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## SEQUENTIAL AND TAPE SAMPLERS — UNATTENDED SAMPLING

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## Introduction

The development of sequential and tape samplers from 1928 to 1983 has been documented in the six previous editions of *Air Sampling Instruments*<sup>(1-6)</sup> and in the *Encyclopedia of Instrumentation for Industrial Hygiene*.<sup>(7)</sup> An objective has been to obtain the maximum information about the identity and concentration of air contaminants with a minimum investment in instrumentation and a minimum number of operating personnel. Another objective has been to relate time/place/contaminant/concentration information to any complaints or other indications of adverse effects on people, animals, vegetation, or materials.

One of the very early sequential samplers was developed and custom-designed for the study of adverse effects on vegetation of sulfur dioxide released into the air from a smelter. This required monitoring of the air over extended periods of time. Thomas<sup>(8)</sup> described this sampler in 1928 and referred to it as an automated impinger.

## Sequential and Tape Sample Collection

### Automated Media Advance

The Thomas impinger is an early example of a group of samplers that contain a device to periodically or continuously introduce controlled amounts of sampling medium into the path of metered air. Current instruments are controlled by a timer or microprocessor so that the system can collect samples and function with little or no operator attention. Devices with automated media advance include: a) moving slide samplers, b) tape samplers, c) rotating drum samplers, d) rotating disc samplers, and e) turntable samplers (individual collectors). These are represented in the drawings in

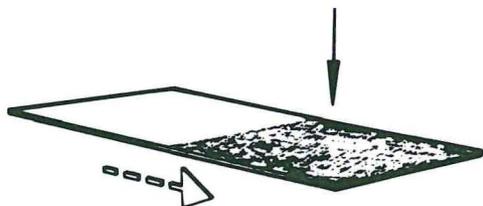
### Figure N-1.

A number of models of tape samplers are currently available from manufacturers such as Andersen/Research Appliance Division; GMD Systems, Inc.; Hund Corporation; Matheson Gas Products; MDA Scientific, Inc.; and Wedding and Associates, Inc. The PIXE Streaker Sampler is an example of a rotating disc sampler, and the Andersen SE 245-10 Sierra Automatic Dichotomous Sampler is an example of a turntable sampler. A moving slide sampler with collection by thermal precipitation and a rotating drum using the impaction principle were described in previous editions of *Air Sampling Instruments*;<sup>(3-6)</sup> however, neither is now commercially available.

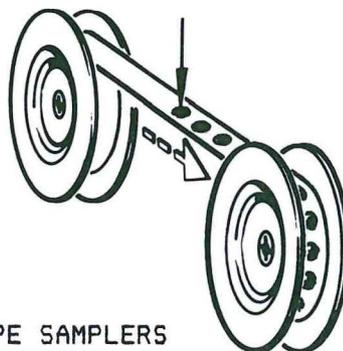
### Branched Sampling Trains

The typical branched sequential sampler, often referred to only as a sequential sampler, is like the automated media advance sampler in that it includes a vacuum pump, flow regulator, flowmeter, and a timer that controls switches and valves. Instead of an automated media advance, this sampler relies on a series of branches. Each branch contains its own individual collector, may contain an open/closed solenoid valve, and connects to downstream members through a manifold. In another design, a multiport rotary valve serves as a branch selector and no manifold is necessary. A generalized representation of a multibranch sequential sampler is shown in Figure N-2.

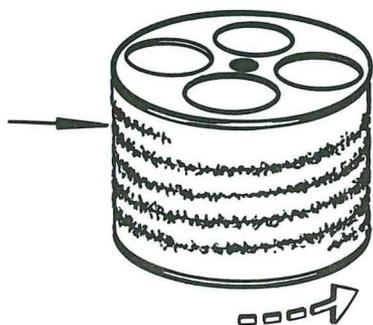
Branched sequential samplers are available from Andersen/Research Appliance Division and Xontech. The Gilian RD 113 Programmable Atmospheric Sampler has 23 branches and is equipped with a selector valve and drive solenoid. It is used with detector tubes or sorption tubes.



a. MOVING SLIDE SAMPLERS



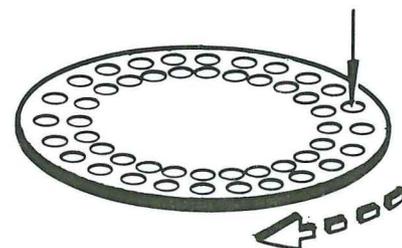
b. TAPE SAMPLERS



c. ROTATING DRUM SAMPLERS



d. ROTATING DISC SAMPLERS



INDIVIDUAL COLLECTORS

e. TURNTABLE SAMPLERS

FIGURE N-1. Samplers with automated media advance.

**Multiple Sampling Trains**

If components are relatively light, compact, and inexpensive, it becomes practical to include multiple complete trains in an integrated system. The samplers may or may not share an inlet and timer. The Aero-Vironment plastic bag samplers belong to this category.

**Sampling Media and Sample Evaluation**

The evaluations and analyses that can be made on any particular sample depend largely upon the sampling medium. The following is a brief summary of sampling media used in sequential and tape samplers.

**Gas and Vapor Sampling Media**

**Whole-Air Samplers**

Samples collected in plastic bags may be analyzed by direct-reading instruments, gas chromatography, mass spectrometry, or other procedures which require only moderate sample volumes. The gases and vapors studied must be sufficiently stable in the container so that they are not lost or contaminated prior to analysis.

Automated syringe samplers have been described in the literature and have been commercially available in the past. Very limited volumes can be collected for observation of odor and subsequent analysis by gas chromatography.

**Liquid Reagents**

Chemical reagent collection solutions may be used in conjunction with spectrophotometric analysis. One

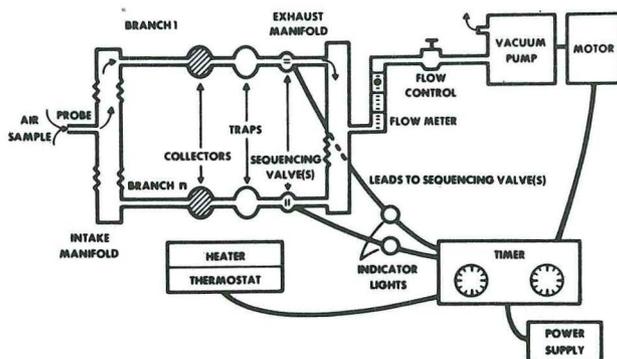


FIGURE N-2. Schematic of a typical multibranch sequential sampler.

example is the Andersen/Research Appliance Division Sequential Sampler designed for use with impinger/bubbler units to sample sulfur dioxide. It is also useful for hydrogen sulfide, nitrogen oxide/dioxide, carbon monoxide, and aliphatic aldehydes. Liquid reagents were also used in the Thomas Automatic Impinger described above.

#### Detector Tubes and Sorbent Tubes

The Gilian RD 113 is designed to be used in conjunction with either detector tubes or sorbent tubes. Detector tubes are evaluated visually. Samples collected in sorbent tubes are analyzed by thermal or solvent desorption, followed by gas or high-performance liquid chromatography.

The Xontech Model 930 On-Site Concentrator uses activated carbon as a collecting and concentrating medium. Dual sorption traps alternately collect at ambient temperatures and are desorbed and flushed during a heated portion of the cycle. The Xontech Model 930 concentrates samples and automatically introduces them into a gas chromatograph.

#### Chemically-Impregnated Paper

Gases and vapors are often detected by paper impregnated with an appropriate chemical reagent. For example, ammonia is readily detected by moistened litmus paper. This is the basis for a number of passive and active samplers, including tape samplers. This approach is most useful with the more chemically reactive gases. Paper tapes for hydrogen sulfide have been available since at least the early 1950s. Tapes are evaluated visually or by making measurements of the changes in light transmission or reflection that occur during sampling. Tape samplers with built-in light measurement capability can function as real time, continuous monitors by following change as it develops. Compact personal tape samplers can obtain a continuous record of exposure to be evaluated at the completion of a shift to give a concentration versus time profile, total dose, and time-weighted average.

#### Particulate Sampling Media

##### Filtration

The filtration medium used with tape samplers must be mechanically strong so that it does not tear under the tension used to draw it through the sampling head, and its chemical and physical properties must be compatible with planned analytical methods. Samples may be filtered onto a moving tape. Individually mounted filters are used in multibranch and turntable samplers. A slowly rotating circular filter is used as a collector in the PIXE Streaker Sampler.

Methods for evaluation of particulate samples obtained by filtration include:

- **Light Transmission and Reflection:** Tapes may be

evaluated by changes in light transmission or reflection. The Coefficient of Haze (COH) Unit was introduced as an index of the concentration of fine particles, reduced atmospheric visibility, and soiling potential. The COH Unit is calculated from the volume of sampled air, the area of the filter spot, and the change in light transmission through the spot. This allows comparison among samples collected over different time spans and at different sampling rates. Correlation among COH values and other indicators of atmospheric particulates occur only when other important factors stay constant. For this reason, correlation tends to be application-specific and site-specific.

- **Light Transmission and Frequency Shift:** The Hund Mass Concentration Extinction Analyzer uses a longitudinally oscillating fiberglass filter tape for particle collection. Simultaneous measurements of decreased light transmission and oscillation frequency permit determination of particle count concentration.
- **Beta Attenuation:** A beta particle source is located on one side of the filter and an appropriate detector is located on the other so that it measures the decreasing energy passing through the filter as the particle load increases. The Wedding TSP or PM<sub>10</sub> Beta Gauge uses either Teflon® or glass fiber filter tape. The MDA BAM 102 Continuous Dust Monitor uses paper tape.
- **Weight Gain:** The Andersen SE-245 Sierra Automatic Dichotomous Sampler has a carousel that holds 20 pairs of low tare weight Teflon or glass fiber filters. Filters can be weighed to determine weight per unit volume of sampled air.
- **X-ray Fluorescence:** Teflon filters used with the Andersen SE-245 lend themselves well to evaluation by X-ray fluorescence or other elemental analysis techniques.
- **Proton-Induced X-ray Emission (PIXE):** The PIXE Streaker Sampler uses a slowly rotating circular Nuclepore filter for continuous collection of a defined size range of particles. The recommended method for analysis is by PIXE.
- **Other Methods:** With appropriate selection of filter media, additional analytical procedures, such as microscopy and chemical analysis, could be readily adapted for use with the sequential and tape samplers.

##### Impaction

Particles may be collected by impaction onto a rotating surface. The position of the deposit then provides the time resolution. This mechanism is used in the PIXE Streaker Sampler for collection of the coarse particles.

Impaction onto a moving surface was popular in

earlier instruments. Collectors included Mylar® films or rotating drums. Several were described in the sixth edition of the *Air Sampling Instruments Manual*.<sup>(6)</sup> The Meteorology Research Moving Slide Impactor<sup>(5)</sup> is another example of a sequential/continuous sampler that collects by impaction.

### Integrated Sample Collection and Evaluation

By performing the sample collection and evaluation concurrently, an instrument can perform as a continuous, real time analyzer. Light transmission, light reflection, beta transmission, and oscillating frequency lend themselves well to this approach. Concurrent evaluation allows the monitor to interact with other instruments including displays, alarms, data loggers, recorders, printers, process controls, microprocessors, and computers.

### Other Unattended Samplers and Analyzers

By limiting a gas chromatograph to a single analysis, it is practical to standardize operation so that the separation can be repeated while unattended over long periods. It is not uncommon to perform an analysis every five minutes, even when several components are being determined.

Heat of combustion sensors and electrochemical sensors are widely used in systems for unattended monitoring of combustible gases, hydrogen sulfide, carbon monoxide, chlorine, and other reactive and toxic gases. More recently, infrared analyzers and photoionization detectors have had widely expanded application in plant monitoring.

### Multisite Monitoring

#### Multiprobe Monitoring

Real time analyzers and repetitive analyzers are sometimes connected to a manifold and probe system so that multiple sites can be sampled according to a predetermined program. This maximizes the efficiency of equipment and operating personnel. The system can include branches for regularly introducing zero and span gases.

#### Multisensor Systems and Multiplexing

Sensors are located at multiple locations in refineries, chemical plants, parking garages, and other places where possible emissions of flammable, reactive, or toxic gases are of concern. Electrical signals between a central controller and a number of sensor locations can be carried over a single cable. This multiplexing is possible because each sensor has a unique identifica-

tion and location enabling the controller to communicate with each in turn.

### Data Display, Alarms, Controls, and Documentation

Real time analyzers are available with various combinations of annunciators, indicator and alarm lights, meters, digital displays, strip chart recorders, data loggers, printers, and video displays. Newer models have standard connections for use with computers. These are used to indicate and document the operational status of the system as well as the concentrations which are being measured.

Alarms and displays may be located both in the area where concentrations are measured and at the central control and security stations. Provision can be made for automatic response to high levels such as the activation or deactivation of fans or switching of valves.

Some systems are designed with minimum provision for documentation. For instance, some simple alarm systems do not display or record the concentration but respond when the alarm level is exceeded with a flashing light and/or audible sound. Other systems produce extensive documentation. Hutchinson<sup>(9)</sup> discusses the use of the personal computer in real time monitoring and data storage. It has long been a practice to use still, movie, and time-lapse photography to document practices and conditions prevailing at times when pollutant concentrations are measured. The videocamera has largely replaced the movie camera in documenting work practices and prevailing conditions. Examples of use of videotaping for assessment of exposures are given by Gressel *et al.*<sup>(10)</sup>

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## Instrument Descriptions

### Sequential Samplers

#### N-1 Sequential Sampler Model PV Research Appliance Division Andersen Samplers, Inc.

A control module contains demistor-entrainment traps, a sequencing rotary plug valve, adjustable flow-meter (2–10 cfh or 0.94–4.7 L/min), pump, and programmer-timer. This module is connected to a sampling module by 12 sections of flexible tubing. The sampling module includes a glass inlet module and 12 polypropylene impinger/bubblers held in a removable rack. The sampling module is insulated and temperature controlled. The plastic tubes, containing appropriate liquid reagents, are brought to and from the sampler sealed with caps. Each tube can be programmed for 0.50 to 23.75 hours of sampling, and the total for the 12 tubes can extend up to 288 hours (12 days). Reagents are prepared and samples are analyzed at a support laboratory. The sampler is particularly suited to the determination of sulfur dioxide; however, hydrogen sulfide, oxides of nitrogen, and other gases reactive to specific reagents can also be collected for analysis.

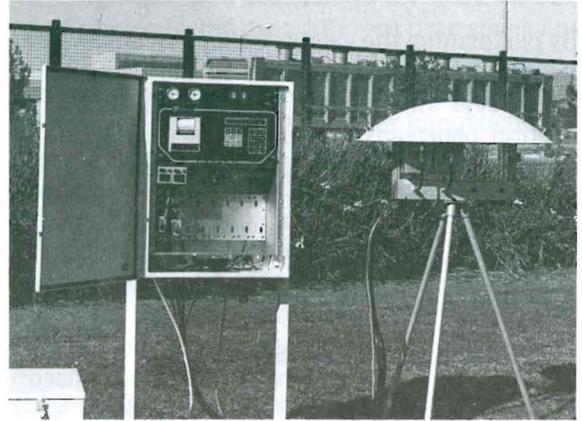


INSTRUMENT N-1. Sequential sampler, Model PV.

#### N-2 Model 920 Automated Air Sampler Xontech, Inc.

A sampling module contains up to four sampling heads for sorbent tubes and four sampling heads for 37-mm or 47-mm filters. Each head is equipped with an isolation valve to protect the sampling media before and after sampling. A pump module has capacity for four 30 L/min and four 200 cm<sup>3</sup>/min sampling channels. A control module contains the microprocessor, controller, mass flow controllers, printer, keypad, and display. The Model 920 features automated collection of particulates, gases, and vapors with precisely controlled sampling times and flow rates with auto-

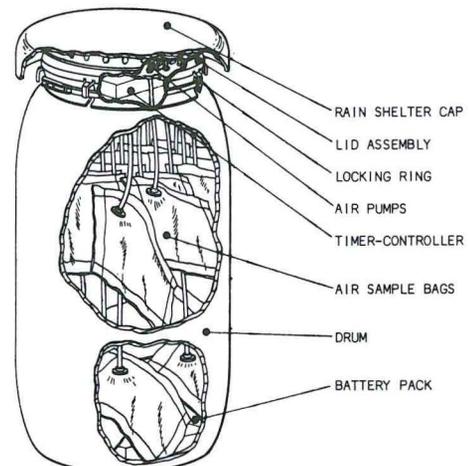
matic reports for each of up to eight channels. A dichotomous head is available for PM<sub>10</sub> sampling. Sampling for PCBs can be conducted using a polyurethane foam plug. The three modules are designed for outdoor operation, and provision is made for warm or cold weather operation.



INSTRUMENT N-2. Model 920 Automated Air Sampler.

#### N-3 Air Quality Sampler II and III AeroVironment

These samplers contain a controller, power pack, and a set of pumps each connected to its own plastic bag. All operations are performed automatically as directed by a preprogrammed sequence. The AQS II is available with an enclosure consisting of either a 120-L or a 225-L drum or without an enclosure. The AQS II is usually supplied with 8, 12, 16, or 24 pumps. Tedlar® bags varying in size from 1 to 100 L are available for use in the sampler. The standard controller is the 24-hour version, but a 96-hour version is also available.



INSTRUMENT N-3. Schematic of the Air Quality Sampler II.

#### N-4 SE-245 Automatic Dichotomous Sampler (Virtual Impactor) Andersen Samplers, Inc.

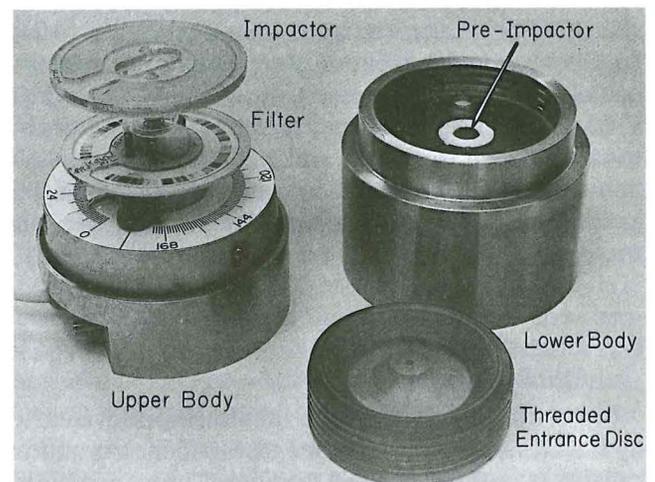
This sampler collects particles in two distinct size ranges. Its inlet is designed to exclude particles larger than 10  $\mu\text{m}$ . Particles entering the sampler are separated into two fractions by the virtual impaction principle (see *Chapter P*). The larger fraction range is from 2.5–10  $\mu\text{m}$  while the other is less than 2.5  $\mu\text{m}$ . The two fractions are collected uniformly on 37-mm disc Teflon® filters. Up to 20 filter pairs are positioned on a rotary filter holder. The sampling period for each pair is selectable from 1 to 99 hours. Starting time is selectable from 0 to 9 days, and the time between sampling periods can be 0 to 99 hours or 0 to 99 days. Automatic filter changing allows for unattended operation for weeks or months. The flow maintained in the branch which collects fine particles is 15 L/min; that in the branch for the collection of coarse particles is 1.67 L/min. The control module weighs 25 kg (55 lb) and is 41 cm  $\times$  56 cm  $\times$  28 cm (16  $\times$  22  $\times$  11 in.). The sampling module weighs 18.8 kg (41.5 lb) and is 142 cm  $\times$  60 cm  $\times$  53 cm (56  $\times$  24  $\times$  21 in.). Teflon filters are recommended, but glass fiber or other filter media can be used. All filters can be weighed; however, Teflon filters are ideal for X-ray fluorescence or other elemental analysis techniques.



INSTRUMENT N-4. Model SE-245 Automatic Dichotomous Sampler.

#### N-5 Streaker Sampler PIXE International Corporation

Air is drawn through a threaded entrance disc with the upper size limit set by a pre-impactor. The air then travels to a rotating impaction stage where a further size differentiation occurs (typically 2.5  $\mu\text{m}$ ). Smaller particles are collected by a rotating filter stage which is continually advanced over a 1 mm  $\times$  8 mm orifice to which reduced pressure is applied. The flow through the Streaker Sampler is about 1 L/min at 633 mm (25 in.) Hg when operated with a 0.3- $\mu\text{m}$  or 0.4- $\mu\text{m}$  pore Nuclepore filter. The sampler can operate for one week or longer on a single filter element. Analysis by Proton Induced X-ray Emission (PIXE) can give particulate element analysis of the 8-mm wide track with one-hour resolution. PIXE is applicable to all elements of atomic number 11 (sodium) and greater. The Streaker Sampler is 12.6 cm high with a diameter of 11.5 cm. It weighs 1.4 kg and requires 4 watts at 115 VAC, 60 Hz.



INSTRUMENT N-5. Streaker Sampler.

#### Tape Samplers

#### N-6 RAC Model G Series Samplers and Monitors Research Appliance Division Andersen Samplers, Inc.

Research Appliance Division offers a number of tape sampler models for the automatic collection of particulate samples. Samplers are easily adapted in the field to sample for hydrogen sulfide with lead acetate-impregnated tape. Models designated by SE (Self-Evaluation) have a built-in densitometer that reads the percent of light transmitted through the filter tape while an air sample is being taken. Models designated by SER (Self-Evaluation and Recorder) automatically record light transmission. An SESR designation indicates the model is equipped with automatic standardization. Samples of particulate are evaluated by measure-

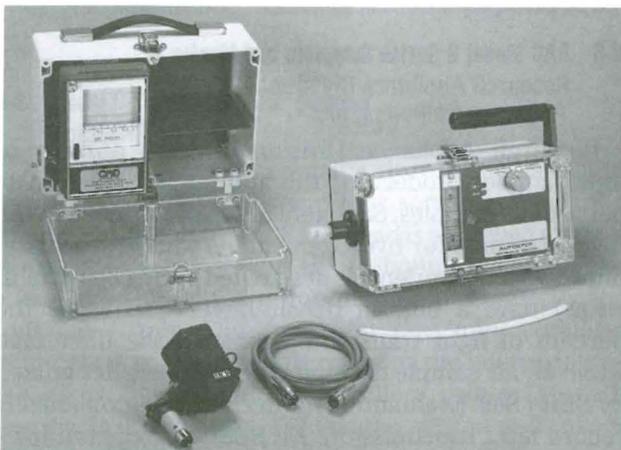


**INSTRUMENT N-6.** Model G Series filter tape sampler/monitor with meter (No. 205035).

ment of the amount of light transmitted through the 2.54 cm (1 in.) spots on the tape. This provides readings related to the coefficient of haze (COH) values. COH values can be determined from the optical density of the spot, its area, and the volume of air sample. All samplers and monitors in the G series are available in either 115 V, 60 Hz or 220 V, 50 Hz models. All have flowmeters in the range of 5 to 20 cfh and sampling cycles of 10 minutes to 4 hours. Weights vary from 34 to 46 lbs. All are 28.6 cm high  $\times$  30.5 cm deep (11.25 in.  $\times$  12 in.) in widths from 36.8 to 52.7 cm (14.5 in. to 20.75 in.).

**N-7 Autostep Portable Monitor**  
GMD Systems, Inc.

The Autostep is available for monitoring isocyanates, hydrazines, phosgene, or other gases at concentrations ranging from a few ppb to a few ppm. The air sample is drawn through an area of the tape and any color change is continuously monitored by an LED/photodiode



**INSTRUMENT N-7.** Autostep portable monitor.

combination. The sampler is equipped with three operating modes, each with a different sampling interval and sampling rate. The search mode is designed for leak detection and has a fast response with extended concentration range. The survey mode allows 20 hours of continuous monitoring. Used with the optional Recorder Module, it gives a record of concentration versus time. The monitor mode allows operation for up to 36 hours by waiting 4 minutes between each 4-minute sample. The Autostep features an environmentally-sealed case; sealed, lead-acid rechargeable batteries; a dual bargraph LCD display with memory; and an extension sampling probe. Options include a strip chart recorder or datalogger and alarm module. A vehicle installation kit is available and is useful for fence line or downwind surveys. A wall-mount installation kit allows for operation from 110 VAC with built-in battery backup.

**N-8 Remote Intelligent Sensor**  
GMD Systems, Inc.

This area monitor is a microprocessor-controlled paper tape cassette system for monitoring isocyanates, phosgene, hydrazine, and other toxic gases. It has audible and visible alarms and an LCD readout. A memory capacity for up to 24 hours of data storage allows review of an entire workday. A memory and printer option allows the output to be sent through a supplied interface directly to a printer for evaluation and analysis. Data may then be printed on demand or on a regular time basis. A communications package option provides two-way communications of all functions and allows as many as 120 Remote Intelligent

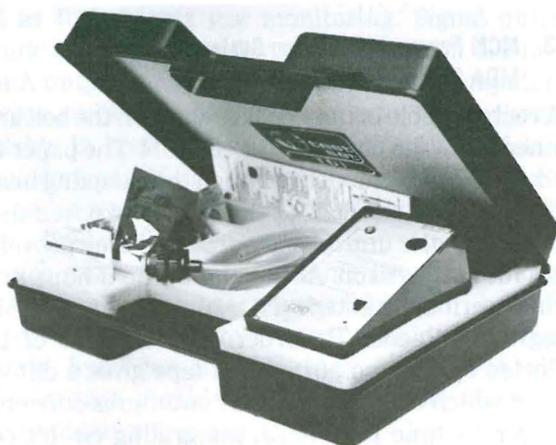


**INSTRUMENT N-8.** Remote intelligent sensor.

Sensors to be networked and controlled from a central location by an IBM (or compatible equivalent) personal computer.

### N-9 Sure Spot TDI Test Kit GMD Systems, Inc.

A test card holds the reactive tape while a precalibrated pump pulls a metered volume of air through it. The intensity of the color stain is proportional to the amount of toluene diisocyanate (TDI) sampled. The spot is evaluated visually against a concentration calculator to obtain a direct readout in ppb TDI. Each test card can serve as a record of test data. The sampler can be worn by the worker using a supplied belt pouch to carry the pump. It can also be used as an area sampler or can be used with a length of tubing for confined space sampling prior to entry.



INSTRUMENT N-9. Sure-Spot™ TDI Test Kit.

### N-10 Personal Continuous Monitor (PCM) GMD Systems, Inc.

The PCM was originally developed for monitoring toluene diisocyanate (TDI). It has been refined so that



INSTRUMENT N-10. Personal Continuous Monitor.

it now can monitor a variety of other gases by changing the paper tape cassette and performing calibration. A chest pack contains a miniaturized tape sampling cassette, tape exposure system, and optics which measure reflectance off the tape. It is connected to a belt pack by a line which combines electrical wiring and vacuum tubing. The belt pack contains a pump, digital microprocessor, and a battery. Each cassette contains enough tape for approximately 200 sampling points. An audible alarm gives warning of excursions beyond the TLV. A separate computer interface allows the PCM to be used with IBM PCs and other similar computers. Data stored in the PCM is passed to the computer for analysis, display, and output to a plotter, printer, and/or disk storage.

### N-11 TLD-1 Toxic Gas Detector MDA Scientific, Inc.

The TLD-1 is available in a variety of monitoring configurations with optional accessories. Any of over 30 gases can be monitored by using the appropriate Chemcassette which acts both for gas collection and analysis. Reflected light is measured as a stain develops. Controlled by a microcomputer, the resulting signal is digitized and matched to an alarm level programmable into its permanent memory. All monitoring data may be sent to remote devices via a 4-mA to 20-mA analog signal. Should gas concentration exceed the pre-set alarm level, built-in local alarms and an alarm relay are activated. Any change in monitoring status, such as loss of power or other disruption, is signalled by either the local alarm and/or a fail-safe diagnostic alarm relay. Several standard signal outputs can be provided. An alarm-only version is well suited for cost-effective monitoring of isolated areas. A portable, battery-powered instrument can be supplied with digital dis-

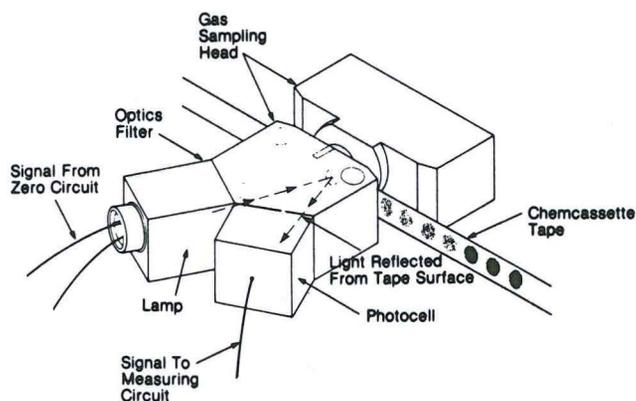


INSTRUMENT N-11. TLD-1/ChemKey Toxic Gas Detector System.

play. A version with a built-in, strip chart recorder gives a permanent record of monitoring information. Concentrations ranging from about 3 ppb to 75 ppm are determined with response times of 10 to 240 seconds, all dependent on the gas being monitored. The portable model with digital display uses a rechargeable, sealed lead-acid battery and will also operate directly off the AC/DC charger. Other monitors in the line operate on 115 VAC, 50/60 Hz; 230 VAC, 50/60 Hz versions are available. Dimensions are 165 mm × 212 mm × 177 mm (6 ½ × 8 ¾ × 7 in.); weight is 3.4 kg (7.5 lbs) or 4.1 kg (9 lbs) for the battery-powered model. Gases detectable with the TLD-1 include: ammonia, bromine, chlorine, diisocyanates (9 compounds), hydrazines (3 compounds), hydrides (8 compounds), hydrogen cyanide, hydrogen sulfide, mineral acids (5 compounds), nitrogen dioxide, ozone, phosgene, and sulfur dioxide.

#### N-12 Series 7100 Continuous Toxic Gas Monitors MDA Scientific, Inc.

The Series 7100 achieves detection speed, accuracy, and sensitivity through a state-of-the-art microprocessor control. Each monitor may be factory programmed to detect and measure up to eight different gases. Switching from one gas to another is easily done by selecting the new response curve and changing the Chemcassette and flow rate. A software program guides the user through start-up and normal operation. A battery back-up protects stored monitoring and system status information. A 4-mA to 20-mA output may be fed directly into computer or control systems for change of status of fans or process equipment. When concentrations exceed programmed alarm levels, the date, time, and concentration are printed out in hardcopy format. The hardcopy capability may also be used to show concentration on a minute-by-minute basis and to print TWA information on demand or on an 8-hour basis. In

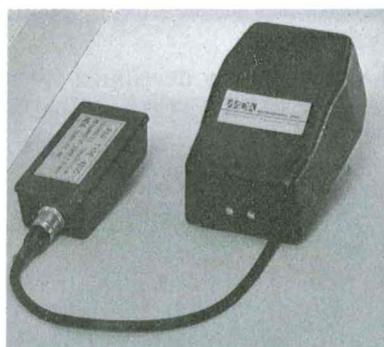


INSTRUMENT N-12. Sampling head and detection system schematic, Series 7100 Continuous Toxic Monitor.

all documentation modes, real time concentration is shown on the alpha/numeric display with readout updated every other second. Dual-level concentration alarms are programmed at the factory but may be changed by the user. The remote printer/alarm interface allows concentration data to be transmitted to control rooms, security stations, etc. Another optional interface, the RS 232, can be used to transmit data directly to a mainframe or desktop computer. The optional Toxiscope allows up to 15 of these monitors to be connected into a centralized surveillance, control, and data acquisition system. Over 30 different reactive and toxic gases (see N-11 description) can be monitored using an appropriate Series 7100 monitor.

#### N-13 MCM Personal Monitoring System MDA Scientific, Inc.

A rechargeable battery pack is worn on the belt and is connected to the chest-mounted MCM. The paper tape is advanced continuously through the sampling head at 2 cm/hr. Only one-half of the tape is exposed to the sampled air; the unexposed portion of time provides a basis for comparison. At the end of the 8-hour monitoring period, the tape is evaluated by the MCM Integrating Reader/Recorder. The amount of light reflected by the two portions of tape gives a different output which is converted to a continuous concentration versus time profile. An integrating circuit computes the total dose in ppm-hours. The MCM is used for monitoring TDI, MDI, phosgene, and toluene diamine.



INSTRUMENT N-13. Battery pack and tape sampler portion of the MCM Personal Monitoring System.

#### N-14 Model 8500 Process Gas Analyzer MDA Scientific, Inc.

This analyzer is based on the MDA Chemcassette system and measures concentration from low-ppb to mid-ppm levels of various reactive gases in real time. Through use of simple conditioning accessories, the Model 8500 may be used for liquid stream analysis as



**INSTRUMENT N-14. Model 8500 Process Gas Analyzer.**

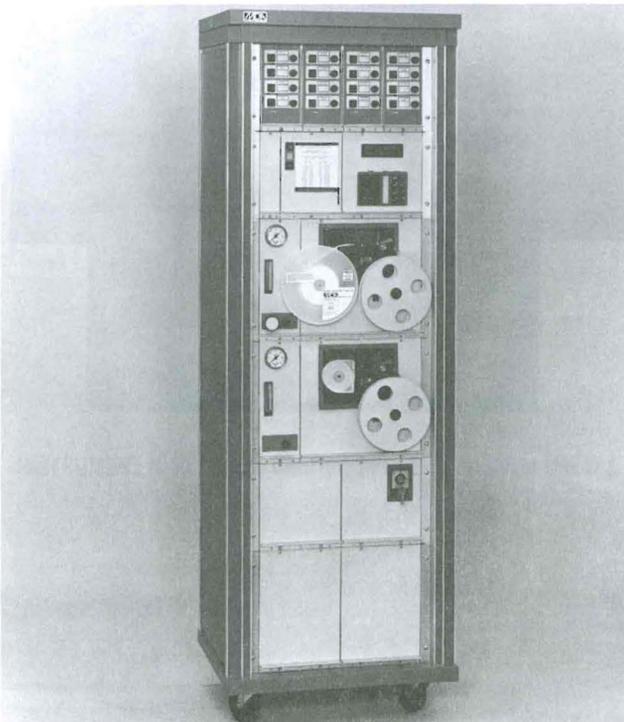
well as for process gas monitoring. Signal outputs include local digital display and audio alarm. A 4-mA to 20-mA output may be fed directly into a computer or process control system. This process gas analyzer is available in both 115 VAC and 230 VAC models. Its dimensions are 38 cm × 60 cm × 36 cm (15 × 24 × 14 in.), and it weighs approximately 44 kg (100 lbs). The model 8500 can be used to monitor vent gases containing such gases as ammonia, arsine, bromine, chlorine, diborane, disilane, germane, hydrogen bromide, hydrogen chloride, hydrogen cyanide, hydrogen fluoride, hydrogen selenide, hydrogen sulfide, nitric acid, nitrogen dioxide, ozone, phosgene, phosphine, silane, stibine, and sulfur dioxide.

**N-15 System 16 Multipoint Toxic Gas Monitor**  
**MDA Scientific, Inc.**

The System 16 allows expansion from 4 to 8, 12, or 16 individual monitoring points by modules. Dual analyzer capability allows monitoring of two or more toxic gases. A Chemcassette head and an NDIR analyzer can be combined in the same system. On-board programming allows selection of dual alarm levels, sampling sequence and frequency, and documentation format. Points can be monitored individually (sequentially) or in groups (parallel). Should the alarm level be exceeded for a group, the System 16 will immediately sample each point in that group to locate the high concentration. The built-in thermal printer records all important monitoring events including concentration alarms, instrument faults, and power losses. System 16 interfaces with emergency response stations, ventilation and process control devices, and local alarm networks. The System 16 requires 600 watts at 5 amps and is 176 cm × 61 cm × 51 cm (69 × 24 × 20 in.). Models with NDIR may be somewhat larger.

**N-16 Model 8040 Arsine/Phosphine Monitor**  
**Matheson Gas Products**

The tape darkens on exposure to arsine or phosphine. Transmitted light is measured, and a meter on the front of the monitor shows the response buildup. When the tape darkens to a pre-set level, the built-in alarm sounds until the monitor is reset. For example, at 10 ppm arsine, it will alarm after 10 seconds of exposure; for 50 ppb arsine, it will alarm after 30 minutes. Every two hours the tape is advanced auto-



**INSTRUMENT N-15. System 16 Multipoint Toxic Gas Monitor.**

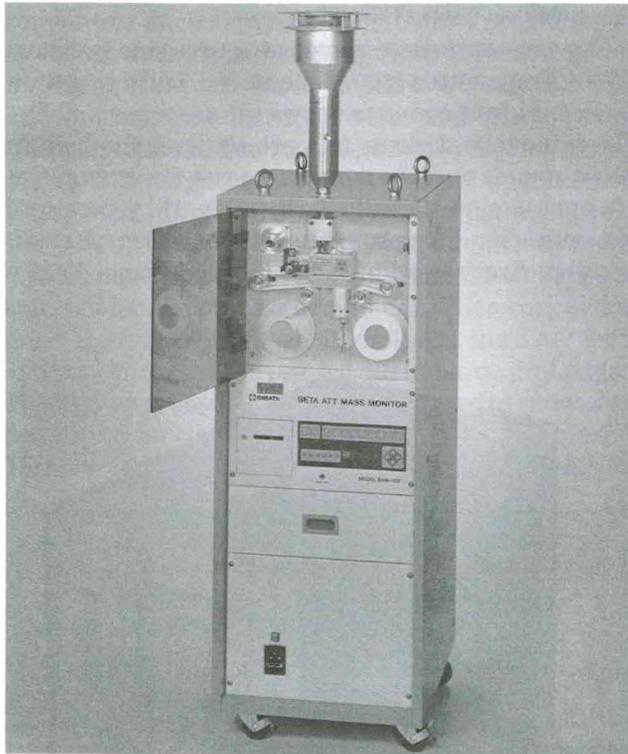


**INSTRUMENT N-16. Model 8040 Arsine/Phosphine monitor.**

matically to place a fresh area in the sampling path. The dimensions of the Model 8040 are 27 cm × 23 cm × 48 cm and weight is 14 kg.

**N-17 BAM 102 Continuous Respirable Dust Monitor**  
MDA Scientific, Inc.

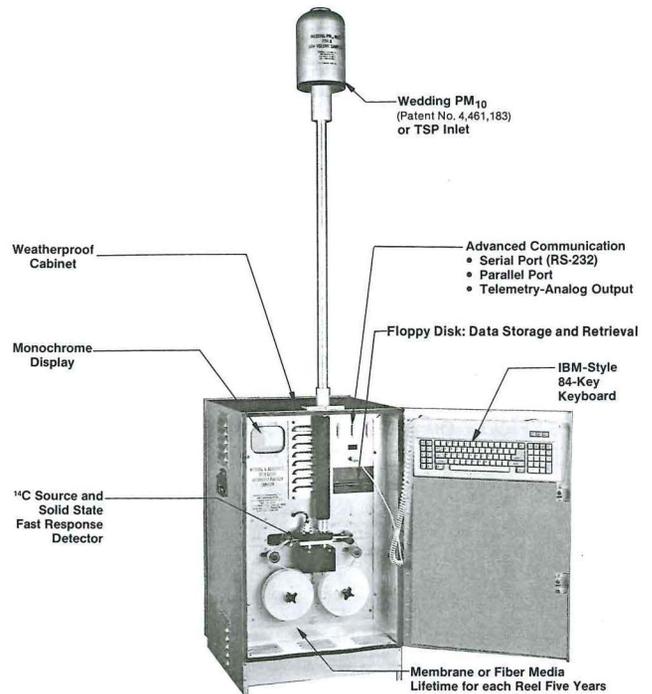
An Andersen or Wedding PM-10 inlet is used so that only particulates 10  $\mu\text{m}$  or smaller enter the monitor. Respirable particulates are collected on an area of filter tape. A sealed C-14 beta source is located on one side of the tape, and a plastic scintillation probe beta detector is on the other side. The weight of particulate collected is related to the decrease in beta energy transmitted through the tape. The BAM 102 continuously and automatically monitors respirable particulates in the concentration range 0 to 10  $\text{mg}/\text{m}^3$ . Documentation includes hourly concentration, 24-hr average, maximum concentration, minimum concentration, calibration verification, and diagnostic data. Relays include power failure, data error, instrument failure, end of tape, change of output signal, and maintenance indicator.



INSTRUMENT N-17. BAM 102 Continuous Respirable Dust Monitor.

**N-18 TSP or PM<sub>10</sub> Beta Gauge**  
Wedding and Associates, Inc.

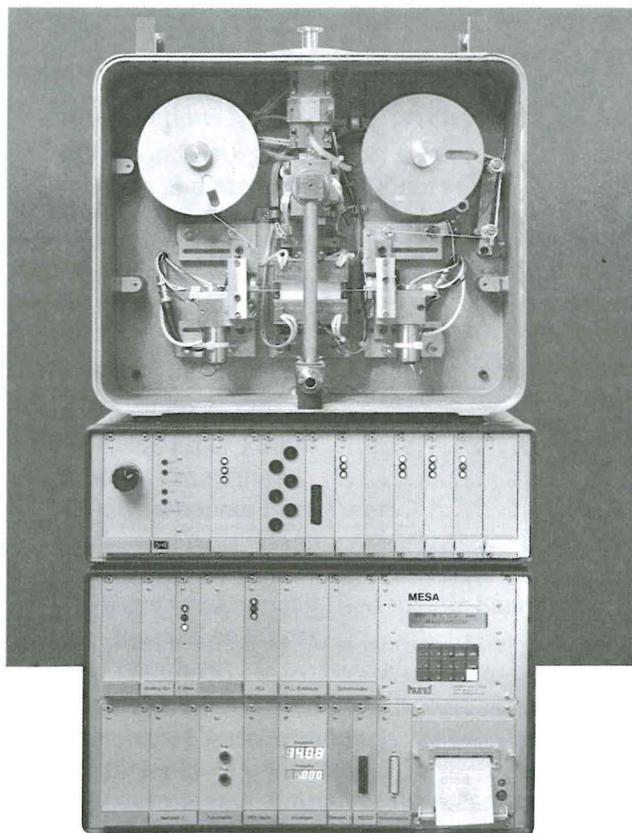
The sampler can be equipped with either the Wedding PM<sub>10</sub> or TSP (Total Suspended Particulate) Inlet. Either a Teflon® or glass fiber filter tape can be employed for particulate collection. A sealed 100 microcurie C-14 source provides the beta energy. The detector is a semiconductor with solid-state signal processing. Data are stored on a floppy disk (360 Kbit). An RS-232, analog telemetry, and up to six channels output are available for remote interrogation. An IBM-style keyboard, parallel and serial ports, and monochrome display are used for on-site interrogation. The measurement range is 0 to 1000  $\text{mg}/\text{m}^3$ .



INSTRUMENT N-18. TSP or PM<sub>10</sub> Beta Gauge.

**N-19 Mass Concentration Extinction Size Analyzer (MESA)**  
 Hund Corporation

The MESA is suitable for the quasi-continuous monitoring of the dust concentration and mean particle size in flue gases or in dusts produced in the processing of powdery substances. The dust is collected on a longitudinally oscillating fiberglass filter tape. Intrinsic frequency is measured before and after particle deposition. Frequency shift is the displayed variable. Sensitivities of more than 50 Hz/mg can be achieved depending on which filter tape is used. An LED (660 nm) is located on one side of the tape and a photodiode on the other. Simultaneous recording of mass concentration and extinction permits calculation of a particle count concentration. Data processing is computer controlled and results are available immediately after measurement.



INSTRUMENT N-19. Mass Concentration Size Analyzer (MESA).

**TABLE NI-1. List of Manufacturers**

AVI	AeroVironment 825 Myrtle Avenue Monrovia, CA 91060 (818) 357-9983
AND	Andersen Samplers, Inc. 4215 Wendell Drive Atlanta, GA 30336 (404) 691-1910 or (800) 241-6898
GMD	GMD Systems, Inc. Old Rural Route 519 Hendersonville, PA 15339-9999 (412) 746-3600
HND	Hund Corporation 401 Broadway New York, NY 10013
MGP	Matheson Gas Products 30 Seaview Drive Secaucus, NJ 07094 (201) 933-2400
MDA	MDA Scientific, Inc. 405 Barclay Boulevard Lincolnshire, IL 60069 (800) 323-2000
PIX	PIXE International Corporation P.O. Box 2744 Tallahassee, FL 32316 (904) 222-0603
WED	Wedding & Associates, Inc. P.O. Box 1756 Ft. Collins, CO 80522 (303) 221-0678 or (800) 367-7610
XON	Xontech, Inc. 6862 Hayvenhurst Avenue Van Nuys, CA 97406 (818) 787-7380

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# AIR SAMPLING INSTRUMENTS

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for evaluation  
of atmospheric  
contaminants

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Susanne V. Hering  
Technical Editor



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