique paramagnetic properties of O_2 and the effect of temperature upon paramagnetism. A sectional view of the analyzing cell is shown in Instrument V-12.1. In this instrument, the glass-covered, platinum wire spirals (1a and 1b) are located in the oblong cavity of a stainless steel block (2). The cavity is partitioned vertically by screens (3). The platinum wire spirals form two legs of a Wheatstone bridge circuit and are heated by the bridge current to approximately 200°C. This spiral (1a) is positioned between the poles (4) of a strong permanent magnet (5).

Ambient temperature: between -1°C and +49°C. Sample gas condition: dewpoint of sample must be below ambient temperature and dust must be below 5 ppm; pressure must be held within ± 1.5% of pressure at which analyzer is calibrated. Stated flow rates are 0.2



INSTRUMENT V-12.1. Sectional view of sensing cell in Model 2 635-II Magno-Therm Oxygen Analyzer.

cfh, 15 cfh, and 30 cfh. Response time: response 3 to 4 seconds, initial; time constant (63.2% of final reading) 6 to 8 seconds. Accuracy: ± 0.5% of span below 30% O_2; ± 3% above 30% O_2. Reference accuracy ± 1%.

V-12.2 Paramagnetic Oxygen Analyzers
Scott Aviation

The Scott-Davis Oxygen Analyzers (Series 11-4500) are systems for measuring the O_2 content of an atmosphere in the range of 0% to 5% or 0% to 50%. The Davis Para-Magnetic Oxygen Analyzer operates on the principle that magnetic lines of flux passes through O_2 more easily than any other gas. O_2 is paramagnetic, i.e., it is attracted by a magnetic field. This paramagnetic property of O_2, caused by its atomic and molecular structure, is inversely proportional to its absolute temperature. When O_2 is heated, it loses its paramagnetic property and becomes diamagnetic (repelled by a magnetic field). Systems are available in self-standing cubicles or wall-mounting cabinets. Measurement is continuous, automatic, and requires no operator. Removal of the magnetic field from the analyzing cell provides immediate zero check. Similarly convenient is measuring normal O_2 content of air (21%), a rapid span check for 0% to 25% range, and serves as an intermediate calibration point for higher spans. Speed of response is 10 seconds for a 90% full scale reading (exclusive of sample line transport lag). Accuracy is ± 5% at full scale deflection.

Aerosol Formation and Detection Systems

V-13.1 Atmospheric Gas Detectors
Environment/One Corporation

The Environment/One atmospheric gas detectors measure trace concentrations of gases and vapors such as mercury, SO_2, and ammonia. The nucleogenic technique used involves the selective creation of submicrometer particles from gas molecules. This is accomplished by a variety of reactions such as photochemical, pyrolysis, acid-base, and others. The particles created are proportional in number to the gas concentration and are counted in the Condensation Nuclei Monitor Model RICH 100. The Condensation Nuclei Monitor operates on the principle of a cloud chamber in which water is condensed upon submicroscopic air particles to produce a cloud of micrometer size droplets. This cloud attenuates a light beam that is focused on a solid-state, light-sensitive element. As the light value is decreased, an electrical pulse is created which is amplified and rectified into a direct current proportional to the condensation nuclei concentration in the sample. The response time varies from 5 to 10 seconds.

INSTRUMENT V-13.1. Condensation Nuclei Monitor, Model RICH 100.

Electron Capture Gas Detectors

V-14.1 Atmosphere Monitors
Ion Track Instruments, Inc.

Three units are available: the Atmosphere Monitor for continuous monitoring of gas streams, the SF_6 Detector Chromatograph for use as a tracer to detect gas system leaks, and the Leakmeter for use as an industrial leak detector designed for detection of leaks of SF_6 tracer gas or any gases that are responsive to the detector. All three units utilize an electron capture detector with the SF_6 Detector/Chromatograph including a gas separation column. All three units sample at a rate of 250 cc/min and utilize a meter as the readout mode. The SF_6 Detector/Chromatograph is extremely specific due to the gas chromatograph column. Response time is one second on the Leakmeter and Atmosphere Monitor and 15 seconds for the SF_6 Detector/Chromatograph.

INSTRUMENT V-14.1. Model 505, SF_6 Detector/Chromatograph.

Photoionization Analyzers

V-15.1 Photoionization Analyzer
H-Nu Systems, Inc.

The Photoionization Analyzer is a portable analyzer

used for the measurement of gases in industrial atmospheres. The sensor consists of a sealed UV light source that emits photons which are energetic enough to ionize many trace species (particularly organics) but do not ionize the major components of air such as O_2, N_2, CO, CO_2, or H_2O. The field created on an electrode drives any ions formed by adsorption of the UV light to the collector electrode where the current (proportional to concentration) is measured. This instrument consists of two separate units: sensor and readout connected by a 3-foot, shielded, multiconductor cable with electrical connector. The case for the readout module is constructed of drawn aluminum. The sensor's outer-body is of aluminum and engineering thermoplastic. Output signal available: 0 to 10 mV recorder jacks. Standard accessories include an AC battery charger and a 3-foot, Teflon®-lined telescoping probe for sampling hard to reach places. Response time: < 5 seconds. Operating time: minimum of 8 hours on 12 VDC rechargeable batteries.

V-15.2 Photovac TIP
Photovac International, Inc.

The TIP stands for *T*otal *I*onizables *P*resent. The instrument is designed to measure any airborne contaminant that is detectable by photoionization. In operation, a small pump continuously draws sample air into an ionization chamber which is flooded with ultraviolet light. The molecules of most light permanent gases (including the air gases H_2, helium, N_2, etc.) are unaffected as they require an ionization energy higher than that generated by the 10.6-eV lamp in order to become ionized. However, any gases or vapors in the air stream which have ionization energy levels below that generated by the lamp are ionized. Inlet flow rate: 275 ml/min. Display: 3.5-in. LCD (0 to 1999 counts, illuminated). Charge/discharge time: approximately 16 hr/4 hr; charger provided. Low battery indication: at 95% discharge. Signal outputs: 1 volt full scale, analog concentration, and modulated pulse for external (optional) earphone. External power: 12 VDC, 0.4 A (TIP has internal regulation). Linearity: 0–100 ppm ± 10%, 100–1000 ppm ± 15%. Response time: 3 seconds (10–90% full scale, 10 ppm benzene).

V-15.3 Model 910 Organic Vapor Meter
Thermo Electron

The AID 910 Organic Vapor Meter is designed as a stationary monitor for most organic vapors in air, excluding methane, ethane, propane, and a few others. The AID 910 operation is based upon the principle of photoionization. The photoionization detector (PID) utilizes a high-energy UV lamp to ionize the sample that is drawn into the instrument. The AID 910 comes confined to two sizes; a bench-mount unit and a NEMA enclosed unit. The sampling rate is variable up to 4 L/min and is user-adjustable. A positive displacement pump provides the source for the air sampling. No external accessories are required to operate the 910; however, a separate module is available to do multiple-point sampling with this unit. No fuel or compressed gases are required. The 910 is equipped with an audible alarm for a low-level and a high-level indications. Using a standard 10 eV photoionization lamp, the 910 may detect a minimum of 0.1 ppm benzene in an air matrix. The instrument displays all data on a linear LCD. As with any PID, the specificity can be varied by the energy of the ionizing lamp. Response time is dependent upon the variable flow rate; 2.5 seconds at maximum flow rate. Span and zero calibration adjustments are found on the front panel of the 910.

Gas Chromatographic (GC) Analyzers

V-16.1 10S Portable Gas Chromatograph
Photovac International, Inc.

The self-contained model 10S air analyzer can be used as a portable or fixed station monitor to provide multicomponent air analyses to the ppb level. The 10S utilizes a photoionization detector that can measure compounds not usually detected by photoionization such as chloromethanes, fluorochloromethanes, and ethane. Automatic sampling is accomplished using a miniature printed circuit card, upon which are mounted very small, three-way solenoid valves, chosen for their extreme reliability and long life. These valves are all under independent computer control and can be interconnected to produce a whole range of different chromatographies. The computer also handles the timing of different valve arrangements, controlling, calibrating, identifying, and quantifying chromatograms; runs the tiny printer/plotter; monitors temperature and battery charge; and provides an auto-zero function at the beginning of each analysis. Chromatography: dual-column, manual injection standard. Multifunction, 6-value (18 ports) option provides wide variety of GC arrangements; "quick-scan" and "analytical" columns and "pre-column backflush" are software selectable. A wide range of interchangeable columns is available. Sampling: manual injection or optional automatic injection, computer-controlled internal sampling pump with provision for connection of sampling line. Injection volumes can be software selectable. Carrier gas: normally, air is used but can use other carriers including NO, HE, and CO_2. Rechargeable internal reservoir will last about two days. Calibration: manual or fully automatic (from portable standard vessel), depending upon option chosen. Analysis time: dependent upon compound sought and any potential interferences.

Display mode: internal or external chart recorder shows chromatograph trace and name compounds with concentrations and TWAs (depending upon which option is chosen). LCD gives 32 characters, alphanumeric or bar graph for 10S10. Warm-up time: 5 to 10 minutes for most tasks.

V-16.2 Hazardous Vapor Monitor, Model GC810
Xon Tech, Inc.

The Model GC810 Vapor Monitor is a portable automatic GC with a preconcentrator which can be used to measure hazardous vapors in industrial environments. Applications include fugitive emissions measurement, workplace surveillance, spill monitoring, confined spaces monitoring, continuous ventilation dust monitoring, and process control monitoring. The Model GC810 comes equipped with an electron capture or argon ionization (H_3 source 150 mCi) detector. The monitor can be used to sample ambient air automatically or used manually to handle injections. Sampling time: 2 seconds to 5 minutes. Sampling rate: up to 1000 cc/min. Fuel: carrier gas, helium. Alarm limits: 1–999% of calibration. Recorder output: 0 to 1 VDC. Alarm indication: audible and visual alarm. Column and detector temperature: 60°C to 200°C. Time response: 20 seconds to 30 minutes. Warm-up time: 20 to 30 minutes. Automatic calibration: 2 to 120 per calibration.

Conductivity Analyzers

V-17.1 Gold Film Mercury Vapor Analyzer
Arizona Instrument Corporation

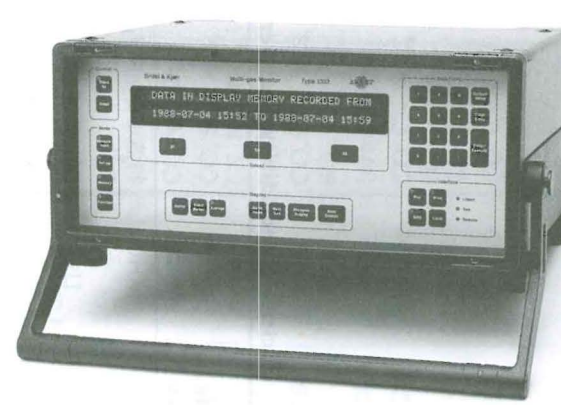
The Model 411 Gold Film Mercury Vapor Analyzer is a portable instrument designed for mercury surveys in workplace environments. The Model 411 uses a patented Gold Film microsensor as the basis of detection. The sensor absorbs and integrates the mercury present in the sample, registering this as a proportional change in electrical resistance. The sensor's selectivity to mercury eliminates many interferences common to atomic absorption such as water vapor, SO_2, aromatic hydrocarbons, and particulates. The Model 411 incorporates an internal pump and digital display with microprocessor control. Activating either the 10-second sample or 1-second survey mode starts the pump that draws a precise volume of air over the Gold Film sensor. Mercury in the sample is adsorbed and integrated by the sensor. The microprocessor computes the concentration of mercury in mg/m^3 and displays the results on the digital meter until the next sample cycle is activated. Response time: sample mode, 10 seconds; survey mode, 1 second. Meter: LCD display. Construction: aluminum alloy. Flow rate: 0.75 L/min.

Infrared Photoacoustic Analyzers

V-18.1 Toxic Gas Monitor Type 1306
Bruel & Kjaer Instruments, Inc.

The Toxic Gas Monitor Type 1306 is designed for the continuous measurement of various toxic gases. Typical applications are area monitoring for process emissions and perimeter monitoring for accidental releases. The monitor can operate unattended for months at a time. The Multigas Monitor 1302 is a portable unit which has typical applications for occupational exposure, tracer gas analysis, and indoor air quality assessment. The measurement technique used in both instruments is based on infrared photoacoustic spectroscopy. This uses the fact that when a gas absorbs modulated light it emits sound proportional to the concentration of the gas. During operation, air is pumped into the measurement chamber. The chamber is sealed and irradiated with modulated, narrowband, infrared light. If the toxic gas of interest is present in the air sample, sound is emitted and measured with a microphone. The signal is processed and the result transmitted to the controlling computer. Selectivity is controlled by fitting the monitor with the appropriate optical filter for the gas of interest. A wide range of filters is available, covering the useful region of the infrared spectrum.

The Toxic Gas Monitor is remotely controlled from a personal computer which can be positioned a considerable distance from the monitor. The monitoring system can incorporate anything from 1 to 254 monitors connected to one computer. The Model 1302 has 32 KB of memory and 80 character display. It has a measurement time of 30 seconds for one gas and up to 100 seconds for five gases. Span drift: 2.5% of reading in 3 months. Zero drift: detection threshold concentration in 3 months.



INSTRUMENT V-18.1. Bruel & Kjaer Multigas Monitor Type 1302.

TABLE VI-1. Electrical Conductivity Analyzers (liquid phase sensor with scrubber)

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm)			Weight (kg)	Power	Alarms		Comments
							H	W	L			Aud.	Vis.	
V-1.1	BAC	MHO	H_2S, SO_2, NH_3	0–5, 10, 20 0–50, 100	—	—	3.9	4.7	2.4	6.8	115 VAC	X	X	A, B
V-1.2	CAL	U3S	SO_2		0.005	—	6.3	5.5	8.3	27.3	115 VAC	—	—	C, D
V-1.3	CAS		SO_2	0–500	0.005	—	4.3	3.1	2.0	5.9	Ni-Cd 24-hr	—	—	C, D
V-1.4	CEA	U2-D5	SO_2	0–0.5, 1, 2, 5, 10, 20	0.02	0.02 ppm or 3%	4.7	3.1	1.6	2.3	pen cell +6V, -6V	—	—	C, D
V-1.5	DVC	Series 9000	H_2S, Cl_2, CO_2, NH_3, SO_2, halogenated hydrocarbons	0–1	variable	2-5%	NEMA type wall enclosures			—	115 VAC	X	X	A, E
V-1.6	SCA	11-1710-RP	H_2S, Cl_2, NO_x, CCl_4 N_2H_4, $CHCl_3$	0–1, 10, 50 (depends on analyte)	variable	10%	7.9	5.9 (portable)	5.1	—	115 VAC	—	—	A, E

* Manufacturer codes given in Table VI-19.

A. H_2S converted to SO_2 in. inlet.

B. Absorbs samples in distilled H_2O.

C. Absorbs samples in acidified H_2O_2 solution.

D. Converts SO_2 to H_2SO_4; temperature compensated.

E. Pyrolysis train on inlet for some analytes.

TABLE VI-2. Potentiometric Analyzers (liquid phase or electrochemical surface active sensors)

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-2.1	CEA	Series 7	AsH_3 B_2H_6, CO, Cl_2, HCl, H_2S, NO_x, PH_3, SiH_4, SO_2	0–1, 500 depends on analyte	0.05–5 depends on analyte	—	2.8	2.6	1.4	2.3	C–Zn or Ni–Cd	X	X	A
V-2.2	CEA	Series U	CO, NH_3, organics, combustibles, Freons	0–250, 500, 100 or % LEL	variable	—	1.7	2.9	1.1	<0.09	Ni–Cd	X	X	A, D
V-2.3	CEA	Series TGA	Cl_2, H_2S, HCN, HCl, SO_2, $COCl_2$, halogens, NO_x, amines, NH_3, Freons	0–3, 150 variable	variable	—	3.1	3.1	5.1	5.9	110 or 220 VAC	X	X	A
V-2.4	DYM	O_2–25H	O_2	0–25%	0.5%	1%	1.0	2.0	0.8	0.4	—	X		A
V-2.5	DYM	Monoguard/ dynaMite	CO, H_2S, O_2, SO_2, NO	0–100, 500 100% (O_2)	—	1 ppm	2.0	1.2	0.4	0.3	9V lithium 250 hr	X	X	A, B, E
							1.3	0.9	0.6	0.2				
V-2.6	EIT	Series 300	SO_2, NO_2, NO_x, H_2S	0–1, 10,000 analyte dependent	0.001 variable	1%	2.6	4.8	5.1	5.5	115-220 VAC	—	—	F
V-2.7	GFG	Series G3000	CO, H_2S	0–200, 50	—	2–3%	1.5	0.9	0.6	0.2	Ni–Cd 100 hr	X	X	A, B
V-2.8	GFG	Polytector	CO	0–200, 5000	2	2 ppm	3.3	1.4	0.9	0.9	—	—	—	A, B, E
			O_2	0–25%	0.2%	0.2%								
			combustibles	0–5%, 100%	0.1%	1%								
V-2.9	ISC	CO260	CO	0–1999	1		1.9	1.1	0.6	0.4	4 AA cells	X	X	A, B
V-2.10	ITS	Series 1000 & 4000	CO, SO_2, H_2S, Cl_2, NO, NO_2, hydrazines	1%	0.1 × TLV	2%	2.9	2.4	4.5	3.6	Ni–Cd or 115 VAC	X	X	A, G
							2.8	1.6	2.8	2.0				
V-2.11	ITS	Series 4000	CO, NO_2, H_2S, SO_2, Cl_2	0.1–10 times TLV	0.5%	2%	2.4	1.2	0.8	0.7	9V 125 hr	X	X	A, B, E
V-2.12	MDA	681	formaldehyde	0.3–99.9	0.3	15%	12	6.3	3.3	0.2	9V			A
V-2.13	MDA	Monitox	CO, Cl_2, N_2H_4, HCN, H_2S, $COCl_2$, SO_2	0–300 analyte dependent	variable	10%	10.5	6.2	2.4	0.15	Px–23 or Px–14 battery	X	X	A
V-2.14	MSA	MiniCO	CO	0–100, 250, 500	2	2%	—	—	—	—	—	X	X	A, B

TABLE VI-2 (con't). Potentiometric Analyzers (liquid phase or electrochemical surface active sensors)

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-2.15	MSA	70-CO 80-H_2S 90-Cl_2	CO, H_2S, Cl_2	0-2, 500 analyte dependent	2% FS	1%	3.3	2.6	1.4	3.4	Ni-Cd	X	X	A
V-2.16	NDR	Ecolyzer Series 2000	CO	0-50, 100, 500, 600 3000	0.5%	1%	2.8	5.1	2.8	4	Ni-Cd	—	—	A
V-2.17	NDR	210	CO	0-1999	1.0	1 ppm	2.1	1.3	0.5	0.34	9V	X	X	A, B
V-2.18	NDR	7100	NO NO_2	0-10, 50 0-2, 10		1-2%					Ni-Cd			A
V-2.19	NEO	Exotox	O_2 CO H_2S	0-25% 0-999 0-999	0.5% 1 1	2.5%	6	3.5	2.1	2	Ni-Cd	X	X	A, M
V-2.20	NEO	Neotox	O_2, CO, H_2S	0-35% 0_2 0-999	0.1% O_2 1	1-2.5%	1.6	0.9	0.7	2.4	9V 200-300 hr	X	X	A, C
V-2.21	ORE	O3T	O_3	1-100 pph/vol	3 pphm/vol	3%	9.4	5.9	5.1	32	110 VAC	X	—	H
V-2.22	ORE	MSA-3	O_3	5 pphm-0.1% (v)	—	—	6.7	4.7	3.9	21	115 VAC	—	—	H, I
V-2.23	PRA	Titrilog II	oxidizable sulfur compounds (e.g., SO_2, H_2S)		0.01-0.02	—	5.6	5.6	8.3	30	115 VAC	—	—	J, K
V-2.24	SEN	Mini Monitor	H_2S, CO, O_2, NO_2, SO_2	0-10, 20, 100, 400, 40%	0.5%	0.5%	1.2	0.4	1.9	0.2	9V 100 hr	X	X C	A, B,
	SEN	SS 2000	H_2, Cl_2, HCl, HF, SO_2, CO_2, NH_3, H_2S, HCN	0-3, 10, 10,000	10%	10%	3.4	1.7	2.7	1.5	Ni-Cd 20 hr	X	X	A
	SEN	SS 4000	SiH_4, AsH_3, PH_3	0-5, 10, 15, 30	8%	5%	14	17	9	2	Ni-Cd 35 hr	X	X	A, C
V-2.25	TEL	990	O_2, CO in flue gas	0-500, 100, 5, 25%	2%	5%	4.8	5.1	2.7	5	Ni-Cd	—	—	A, L, M

* Manufacturer codes given in Table VI-19.

A. Electrochemical sensor.
B. Diffusion sampling.
C. Intrinsically safe.
D. Explosion proof units available.
E. Data logger capabilities.
F. Uses temperature compensated Faristor sensor.
G. Available in variety of fixed units.
H. Absorbing solution is potassium iodine.
I. Endpoint is a titration with sodium thiosulfate.
J. Cell reagent is KBr, where Br_2 is generated.
K. Liquid prefilters are required for some analytes.
L. Designed for combustion process measurements.
M. Separate sensors for CO and O_2.

TABLE VI-3. Coulometric Analyzers (liquid phase or surface active sensors)

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm)			Weight (kg)	Power	Alarms		Comments
							H	W	L			Aud.	Vis.	
V-3.1	ADS	EA-1	Flammable toxic gases	ppm & % LEL	small concentrations	% of LEL	3.2	4.1	2.2	<4.5	90–120 VAC 190–240 VAC	—	—	A
V-3.2	BAC	Sentox	H_2S	0–50	3	3–10 ppm	4.1	2.7	2.6	3.2	Ni-Cd	X	X	B
V-3.3	BAC	K Series	O_2 combustibles	0–5, 25% O_2	0.5% O_2	0.1%	1.2	1.7	2.3	1.3	battery	X	X	C, D
				0–1, 4, 100% LEL	0.01% LEL	—	1.6	2.2	3.0	2.6				
V-3.4	BAC	Sniffer® 103	O_2 combustibles	0–25% O_2 0–100% LEL	—	—	2.4	1.4	0.9	0.7	9V	X	X	C, D
V-3.5	BEC	946	trace acid base concentration	0–1, 10, 100	0.05	5%	11.8	11.8	4.7	wall mount	107–127 VAC 214–254 VAC	—	—	E
V-3.6	BEC	OM-11EA OM-11	O_2	0–5, 10, 25%	0.05%	1%	—	—	—	wall mount	115/230 VAC	—	—	F
V-3.7	BEC	950	O_3	0–0.025, 0.05, 0.1, 0.25, 0.5, 1.0, 2.5	0.001	1%	—	—	—	wall mount	115/230 VAC	X	—	G
V-3.8	BEC	952	NO, NO_2, NO_x	0.25, 0 5, 1.0, 2.5, 5, 10, 25	0.005	1%	—	—	—	wall mount	115/230 VAC	X	—	H
V-3.9	DYM	2300	CO		—	10%	4.3	3.7	2.0	6.4	117 VAC	X	—	B
V-3.10	EDW	60-625 60-600 60-620	O_2	0–25% 0–50% 0–25%	19.5%	0.2	1.2.	1.2	2.0	0.5	117 VAC (2) 9V	X	—	
V-3.11	ERI		SO_2	0–1, 5 in air; 0–0.05, 1000 ppm in solution	0.1	5%	2.9	2.2	3.0	—	115 V 60 Hz	—	—	I
V-3.12	GAT	OX-80	O_2	0–50%	0.1%	—	2.2	1.2	0.4	0.4	Ni-Cd	X	—	C, J
V-3.13	GFG	G 3000 Microox®	O_2	0–25%	0.1%	0.5%	1.5	0.9	0.6	0.2	Ni-Cd	X	X	C, J
V-3.14	ISC	OX 231	O_2	variable	0.1%	—	1.9	1.1	0.6	0.5	4 AA cells	X	X	C, J
V-3.15	LSP	Scen-Trio	O_2, toxic gas, combustibles	variable	—	0.5%	3.1	0.8	2.0	1.4	Ni-Cd	X	X	B, C, D, J

TABLE VI-3 (con't). Coulometric Analyzers (liquid phase or surface active sensors)

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-3.16	LSP	LP-COM-19GR	O_2	0–50%	—	0.5%	0.5	1.4	2.4	0.5	Alkaline	X	X	C, J
V-3.17	MDC	724-2	O_3	0–100 pphm O_3	0.003		3.0	2.4	4.5	4.8	115 VAC			K
		725-11	NO_2	0–30	0.1									
		725-21	Cl_2, F_2	0–1.5	0.05									
V-3.18	MDA	3300	O_2	0–100% 0–25%	—	2%	1.2	2.0	2.0	0.5	2.9V	X	—	C
V-3.19	MSA	E	O_2	0–25%	0.5% O_2	2% FS**	2.7	1.6	2.3	2.6	battery	—	—	C
		S		5–40%		5% FS								
V-3.20	MSA	245	O_2	0–25%	2% O_2	1% FS	0.8	1.0	2.0	0.3	—	—	—	C
		245R					0.8	1.0	2.0	0.4	—	—	—	
		245RA					0.8	1.0	2.0	0.5	2V alk.	X	—	
V-3.21	MSA	Toxgard®	HCN	0–50	1.0	—	7.7	3.9	2.0	—	115 VAC	—	—	L
			H_2S	0–50	1.0	—								
			Cl_2	0–5	0.25	—						X	X	
V-3.22	MSA	C	H_2S, HCN	0–50	—	2% FS	3.1	2.4	1.4	3.6	120 VAC	—	—	L
			CO	0–100	—							X	X	
V-3.23	PEI	PW 9700	SO_2, NO_2, NO, CO, H_2S, O_3	variable	0.005 NO_2, NO, SO_2, O_3 0.1 CO	2% FS	wall mount			22	110, 125, 200, 220, 240 VAC	—	—	M
V-3.24	SCA	S103	O_2	0–25%	—	0.8%	1.2	2.5	0.6	0.5	—	—	—	C, J
V-3.25	TEL	Series 330	O_2	0–25%	—	0.25% O_2	4.0	2.4	1.5	1.7	4 C cells	—	—	C
V-3.26	WPD	44000	NO_2, SO_2, H_2S, CO	—	—	—	4.3	3.5	3.5	>4.5	4–4.5 V, 1.5 V Ni-Cd	—	—	N

* Manufacturer codes given in Table VI-19.
** FS = full scale.
A. Uses Cold Sensor™.
B. Metal oxide semiconductor sensor.
C. Electrolytic cell for oxygen.
D. Catalytic (platinum) sensor for combustibles.
E. Measures pH shifts and converts to ppm.
F. Designed to measure oxygen in vehicle emissions.
G. Uses chemiluminescent method based on reaction with ozone and ethylene.
H. Measures chemiluminescence of reaction of ozone with NO.
I. Uses electrochemical cell covered with SO_2 permeable membrane.
J. Diffusion sensor.
K. Nonspecific electrochemical sensors for oxidants.
L. Amperometric-type, two-electrode sensor.
M. Measuring modules are electrochemical but are specified for each pollutant of interest.
N. Electrochemical sensors for ambient and stack sampling.

TABLE VI-4. Flame Ionization Detectors

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-4.1	BEC	6710	trace hydrocarbon	100 ppm – 100% LEL	300	—	15.1	8.7	4.8	122.75	100 VAC	—	—	A, B, C
V-4.2	BEC	400	hydrocarbons	1–1000	0–4 @ 10% scale as CH_4	1% FS**	7.4	3.4	6.2	29.5	110 VAC	—	X	A, D
V-4.3	BEC	402	hydrocarbons	1–5000	5	1% FS	7.2	10.8	4.5	68.2	110 VAC	—	—	A
V-4.4	CSI	HC5000	hydrocarbons	0–10, 50, 100, 500, 1000	0.1 CH_4	0.1 ppm CH_4	4.8	7.5	7.9	18.2	110 VAC	—	—	B
V-4.5	FOX	OVA	organic vapor	$1–10^5$	1		3.4	4.6	1.7	5.0	12 VDC batt. pack	X	—	A, B, D
V-4.6	SCA	11-654	hydrocarbons	ppm – Vol. % by element	<2 benzene	Vary by element	3.9	4.3	7.1	13.6	110 VAC	—	—	A, B
V-4.7	TEL	TAI 400	total hydrocarbons	10–1000	2 CH_4	1% FS	6.3	6.7	3.5	—	110 VAC	—	—	A
V-4.8	TEI	580	organic vapors	0–2000	0.1 benzene	0.1 ppm benzene	7.6	22.8	25.4	3.75	—	X	X	A, B, E
		585		0–10000								X	X	
V-4.9	TEI	710	total hydrocarbons	0–20000	0.1	0.1 ppm	25	37	35	6.4	Ni-Cd	—	—	A, B,
		712			1.0							X	—	E
V-4.10	TRA	350F	total hydrocarbons	0.01–200	0.01	—	—	3.5	7.5	—	115 VAC	—	—	A, D

* Manufacturer codes given in Table VI-19.
** FS = full scale.

A. Temperature controlled.
B. Processor controlled.
C. Explosion proof.
D. Gas shut off.

TABLE VI-5. Thermal Conductivity Detectors

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm)			Weight (kg)	Power	Alarms		Comments
							H	W	L			Aud.	Vis.	
V-5.1	BEC	7-C Series	H_2, Ar, O_2	vary by analyte 0–500 H_2	vary by analyte	2% FS**	7.2	6.0	4.4	—	220 115 VAC	—	—	A, B
V-5.2	DET	Analograph	H_2, He, O_2, CO, CO_2, CH_4, C_2H_6, C_2–C_6 hydrocarbons	vary by analyte	vary by analyte	—	2.8	5.3	5.7	11.4	110 VAC	—	—	C
V-5.3	MGP	Leak Hunter 8065	nonflammable gases	—	He:1×10^{-5}; CO_2:3.5×10^{-5}; Freon 12: 1.2×10^{-5}; cc/sec leak rate	—	1.4	3.9	5.5	2.3	4×1.5 V Dry cell or Ni-Cd	X	X	D

* Manufacturer codes given in Table VI-19.
** FS = full scale.

A. Explosion proof available.
B. Corrosion resistant cells.
C. A separate Servocorder available.
D. Designed for leak detection not quantitation.

TABLE VI-6. Heat of Combustion Detectors

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-6.1	BAC	Gastron 282 310	combustible gases	hydrocarbon: 0–500; H_2: 0–25	hydrocarbon: 50; H_2: 10	—	—	—	—	1.9	Ni-Cd	X	X	A
V-6.2	BAC	Sniffer® 500 Series	O_2 deficiency H_2S, CO, combustible gases	O_2: 0–25%; H_2S: 0–100; CO: 0–500; combustibles: 0–10,000	variable	5% FS**	3.0	3.9	2.5	4.3	6 VDC Pb-acid	X	X	A, H
V-6.3	BAC	Super Sniffer®	combustible gases and vapors	0–1000 0–100% LEL	variable	5% FS	1.2	2.4	3.0	3.1	Ni-Cd	—	—	A
V-6.4	BAC	TLV Sniffer®	combustible vapors	0–100, 1000 10000	3	5% FS	22.8	9.5	16.8	2.3	Ni-Cd 6 size D	X	—	A
V-6.5	BAC	Ultra I & II	combustible gases and vapors	0–20% LEL 0–100% LEL	—	5% FS	3.3	1.1	2.3	1.4–1.6	4 size D	—	—	A, M
V-6.6	CHE	12	combustible gases	—	1	—	2.3	1.0	0.6	0.5	6 or 12 VDC Ni-Cd	X	—	B, C
V-6.7	DVC	1000 Series	CO	0–500	—	2% FS	—	—	—	—	115 VAC 220 VAC	—	X	A
V-6.8	DVC	5000 Series	combustible gases and vapors	0–100% LEL	—	3% FS	—	—	—	—	—	—	X	A, D
V-6.9	DYM	LCD combo	combustible gases, O_2 deficiency	0–100% LEL	—		2.8	1.6	1.2	1.4	5 size C	—	—	A, H
V-6.10	DYM	ABL-50	CO	2–50	2	10% FS	5.1	5.5	2.2	7.3	110 VAC 12 VDC	X	X	E, F
V-6.11	EEC	03 HCS	combustible gases and vapors	0–100% LEL	—	—	3.1	0.7	1.2	0.8	2 size D	—	—	A, G
		05 HCS		0–10, 100% LEL	—	—	3.5	1.1	1.4	1.1	2 size D	X	—	A, D, G
		06 HCS			—	—	2.3	2.5	1.4	1.8	8 size D	—	—	A
		07 HCS		0-100% 0–1000; 0–100% LEL	—	—	3.5	1.1	1.2	—	Ni-Cd or 110 VAC	X	—	A, D
V-6.12	GAT	GX-3A	O_2 deficiency combustible gases	0–25% 0–100% LEL 0–1000	—	5% FS	4.3	2.8	2.2	5.5	6 size D Ni-Cd	X X	X X	A, H
V-6.13	GMI	170	combustible gases	0–100% LEL	—	5%	1.6	0.8	3.1	1.4	115 VAC	—	X	A, D
		1100E			—		1.6	2.4	0.7	1.1	2 size D	—	X	

TABLE VI-6 (con't). Heat of Combustion Detectors

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm)			Weight (kg)	Power	Alarms		Comments
							H	W	L			Aud.	Vis.	
V-6.14	GMI	H_2S Monitor	H_2S	10–100	1.0	5%	1.6	1.6	3.1	1.8	150/130 VAC 220/240 VAC	X	—	B, D
V-6.15	GFG	Exotector®	combustible gases	0–10% LEL 0–100% LEL	variable 0.1–5% LEL	2% LEL	2.0	1.4	0.8	0.6	Ni-Cd	X	X	A, D or F, G, M
V-6.16	HRD	647	combustible gases	0–5% comb. 0–10% comb. 0–100% LEL	0.25% LEL	1% FS	5.0	3.8	3.5	—	115 VAC	—	X	A
V-6.17	HAI	510	combustible gases	0–100% LEL	—	5% FS	2.0	2.8	3.1	5.5	115 VAC	X	—	A, G
V-6.18	ISC	CD212	CH_4	0–5% by volume	0.1% by volume	—	1.9	1.1	0.6	0.5	5 V Ni-Cd	X	—	A, D
V-6.19	LSP	Gasponder® I-IV	combustibles O_2, CO, H_2S	CH_4: 0–100% LEL CO: 0–400 H_2S: 0–100 O_2: 0–30%	variable	CH_4: 5% LEL CO: 2% H_2S: 2% O_2: 0.5%	1.1	2.1	3.0	1.4–1.8	battery	X	X	A, H
V-6.20	MAC	RCM REM	CO EtO	0–100, 500 0–50, 250	10 5	10–25%	0.6	1.1	2.0	0.5	Ni-Cd or 120 VAC	—	X	B
V-6.21	MAC	RGM	combustible gas	0–1, 5%	100	10–25	0.5	1.1	2.0	0.5	Ni-Cd			
V-6.22	MGP	8957	Cl_2, AsH_3, H_2 H_2S, PH_3, etc.	—	vary by analyte	—	1.1	2.4	0.5	0.4	4 size AA Ni-Cd	X	X	B, I
V-6.23	MSA	260 100	combustible gas and O_2	0–100% LEL O_2 0–20% vol.	—	5% FS comb. 2% FS O_2	2.8	3.9	1.5	3.2	2.4 VDC battery pack	X	X	A, H, J
V-6.24	MSA	Explosimeter® 2A	combustible gas	0–100% LEL	2% LEL	5% FSD	1.3	2.1	2.2	1.8	6 size D cells	—	—	A
V-6.25	MSA	Series 510	combustible gas	0–100% LEL	—	2%	2.4	5.6	5.3	—	105, 115, 230 VAC	X	X	A, K
V-6.26	MSA	Spotter™ QII	combustible gas	0–99% LEL	0.1% LEL pentane	5%	2.3	1.0	0.6	0.3	2.4 VDC Ni-Cd	—	—	A, D
V-6.27	MSA	60, 62	combustible gases	0–5, 100% CH_4 (vol) 0–100% LEL	—	15% FC	2.6	2.9	1.6	2.3	8 ZnC	—	—	A, L, M
V-6.28	NMS	G-2000	CH_4	0–2% CH_4	—	—	0.8	1.5	0.5	0.3	3.6 VDC Ni-Cd	—	—	A, D
V-6.29	SCA	S101	combustible gases, O_2, CO, H_2S	0–100% LEL 0–25% O_2 0–199% H_2S	—	3% LEL 0.8% O_2 5 ppm H_2S	1.2	2.5	0.6	0.5	battery	X	X	A, D, G

TABLE VI-6 (con't). Heat of Combustion Detectors

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-6.30	SCA	Vapotester	combustible gases	0–100% LEL hexane in air	—	—	2.4	2.3	1.4	1.8	8 size D cells	—	—	A
V-6.31	SCA	3800 Series	combustible gas	0–100% LEL	—	1% FS	1.4	3.5	2.3	—	117 VAC	X	—	A, D, L
V-6.32	SMC	10HS	H_2S	0–50	—	—	3.0	1.5	0.7	0.7	Ni-Cd	X	—	B, F, G
V-6.33	SMC	2000 Series	combustible gases	H_2: 100–5000 CH_4: 200–20,000	H_2: 80 CH_4: 150	—	10.6 × 0.8 round			0.7	120 VAC	X	—	B, G
V-6.34	TEL	102	combustible gases	0–100% LEL	—	0.5% FSD	1.4	3.7	2.8	3.2	115 VAC	—	—	A, D

* Manufacturer codes given in Table VI-19.
** FS = full scale.
A. Heated catalytic combustion sensor.
B. Metal oxide semiconductor sensor.
C. No meter readout; uses rate of clicking relative to concentration.
D. Diffusion sampler.
E. Air-line monitor.
F. Continuous line monitor - auto reset.
G. Intrinsically safe for Class I, Groups B, C, D (GG-groups B & D).
H. Electrochemical cell for O_2 deficiency.
I. Designed as leak detector.
J. Model 100, combustible gas only.
K. Explosion proof model available.
L. Silicon compounds interfere.
M. Thermal conductivity dector for use in the absence of oxygen.

TABLE VI-7. Colorimetric Analyzers

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-7.1	CEA	555	SO_2, NO_2, NO_x NH_3, Cl_2, TDI HCHO, HCN, halides, oxidants	Variable 0–0.25, 10	0.025-SO_2	1%	4.7	7.9	2.2	11.4	12 VDC	—	—	A, B

* Manufacturer codes given in Table VI-19.
A. Recorder output optional.
B. Reagents required.

TABLE VI-8. Infrared Photometers

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm)			Weight (kg)	Power	Alarms		Comments
							H	W	L			Aud.	Vis.	
V-8.1	ASP	5600	combustible gases	0–100% LEL	—	3%	2.8	2.8	2.6	5.5	110/220 VAC 12 VDC backup	X	—	A
V-8.2	BEC	864/865	vehicle exhaust	0–100, 500, 1000 CO	—	1% FS**	3.4	5.2	8.8	22.7–27.3	110 VAC		—	B
V-8.3	BEC	866	CO	0–50	—	0.2 ppm	7.2	4.8	10.2	25.9	115 VAC		—	B, C
V-8.4	CAL	SC/LC	CO, N_2O, NO, NO_2, CH_4, SO_2, C_2H_4	most 0–50% v/v	100—N_2O 500—CO, NO, NO_2, CH_4M SO_2 1000—C_2H_4	2% FS	8.0	7.1	4.1	25.5	110/220 VAC		—	B
V-8.5	CEA	RI-411	CO_2	0–9950	50	2% FS	3.9	3.0	1.8	—	Ni-Cd 6-D cells 115 VAC adapter	X	—	D
V-8.6	CEA	RI-550A	CO, CO_2, CH_4 ethane, propane butane, ethylene	—	1% FS	2% FS	3.1	3.4	5.0	9.5	110/220 VAC		—	E
V-8.7	FOX	MIRAN-I	gases that absorb between 2.5–14.5μm	varies by gas <1 ppm–1%v	varies by gas; most <1 ppm	2%	70	28	18	11.4	115/230 VAC		—	E
V-8.8	GAT	RI-413	Freon- R-11, 12, 113, 114, 502	0–9990 (R-11, R-12, R-22, R-502) 0–7900 (R-113) 0–4900 (R-114)	—	5% FS	3.9	3.0	1.8	3.0	Ni-Cd 115 VAC adapter	—	X	B, D
V-8.9	IIT	IR—702	many gases	—	—	1% FS		—		—	90–130 VAC		—	B
V-8.10	IIT	IR-711	hydrocarbons	0–100% LEL (JP-5) 0–1000 ppm	—	2%		—		4.1	—		—	B

TABLE VI-8 (con't). Infrared Photometers

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-8.11	MSA	202	CO, CO_2, SO_2, fluorocarbons, hydrocarbons, etc.	application dependent		1% FS	7.5	5.1	4.9	34.5	115 VAC	—		B, F
V-8.12	MSA	3000	CO, CO_2, SO_2 fluorocarbons, hydrocarbons, etc.	application dependent		0.5% FS	8.4	3.7	2.7	20.0	105/220 VAC	—		B

* Manufacturer codes given in Table VI-19.
** FS = full scale.
A. Dual wavelength.
B. Dual beam.
C. Model available for vehicle exhaust and bag sampling.
D. Microprocessor controlled.
E. Specified vapor analyzer available.
F. MOD202X Suitable for Class I, Groups B, C, D.

TABLE VI-9. Ultraviolet and Visible Light Photometers

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-9.1	BAC	MV-2	Hg vapor	0.02, 1.0 mg/m^3	0.01 mg/m^3	5% FS**	4.5	1.9	1.7	2.7	12 V Ni-Cd			A, B
V-9.2	BAR	AISI	SO_2	1.0–500, 2000, 40.000	2 or 40 ppm meters	—		—		45.5	Battery or 115 VAC	—		B
V-9.3	BEC	K-23B	Hg vapor	0–0.1, 1.0 mg/m^3	0.2% FS	10%	5.1	3.3	1.8	7	115 VAC	—		B
V-9.4	DEC	1003	O_3	0.01–9.99	0.01	2%	2.0	5.9	7.3	20.5	115-130 VAC	—		B
V-9.5	DUP	460 461	SO_2, NO_2, NO_x NO_x	0–200, 100% SO_2 or NO_2 0–150, 100% NO_x	4 SO_2/NO_2	1% FS		—		—	115 VAC E	—		B, C,
V-9.6	LER	SM-1000	NO, NO_2, SO_2, NH_3, etc.	0–2.0	0.01	0.01 ppm	4.3	4.3	6.3	varies	110 VAC	—		F
V-9.7	MDC	727-3	O_3	0–9.99	0.02	1%	4.3	2.4	9.1	6.8	115 VAC	—		B
V-9.8	SSI	38	Hg and organic vapors	0–01 mg/m^3	0.01 mg/m^3	5%	1.2	1.6	6.7	3.6	120 VAC	—		A, B, D

* Manufacturer codes given in Table VI-19.
** FS = full scale.
A. Organic vapors may interfere.
B. Ultraviolet absorption.
C. Designed for Class I, Group D.
D. Dual beam.
E. Visible absorption.
F. Utilizes second-derivative spectroscopy in UV and visible spectrum.

TABLE VI-10. Photometric Analyzers

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-10.1	BAC	US400	CO	0–5	0.1 ppm/mv	—	panel mounted			15.9	115V ± 10		—	A, C
V-10.2	BEC	DIF 7000	CO	0–20, 50, 100, 200	0.1	1% FS**	2.2	6.7	6.6	14.5	115 VAC ± 10%		—	B, C
V-10.3	BEC	950 A	O_3	0–0.025 to 25 (7 ranges)	0.01	2% FS	3.4	7.5	8.4	—	105–125V		—	C, D
V-10.4	BEC	952 A	NO, NO_2, NO_x	0–0.25 to 25 (7 ranges)	0.01	0.005 ppm	3.4	7.5	8.4	—	105–125V	X	—	C, E, F
V-10.5	BEC	953	SO_2	0.25, 0.5, 1.0, 2.0	0.004	0.003 ppm	4.8	7.5	8.7	40.9	105–125 VAC		—	C, G
V-10.6	CSI	1100	O_3	0–1, 5, 10	0.01 pphm	1% FS	4.1	6.7	6.9	18.2	105–125 VAC		—	C, D
V-10.7	CSI	530 R	NO, NO_2, NO_x	0–0.1, 0.25 0.5, 1.0, 5.0	0.004	0.002 ppm	4.8	6.7	7.9	27.3	105 VAC 130 VAC	X	—	C, E, F
V-10.8	CSI	325–2R 04350–2R	O_3	0–0.1, 0.5, 1.0, 5, 10	0.001	0.001 ppm	4.8	6.7	7.9	18.2	105–125 VAC		—	C, D
V-10.9	CSI	SA 285	sulfur compounds	0–50, 100, 500, 1000 ppb	1% FS	1% FS	4.8	6.7	7.9	22.7	115 ± 10 VAC	X	—	C, H
V-10.10	CSI	SA 700	SO_2	0–250, 500, 1000, 5000, 10,000 ppb	5 ppb	2% FS	4.8	6.7	7.9	20.0	105–130 VAC 220 VAC		—	C, I
V-10.11	CSI	PA 460	phosphorus gas	0.001–10	0.001	19 (460)	7.5	4.8	7.9	18.2	115 VAC		—	C
		PA 465				20 (465)	3.5	3.9	6.3	9.1	external 115 VAC internal 12 VDC			H
V10.12	GAT	Halide	halogenated compounds	1000–10,000	50–100	3%	4.3	2.8	2.8	5.9	120/130 VAC		—	J
V-10.13	SCA	Halide	halogenated hydrocarbons	0–500	10	10%	6.3	3.8	5.9	15.9	110 VAC		—	J
V-10.14	TRA	271 HA	sulfur compounds	0–100 ppb < 0–1	4 ppb	<1%	3.5	7.5	9.4	27.3	115 V		—	C, H

* Manufacturer codes given in Table VI-19.
** FS = full scale.
A. Sensors employ analysis of mercury vapor by UV absorption which is generated by oxidation of CO with mercury oxide.
B. Utilizes dual-isotope fluorescence detection.
C. Intended for unattended operation.
D. Uses chemiluminiscent reaction of O_3 with ethylene as basis for detection.
E. Uses chemiluminiscent reaction of NO with ozone as basis for detection.
F. NO_2 converted to NO for analysis.
G. Utilizes SO_2 fluorescence reaction with UV light for detection.
H. Uses flame photometric detector.
I. Uses SO_2 absorption of UV light.
J. Utilizes increased spectral enhancement of an AC spark by a halogen for detection.

TABLE VI-11. Photometric Analyzers of Surface Deposits

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-11.1	FLM	533	H_2S	—	0.1	—	3.1	2.4	1.2	1.8	9.6V Battery	X	X	A
V-11.2	HAI	722AEX-A	H_2S	0–100	1	3%	8.3	5.1	5.1	27.3	—	X	—	A
V-11.3	MDA	Miniguard	H_2S, $COCl_2$, TDI, Cl_2, SO_2, NH_3	variable	variable fraction of TLV	—	2.0	0.5	1.0	0.3	3-AA	X	—	A, B

* Manufacturer codes given in Table VI-19.

A. Utilizes automatic paper tape sampler.

B. Designed as a personal monitoring system.

TABLE VI-12. Paramagnetic Analyzers

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-12.1	HRD	633-II	O_2	1–10% 16–21%	0.01%	0.5%	10.8	3.9	4.8	52.3	115 VAC	—		A, B
		635-II	O_2	90–100%										
V-12.2	SCA	11-4500	O_2	0–5 to 0–50%	—	5%	30.7	9.4	9.4	—	115 VAC	—		A

* Manufacturer codes given in Table VI-19.

A. Sensor utilizes the attraction of O_2 in a magnetic field.

B. Intrinsically safe for use in Class I, Groups C and D.

TABLE VI-13. Aerosol Formation and Detection Systems

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-13.1	EOC	Rich 100	Hg, SO_2, NH_3	Hg: 10–2000 ng/m^3 SO_2: 0.005–5 NH_3: 0.01–1	see range	—	5.5	3.1	5.1	16.8	12 or 24 VDC 115 VAC	—		A

* Manufacturer codes given in Table VI-19.

A. Creates particles about gas molecules which are counted with a condensation nucleimonitor.

TABLE VI-14. Electron Capture Gas Detectors

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-14.1	ITI	505 Leakmeter	SF_6, CCl_4, Freons, etc.	—	0.1 (Freons) 0.01 ppb (SF_6)	—	43 45	39 40	23 75	14 10	110 VAC	X	—	A

* Manufacturer codes given in Table VI-19.
A. Three models available which use electron capture detectors. The SF_6 detector utilizes a column preselector.

TABLE VI-15. Photoionization Analyzers

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-15.1	HNU	PI-101	most organics	0–20, 200, 2000	0.2 (benzene)	—	4.3	2.1	3.2	4.1	Ni-Cd 12 VDC	X	—	A
V-15.2	PII	TIP™	most organics	0–2000	0.05 (benzene)	1%	45 long × 6.3 diameter			1.4	Ni-Cd	X	—	A
V-15.3	TEI	910	most organics	0–1000	0.1 (benzene)	—	23	43	46	11.8	110 VAC	X	X	B

* Manufacturer codes given in Table VI-19.
A. Portable units.
B. Designed for Stationary, bench mounting.

TABLE VI-16. Gas Chromatograph Analyzers

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm) H	W	L	Weight (kg)	Power	Alarms Aud.	Vis.	Comments
V-16.1	PII	105	most organics	—	0.1 ppb (benzene)	—	46	16	34	11.8	batteries 110/220 VAC or 12 VDC	—		A, B
V-16.2	XON	GC 810	hazardous vapors	10 ppb–100 ppm	5 ppb	—		—		—	batteries 110/220 VAC or 12 VDC	X	—	A, C

* Manufacturer codes given in Table VI-19.
A. Designed for portable operation.
B. Uses photoionization detector.
C. Uses electron capture or argon ionization detector.

TABLE VI-17. Conductivity Analyzers (solid phase)

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm)			Weight (kg)	Power	Alarms		Comments
							H	W	L			Aud.	Vis.	
V-17.1	AIC	411	Hg	0.001–1.999	0.001	5%	5.1	2.4	1.6	2.3	7.2 VDC or 110 VAC	—		A

* Manufacturer codes given in Table VI-19.

A. Collects a 1 or 10 second sample on a gold film sensor.

TABLE VI-18. Infrared Photoacoustic Analyzers

Instrument No.	Mfg./ Supp.*	Model	Analytes	Range (ppm)	Detection Limit (ppm)	Precision (±)	Dimensions (cm)			Weight (kg)	Power	Alarms		Comments
							H	W	L			Aud.	Vis.	
V-18.1	BKJ	1306	Various toxic gases	4–5 orders of magnitude	low ppm 0–2 NH_3	1% FS**	62	3.1	1.6	5.5	VAC	—		A, B
		1302			0.02 phosgene 0.005 SF_6	—	5.5	4.7	2.4	8.0	VAC or battery	—	X	

* Manufacturer codes given in Table VI-19.
** FS = full scale.

A. Measurement is by infrared photoacoustic spectroscopy.
B. Can operate unattended for months.

TABLE VI-19 List of Instrument Manufacturers

ADS Adsistor Technology, Inc.
Box 51160
Seattle WA 98115
(206) 523-6468

AIC Arizona Instrument Corp.
P.O. Box 336 Highway 89A
Jerome, AZ 86331
(800) 952-2566

ASI Astro International Corp.
100 Park Avenue
League City, TX 77573
(713) 332-2484

BAC Bacharach, Inc.
625 Alpha Drive
Pittsburgh, PA 15238
(412) 963-2000

BAR Barringer Research, Ltd.
304 Carlingview Drive
Rexdale, Ontario,
Canada M9W 5G6
(416) 675-3870

BEC Beckman Instruments, Inc.
Process Instruments Division
2500 N. Harbor Boulevard
Fullerton, CA 92634
(714) 871-4848

BKJ Bruel & Kjaer Instruments, Inc.
185 Forest Street
Marlborough, MA 01752
(617) 481-7000

CEA CEA Instruments, Inc.
16 Chestnut Street
Box 303
Emerson, NJ 07630-0303
(201) 967-5660

CAL Calibrated Instruments, Inc.
731 Saw Mill River Road
Ardsley, NY 15020
(914) 693-9232

CAS Casella London Limited
Regent House, Britannia Walk
London N1 7ND, England

CHE Chestec, Inc.
P.O. Box 10362
Santa Ana, CA 92711
(714) 730-9405

CSI Columbia Scientific Industries
P.O. Box 203190
Austin, TX 78760
(512) 258-5191

DEC Dasibi Environmental Corp.
515 W. Colorado Street
Glendale, CA 91204
(818) 247-7601

DET Deutsch Engineering &
Testing Services
P.O. Box 389
Monsey, NY 10952

DVC Devco Engineering, Inc.
Control Systems Division
36 Pier Lane West
Fairfield, NY 07006
(201) 228-0321

DUP DuPont Company
Instrument Products Division
Wilmington, DE 19898
(800) 344-4900

DYM Dynamation Incorporated
3784 Plaza Drive
Ann Arbor, MI 48104
(313) 769-0573

EEC ERDCO Engineering Corp.
P.O. Box 1310
Evanston, IL 60204
(312) 328-0550

EDW Edmont-Wilson
Division of Becton Dickinson
& Company
1300 Walnut Street
Coshocton, OH 43812
(614) 622-4311

EIT Eitel Manufacturing, Inc.
33208 Paseo Cerveza, Unit G
San Juan Capistrano, CA 92675
(714) 240-3933

EOC Environment/One Corp.
2773 Balltown Road
Schenectady, NY 12309
(518) 346-6161

ERI Ericson Instruments
P.O. Box 226
Ossining, NY 10562

FLM Fleming Instruments, Ltd.
Caxton Way, Sevenage
Hertfordshire, England

FOX Foxboro Company
Foxboro, MA 02035
(800) 343-0933

GFG GfG Gas Electronics, Inc.
P.O. Box 1078
Cavapolis, PA 15108-6078
(314) 781-2233

GAT GasTech, Inc.
8445 Central Avenue
Newark, CA 94560
(415) 794-6200

GMI General Monitors, Inc.
3019 Enterprise Street
Costa Mesa, CA 92626
(714) 540-4895

HNU H-Nu Systems, Inc.
160 Charlemont Street
Newton, MA 02161
(800) 527-4566

HRD Hays-Republic Division Corp.
3695 Interstate Parkway
Riviera Beach, FL 33404
(305) 842-1900

HAI Houston Atlas, Inc.
9441 Baythorne Drive
Houston, TX 77041

ISC Industrial Scientific Corp.
355 Steubenville Pike
Oakdale, PA 15071-1093
(800) 338-3287

III Infrared Industries, Inc.
Western Division,
Instrumentation Group
P.O. Box 989
Santa Barbara, CA 93102
(805) 684-4181

ITS Interscan Corp.
P.O. Box 2496
Chatsworth, CA 91311
(800) 458-6153

ITI Ion Track Instruments, Inc.
Three A Street
Burlington, MA 01803
(617) 272-7233

LER Lear Siegler
Environmental Technology
Division
One Inverness Drive East
Englewood, CO 80110
(800) 525-7459

LSP Lumidor Safety Products
5364 N.W. 167th Street
Miami, FL 33014
(305) 625-6511

MDA MDA Scientific, Inc.
405 Barclay Boulevard
Lincolnshire, IL 60069
(800) 323-2000

MAC Macurco, Inc.
3946 S. Mariposa Street
Englewood, CO 80110
(800) 237-9049

MDC Mast Development Company
2212 East 12th Street
Davenport, IA 52803
(800) 553-8993

MGP Matheson Gas Products
30 Seaview Drive
Secaucus, NY 07094
(201) 867-4100

MSA Mine Safety Appliance
Company
600 Penn Center Boulevard
Pittsburgh, PA 15235
(800) 672-2222

TABLE VI-19 (con't). List of Instrument Manufacturers

NDR	National Draeger, Inc. 101 Technology Drive Pittsburgh, PA 15230 (412) 787-8383
NMS	National Mine Service Company 600 N. Bell Avenue Carnegie, PA 15106 (412) 429-0800
NEO	Neotronics P.O. Box 370 2144 Hilton Drive, S.W. Gainesville, GA 30503 (800) 535-0606
ORE	Ozone Research and Equipment Corp. 3840 North 40th Avenue Phoenix, AZ 85019 (602) 272-2681
PEI	Phillips Electronics Instruments 85 McKee Drive Mahwah, NY 97430
PII	Photovac International, Inc. 739B Park Avenue Huntington, NY 11743 (800) 387-5700
PRA	Process Analyzer, Inc. 3 Headly Place Fallsington, PA 19054 (215) 736-2596
SCA	Scott Aviation 225 Erie Street Lancaster, NY 14086 (716) 683-5100
SEN	Sensidyne, Inc. 12345 Starkey Road, Suite E Largo, FL 33543 (813) 530-3602
SMC	Sierra Monitor Corp. 1991 Tarob Court Milpitas, CA 95035 (408) 262-6611
SSI	Sunshine Scientific Instruments 1810 Grant Avenue Philadelphia, PA 19115 (215) 673-5600
TEL	Teledyne Analytical Instruments 16830 Chestnut Street La Puenta, CA 91748 (818) 961-9221
TEI	Thermo Electron Instruments 108 South Street Hopkinton, MA 01748 (617) 435-5321
TRA	Tracor, Inc. Analytical Instruments Division 6600 Tracor Lane, Building 27 Austin, TX 78725 (512) 429-2051
WPD	Western Precipitation Division Joy Manufacturing 4565 Colorado Boulevard Los Angeles, CA 90039 (818) 240-2300
XON	XonTech, Inc. 6862 Hayvenhurst Avenue Van Nuys, CA 91406 (818) 787-7380

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