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DETECTION OF VEHICLE EXHAUST/ PETROLEUM VAPORS

Margaret Schafer

Franklin Institute Research Laboratories

Prepared for:

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DETECTION OF VEHICLE EXHAUST/PETROLEUM VAPORS

by

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March 1971

Final Report

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U. S. ARMY LAND WARFARE LABORATORY
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This report describes the results of a literature search and investigation to determine (a) the trace quantities of vehicle exhaust products (including fuel additives) present in the atmosphere near vehicles and (b) hydrocarbon and petroleum vapors in the atmosphere due to any source. The object of the study was to determine specific compounds present, the quantities present, techniques for detecting these trace compounds and equipment presently commercially available for this purpose.

FOREWORD

The work described in this report was performed under a work assignment (number 32) of Contract No. DAAD05-68-C-0283. The Franklin Institute Research Laboratories wishes to acknowledge the technical assistance given by Mr. C. McDowell of The Applied Physics Branch, U.S. Army Land Warfare Laboratory.

The principle engineer on the project at FIRL was Dr. M. Schafer, Senior Research Scientist, Chemistry Department. Other FIRL contributors included W. Collins, Manager of the Multidisciplinary Projects Laboratory, S. Huston of the Systems Science Department and B. Epstein of Science Information Services.

ABSTRACT

This report describes the results of a literature search and investigation to determine (a) the trace quantities of vehicle exhaust products (including fuel additives) present in the atmosphere near vehicles and (b) hydrocarbon and petroleum vapors in the atmosphere due to any source. The object of the study was to determine specific compounds present, the quantities present, techniques for detecting these trace compounds and equipment presently commercially available for this purpose.

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1. INTRODUCTION

This report contains information obtained from the literature on the possible pollutants emitted from military targets and the currently available methods of detection. This search is by no means exhaustive, but was conducted within the level of effort of the program. As much as possible of the trade literature on monitors has been covered. However, there are undoubtedly some instruments we may have missed.

The use of air pollutant monitors to spot military targets is very definitely feasible within the limits of current technology. If the exact type of target were defined as well as the monitoring conditions, we could make specific recommendations.

2. SOURCES

For both stationary and mobile sources the concentration of pollutants emitted depends on the combustion conditions. In industrialized countries where there are emission control standards the emissions will be different than in countries where there are no restrictions. Appendix A gives the concentrations of pollutants emitted from sources under various conditions. The types of pollutants emitted by each source are summarized in Table 1.

It should also be considered that these pollutants undergo a large variety of photochemical reaction. Consequently the types of compounds present as well as the concentrations will vary over a period of time.

Table 1

POLLUTANT

Source	NO_2	SO_2	CO	Aldehydes	Hydrocarbon	Paraffins	Olefins	Aromatics	Acetylene
Natural Gas Fired Appliances	*			*					
Natural Gas Fired Industrial & Commercial Equipment	*	*	*	*					
Auto Exhaust	*		*			*	*	*	*
Aircraft	*			*	*				
Diesel Motor	*		*	*	*				
Oil-Fired Equipment	*	*	*	*					
Solid Fuel Fired Equipment	*							*	

3. LABORATORY TECHNIQUES

Many laboratory instrumental techniques have been applied to the analysis of air pollutants. All of this type of instrumentation is available commercially. However, as they are produced for laboratory analysis they are usually too large and cumbersome, and also more versatile than necessary, for a portable or semi-portable pollutant monitor. All of this type of instrumentation can be modified for a particular set of sampling conditions and many companies are producing monitors which are based on laboratory instrumentation. These monitors are mostly produced for non-military applications whose conditions are not the same as those used for spotting military targets. Consequently, we are including this discussion of laboratory-type instrumentation, because after the type of target and monitoring conditions are defined it may be easier to streamline laboratory equipment to do the analysis rather than to try to use a civilian type of monitor. The sampling requirements may be quite different in the two cases. Especially if the monitor is required to be in an airplane or helicopter.

3.1. Total Analysis for Organic Substances

Mass spectrometry, dispersive and non-dispersive infrared instrumentation and flame ionization analyses have been applied to the analysis for total organic substances. However, since different organic substances respond differently to the different measurement techniques, care is needed in interpreting and comparing any data.

3.1.1. Mass Spectrometry

Mass spectrometry has been applied to total organic substance analysis and fairly good agreement was obtained among the investigators. In these measurements the samples were collected by freezing and then injected into the mass spectrometer. However, a diaphragm which allowed only the pollutant to diffuse through could also be used. The problem with using mass spectrometry to measure mixtures of pollutants is that the data is very difficult to interpret. The sample is ionized in the mass spectrometer so that it acquires a charge and is fragmented. Then the mass of the fragments is determined by their deflection in a magnetic field. Each compound has a characteristic fragmentation or cracking pattern which can be used for identification. However, when mixture of pollutants is introduced, their cracking patterns are superimposed and relative peak heights depend not only on the compounds present but also on the relative amounts. For this type of analysis a computer is often attached to the mass spectrometer so that the pattern can be compared electronically to those of known mixtures.

Another means of simplification is possible. The mixture can be fed first through a gas chromatograph which will separate most of the components of the mixture. Each component will then be fed into the mass spectrometer for identification.

3.1.2. Infrared Techniques

Both dispersive and non-dispersive infrared techniques have been used to measure total hydrocarbons. In many of these cases oxygenated compounds were removed chemically and then the 3.45 μ band was used to estimate total hydrocarbon. This is often referred to as ppm n-hexane. The widespread use of non-dispersive infrared measurements and the comparison to n-hexane comes from its being accepted as a standard in California. Since methane and unsaturated hydrocarbons give a reduced response at 3.45 μ after their concentrations are measured by using another infrared frequency. Although most of these analyzers are designed with complicated optics and long path length cells, the characteristic infrared absorption and emission spectra of organic substances are well suited to remote monitoring techniques.

3.1.3 Flame Ionization Analyzers

The flame ionization analyzer for total hydrocarbons is similar to the flame ionization detector for gas chromatography. Its response is fairly proportional to the number of carbon atoms in the molecule and is unresponsive to inorganic materials. It has been widely used for monitoring total hydrocarbons, particularly from automobile emissions. Its only drawback is that large molecules tend to be adsorbed on the walls before they reach the detector.

3.2. Analysis of Hydrocarbons

Mass spectrometry and infrared spectrometry are difficult to use for measuring trace quantities of particular hydrocarbon in a polluted atmosphere. Both of these techniques require concentration of the sample before it can be measured. Gas chromatography allows the analysis of particular hydrocarbons without concentration of the sample. In gas chromatography the sample passes through a column packed with a solid or a liquid suspended on a solid. The length of time a particular hydrocarbon takes to pass through the column depends on how strongly it interacts with the substrate. Thus with the proper choice of column packing material a sample containing a mixture of materials will emerge as a series of peaks each containing one material. There are several types of detectors used with gas chromatographs; the common ones are flame ionization and thermal conductivity. For hydrocarbons flame ionization is the most sensitive

3.3. Paraffinic Hydrocarbons

Mass spectrometry, infrared spectrophotometry and gas chromatography have been used. There are also techniques available to remove all hydrocarbons except paraffinic hydrocarbons so that a flame ionization analyzer can be used.

Analysis of particular paraffinic hydrocarbons by mass spectrometer is difficult, because of the low intensity of the high mass peaks and interference from other hydrocarbons. Usually methane is determined from the m/e peak of 15 and higher paraffins are determined as a group. A mercuric perchloride tube can be used to remove olefins and oxygenated compounds in order to simplify the mass spec analysis. Mass spec has been used successfully in areas such as petroleum refineries where paraffin concentrations are high.

Infrared spectrophotometry has not proved useful for the analysis of paraffinic hydrocarbons. Methane can be analyzed by its absorption peak at 7.6 μ, but analysis of other paraffins is not practical. Although the peak at 3.4 μ is largely a paraffin absorption, there is too much interference from paraffin groups on other hydrocarbons.

Gas chromatography is the best way for analyzing mixtures for paraffinic hydrocarbons. Various substrates such as silica gel can be used to separate paraffinic hydrocarbons up to the hexanes. Chromatographic techniques for separating higher molecular weight hydrocarbons such as in diesel fuel have also been developed. Sometimes two columns are combined; one to remove unsaturated hydrocarbons and the second to separate the paraffins.

3.4. Acetylene and Acetylenic Hydrocarbons

The use of mass spectrometry for analysis of acetylene in air is limited by sensitivity because the concentrations are around 0.2 ppm. However, it has been used with minor corrections for analysis of acetylene in automobile emission where the concentrations are higher. Analysis of higher molecular weight acetylenic compounds are interfered with by diolefins and cycloolefins.

Infrared spectrometry can be used to identify acetylene by its absorption band at 13.7 μ. Corrections for carbon dioxide are necessary.

Gas chromatography can be used to analyze and separate acetylene from most types of samples. Various substrates such as silica gel, 20 m Carbowax on alumina and dimethylsulfolane on firebrick can be used. Higher molecular weight acetylenic compounds have also been separated by gas chromatography.

3.5. Olefinic Hydrocarbons

Many types of procedures have been developed for determining olefins in emissions and polluted atmospheres, these include: spectrophotometric, coulometric, mass spectrometric, infrared and gas chromatographic.

Several methods involving the bromination of olefins have been used. An instrument based on a "bromocoulometric" system has been developed. The bromination is carried out before coulometry, and the amount of olefin is proportional to the time needed to generate the bromine absorbed by the sample. This technique is interfered with by inorganic pollutants such as sulfur dioxide and nitrogen dioxide.

Mass spectrometry gives an incomplete analysis of olefins. Only a few can be identified by this technique, the rest encounter difficulties with overlap and sensitivity.

Infrared spectroscopy has been useful in identifying certain olefins. However, in most cases a long pathlength is necessary.

Gas chromatography has proven to be a very powerful tool for the analysis of olefins. It is possible to separate olefins up to the pentenes on substrates such 20 m Carbowax, β, β' oxidipropionitrile on alumina or dibutylmaleate. Higher molecular weight hydrocarbons can be analyzed by temperature programming the column. Diolefins react with nitrogen dioxide so automobile exhaust samples must be diluted if they have to be stored for long periods of time before analysis.

3.6. Aromatic Hydrocarbons

Mass spectrometry has been used to identify benzene, toluene, xylenes and styrene in emissions and polluted atmospheres. Also total aromatics have been determined.

Infrared methods have not been extensively used.

Gas chromatography can be used to separate and identify aromatic hydrocarbons. Aromatic hydrocarbons in the six to eleven carbon atom range can be separated on a Carbowax 1540 column and identified with flame ionization detector. By the use of temperature programming it is possible to analyze both aliphatic and aromatic hydrocarbons on the same column.

3.7. Oxygenated Compounds

Instrumental analytical techniques have not proved useful for the analysis of oxygenated compounds. Most analyses are done with wet chemical or colorimetric techniques. Although infrared spectroscopy, mass spectrometry and gas chromatography have been tried, they have not developed into useful techniques.

4. INORGANIC GASEOUS POLLUTANTS

4.1, Sulfur Dioxide

The most commonly used methods for sulfur dioxide analysis are conductimetric, titrimetric, colorimetric, turbidimetric and iodimetric. These methods can be carried out manually or incorporated into monitoring instruments.

The West-Gaeke Method (colorimetric) is applicable to the determination of sulfur dioxide in the concentration range 0.005 to 5 ppm. The sulfur dioxide is absorbed in 0.1 m sodium tetrachloromercurate and the dichlorosulfitomercuric ion is formed. The addition of acid-bleached pararosaniline and formaldehyde to the complexion produces red-purple pararosaniline methylsulfonic acid which is determined spectrophotometrically.

Hydrogen Peroxide Method (titrimetric) is applicable to the determination of SO_2 in the concentration range 0.01 to 10.0 ppm. SO_2 is absorbed in 0.03 N hydrogen peroxide reagent (adjusted to about pH 5). The sulfuric acid formed is titrated with standard alkali.

The conductivity method can be applied to sulfur dioxide in the concentration range of 0.01 to 2 ppm. The sulfur dioxide is absorbed in a slightly acidic hydrogen peroxide solution. The change in conductivity of the solution is monitored. This method is interfered with by any gas which forms a strong electrolyte in solution.

Iodimetric method has been used to monitor sulfur dioxide concentrations. A set of standards is prepared by measuring the optical absorption of dilute starch-iodine solutions containing various amounts of sulfuric acid. This is compared with the absorption of a starch-iodine solution in which the sulfur dioxide from the atmospheric sample has been absorbed.

Barium Sulfate method (turbidimetric) uses a dilute hydrogen peroxide solution to absorb the sulfur dioxide. It is then precipitated as barium sulfate and the suspension stabilized by glycerol-alcohol. The turbidity of the solution is measured with a spectrophotometer.

Sulfur dioxide can be measured also on a special gas chromatograph with a flame photometric detector.

4.2. Nitrogen Dioxide

The Saltzman method is sensitive to nitrogen dioxide over a range of a few parts per billion to about 5 ppm. This method is based on the Guiess-Ilosvay reaction in which a pink-cloud dye complex is formed between sulfanilic acid, nitrite ion, and α-naphthylamine in an acid medium. The color is measured photometrically.

Nitrogen oxide can also be measured on a special gas chromatograph with a flame photometric detector.

4.3. Carbon Monoxide

Various colorimetric methods as well as gas chromatography and infrared spectroscopy have been used to measure carbon monoxide.

The gas chromatographic technique used to measure carbon monoxide employs a flame ionization detector and a double column. The sample goes through a column packed with di-2-ethyl-hexyl sebacate on 60-80 mesh "columnpak" and then a column packed with 42-60 mesh molecular sieves to separate the carbon monoxide. The carbon monoxide is then catalytically reduced with hydrogen to methane with a catalyst such as nickel powder and the methane is measured quantitatively with the flame ionization detector.

The infrared absorption of carbon monoxide has been utilized in the construction of several non-dispersive infrared spectrometers. These have pressurized longpath length cells in addition to the usual source, detector, chopper and amplifiers in as usual infrared spectrophotometer.

5. CONCLUSIONS

Table II gives a summary of the laboratory methods best applicable for the analysis of various pollutants. In Table III is given the commercial air pollutant monitors and the pollutants they detect. These monitors are described in Appendix B. Since these descriptions were obtained from sales literature in which the units are described as magic boxes, some of the techniques are not too clear.

There are two new techniques which should be mentioned. One is the use of the microwave spectra for the development of instrumentation. This is currently thought highly of by NAPCA (private communication R. Stevens). The second is the Pyrochrom Analyzer which although it has not been applied to air pollution studies has been used successfully for other analytical applications. This system could easily be converted to a monitor for a particular pollutant (private communication Eugene Levy - Control Data Systems.

TABLE II

ANALYTICAL TECHNIQUE

Pollutant	Wet Chemical	Mass Spectrograph	Infrared	Gas Chromatograph	Flame Ionization
Total Organic		*	*		*
Paraffins		*	*	**	
Acetylenic Hydrocarbons		*	*	**	
Olefins	*	*	*	**	
Aromatics	*			**	
Oxygenated Hydrocarbons	*				
SO_1	*				
NO_2	*				
CO	*		*	*	

Legend ** Best Method

TABLE III

POLLUTANT

Commercial Unit	CO	SO_2	NO_2	Hydrocarbon
Intertech System	*	*	*	
Beckman Hydrocarbon Analyser			*	
Beckman IR	*	*		*
Beckman Ultraviolet Photometer			*	
Combust Gas Detect				*
Portable Gas Chromatograph	*			*
Melpar		*		
Dynasciences		*	*	

APPENDIX A

	Nitrogen Oxides as (NO_2) ppm	Aldehydes ppm	Ammonia ppm	Acids ppm	SO_2 ppm	Carbon Monoxide %	Reference
Natural Gas Fired Appliances							
Bunsen Burner	21	2					(1)
Range, top burner	22						(1)
Range, oven	15	11					(1)
Water Heater, 20 gal.	25	--					(1)
Water Heater, 100 gal	45	8					(1)
Floor Furnace	30	3					(1)
Forced Air Furnace	50	--					(1)
Steamboiler							
Low fire	40	5					(1)
High fire	90	--					(1)
Industrial Burners	216	49	0.5	30	4		(2)
Natural Gas Fired Industrial and Commercial Equipment							
		Typical Ranges					
Scotch Marine Boilers	8-56	2-7				0.0-0.2	(3)
Fire Tube Boilers	35-34	4				0.0-0.1	(3)
Water Tube Boilers	16-127	3-11				0.0-0.2	(3)
75 gal Water Heaters	46	2				0.001	(3)
Space Heater	19	2				0.0	(3)
Bake Oven	20	6				0.0	(3)
Industrial Ovens, Indirect	16-34	3-6				0.0	(3)
Ceramic Kilns, Indirect	3-66	2-7				0.00-0.04	(3)

Solid Fuel Various Firing Methods for Bituminous Coal	Benzo(a)pyrene*	Pyrene*	Benzo(e)pyrene*	Perylene*	Benzo(ghi)perylene*	Anthracene*	Coronene*	Anthracene*	Phenanthrene*	Fluoranthene*	Benz(a)anthracene*	Single atom hydrocarbon**	Carbon monoxide**	Formaldehyde*	Nitrogen oxides*
Pulverized Firing	0.04-0.13	0.2-0.4	0-0.5	0-0.15	0.02 1.42	0-0.02	0-0.15					1-10	5-44	0.1-0.25	0.38-0.95
Cyclone	0.49	2.25	0.87	0.07	0.44		0.01			0.17		--	--	0.17	2.5
Spreader Stokers	0.04 0.057	0.23 1.3	0.13 0.77				0.02 0.057			0.11 0.79			29	0.06	0.65
Chain Grate Stoker	0.082	0.86	0.29							1.50		5	510	0.14	
nderfeed Stokers	22	35	17	3.5	9.9	0.64	0.73	1.9	22	83.9	8.6	36-120	160-1100	0.21-0.38	0.30
	0.26 8.4	3.7 17	0.51 119		1.28		2.64		2.2 64	7.1 103	1.23				0.36
Hand Fired	880	1,320	220	132	650	198	66	880	2,200	2,200		730	3500		0.11
Reference	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(5)

*Pounds per billion Btu input.

**Pounds per million Btu input.

+Units: pounds per million-million Btu input.

Industrial and Commercial Oil Fuel Equipment

Equipment	Rated Size (hp)	Oil Rate (ghp)	SO_2 (ppm)	SO_3 (ppm)	CO (%)	Aldehydes (as formaldehyde) (ppm)	Nitrogen Oxide (as NO_2) (ppm)	Remarks: Oil Properties API gravity	Remarks: Oil Properties S (%)	Remarks: Oil Properties Ash (%)	Excess air (%)	Ref. (3)
Number 2 Fuel Oil												
Firetube boiler	60	9	355	1.6	0.01	9	47	31	1.05	1.02	65	
	300	39.6	7	0	0	6	14	35	0.29	0.01	220	
Scotch marine boilers	200	21.0	11	5.6	0.02	52	21	34	0.97	0	210	
	350	85.3	17	0	0	3	72	33	0.42	0	94	
Water tube boiler	100	6.1	98	1.4	0	5	36	29	0.71	0	290	
	200	9.7	trace	0	0.002	8	55	35	0.55	0	370	
	245	23.1	102	0.5	0.002	7	33	33	0.21	0.07	115	
Oil heater	--	5.2	138	2.8	0.002	11	34	34	0.80	0	120	
Number 1 Fuel Oil												
Scotch marine boiler	150	15.3	28	1.7	0.001	5	20	40	0.09	0	150	
Ceramic kiln	--	10.0	0	0	0.04	3	27	45	trace	0	21	
	--	20.0	trace	0	0	3	20	45	trace	0	373	
Heavy Fuel Oil												
Firetube boiler	120	36.3	414	4.7	0.003	7	368	16	1.0	0	68	
Scotch marine boiler	125	23.1	264	3.2	0	9	128	11	1.78	0.18	180	
Water tube boiler	245	99.4	397	0.4	0	8	387	11	0.44	0.13	43	
	425	160.0	700	6.7	0.001	4	275	8	3.06	0	110	
	460	80.5	362	2.2	0	7	199	12	0.78	0.12	107	
	500	248.0	594	3.6	0	17	256	15	1.39	0.04	92	
	580	57.5	640	2.2	0	8	206	13	1.30	0.03	95	
	870	168.0	344	1.2	0	48	256	9	1.94	0.03	73	

DIESEL EMISSION

	Unburned Hydrocarbon	Formaldehyde	NO_x	CO	CO_2	
Two-cycle engine, No. 2 fuel	ppmC	ppm	ppm	%	%	Reference
Full Load	467	13	622	0.1	6.0	(6)
Half Load	605	8.1	392	0.03	3.6	(6)
No Load	530	7.3	147	0.03	1.53	(6)
Idle	401	11	210	0.03	1.0	(6)
Four-cycle engine, No. 2 fuel						
Full Load	29	4.3	921	0.2	10.6	(6)
Half Load	68	6.8	493	0.03	5.2	(6)
No Load	73	[illegible].8	109	0.03	1.21	(6)
Idle	104	6.8	119	0.03	0.9	(6)

AUTOMOBILE EXHAUST

	Carbon monoxide	Nitrogen oxides	Paraffins C_1 to C_5	Paraffins C_6 and heavier	Olefins C_2-C_4	Olefins C_5 and heavier	Aromatics biolenzene	Benzene	Acetylenes	Total hydrocarbon	Remarks and ref.
	%	ppm	ppm								
blow-by	trace	trace	3150	4780	230	1420	5150	270	60	15060	After (7) 1963 this type of emission is totally controlled in U.S. made cars.
exhaust	3.12	850	130	155	500	30	190	75	285	1365	

AIRCRAFT TURBINE EMISSIONS

Engine Mode	Hydrocarbon ppmC	NO_x ppm	Aldehydes ppm	Reference
Idle	150	5	5	
Cruise	5	50	1	
Takeoff	2	5	Trace	

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APPENDIX B

B

THE INTERTECH SYSTEM FOR GAS ANALYSIS

INTERTECH CORPORATION
PRINCETON, NEW JERSEY

SAMPLING: By a probe designed for the sampling conditions

The Intertech System is comprised of various components, sensors, recorders, probes, etc., which can be combined to form a unit. Which components are chosen depends on the concentration of gases present and the conditions under which they are to be sampled.

Infrared Absorption - Uras 2

CO	0-25 ppm
CO_2	0-15 ppm
SO_2	
NO	

This detector is based on the infrared absorption of the pollutants. Parallel light beams pass through the sample and nitrogen and the difference in infrared energy transmitted causes a temperature differential and thus a pressure differential which is monitored as capacitance and converted to an electrical signal.

BECKMAN HYDROCARBON ANALYZER

BECKMAN INSTRUMENTS INC.
PROCESS INSTRUMENTS DIVISION
FULLERTON, CALIFORNIA 92634

Monitors
Hydrocarbons as methane
Methane 0-1 ppm

Hydrocarbons burned in a hydrogen flame cause a large number of ions. By applying a polarizing voltage in the flame vicinity an ionizing current is established which produces a signal which can be amplified.

BECKMAN INFRARED ANALYZERS
MODEL IR-315A, IR-415A, IR-215A

BECKMAN INSTRUMENTS INC.
PROCESS INSTRUMENTS DIVISION
FULLERTON, CALIFORNIA 92634

MONITORS

CO_2
CO
C_2H_2 ppm
CH_4
SO_2

Uses infrared absorption to produce a signal. The sample gas is contained in a detector section which is separated into two parts by a diaphragm. Infrared radiation (as parallel beams) passes through two compartments, one containing the sample and the other non-absorbing gas, and falls onto the two sections of the detector. The sample gas absorbs some of the infrared radiation so that the two sides of the detector receive different amounts of infrared radiation which is absorbed causing a temperature difference and, therefore, a pressure difference. The pressure difference deflects the diaphragm separating the two sides. The incident radiation is chopped so that the diaphragm moves back and forth. This movement creates the signal which is monitired.

ULTRAVIOLET FILTER PHOTOMETER
BECKMAN MODEL 255A

BECKMAN INSTRUMENTS INC.
PROCESS INSTRUMENTS DIVISION
FULLERTON, CALIFORNIA 92634

MONITORS

NO_2 ppm

This instrument utilizes the ultraviolet absorption of NO_2 to produce an electrical signal. Light from a tungstem lamp is split and by chopping the beams the light passes alternately through the sample and a reference. Difference in intensities at the photomultiplier produces a signal which is amplified.

COMBUSTIBLE GAS DETECTOR
MODEL 170

GENERAL MOTORS INC.
3019 ENTERPRISE STREET
COSTA MESA, CALIFORNIA 92626

Hydrogen Hydrocarbons	0-100% lower explosive limit

Unit consists of control unit and remote sensing probe. Gas diffuses into the sensing probe and is oxidized at the catalytic surface causing a temperature rise which produces an electrical signal. Unit can be battery operated.

PORTABLE GAS CHROMATOGRAPH
SERIES 500

ANALYTICAL INSTRUMENT DEVELOPMENT INC.
250 S. FRANKLIN STREET
WEST CHESTER, PENNSYLVANIA 19380

SAMPLING: By injection

Portable laboratory gas chromatograph. Contains rechargeable batteries and gas supply so that it can operate up to eight hours as a portable unit. Equipped with flame ionization, thermal conductivity and electron capture detectors.

AIR POLLUTION SULFUR ANALYZER

MELPAR INC.
6631 IRON PLACE
SPRINGFIELD, VIRGINIA 22150

MONITORS

SO_2 0.01 ppm to 10 ppm
H_2S
SO_3
Mercaptans
Total Sulfur

SAMPLING: Air is drawn into the analyzer by the sampling pump

The analyzer is comprised of four subsystems. A Melpar Flame Photometric Detector (FPD), patent pending, a Photometer, a Gas Flow System, and Power supplies. It requires a hydrogen gas supply and 120 volt 60 Hz, 200 watts electrical power for normal operation.

The Melpar Flame Photometric Detector (FPD) utilizes the photometric detection of the 394 mu-centered band emitted by sulfu ntaining compounds in a hydrogen-rich/air flame. Its specificity arise the employment of a harrow band-pass interference filter and a ge rrangement that optically shields the photomultiplier tube fro nary flame.

DYNASCIENCES AIR POLLUTION MONITORING
9601 CANOGA AVENUE
CHATSWORTH, CALIFORNIA 91311

MONITORS

NO_x	5 ppm - 1500 ppm
NO_2	
SO_2	2 ppm - 5000 ppm

This monitor uses a unique electrochemical technique which allows the entire analytical process to be accomplished in a small totally enclosed and sealed transducer. Transducer converts the pollutant concentration to a current signal. Sample is drawn into the sampling conditioning unit by a pump and then into contact with the transducer.