

REGIONAL COPPER-NICKEL STUDY

AIR QUALITY PROGRAM

OPERATIONS MANUAL

JULY 22, 1976

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Prepared By

John Seltz

Mary West

Minnesota Pollution Control Agency

July 22, 1976

Revised By

Laura King

Dave Kelso

Bill Endersen

Daryle Thingvold

Regional Copper-Nickel Study

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1. INTRODUCTION, SCOPE, AND IMPACT ANALYSIS

1.1. Introduction

The air quality program of the Minnesota Environmental Quality Board (MEQB) Regional Copper-Nickel Study is determining air quality in a region in northeastern Minnesota. The region includes areas where copper-nickel mining and smelting operations may be located. Possible smelter locations are largely speculative at this time, but probably lie in the area between the mining region (near the Duluth Gabbro Contact) and the Lake Superior coast. Duluth also has been suggested as a likely area.

The main air pollutants expected from mining operations in this area are particulates emitted from blasting and crushing operations, tailing ponds, and ore transfer facilities. Based on the ore's mineralogy, the particulates may contain metal sulfides, fluoride, and asbestiform minerals as possible harmful constituents. A pyrometallurgical smelter would release additional particulates along with sulfur and nitrogen oxides. Hydroprocessing of the ore, another option, requires fine crushing, and might result in greater particulate emissions.

Maximum ambient levels of particulates, sulfur dioxide, and nitrogen dioxide have been determined by the United States Environmental Protection Agency (USEPA) and appear in 40 CFR 410, April 1971. These standards are based upon research as reported in the Air Quality Criteria documents published in the USEPA (AP-49, AP-50, AP-84). Primary standards are designed to

protect health; secondary standards are designed to protect property and plant life. The ambient air standards have been challenged several times since 1971, resulting in modifications. A summary of current USEPA and Minnesota air standards is given in Table A-1.

More recently, the consensus of scientists has been that composition and size of air particulates, rather than gross weight measurement, determine toxicity. However, no standards based on particle size or composition have yet been recommended.

Both gaseous and particulate fluorides may be emitted from mining and smelting operations. Fluoride accumulates in plant tissue and therefore may be transported up the food chain. Fluoride can cause osteoporosis in mammals and direct damage in the form of marginal necrosis in plantlife.

1.2. Scope of Study

Regional baseline data was obtained for sulfur dioxide, nitrogen dioxide, total suspended particulates, suspended metals, particulate sulfate, fibers, and gaseous and particulate fluorides. Rainfall and bulk deposition samples were collected for metal and sulfate analysis. Cascade impactor samples of air particulates were collected and analyzed by the University of Minnesota (U of M) environmental engineering program for trace metals and sulfate. A study conducted by the Mechanical Engineering Department at the U of M utilized a mobile van equipped with a variety of analyzers to determine the transport and chemical characteristics of local sources of emissions. The results of the U of M studies are contained in separate reports. The guideline in locating samplers was primarily to devise an area-representative

network, and secondarily to get some idea of the present degradation of the air caused by existing sources. An outline of the time schedule chart for program development is given in Table A-2.

High-volume filters are retained after weighing for possible future use. Portions of plastic membrane filters remaining after metals and sulfate analyses are retained in plastic petri dishes for possible future analyses. Approximately 30 filters have been analyzed for asbestiform fibers.

1.3. Impact Analysis

Projected regional levels of atmospheric particulates and SO_2 are estimated by combining the measured existing concentrations of these pollutants with proposed increments which are obtained by dispersion modeling of mine and smelter emissions. Data gathered in the vicinity of existing source also can be used to calibrate or validate dispersion models. Other impact assessments were performed to estimate long distance transport and possible changes in dry deposition and precipitation chemistry resulting from copper-nickel mining and smelting. Data gathered from the meteorological program was an integral part of the impact analyses procedure.

The air quality program provides necessary input into the water quality, aquatic biology, terrestrial ecology, and leaching programs. Correlations studied between atmospheric pollutant levels and rain, soil, and plant tissue levels in sulfur and metallic elements are made. Ambient air concentrations of sulfur dioxide affect the acidity of rainfall, which may in turn affect the rate of leaching of metals and metal sulfides by rain, and the pH balance of lakes and streams.

2. SAMPLING STATIONS

Maps showing air quality station locations are given in Figure A-1 and Figure A-2. Site inventory forms are given in Appendix A-1. These forms are standard SAROAD forms and include latitude and longitude, UTM coordinates, address, and written description. A tabulation of site numbers is given in Tables A-3, and Table A-4 gives a listing of equipment at each station. Photographs and slides of the stations are on file at the Regional Copper-Nickel Study offices.

3. METHODOLOGY

3.1. Techniques

3.1.1. Total Suspended Particulates (High-Volume Method)

Total suspended particulates (TSP) are measured by the method given in 40 CFR 50, Appendix B with two exceptions. A brushless motor is used in place of the AC-DC motor at the locations which are indicated in Table A-4. Brushless motors are used to avoid contamination (e.g. copper from the brushes) of the membrane samples. Because of differences in the air flow system, a Magnehelic pressure gauge and orifice are used to measure flow in place of the "Visifloat" or transducer.

The sampler employs a high speed, low torque motor to draw a large volume of air, approximately 1.4 cubic meters per minute (50 cubic feet per minute), through a preweighed, 8 inch by 10 inch glass fiber filter. The filter is then reweighed, and the weight gain divided by the air volume sampled, giving the weight of suspended particulates in micrograms per

cubic meter of air. This Federal Register reference technique is used nationwide and should provide data that are comparable to locations in the state and country. Detailed operation, calibration, laboratory, and data analysis procedures are given in Appendix A-2 (available from the Minnesota Pollution Control Agency (MPCA) and Regional Copper-Nickel Study offices).

3.1.2. Suspended Particulates (Membrane Sampler)

The membrane sampler uses a carbon vane pump to draw approximately 0.1 cubic meters per minute of air through a 102mm Millipore HA 0.45 μm mean pore size filter. The sampler collects a particulate sample on a synthetic plastic filter. Use of this filter facilitates the analysis of the particulate for sulfate, metallic ions, and asbestiform minerals which otherwise would be difficult or impossible to analyze if glass fiber filters were used. This type of sampler is in wide use, including its use by the USEPA and its national air sampling network stations.

Because of face velocity and air temperature differences, particulate mass measurements made with this sampler are not directly comparable with those made with the high-volume sampler. However, an attempt will be made to formulate a correlation factor on coincident samples taken at the five sites where both membrane and high-volume samplers are located.

In the beginning of the program, membrane filter samples were preweighed by the U of M plant pathology department. Now they are preweighed by the Minnesota Department of Health (MDH). After exposure, filters are returned to the MDH lab for final weighing and analysis of the following parameters:

aluminum (Al), cadmium (Cd), copper (Cu), iron (Fe), magnesium (Mg), nickel (Ni), zinc (Zn), and sulfates. Subsequently, arrangements were made through the mechanical engineering department, U of M, to have most of the filters analyzed by the USEPA, Research Triangle Park, using X-ray fluorescent. See Appendix A-3 for information about which filters were analyzed by the USEPA. In addition, analyses for fibers are performed six times per year for samples from five sites. Detailed operation, calibration, and data handling procedures are given in Appendix A-3 (available from MPCA or Regional Copper-Nickel Study offices). Laboratory procedures are given in a separate manual.

3.1.3. Sulfur Dioxide (24-Hour Bubbler)

Sulfur dioxide was measured at 11 locations using the USEPA Federal Register reference technique documented in 40 CFR 50, Appendix A. Beginning with August 1, 1977, all but four sites were discontinued because measured concentrations were nearly always zero. See Appendix A-4 for which sites were discontinued. This method involves drawing 200 ml/min of air through a 50 ml solution of potassium tetrachloromercurate. A relatively stable complex is formed, which is returned to the laboratory and reacted with pararosaniline and formaldehyde forming a colored complex. The absorbance of this complex is then measured spectrophotometrically. The method's detection limit is in the 10-25 $\mu\text{g}/\text{m}^3$ (5-10 ppb) range.

Thermal degradation of the exposed solution has been suggested recently (e.g. Bruckman, 1975). To minimize this effect, the bubbler cases are sheltered from direct sunlight. (They are also heated when internal

temperature falls below 4° C.) Bubbler solutions are picked up within four working days after exposure and thereafter continuously refrigerated until returned to the MDH laboratory (maximum four weeks). Maximum-minimum thermometers were placed in some bubbler cases during July and August to check on temperatures that sometimes could lead to sample degradation.

This method is in use nationwide for measurement of ambient air and represents a compromise between cost of continuous measurement and the need for monitoring at many locations. Detailed operation, maintenance, calibration, and laboratory procedures are given in Appendix A-4 (available from MPCA or Regional Copper-Nickel Study offices).

3.1.4. Nitrogen Dioxide (24-Hour Bubbler)

Nitrogen dioxide is monitored at the same sites as sulfur dioxide and using the USEPA Federal Register technique given in 40 CFR 50, Appendix F (revised June 8, 1973). As with sulfur dioxide, this method has a detection limit of approximately 6 $\mu\text{g}/\text{m}^3$ (3 ppb). Nitrogen dioxide is collected by bubbling air through a sodium hydroxide-sodium arsenite solution to form a stable solution of sodium nitrite. The nitrite ion produced during sampling is reacted with phosphoric acid, sulfanilamide, and N-1-naphthyl-ethylenediamine dihydrochloride to form an azo dye and then determined colorimetrically. This technique uses the same physical equipment as the sulfur dioxide bubbler technique.

As with other federal reference techniques, the widespread use and general acceptance of this technique justifies its use. Operation, maintenance,

and calibration techniques are the same as for the sulfur dioxide bubblers and are given in Appendix A-4. Laboratory procedures are also given in Appendix A-4.

3.1.5. Sulfur Dioxide (Continuous Measurement)

Continuous measurement of sulfur dioxide was performed at two sites; later one site was discontinued because the loaned instrument was returned (see Table A-4). Enhanced detection limit, freedom from interferences, and the time resolution obtained are advantages of this method. The continuous monitors are Philips Model 9700. See the product information sheet (Appendix A-5, available from MPCA or Regional Copper-Nickel Study offices) for a diagram of the analyzer and a description of the measurement technique. The Model 9700 has been approved by the USEPA for use as an equivalent method for sulfur dioxide analysis (40 CFR 53, February 18, 1976). Use of this analyzer eliminates the need for compressed gas cylinders which are necessary with other analyzers, making it preferable for remote operation. This instrument also automatically zeroes and spans, and keeps records in the form of strip charts. Calibration is performed with a liquid sulfur dioxide permeation source similar to that specified in 40 CFR 50, Appendix A. Detailed operation, calibration, and maintenance procedures are given in Appendix A-6 (available from the MPCA or Regional Copper-Nickel Study offices).

3.1.6. Fluoride (Tape Sampler)

Gaseous and particulate fluoride sampling was done at two locations, both near existing industrial operations (see Table A-4). An RAC Model D1-2T

sampler is used to collect the sample. This sampler uses two rolls of specially treated filter paper through which air is drawn simultaneously. One paper collects particulate fluorides and the other paper collects gaseous fluorides. Sampling is conducted at approximately $0.02 \text{ m}^3/\text{min}$ ($0.5 \text{ ft}^3/\text{min}$) for four hours through each spot on the tape. Six four-hour spots form a composite 24-hour sample. Samples are returned monthly to the MDH laboratory for analysis. The paper tape sampler is the only alternative to complex, expensive, and continuous analysis. Sensitivity is better than $2 \text{ } \mu\text{g}/\text{m}^3$. Detailed operation, maintenance, and calibration procedures are given in Appendix A-7 (available from MPCA or Regional Copper-Nickel Study offices). Laboratory procedures are outlined in a separate manual.

3.1.7. Rainfall (Event Precipitation Sampler)

Event rainfall samples were collected at two sites during the 1977 warm season. The samplers open at the onset of rainfall and close after a 16 ounce (473 ml) linear polyethylene sample bottle has filled (which corresponds to .11 inches of rainfall) or when the precipitation terminates. Field measurements of pH are made for samples that fill at least one-third of the bottle. The samples are then acidified and shipped to MDH where they are analyzed for the following parameters (listed in order of priority): sulfate, Cu, Ni, Fe, Pb, Al, Mn, Mg, Ca, P, Na, total organic carbon, chloride, Zn, and K. The analyses are conducted in order listed until ~~all analyses are completed or~~ until the sample amount has been exhausted.

3.1.8. Rainfall (Bulk Precipitation Sampler)

Combined wet and dry deposition samples are collected by four stovepipe-type bulk deposition samplers. Samples are collected monthly and sent to MDH for the following analyses (listed in order of priority): Cu, Ni, Cd, Zn, Pb, Al, Fe, pH, Ca, Mg, Na, K, As, chloride, sulfate, alkalinity, fluoride, total organic carbon, conductivity, suspended residue, filterable residue, P, N, and Si. The analyses are conducted in order listed until all analyses are completed or until the amount of sample has been exhausted.

3.1.9. Size-Differentiated Air Particulates

Size-differentiated air particulate samples are collected twice per month, September 1 to November 20, 1976, and April 5 to June 30, 1977; and once per month December 1, 1976, to April 5, 1977. Air particulates are collected with three Delron Cascade Impactors (Model DC1-6) which have a calibrated air flow of approximately 12.5 liters per minute. Air particulates are differentiated in jet stage cutoffs of approximately 16, 8, 4, 2, 1, and 0.5 μm diameter particles. A backup filter collects all particles less than 0.50 μm . The impaction surface at each of the six stages is a Nucleopore 0.4 μm membrane filter or Whatman 41 filter coated with Apiezon L set on a glass slide. The backup filter is a Nucleopore membrane filter with pore size of 0.6 or 0.4 μm . Twelve-hour to 24-hour sampling periods are required to obtain sufficient sample for analysis of sulfate and selected trace metals (tentatively selected are Cu, Ni, Fe, Al, and Zn).

Impactors collect samples at rotating sites. One cascade impactor collects air particulates for selected trace metal analysis, the other for sulfate

analysis. The rotating site cascade impactors are operated and manned by U of M environmental engineering personnel. Consult the operations manual submitted by this group for laboratory procedures.

3.2. Sampling Frequency

Sulfur dioxide and nitrogen dioxide bubblers, membrane, and high-volume samplers are operated for 24-hour periods (midnight through midnight) once every six days, yielding a randomized temporal sample. Sixty samples per year are obtained from each site for each parameter. The sampling days coincide with the MPCA statewide schedule, and thus allow data comparison. A detailed sampling schedule is given in Appendix A-8 (attached).

Implications of sampling frequency and precision for air quality measurements have been considered by William Hunt, 1970. Precision of a method in arriving at an expected true geometric mean for other than continuous sampling is dependent on sampling frequency and the magnitude of the geometric mean. For background sampling, rather uniform measurements and a low geometric mean can be expected. For example, the 1975 MPCA Duluth Airport site's high-volume TSP data gave a geometric mean of $18.5 \mu\text{g}/\text{m}^3$ and standard deviation of $1.7 \mu\text{g}/\text{m}^3$.

At the 95 percent confidence level, one-in-six-day sampling yields a precision of about plus or minus 10 percent for the annual geometric mean and plus or minus 25 percent for the quarterly geometric mean. It can be expected that particulate data from the copper-nickel sites will yield roughly this degree of precision. It is also expected that bubbler data

will fall within these ranges as a small geometric standard deviation is expected. All of the preceding assumes a log normal distribution, common for air data. Projections of yearly maximum or near-maximum 24-hour averages for periodic sampling can be made (Larson, 1971).

Continuous fluoride determinations are run at two locations and provide time resolution of up to four hours. Sulfur dioxide is sampler continuously at two locations, and data are reduced to one-hour averages.

3.3. Equipment Used

Copies of product information brochures and instrument manuals are included in Appendix A-5. A listing of instruments and their serial numbers appears in Table A-5.

3.4. Quality Control Provisions

For a discussion of general quality control problems and those problems peculiar to sulfur dioxide and particulates analyses, please refer to the following: 1) USEPA Quality Control Provisions in Processing Air Pollution Samples, APTD-1132, March, 1973; 2) USEPA Guideline for Development of a Quality Assurance Program--Reference Method for the Determination of Suspended Particulates in the Atmosphere (High-Volume Method), USEPA-R4-028b, June, 1973; 3) USEPA Guideline for Development of a Quality Assurance Program--Reference Method for the Determination of Sulfur Dioxide, USEPA-R4-73-028d; and 4) USEPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volumes 1 and 2.

Detailed operation, maintenance, and calibration procedures are given in appendices, which are available from MPCA or Regional Copper-Nickel Study offices (bulk prohibits including them with main text). Audit procedures have been devised by the MPCA for the bubbler, continuous sulfur dioxide, and high-volume sampler procedures. These are given in Appendix A-11 (available from MPCA and Regional Copper-Nickel Study offices). The Copper-Nickel Study monitoring network complies with the state monitoring network quality assurance (QA) procedures. The appendices comprise the major components of the QA program. Rejection limits have been set for the high-volume and bubbler samplers and are in development for continuous sulfur dioxide and MDH laboratory procedures. Rejection limits will be set for fluoride and membrane sampler parameters after more data is obtained. Quality assurance in the field has been the responsibility of the field operator. Additional quality assurance checks are performed routinely by MDH and MPCA as part of their normal operation. A detailed calibration and audit schedule is given in Appendix A-8.

All procedures are accurate to an expected value of at least plus or minus 20 percent. A dynamic true value will be derived for each procedure as quality control data become available. The state QA program has been in the development process since September, 1975. However, sufficient data for accuracy determinations of all parameters have not been compiled.

Federal Register 40 CFR 50 states that in the high-volume method, the relative standard deviation (coefficient of variation) for single analyst variation (repeatability) is 3.0 percent and the value for multilaboratory variation (reproducibility) is 8.7 percent. For the sulfur dioxide bubbler

technique, the Register states that the relative standard deviation at the 95 percent confidence level is 4.6 percent for the analytical procedure using standard samples. Relative standard deviations of five and six percent can be expected for nitrogen dioxide concentrations of 40 $\mu\text{g}/\text{m}^3$ and 60 $\mu\text{g}/\text{m}^3$, respectively, based on automated analysis of samples collected from a standard test atmosphere. As mentioned before, these accuracy statements are not necessarily valid for the Copper-Nickel Study case.

4. RECORD KEEPING AND DATA TRANSMISSION

All field data are kept in a loose-leaf notebook by the Copper-Nickel Study field person. However, the Fernberg Road continuous sulfur dioxide monitor is kept in a climate controlled shelter, and, therefore, one notebook is maintained with this monitor at all times. The MINNAMAX sulfur dioxide monitor was located in the MINNAMAX office building, and comments were made directly on the strip charts.

Information maintained in the field notebook is as follows:

Sulfur dioxide (continuous):

| | |
|----------------------|-------------------------|
| Date | Flow information |
| Operator | Daily zero and span |
| Dates of calibration | Maintenance information |
| Calibration data | General comments |

High-Volume (Figure A-3):

| | |
|----------------|---------------------------|
| Date of sample | Current calibration curve |
| Filter # | Analyses data |
| Initial weight | Site # and location |
| Initial flow | Motor # |
| Final flow | Operator |
| Elapsed time | General comments |

Membrane samplers (Figure A-4):

| | |
|--------------------------------------|---------------------------|
| Date of run | Elapsed time |
| Filter # | Analyses data |
| Initial weight | Site # and location |
| Initial flow (H ₂ O), cfm | Motor # |
| Final flow (H ₂ O), cfm | Current calibration curve |
| Operator | General comments |

Sulfur dioxide and nitrogen dioxide bubblers (Figure A-5):

| | |
|---------------------|------------------|
| Site # and location | Elapsed time |
| Motor # | Pump pressure |
| Date of run | Operator |
| Analyses data | General comments |
| Flow | |

Fluoride samplers:

| | |
|------------------|---------------------------|
| Date | Current calibration sheet |
| Operator | Site # and location |
| Tape changes | Instrument # |
| Flow information | Analyses data |

Other (for selected sites):

| | |
|---------------------|------------------|
| Temperature | Time |
| Minimum temperature | Snow depth |
| Maximum temperature | General comments |

The Virginia, Hibbing, Mountain Iron, Scanlon, and Duluth sites are operated by St. Louis County Health Department (SLCHD). SLCHD performs their own analyses for high-volume samplers and bubblers. Record keeping is also done by SLCHD with the exception of membrane samplers which Copper-Nickel personnel maintain on the same basis as other Copper-Nickel sites. Membrane filters are picked up monthly by Copper-Nickel personnel and are hand-carried to the MDH lab for analysis. In addition to the two Copper-Nickel Duluth sites (West End and Airport), information was obtained for other air quality sites located in Duluth. This information will come from the MPCA data bank, and is considered by the Copper-Nickel staff only as additional information for the regional characterization.

5. RESULTS, ANALYSES, AND REPORTS

5.1. Numerical Analyses Performed on Raw Data

5.1.1. High-Volume Sampler Data

High-volume sampler beginning and ending flow, exposure time of sample, and filter clean and loaded weights are recorded as raw data items. From the initial and final flows, an average flow \bar{Q} is determined using the following formula:

$$\bar{Q} = \frac{Q_i + Q_f}{2}$$

where Q_i is the initial flow and Q_f is the final flow, both in ft^3/min . From this average flow, the calibration flow \bar{Q}' is determined by reading the motor indicator calibration curve. From \bar{Q}' , the true volume of air passing through the filter is determined using the formula:

$$V = \bar{Q}' \times T \times 0.0283 \text{ m}^3/\text{ft}^3$$

where T is the time in minutes. The final mass concentration in $\mu\text{g}/\text{m}^3$ is determined using the formula:

$$\text{TSP} = \frac{(W_f - W_i) \times 10^6 \mu\text{g}/\text{g}}{V}$$

where W_f is the loaded weight and W_i is the clean weight, both in grams.

Quality assurance checks performed on data before calculations are made are as follows:

$$1320 \text{ minutes} \leq T \leq 1560 \text{ minutes}$$

$$32 \text{ ft}^3/\text{min} \leq \bar{Q}' \leq 72 \text{ ft}^3/\text{min}$$

$$3.0 \text{ gm} \leq W_i \leq 4.5 \text{ gm}$$

$$W_i \leq W_f \leq 5.5 \text{ gm}$$

If raw data fall outside these ranges or a problem with a sample is indicated (e.g., equipment failure), the sample is assigned an error code (-1 through -8) appropriate for the problem noted. Error codes and their messages are given in Table A-6.

5.1.2. Bubbler Analyses

Raw data obtained for bubbler analyses are air flow, time of exposure, and absorbing solution concentration of the desired ion in $\mu\text{g}/50 \text{ ml}$ of sample. Ambient concentrations are determined from these data via the formula:

$$C_a = \frac{M_v}{SF \times MW \times CE} \times \frac{(C_s/50) \times v}{Q \times T \times 10^{-3} \text{ l/cm}^3}$$

where:

C_a = ambient concentration, ppm

M_v = molar volume = 24.5 l/mole

SF = stoichiometric factor of the method

CE = collection efficiency of the method

v = volume of absorbing solution = 50 ml

C_s = solution concentration, $\mu\text{g}/50 \text{ ml}$ sample

Q = flow rate, cm^3/min

T = time of exposure, minutes

MW = molecular weight, $\mu\text{g}/\text{mole}$

For sulfur dioxide bubbler method, SF = 1, CE = 1, yielding:

$$Ca = \frac{24.5 \text{ } \mu\text{l/mole}}{1 \times 64 \text{ } \mu\text{g/mole} \times 0.85} \times \frac{(Cs/50) \times 50 \text{ ml}}{Q \times T \times 10^{-3} \text{ l/cm}^3}$$

$$Ca = 626 \times \frac{Cs}{Q \times T}$$

To convert ppm to $\mu\text{g/m}^3$, multiply Ca by 1881 for nitrogen dioxide and by 2620 for sulfur dioxide.

As with the high-volume sampler data, quality assurance checks are performed on the raw data. Checks for both sulfur dioxide and nitrogen dioxide are as follows:

$$0.5 \text{ } \mu\text{g/50 ml} \leq Cs \leq 100 \text{ } \mu\text{g/50 ml}$$

$$180 \text{ cm}^3/\text{min} \leq Q \leq 220 \text{ cm}^3/\text{min}$$

$$1320 \text{ min} \leq T \leq 1560 \text{ min}$$

Error codes for bubbler data are the same as for high-volume data and are given in Table A-6.

5.1.3. Continuous Sulfur Dioxide Data Analysis

Continuous sulfur dioxide data are read as hourly averages from strip charts in accordance with Data Analysis Procedure #4 (Appendix A-6) and reported on data sheets.

5.1.4. Fluoride Data Analysis

Fluoride data analysis is performed by the MPCA data analysis group and

the results entered into the computer. Ambient concentrations are arrived at using the formula:

$$Ca = \frac{Ct \times 10^3}{Q \times T}$$

where:

Ca = concentration of F (particulate or gas) in air, $\mu\text{g}/\text{m}^3$

Ct = amount of F in tape segment analyzed, μg

Q = flow, l/min

T = time represented by tape segment, minutes

Quality assurance checks for this method are undetermined at this time.

still true?

5.1.5. Membrane Sampler Analysis

Results of weighings and metal analyses are returned to the MPCA. Computa-
tion of particulates and metals concentration in air are performed as follows.

*are returned to Cu-Ni or MPCA
Municipal General Copper-Nickel Study Office.*

For particulates the formula is:

$$Ca = \frac{(Wf - Wi) \times 10^3}{Q \times T}$$

where:

Ca = concentration in air, $\mu\text{g}/\text{m}^3$

Wf = loaded weight of filter, mg

Wi = clean weight of filter, mg

\bar{Q} = average flow (from calibration curve), m³/min

T = time of sample, min

For metals the formula is:

$$Ca = \frac{Wm \times Af}{As \times \bar{Q} \times T}$$

where:

Wm = weight of metal in sample, μ g

As = area of sample, cm²

Af = exposed area of filter = 67 cm²

Again, no quality assurance data checks for this method ^{HAVE BEEN} established. ~~Still true~~

5.2. Reports

Quarterly data summaries are forwarded to the Minneapolis and Ely

Regional Copper-Nickel Study offices from the MPCA. ^{In addition, data are periodically reported to}

^{periodic} ~~monthly~~ progress reports on program status are sent ^{periodically () brief} from the Ely field ^{Copper-Ni} in preliminary form.

person to the Minneapolis office and to the MPCA. ^{Approximately one per month}

6. STUDY STAFF AND ASSOCIATED PERSONNEL

Resumes for the MPCA Division of Air Quality staff involved with the

Copper-Nickel Study appear in Appendix A-9 (available from MPCA and

Regional Copper-Nickel Study offices). Others associated with the air

quality program include ~~Dr. Sagar Krupa~~, Dr. Steven Eisenreich, Mr. Bruce

Watson, and Mr. Gary Magil. ~~Dr. Krupa is a professor in the Plant Path-~~

my want
do include
file,
Joe B.
+
Laura K
resumes
in here

~~ology Department at the University of Minnesota, St. Paul. He served as~~
~~a consultant to the study and plant pathology program director: Dr. Krupa~~
~~recommended station parameters and locations which would coordinate well~~
~~with the plant pathology program.~~ Dr. Eisenreich is a professor in the
environmental engineering program, Civil and Mineral Engineering Department
of the University of Minnesota, Minneapolis. Dr. Eisenreich is responsible
for ~~the~~ ^g cascade impactor sample collection and analysis ^{and} ~~He~~ also serves
as a consultant to the Copper-Nickel Study. Dr. Eisenreich recommended
station locations. Mr. Watson and Mr. Magil are directors of the meteor-
ology program. They gave advice on station locations which would provide
the best input into area-wide concentration mapping and diffusion model
calibration.

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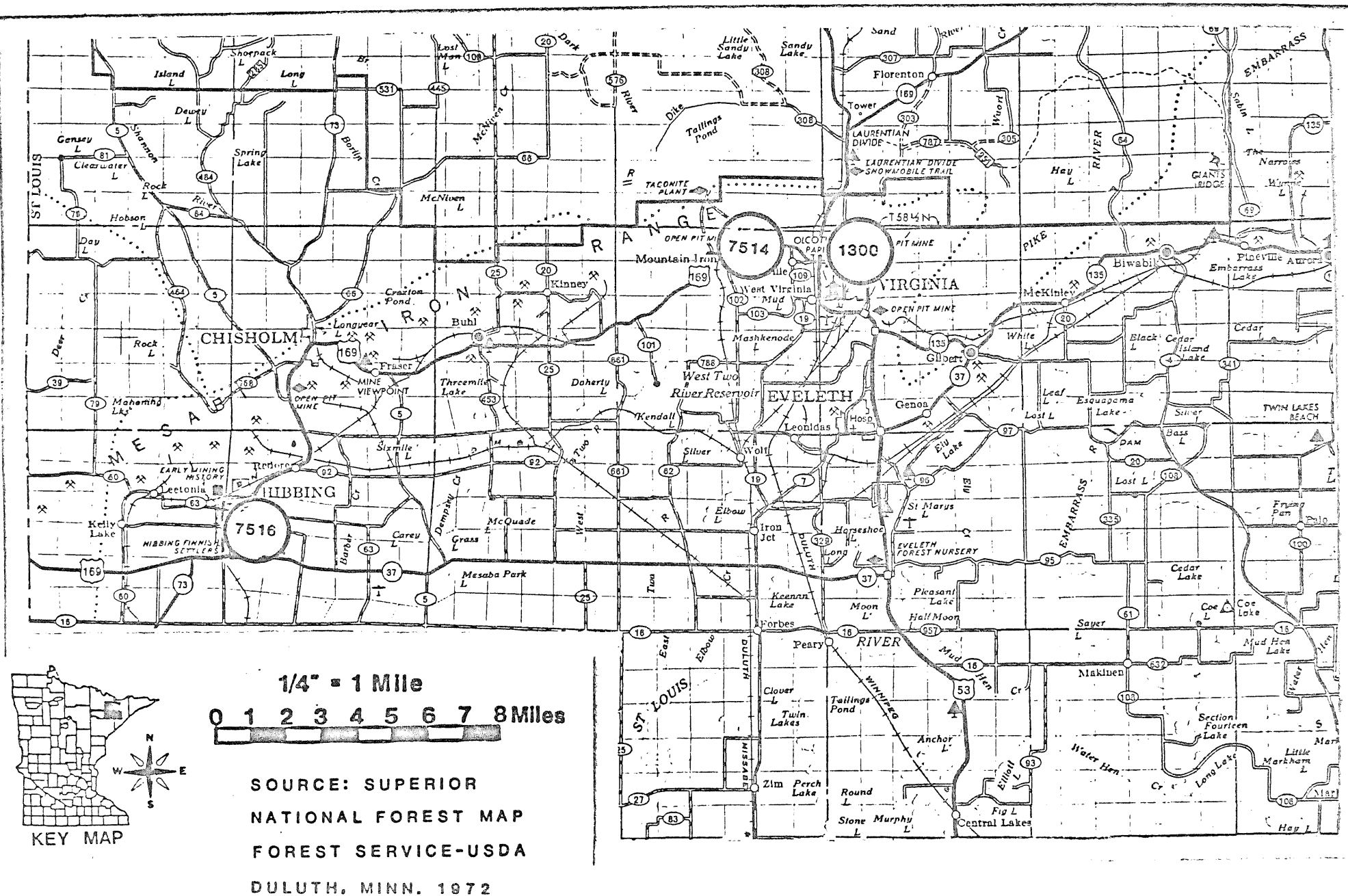
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USEPA. Quality Assurance Handbook for Air Pollution Measurement Systems. Volumes 1 and 2.



HIGH-VOLUME FIELD SHEET

Motor # _____

[illegible]

MEMBRANE FIELD SHEET

Motor # _____

[illegible]

BUBBLER FIELD SHEET

Motor # _____

[illegible]

Table A-1. UNITED STATES ENVIRONMENTAL PROTECTION AGENCY AND MINNESOTA STATE AIR QUALITY STANDARDS.

| <u>Pollutant</u> | <u>Level</u> | <u>Wording</u> | <u>USEPA</u> | <u>Minnesota</u> |
|---------------------|--------------|--------------------------------|-------------------------------|------------------------------|
| Sulfur dioxide | primary | annual arithmetic mean | 80 $\mu\text{g}/\text{m}^3$ | 60 $\mu\text{g}/\text{m}^3$ |
| | primary | second highest 24-hour average | 365 $\mu\text{g}/\text{m}^3$ | 260 $\mu\text{g}/\text{m}^3$ |
| | secondary | second highest 3-hour average | 1300 $\mu\text{g}/\text{m}^3$ | 655 $\mu\text{g}/\text{m}^3$ |
| Particulate | primary | annual geometric mean | 75 $\mu\text{g}/\text{m}^3$ | 75 $\mu\text{g}/\text{m}^3$ |
| | secondary | annual geometric mean | 60 $\mu\text{g}/\text{m}^3$ | 60 $\mu\text{g}/\text{m}^3$ |
| | primary | second highest 24-hour average | 260 $\mu\text{g}/\text{m}^3$ | 260 $\mu\text{g}/\text{m}^3$ |
| | secondary | second highest 24-hour average | 150 $\mu\text{g}/\text{m}^3$ | 150 $\mu\text{g}/\text{m}^3$ |
| Nitrogen dioxide | primary | annual arithmetic mean | 100 $\mu\text{g}/\text{m}^3$ | 100 $\mu\text{g}/\text{m}^3$ |

Table A-2. TIME SCHEDULE FOR AIR QUALITY PROGRAM.

| <u>Date</u> | <u>Item</u> |
|---|---|
| January 1 - September 30, 1976 | site selection, equipment procurement, and installation of equipment |
| October 1 - October 31, 1976 | limited operational shakedown period |
| November 1, 1976 - ^{March 31,} July 1, 1978 | regional monitoring ^{and data analysis} period |
| January 1, 1977 - July 1, 1978 | impact analysis--modeling for regional study ^{and characterization rep.} development |
| July 1, 1978 and after | site specific monitoring and impact analysis |
| | Final report, revisions and communication of results |

update as needed

Table A-3. TABULATION OF SITE NUMBERS.

| <u>Site Name</u> | <u>MPCA Site Number</u> | <u>SAROAD Site Number</u> |
|---|-------------------------|---------------------------|
| Fernberg Road | 7001 ✓ | 241840005 |
| Ely High School | 7002 ✓ | 241100002 |
| Kawishiwi Lab | 7003 ✓ | 241840002 |
| Environmental Learning Center | 7004 ✓ | 241840003 |
| Bear Head State Park | 7005 ✓ | 243260005 |
| Erie Dunka Road | 7006 ✓ | 241560002 |
| Toimi Koski Home | 7007 ✓ | 241840004 |
| Erie Mining Office Building | 7008 ✓ | 241560003 |
| Hoyt Lakes--Police Station | 7009 ✓ | 241560004 |
| Hoyt Lakes--Golf Course | 7010 ✓ | 241560005 |
| Whiteface Reservoir | 7011 ✓ | 243260006 |
| Mountain Iron | 7514 | 243260001 |
| Virginia | 1300 | 243860001 |
| Hibbing | 7516 | 241500001 |
| Duluth--West End | 7527 ✓ | 241040019 |
| Duluth--Airport | 7506 ✓ | 243260003 |
| Scanlon | 7412 ✓ | 240760011 |
| Babbitt | 7013 | |
| MINNAMAX Office Building | 7012 | 243260007 |
| *Duluth--107th Avenue West | 7501 | 241040002 |
| *Duluth--South 88th Avenue West | 7502 | 241040003 |
| * Duluth--60th Avenue W and Grand Avenue | 7503 | 241040004 |
| *Duluth--1628 West Superior Street | 7504 | 241040005 |
| *Duluth--Regent Street | 7505 | 241040006 |
| *Duluth--West First Street | 7512 | 241040013 |
| *Duluth--314 West Superior Street | 7522 | 241040016 |
| *Duluth--KDAL | 7523 | 241040017 |
| *Duluth--314 West Superior Street | 7526 | 241040018 |
| *Duluth--Del Zotto Mfg | 7552 | 241040020 |
| *Duluth--Morgan Park High School | 7553 | 241040021 |

*These sites are not part of the Regional Copper-Nickel Study network; however, available information will be obtained from the Minnesota Pollution Control Agency.

add site 7506 to Duluth list

Range, Township &
Section number

delete

Table A-4. AIR QUALITY SITES AND PARAMETERS.

check with
↓ Kelso to be
sure correct
← fill in
when known

| MPCA Site # | Site Name | Parameters | Beginning Operation Date | Ending Operation Date | Land Ownership | Power Supplier | Comments |
|-------------|-------------------------------|---|--|-----------------------|----------------|----------------------------------|---|
| 7001 | Fernberg Road | SO ₂ BHV M ER BD BR 2/14/77 | 2/1/77 2/6/77 2/6/77 5/1/77 2/1/77 | | USFS | Northern Electric Co-op Virginia | Installation delayed due to electric company service delay and shelter type and access uncertainty. |
| 7002 | Ely High School | B HV | 2/6/77 11/2/76 | | Ely | Ely | |
| 7003 | Kawishiwi Lab | B 2/6/77 BHV | 10/21/76 10/9/76 | | USFS | USFS | |
| 7004 | Environmental Learning Center | B 3/14/77 M | 10/21/76 10/9/76 | | ELC | ELC | |
| 7005 | Bear Head State Park | B 2/6/77 M | 10/21/76 10/9/76 | | State DNR | State DNR | |

KEY: BHV = brushless high-volume sampler
 SO₂ = continuous SO₂ analyzer
 C = cascade impactor
 F = fluoride sampler
 B = bubbler, SO₂ and NO₂ sampler

HV = existing St. Louis County high-volume sampler
 M = 102-mm membrane sampler
 ER = event rain sampler
 BD BR = bulk rain sampler
 deposition (wet/dry precipitation)

Table A-4. AIR QUALITY SITES AND PARAMETERS (contd.).

Page 2 of 4

| MPCA Site # | Site Name | Parameters | Beginning Operation Date | Ending Operation Date | Land Ownership | Power Supplier | Comments |
|-------------|---|---|--|-----------------------|----------------|----------------------------------|---|
| 7006 | Erie Mining Company Milepost 9 Dunka Road BD | B BHV M BR 2/15/77 | 2/6/77 11/8/76 11/8/76 2/1/77 | | Erie | Erie | |
| 7007 | Toimi Koski Home | B BHV M | 2/6/77 12/14/76 12/14/76 | | Edward Koski | Two Harbors Co-op | Operation delayed due to power company service delay. |
| 7008 | Erie Mining Office Building | BHV M F 4/6/77 | 10/9/76 10/9/76 4/1/77 | | Erie | Erie | Fluoride sampler shipment delayed at manufacturer. |
| 7009 | Hoyt Lakes Police Station | B HV 1/7/77 | 2/6/77 1/25/77 | | Hoyt Lakes | Hoyt Lakes | |
| 7010 | Hoyt Lakes Golf Course | B 2/6/77 BHV M ER 5/17/77 BR 2/15/77 | 10/21/76 10/9/76 10/9/76 10/3/76 2/1/77 | | Hoyt Lakes | Hoyt Lakes | |
| 7011 | Whiteface Reservoir | B M | 2/6/77 → 1/13/77 | | MP&L | Northern Electric Co-op Virginia | Operation delayed due to power company service delay. |

Table A-4. AIR QUALITY SITES AND PARAMETERS (contd.).

Page 3 of 4

| MPCA Site # | Site Name | Parameters | Beginning Operation Date | Ending Operation Date | Land Ownership | Power Supplier | Comments |
|-------------|---------------------------|-----------------|--|-----------------------|----------------|----------------|---|
| 7012 | MINNAMAX Office | SO ₂ | 12/15/76 | 3/10/77 | AMAX | AMAX | Special site, not considered part of regular air quality network. |
| 7013 | Babbitt Town Hall | M 2/18/77 | 2/12/77 | | Babbitt | Babbitt | Delay due to unavailability of extra membrane sampler. |
| 7514 | Mountain Iron Post Office | HV F 6/11/77 | existing 3/1/77 | | Post Office | Post Office | Fluoride sampler shipment delayed at manufacturer. |
| 1300 | Virginia | HV | existing | | City Hall | City Hall | |
| 7516 | Hibbing | HV | existing | | Hibbing | Hibbing | |
| 7506 | Duluth Airport | B HV M | 10/3/76 existing 10/27/76 | 2/15/77 | Duluth | Duluth | Membrane sampler moved because of power problems. |
| 7527 | Duluth West End | B HV M | → 10/27/76 10/27/76 | | Duluth | Duluth | Delay due to inability of St. Louis County in locating site. |
| 7412 | Scanlon | M HV B | 2/18/77 existing existing | | | | Membrane sampler ^{moved} obtained from Duluth Airport site. |

Table A-4. AIR QUALITY SITES AND PARAMETERS (contd.).

Page 4 of 4

| MPCA Site # | Site Name | Parameters | Beginning Operation Date | Ending Operation Date | Land Ownership | Power Supplier | Comments |
|-------------|-------------|------------------------|--------------------------|-----------------------|----------------|----------------|----------|
| | Spruce Road | BP BR 2/14/77 ER | 2/11/77 5/25/77 | | USFS | NONE | |

any
these sites → MPCA Site Numbers 7501, 7502, ~~7503~~, 7504, 7505, ~~7511~~, 7512, 7522, 7523, 7526, 7552, and 7553 are existing sites.
 Information from these sites will be obtained from the Minnesota Pollution Control Agency, ~~These sites~~ and therefore
 should not be considered part of the Regional Copper-Nickel Study network.

is any power used?

5
Table A-0. LISTING OF INSTRUMENTS AND SERIAL NUMBERS.

| <u>Instrument Type</u> | <u>Manufacturer</u> | <u>Model #</u> | <u>Serial #</u> |
|---------------------------------------|---------------------|----------------|-----------------|
| Brushless high-volume | General Motors | 5000 | 79284 |
| " | " | " | 79287 |
| " | " | " | 79288 |
| " | " | " | 79295 |
| " | " | " | 79298 |
| " | " | " | 79302 |
| Membrane sampler | RAC | 2349 | 1246 |
| " | " | " | 1247 |
| " | " | " | 1248 |
| " | " | " | 1249 |
| " | " | " | 1250 |
| " | " | " | 1251 |
| " | " | " | 1252 |
| " | " | " | 1253 |
| " | " | " | 1254 |
| " | " | " | 1255 |
| " | " | " | 1256 |
| Bubblers | RAC | 2333 | 4219 |
| " | " | " | 4220 |
| " | " | " | 4221 |
| " | " | " | 4222 |
| " | " | " | 4223 |
| " | " | " | 4224 |
| " | " | " | 4225 |
| " | " | " | 4226 |
| " | " | " | 4227 |
| " | " | " | 4228 |
| " | " | " | 4229 |
| Sulfur dioxide Continuous Analyzer | Philips | PW9700 | |
| Fluoride Tape | RAC | D1-2T | |

update

Table A-6. ERROR CODES AND MEANINGS.

| <u>Error Code</u> | <u>Significance</u> |
|-------------------|----------------------------------|
| -1 | no analysis |
| -2 | MPCA personnel |
| -3 | laboratory error |
| -4 | equipment operator error |
| -5 | vandalism |
| -6 | natural error |
| -7 | equipment failure |
| -8 | other, computer and QA rejection |

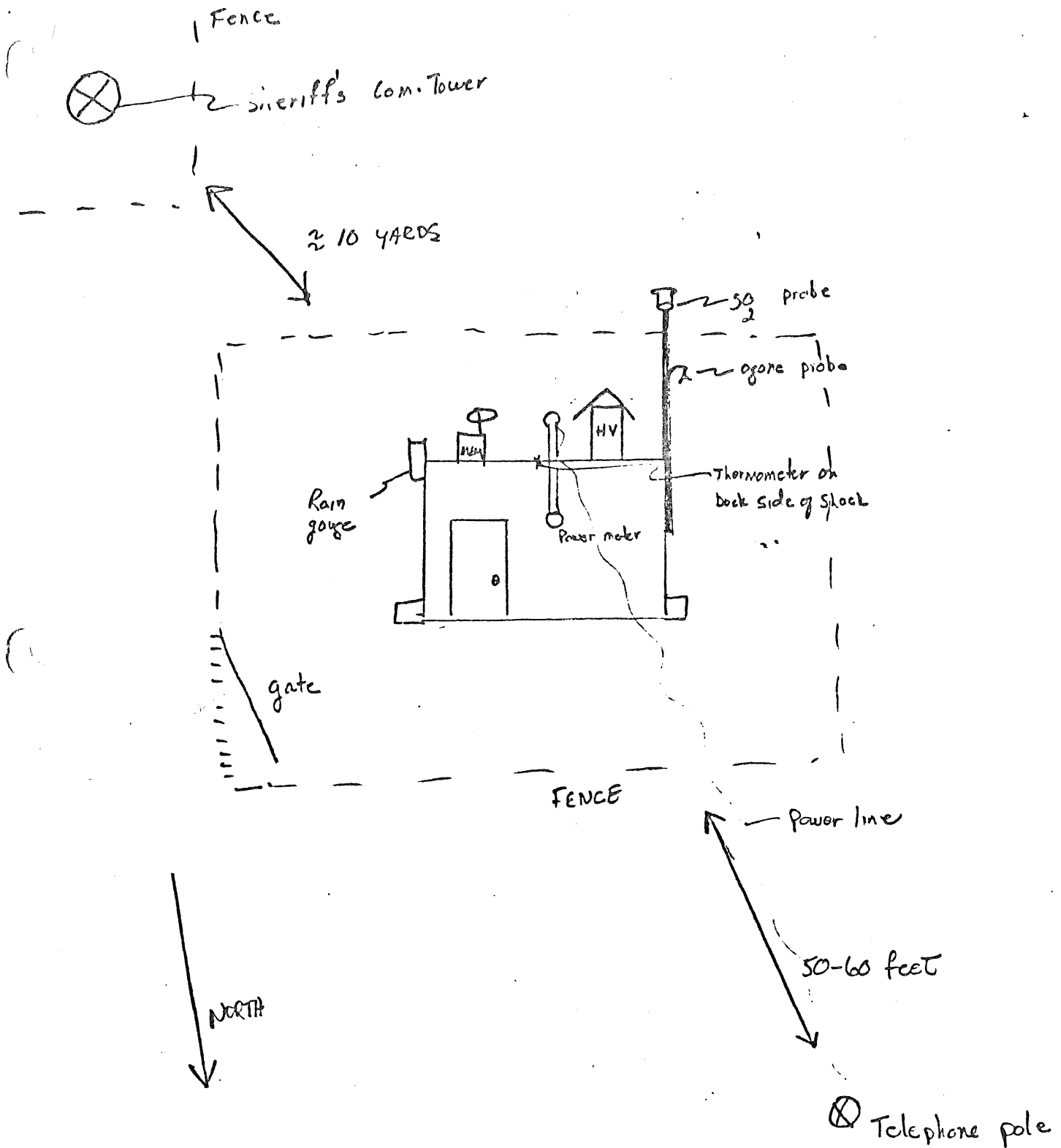
APPENDIX A-1

DETAILED SITE DESCRIPTION FORMS

needed

*SARPAD Forms
get from Kelso
or Foley*

INCOMPLETE

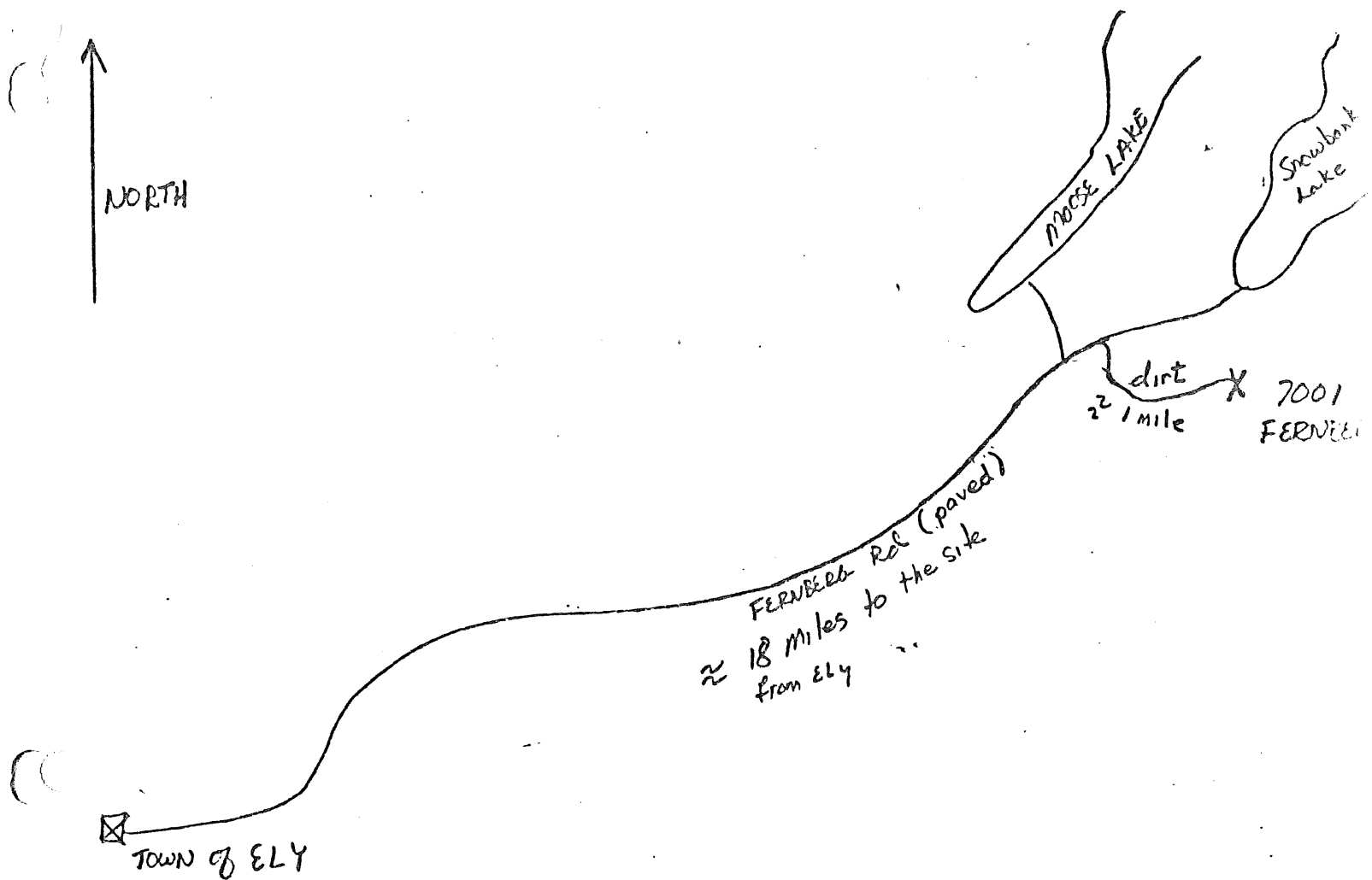


Overhanging trees are ~ 50 feet from the monitoring shack

the rest of the surrounding area is forest.

| | | |
|--------------------------------------|--------------------|------------------------------|
| SO ₂ probe height - 12 ft | HV height - 12 ft | Rain gauge height 9 ft. |
| ozone probe height - 10 ft | mem height - 10 ft | thermometer height 8 1/2 ft. |

SITE 7001 FERNBELL ROAD
(TSP, MEM, SO₂ continuous, gase, rain gauge, snow depth, min/max Temp)



Site is total woods
No sources nearby

Figure 3

SITE 2002 ELY HIGH SCHOOL
(TSP, SO₂-NO₂ bubbler)

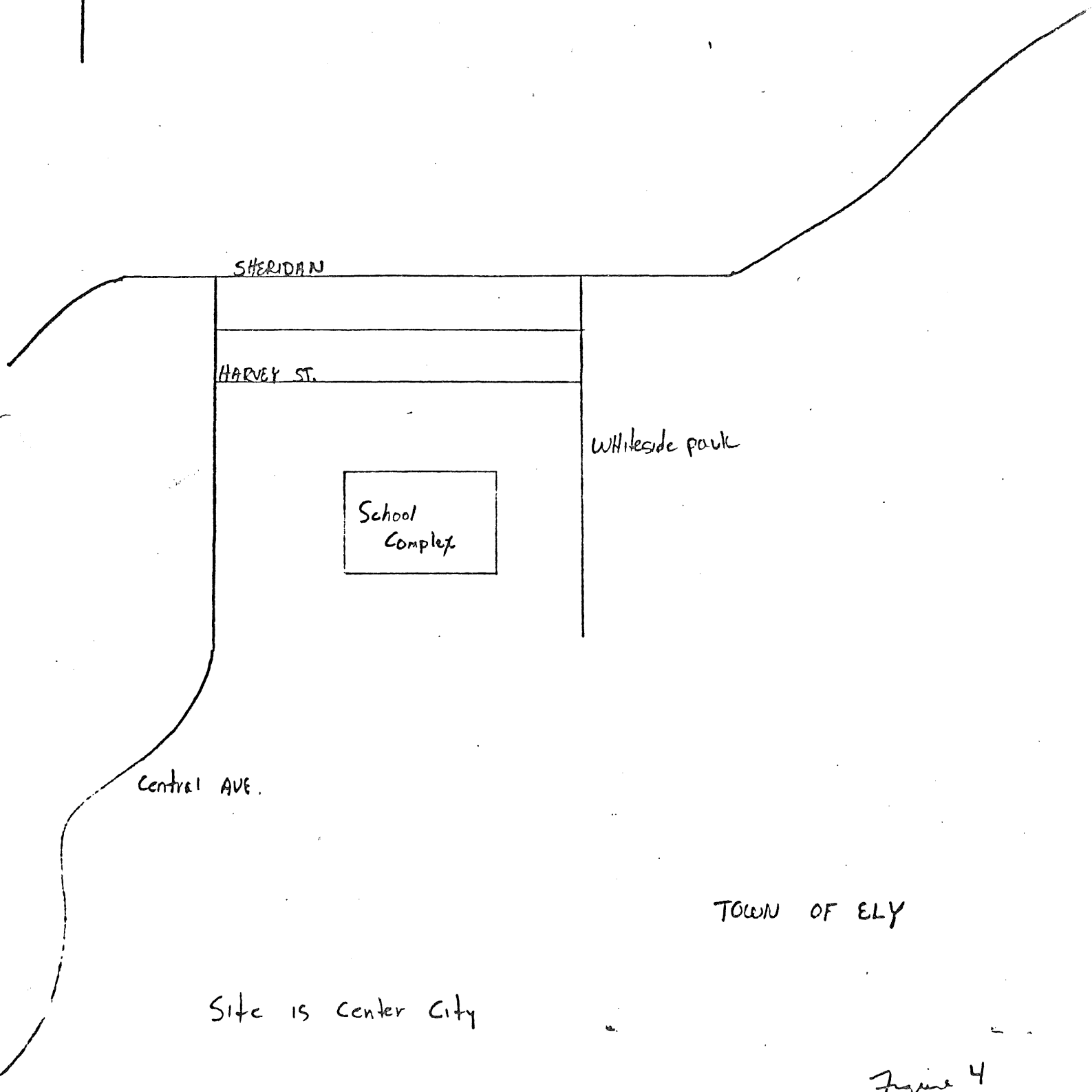
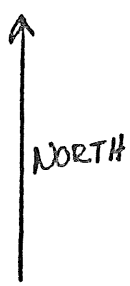
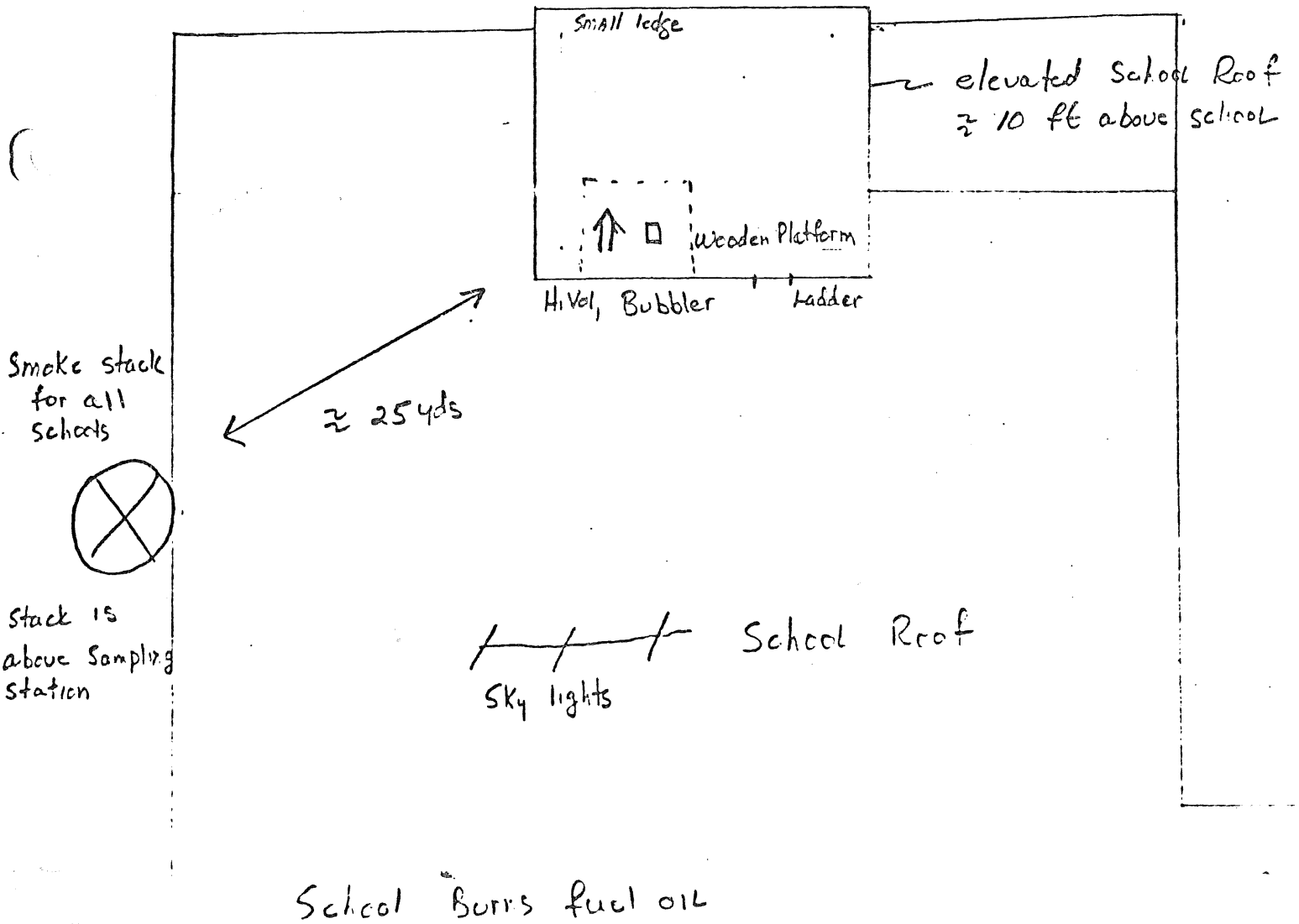
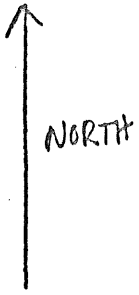
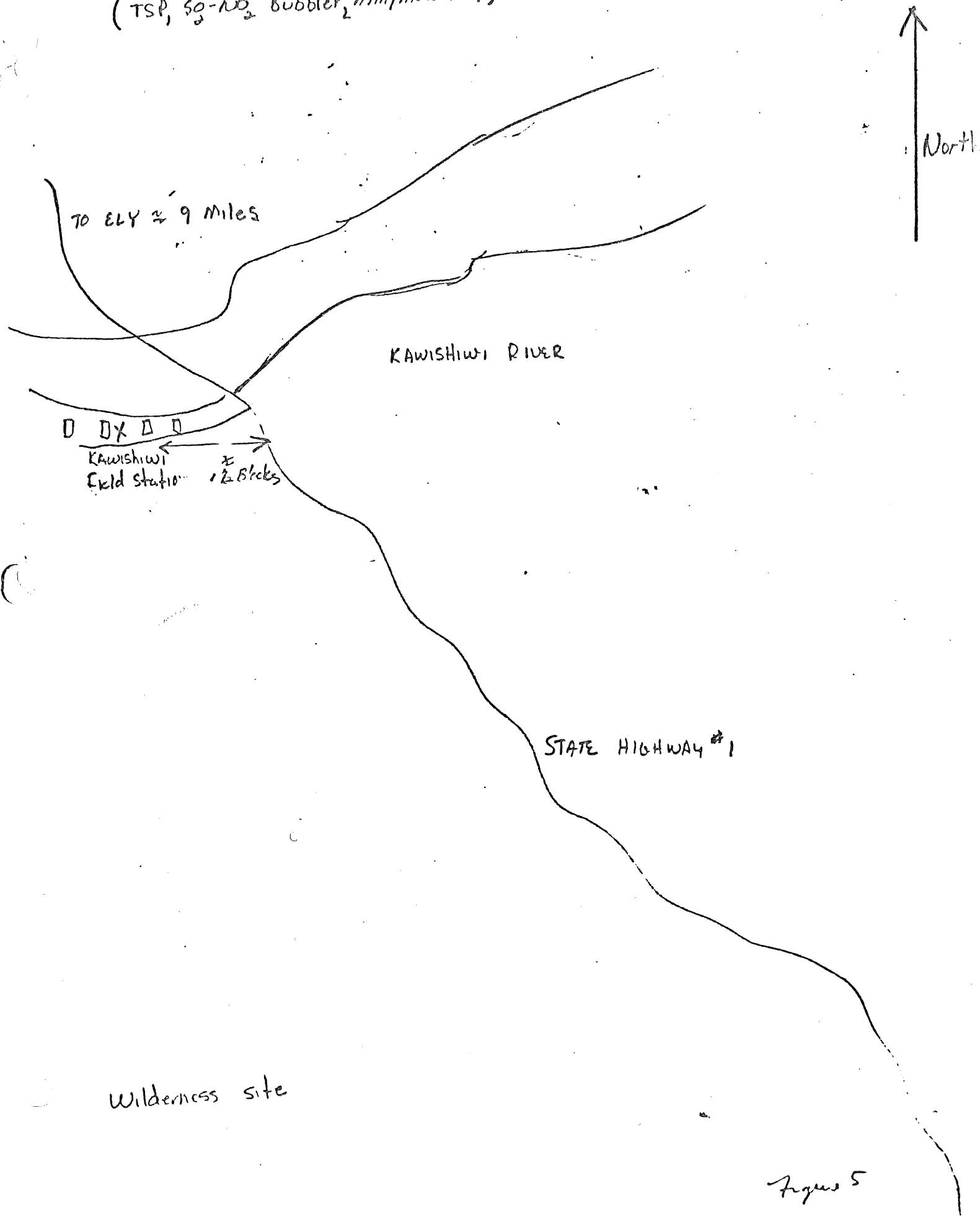


Figure 4

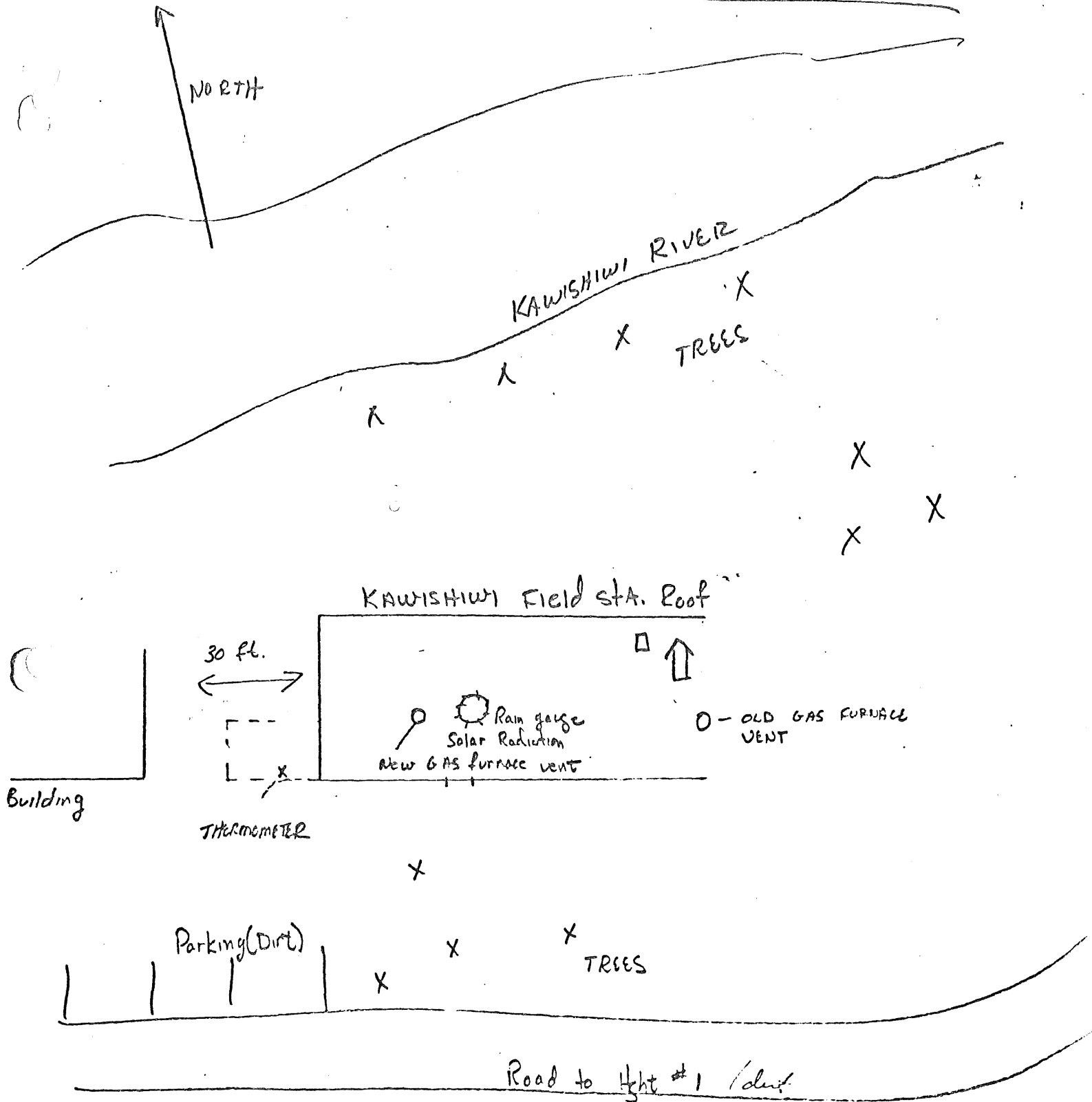


HV Height - 50 ft

SITE 7CC3 KAWISHIWI FIELD STATION
(TSP, SO₂-NO₂ Bubbler, min/max temp, snow depth)



2003 KAWISHIWI



ALL TREES ARE AT LEAST 60+ feet from the site

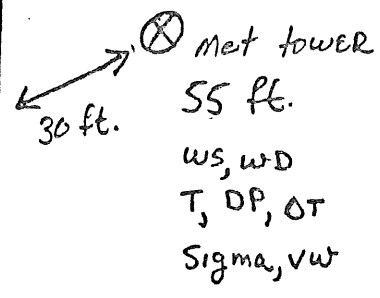
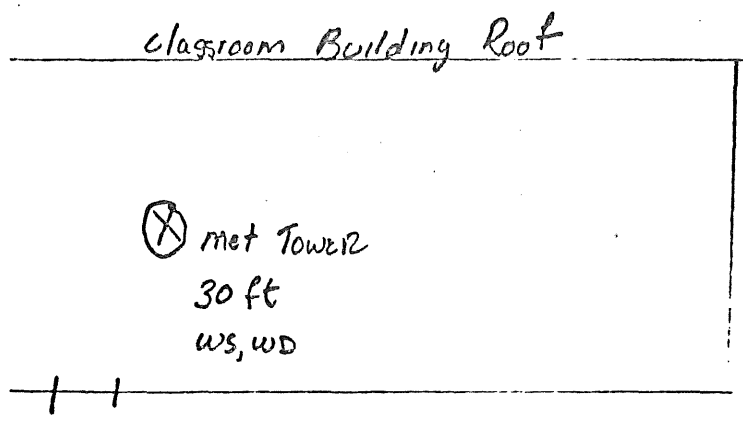
NO major obstructions

HV Height - 12 ft. THERMOMETER HEIGHT - 5 ft

Bubbler Height - 11 ft.

D Kelec 8-1-12

NORTH →



Service Road, Power



Temp. (ELC)



Rain gauge (ELC)

Met towers are unrestricted

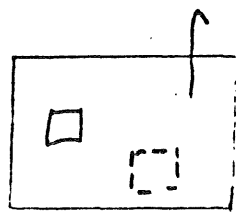
NORTH →

open field

Some shrubs and brush surround the site. No major obstructions. No large trees

Storage shed

50 yds.



Monitoring stand

60 ft.

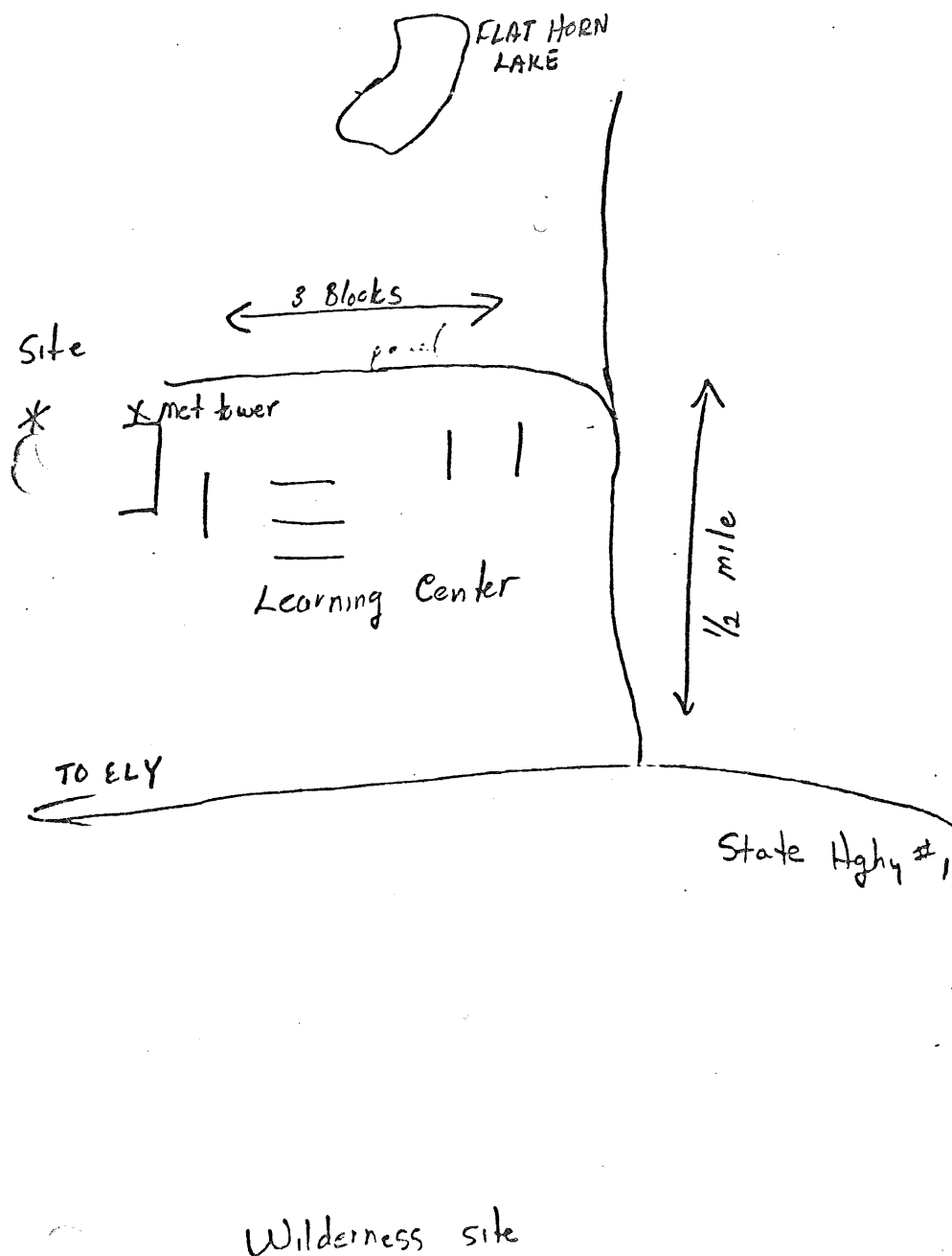
- Membrane height 8 ft
- Bubbler height 10 ft
- Thermometer height 4 ft located on stand



old incense burner not used

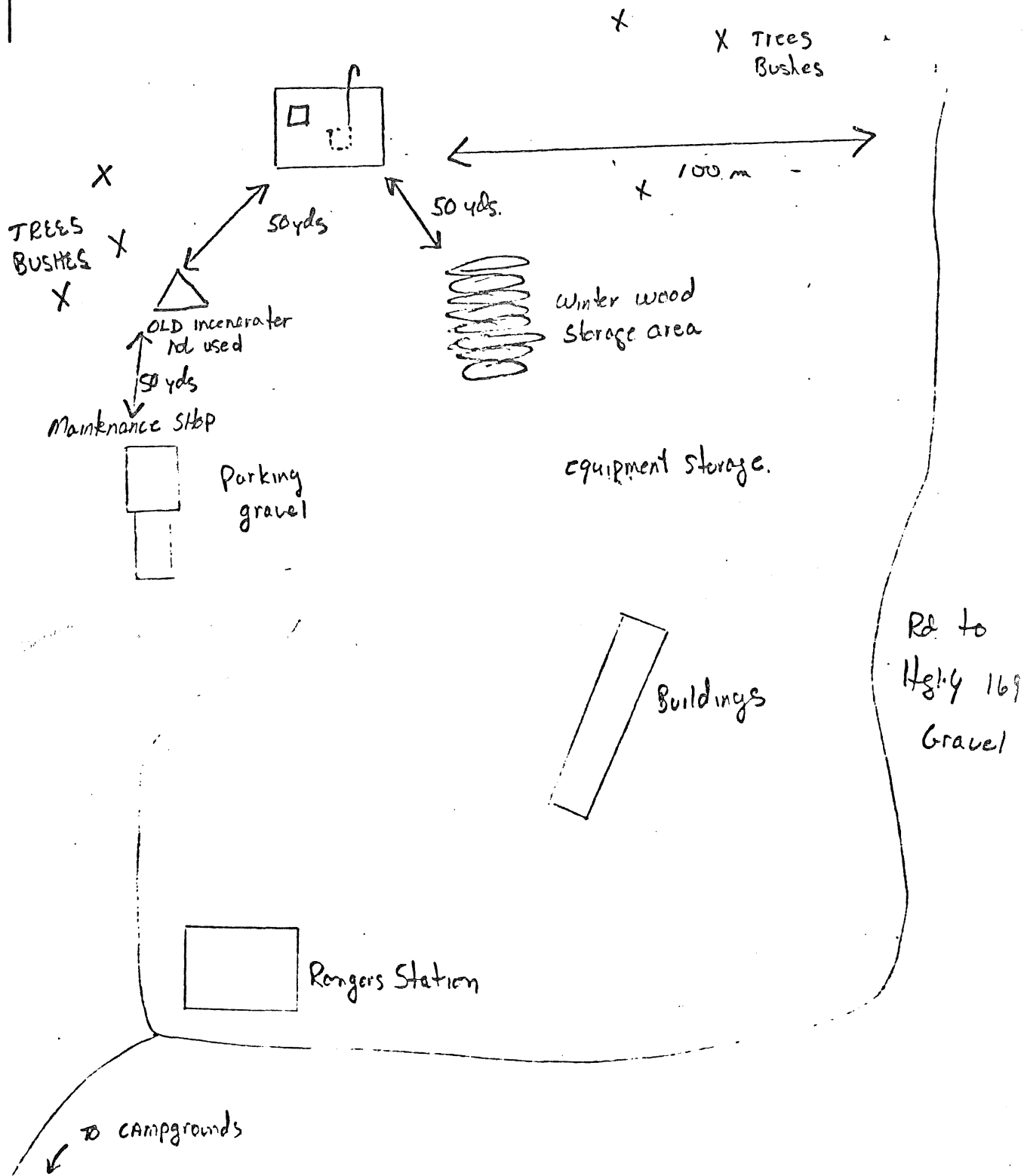
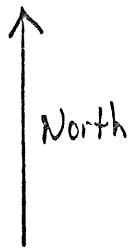
SITE 7004 ENVIRONMENTAL LEARNING CENTER
(mem, SO_2 - NO_2 bubbler, min/max temp, Snow depth, Meteorology)

North



(CUES)

Figure 6



Wilderness site
 Totally surrounded by trees, bushes
 Main height 8 ft. Thermometer height 4 ft

SITE 7005 BEAR HEAD STATE PARK

(mem, SO_2 - NO_2 bubbler, min/max temp, snow depth)

2

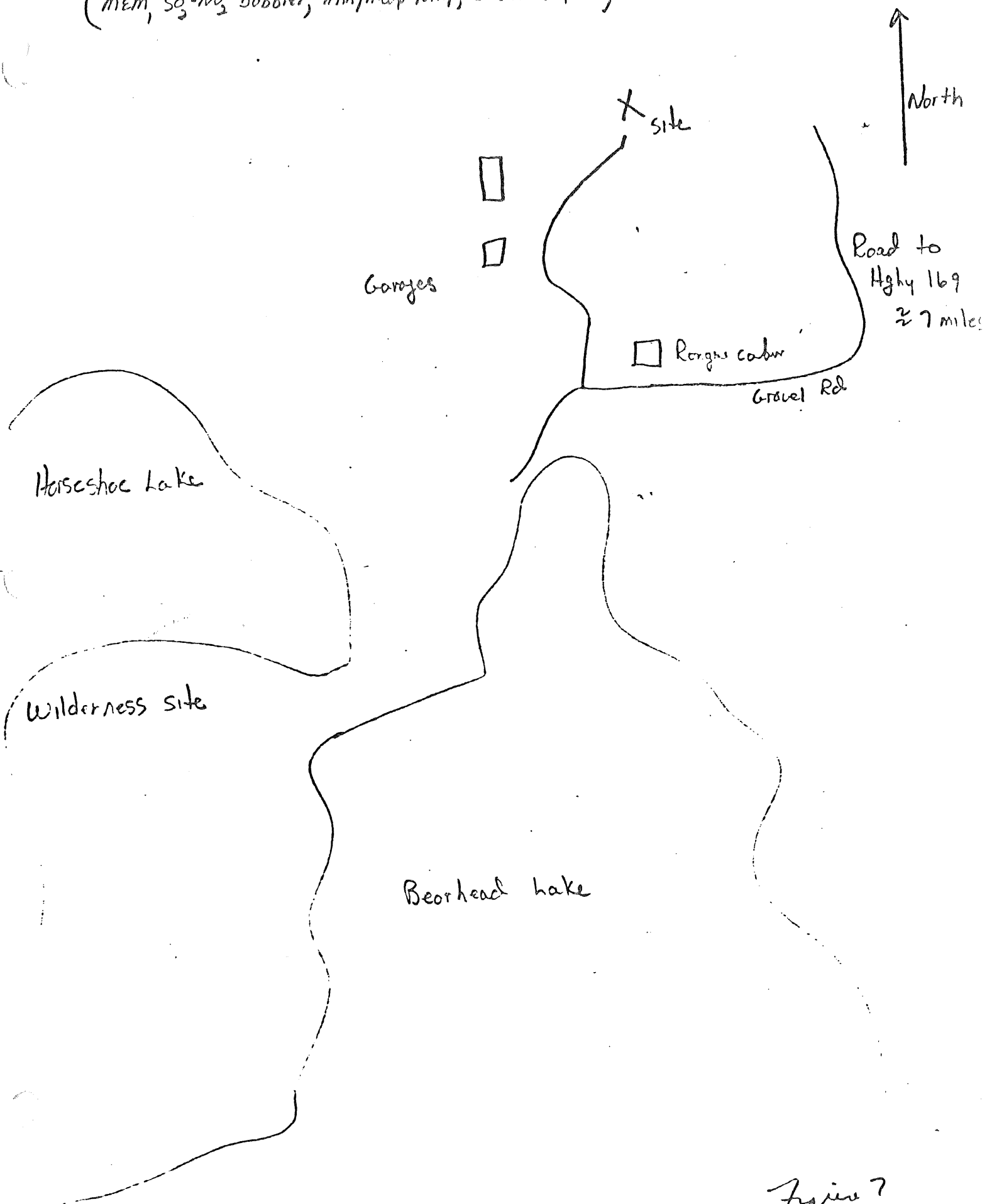


Figure 7

SITE 2006 DUNKA ROAD

(TSP, MEM, SG-NO₂ Bubbler, min/max Temp, Snow depth)
bulk Sampler

general wooded area

NORTH

ERIE MINING Rd - Dunka

TO RABBIT
≈ 15 miles

Dunka Junction

300 ft

⊗ site

70 ft

Trees, Bushes

dirt access Rd
used during
logging

Gravel

ERIE Railroad

TO ERIE MINING
≈ 10 miles

General low
bushes, clearing

Swamp
AREA

300 ft

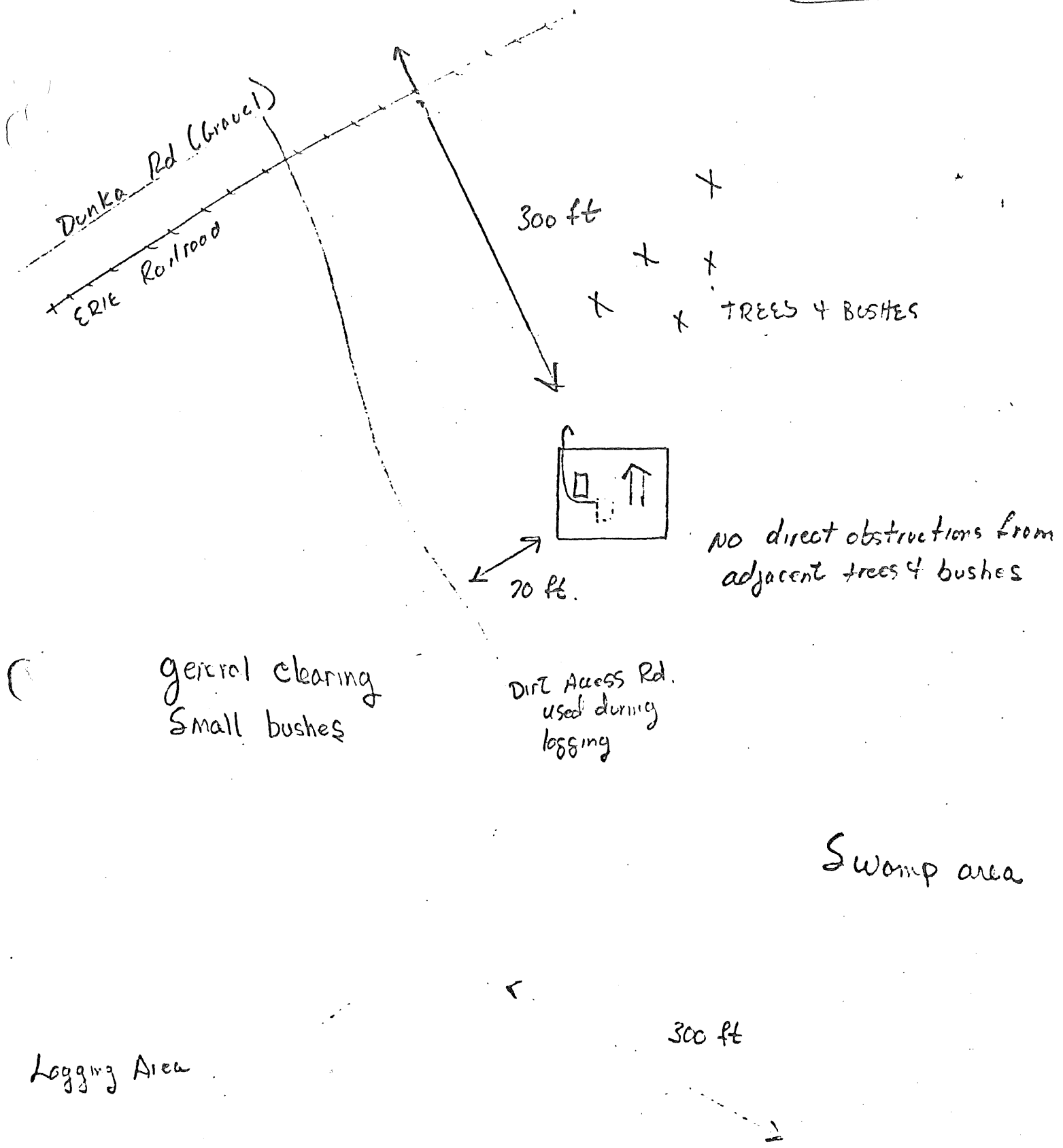
⊗

Bulk pre-
Sampler

Forest
Line

logging

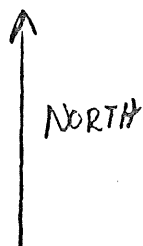
Figure 8



Membrane height - 8 ft bubbler height - 10 ft.
TSP height - 10 ft Thermoneck height - 4 ft

⊗ BULK Sampler

7007 101M1



TREES

General clearing

low bushes



Power Pole

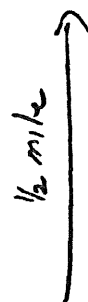
300 ft

Dead End



MR. Koski's House

Site is not overgrown, no
obstructions within 60 ft.
Wilderness site.



Private Road - Gravel

Highway # 16

TO Highway # 4 \approx 20 miles

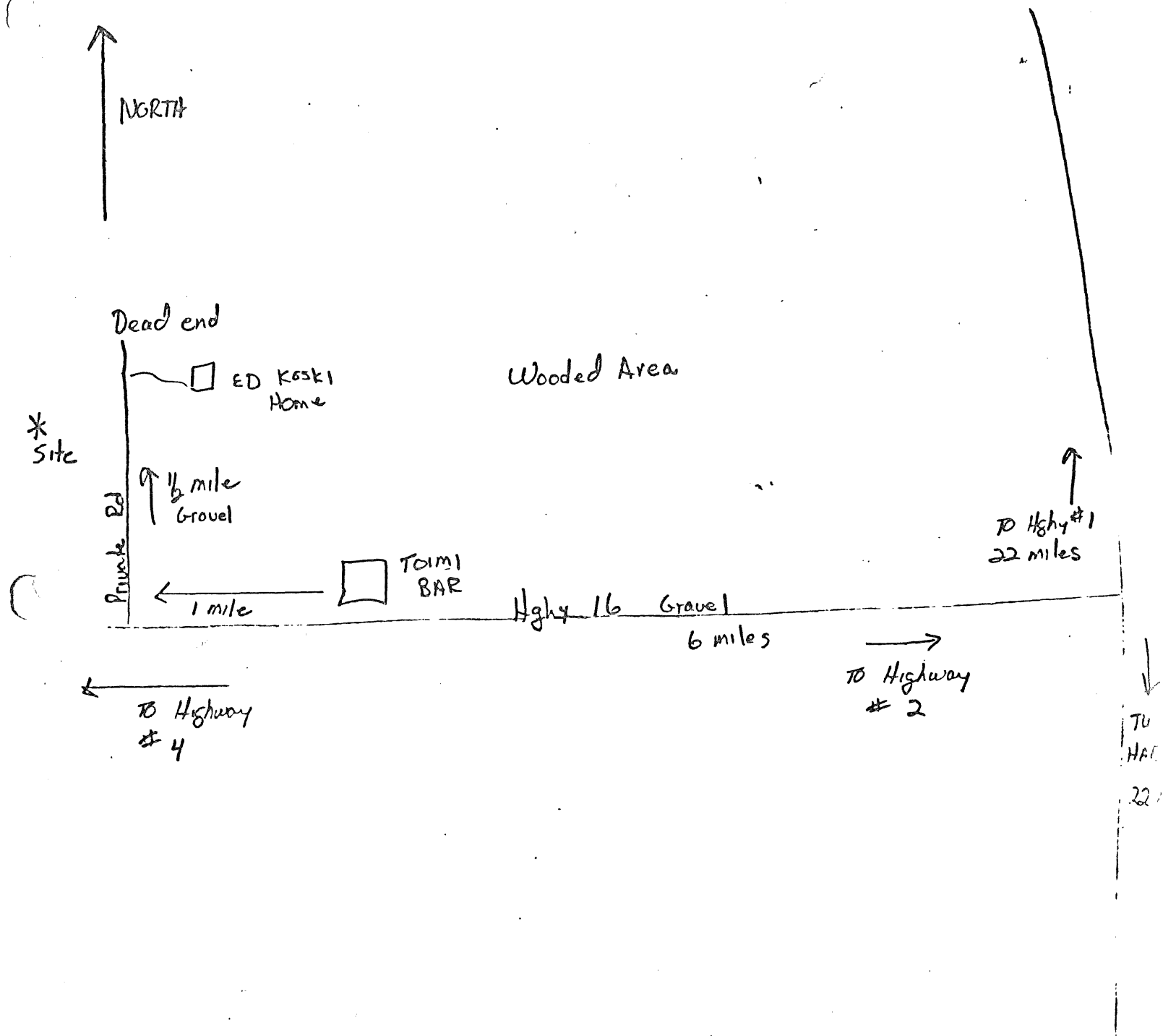
TO Highway # 2
7 miles

TSR height - 10 ft Thermometer height 4 ft
mem height 8 ft
Bubbler height 9 ft

D. Kelso 8-1-78

SITE 7007 TOIMI

(TSP, mem, SO_2 - NO_2 bubbler, Min/max temp, Snow depth)



SITE 7008 ERIE MINING OFFICE
(TSP, MEM, Fluoride)

HILLS

MINE
DUMP
AREA

KNOX MINE

TAILINGS
BASIN

TAILINGS
BASIN

NORTH

ERIE PROCESSING
PLANT

TACONITE
Storage

ERIE Mining office Bldg.
Site

MINE Dumps

DUMPER

TO PLANT
2 miles

ERIE MINING #110

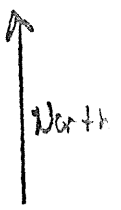
TO Hoyt Lakes
6 miles

Short cut Grand Rd to Hwy 135

Figure 10

7008 ERIE

Plant

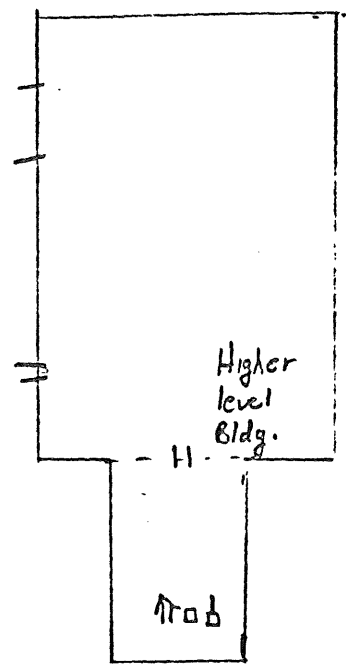


1 km

Gate

ERIE MINING Rd #110

Paved
Parking lot



ERIE Mining office

Paved
Parking lot

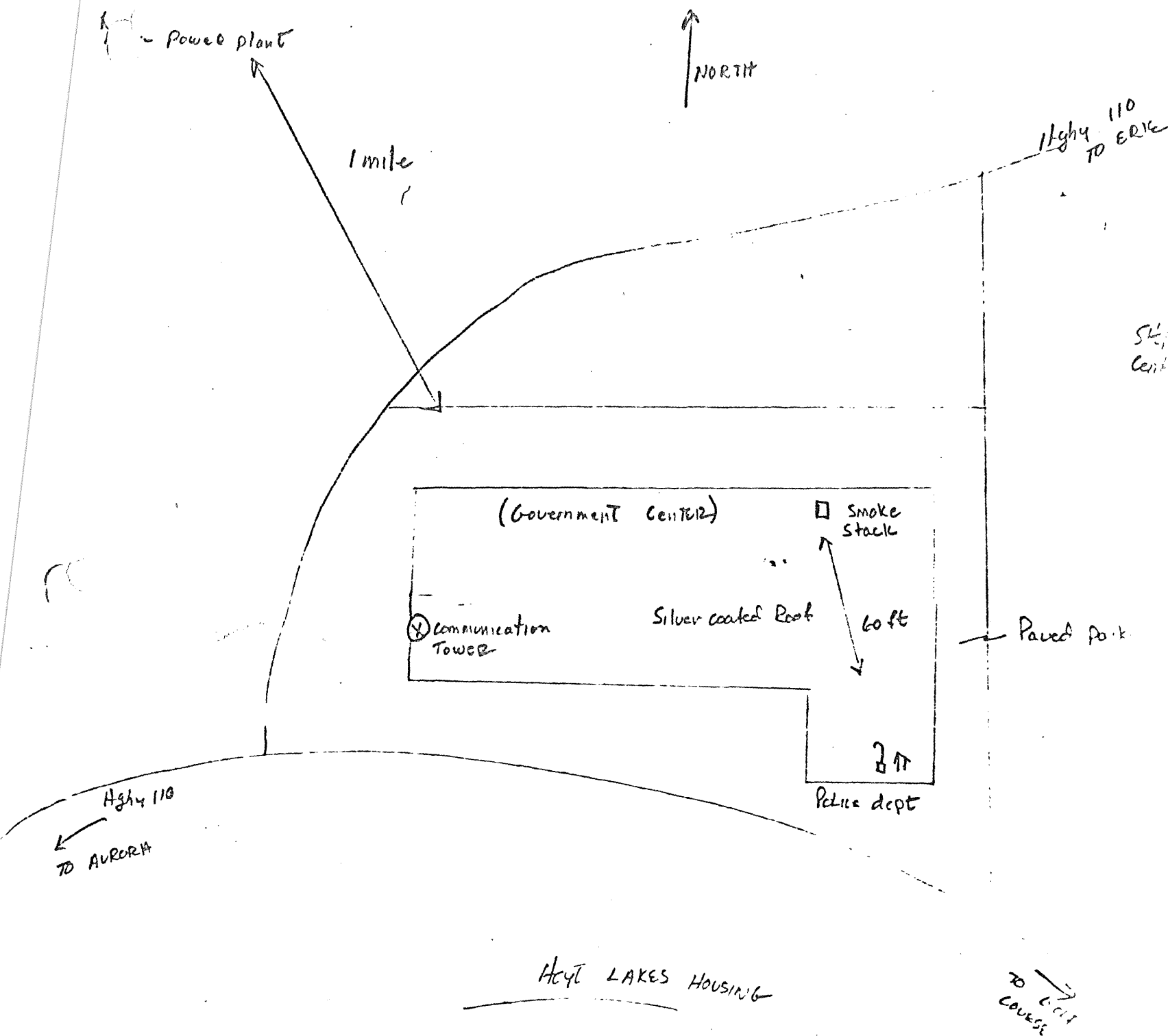
TO HART LAKES

TSP Height 23 ft
Mem Height 21 ft
Fluoride Height 23 ft

Monitors are unrestricted by
Building for processing plant.

D. Kelsa 8-1-78

2009 Hoyt Lakes



no obstructions

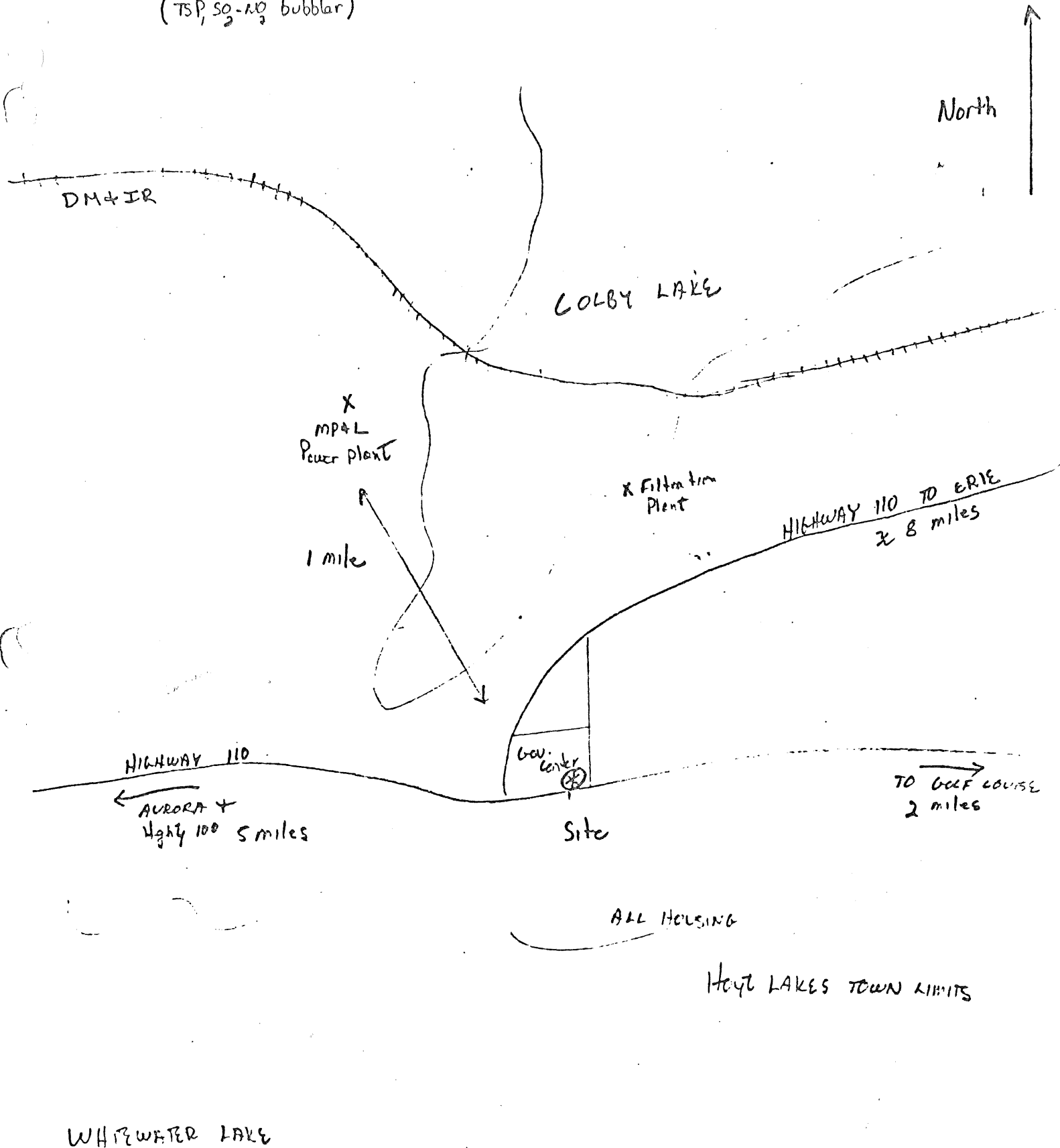
community site

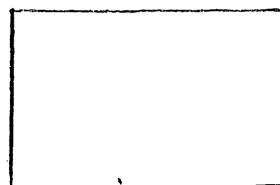
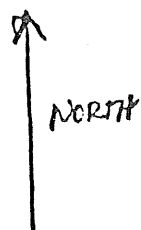
HV Height 17 ft

Building Height 15 ft

D Kaled 8-2-78

SITE 2009 HOYT LAKES POLICE DEPARTMENT
(TSP, SO₂-NO₂ bubbler)





GOLF COURSE
LODGE

North

x

x x

x TREES

x

x

50 ft. Bulk
Sampler

30 ft.

10 ft.

Site



STORAGE
SHED

Golf Course
Grass



Rain sampler

panel

↓ Hwy 116

Open site on all sides but west.
Trees do not overhang site, may interfere
with rain sampler.

HV Height 10ft Thermometer Height 4 ft.
Bubble Height 12ft Rain gauge Height 7 ft
Bulk height 4 ft

Hwy 116

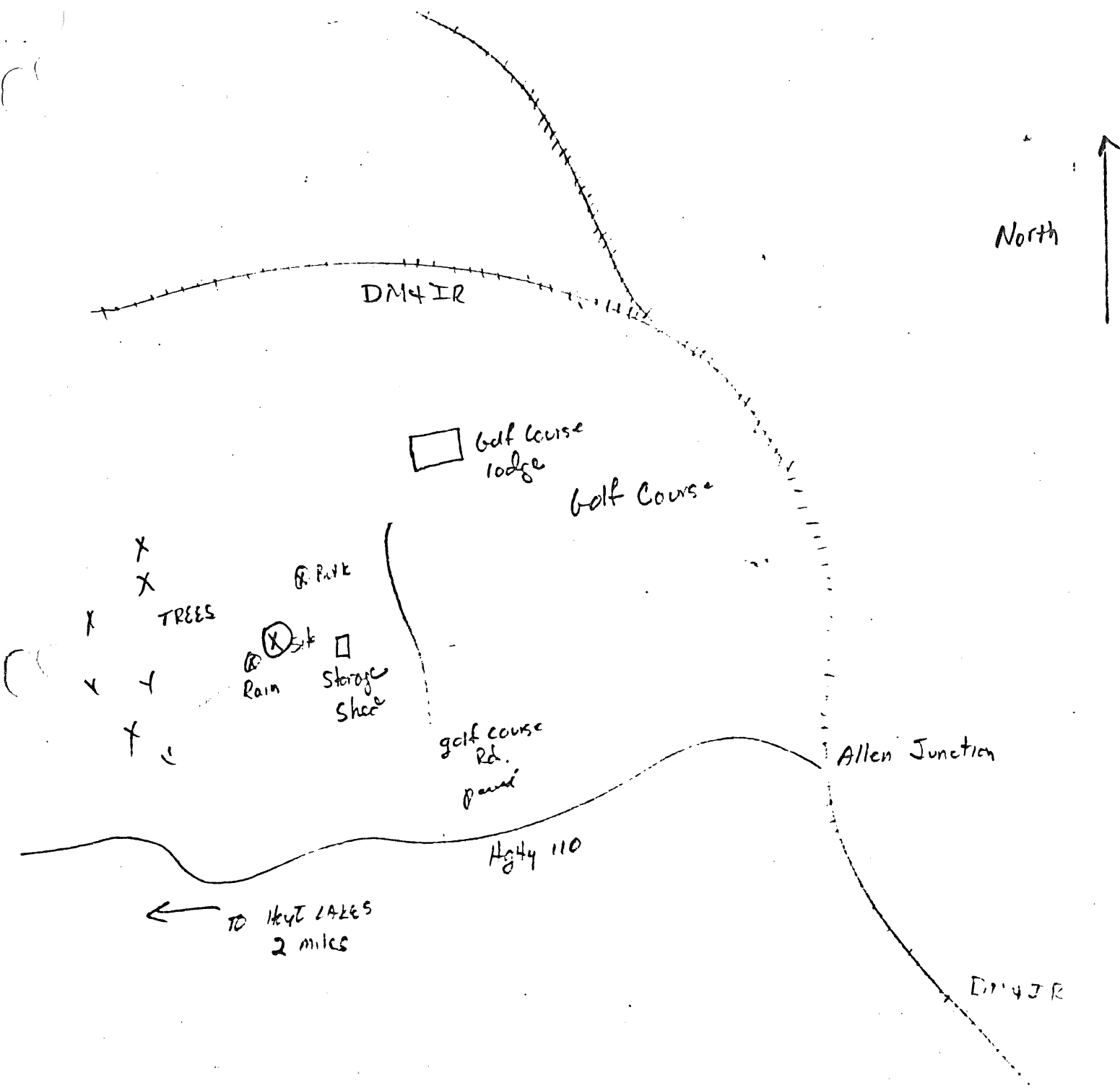
→ TO Allen
Junction

← TO LAKE
2 miles

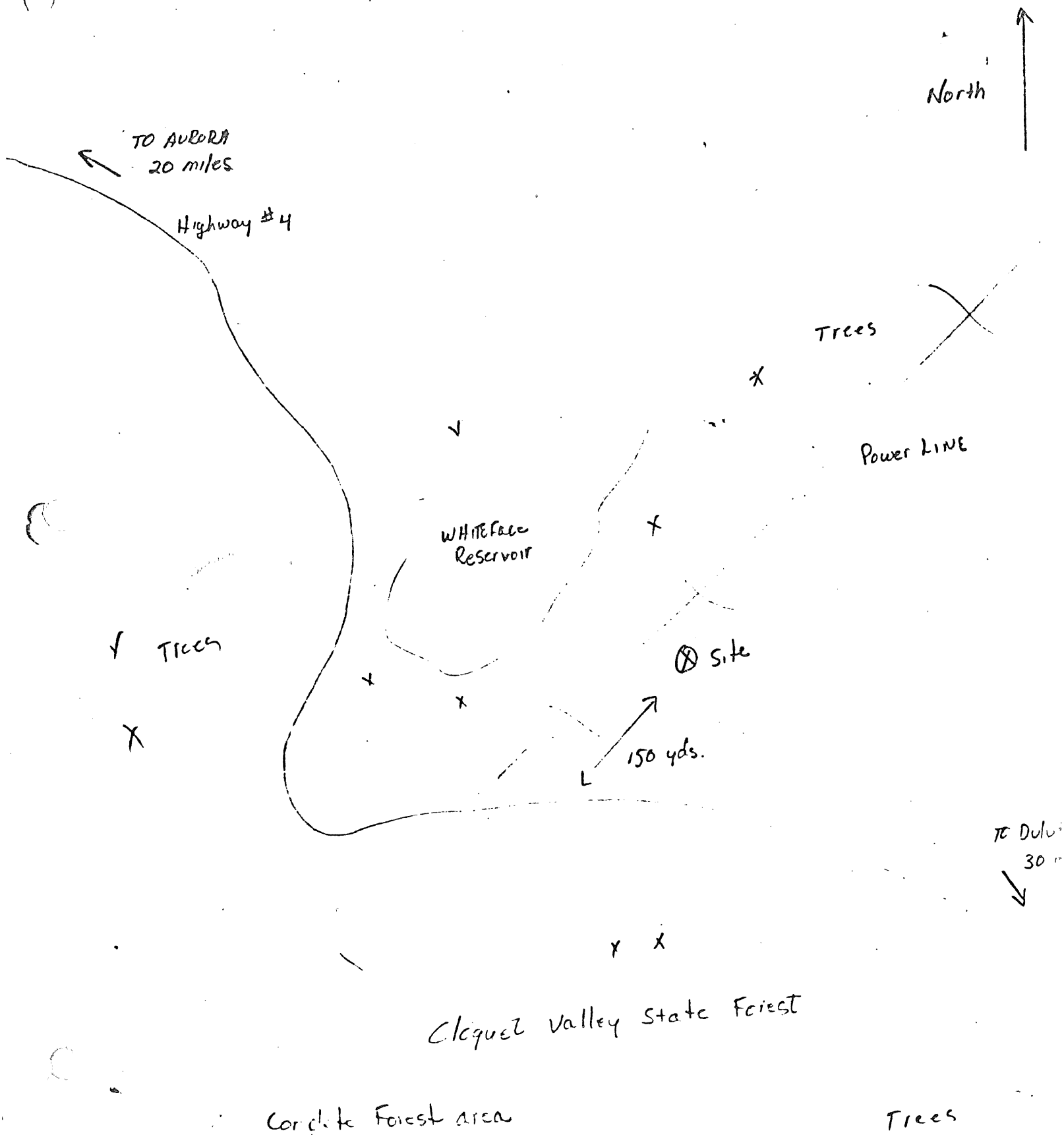
D Kelsey 8-2-78

SITE 7010 HOYT LAKES GOLF COURSE

(TSP, mem, SO₂-NO₂ bubbler, min/max Temp, snow depth, Continuous rain gauge)



SITE 7011 WHITEFACE Reservoir
(mem, SO_2 - NO_2 bubbler, min/max temp, snow depth)



7011 WHITEFACE

To Aurora

Whiteface Reservoir

North

15 ft.



x
x
x
trees

clearing

Power line
right of way

150 yds.

x
x
TREES

Completely Forested

Highway
4

To Duluth
30 miles

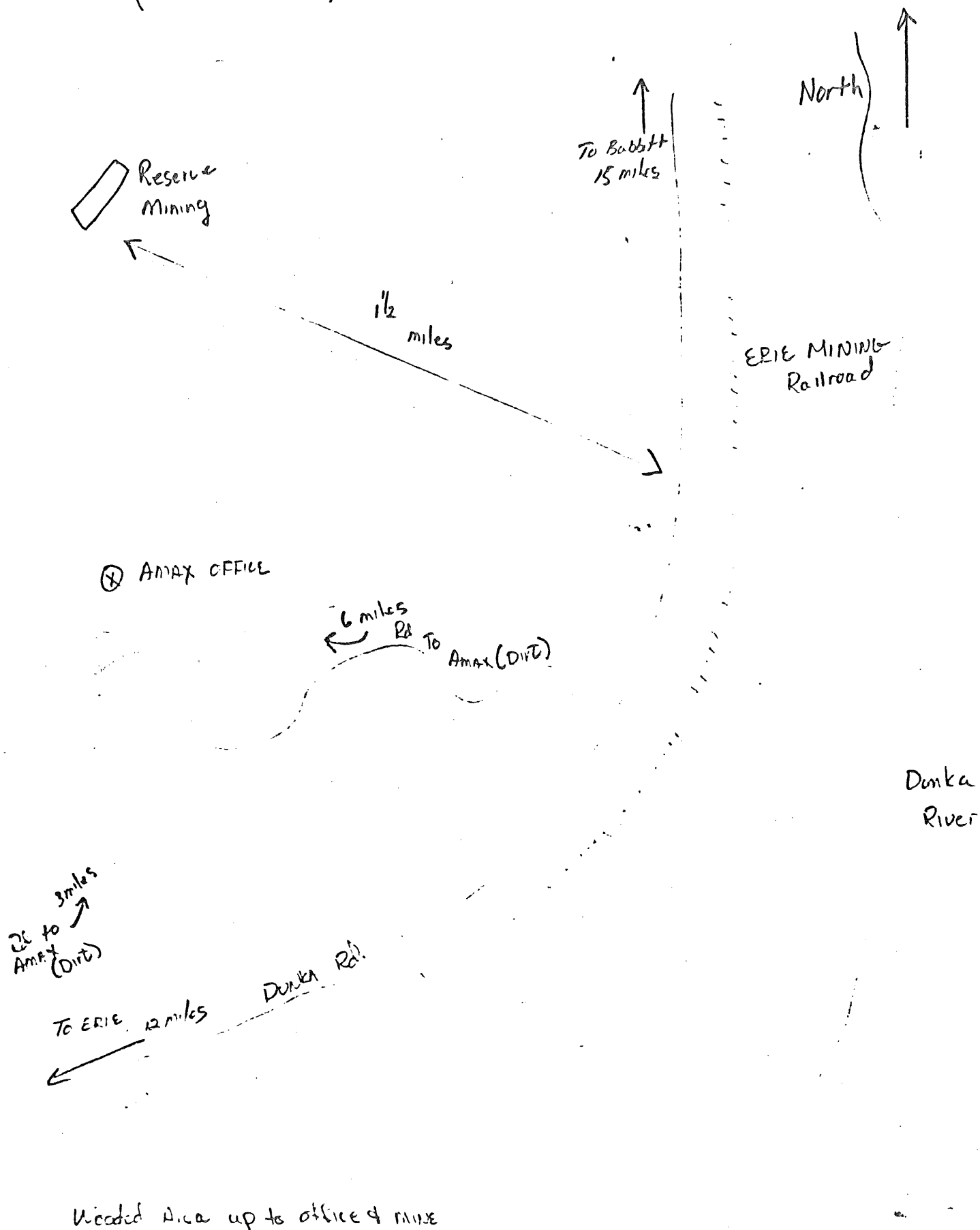
Mer height 8 ft

Butler height 10 ft.

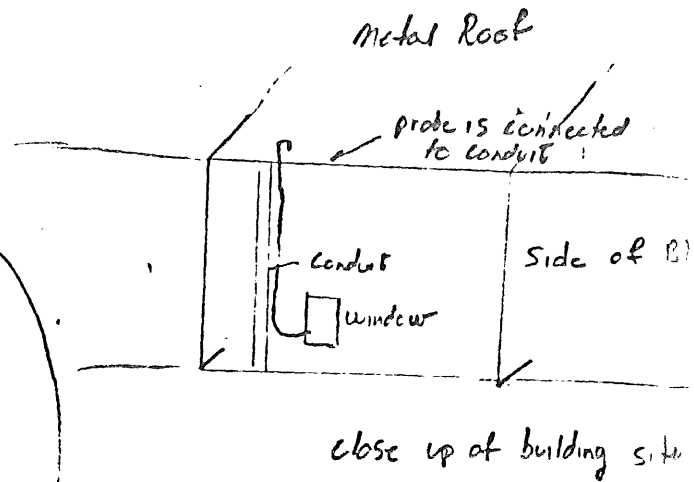
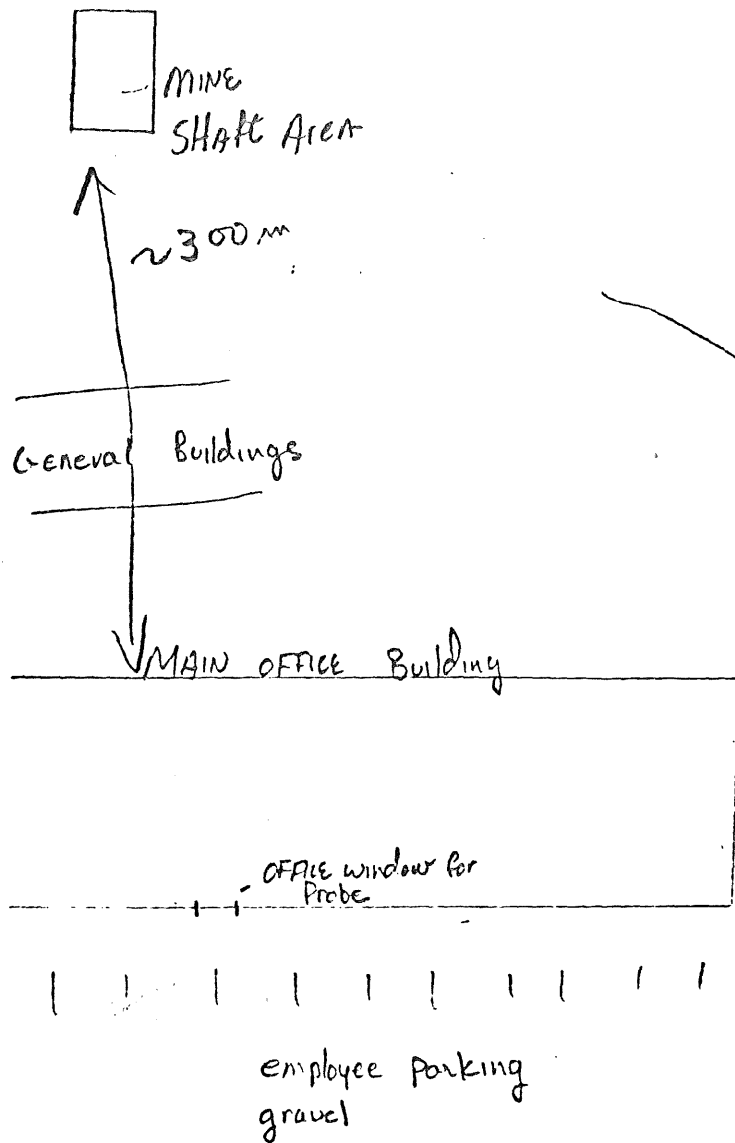
11 ft

D Feb 8 1958

SITE 2012 Minnamay OFFICE
(Continuous SO_2)



7012 Amox



Probe was teflon,
Philips SO_2 monitor

dirt

+ x
+ x
trees

x
x
TREES
x
x
x

Rd to Donka Rd.

SO_2 probe height 12 ft.

D R 50 8-2-78

Parking lot

North

Police Parking
Paved

Police Dept

GAS
Station

Com. Tower

Smoke
stack
fuel oil

60 ft.

40 ft

70 ft

Grass

Grass

Pitch & gravel roof

Paved
Rd.

CITY HALL ROOF

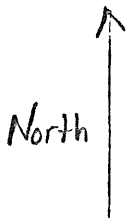
Wide open community site

Paved Rd.

New height 13 ft.

D. Kelsa 8-2-78

SITE 7013 Babbitt
(mem)



↑ TO ELY 15 miles
Highway 21

State Forest

TO Hwy 135 18 miles
← Highway 21

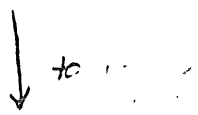
Water tower

site
Gas Station
Gov. Center

TOWN OF Babbitt

Housing

Small trees,
lowland



Firehouse

Firehouse

Minute Complex

7514 MIC. IRON

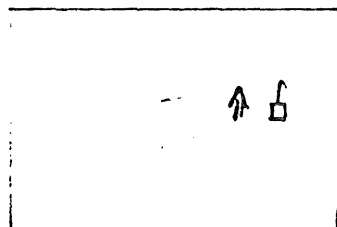
North, ↑



lookout
observation
station



Parking
Paved



U.S. POST OFFICE

General clearing
No obstructions

Paved Rd

US 169

Town of McIntosh Iron

TSP Height - 12 ft

fluoride height 12 ft

D. Kelso 8-3-70

SITE 7514 Mountain Iron Post office
(TSP, Fluoride - run by SLAND)

MINNTAC
PROCESSING
PLANT

North ↑

MINNTAC
OPEN PIT

U.S.
Post office

US 169

→ D Virginia
3 miles

Mainly
Residential

BN

Mountain IRON

Tailings BASIN

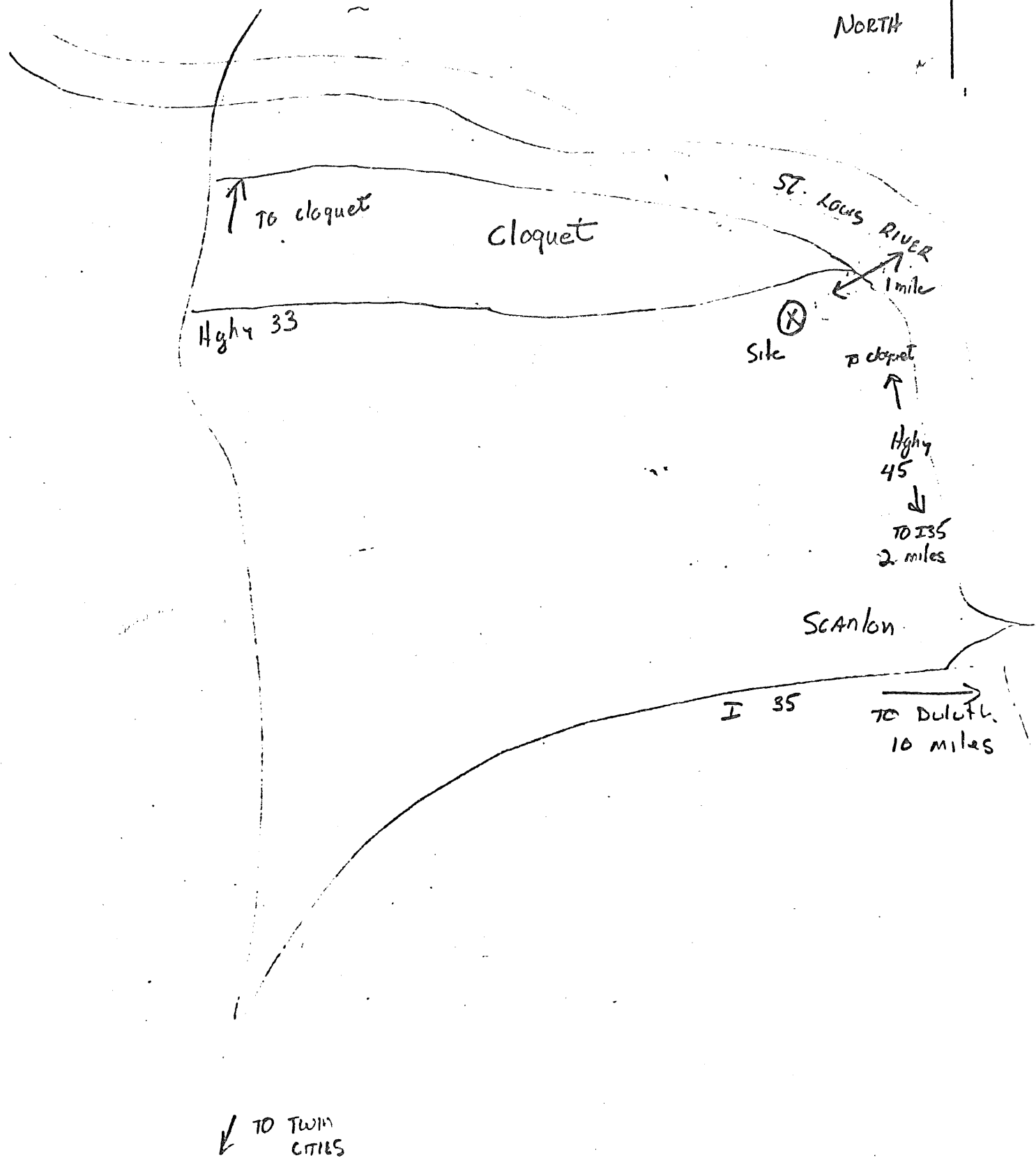
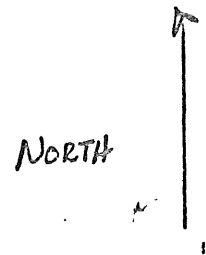
VIRGINIA

DMY-IR

Figure 16

SITE 7112 Scanlon / cloquet

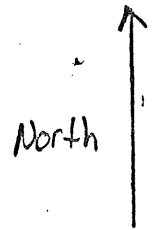
(TSP, mem, SO₂ bubbler -- run by SLCHD)



(over)

Figure 17

7412 cloquet



← to cloquet

Highy 45

Residential
Area

Trees, Bushes

50 yds



Sewage
Pumping
Station

Paved Access
Rd.

Paved Rd.

General clearing around the site

to US
61, I
↓

TSP Hgt 12 ft
Bubble Hgt 10 ft

D Kelso 8.3.78

Trees

North

MAIN Runway

4 blocks

AIR FORCE Bldg
Gravel
50 ft.

flat lowlands

Brush, shrubs

FENCE

GATE

Access Rd

Trees

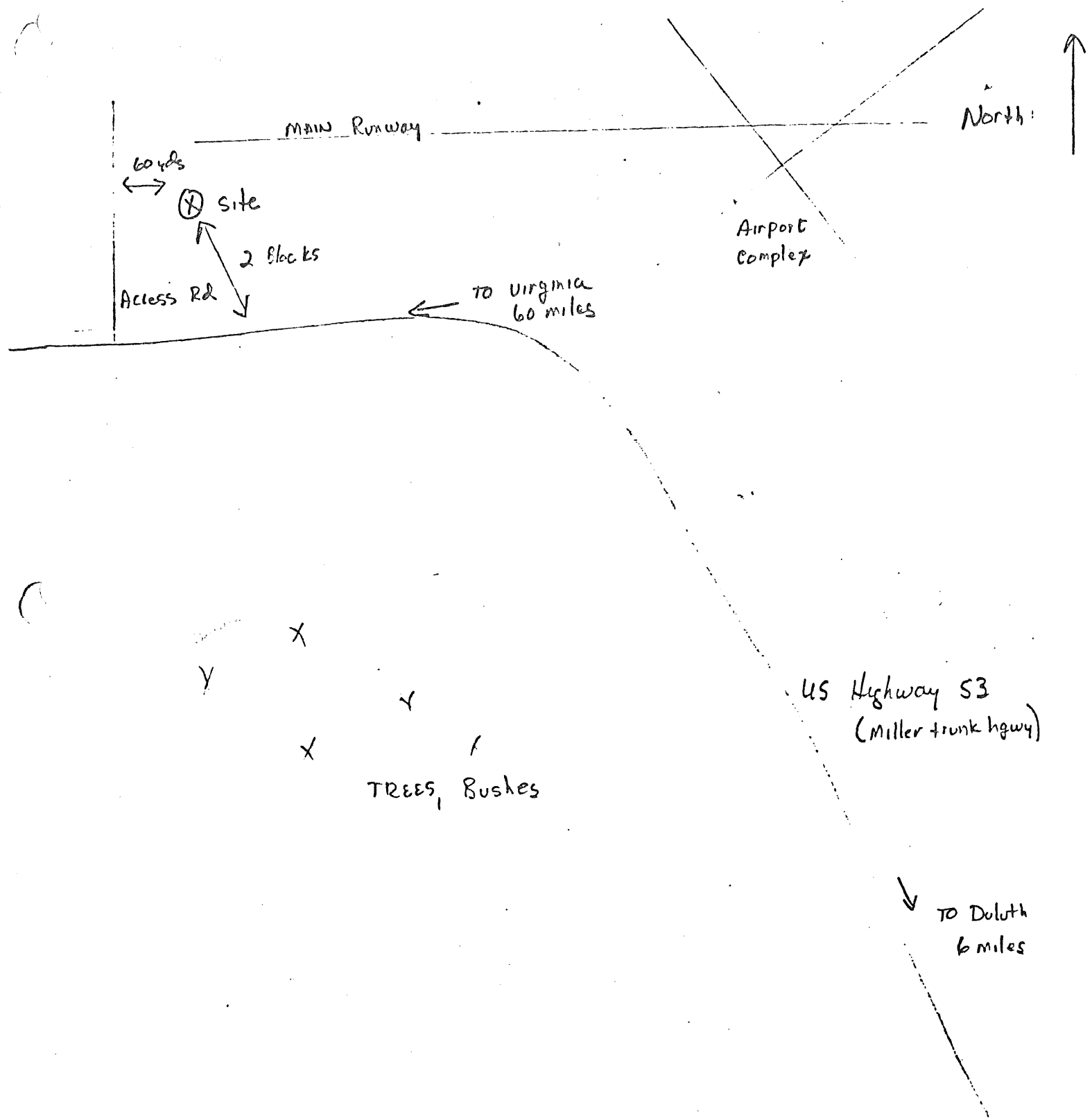
Samplers are on the ground

↓ TO U.S.
53

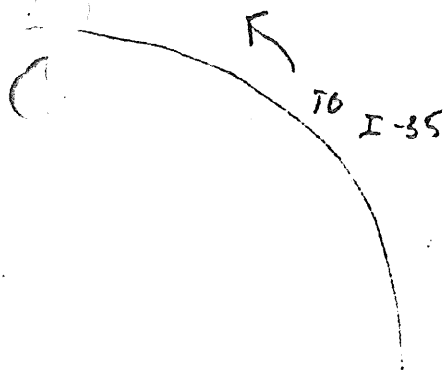
TSP height - 4 ft
cotton height - 4 ft

D. Kelso 8-3-78

SITE 7506 Duluth Airport
(TSP, SO_2 - NO_2 - run by SLCHD)

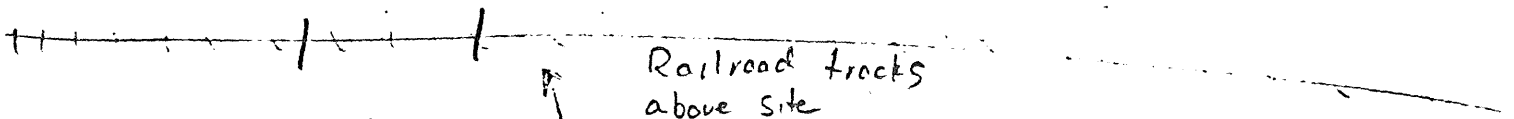


7527- D144



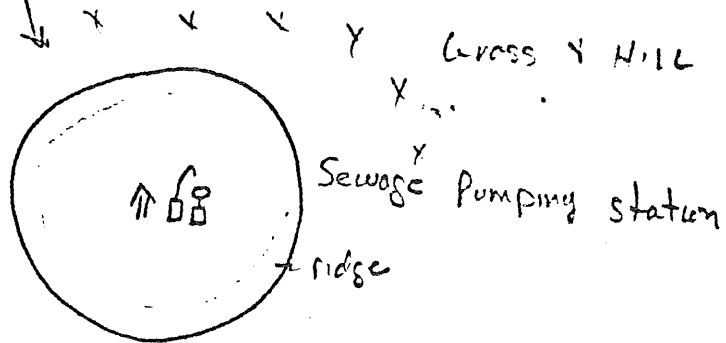
North

Bridge



Railroad tracks
above site

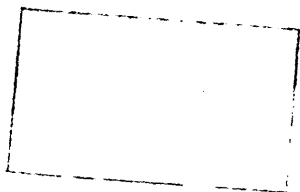
40 ft.



60 ft

Gravel Parking lot

Railroad Area



ELLIOTT AREAS

Railroad ore loading facilities

TOP RIGHT 1941
BOTTOM LEFT 1941

D. L. ...

SITE 7527 ONEOTA ST - Duluth
(TSP, mem, SO_2 - NO_2 - run by SLCHD)

CITY OF Duluth

North

I-35

Superior st.

DM & IR

40th AVE WEST EXIT

Paved

DW + P

Paved Rd

B.N.

St. Louis Bay

⊗ site

ONE LEAF 16 DOCKS

APPENDIX A-2

HIGH-VOLUME SAMPLER OPERATIONAL AND CALIBRATION PROCEDURES

Operation Procedure

Maintainance Procedure

Laboratory Calibration Procedure

Field Calibration Procedure

High-Volume Flow Table

Data Analysis

Laboratory Procedure

Brushless High-Volume Operation

Brushless High-Volume Calibration

OPERATION PROCEDURE 4

Hi-Volume Sampler Operation Procedure
(Pressure Transducer System)

A. General

Hi-volume samplers are operated once per six days from mid-night to midnight. Units operating with pressure transducers (Dickson) may be equipped with Intermatic or Paragon timers which measure time to ± 15 minutes; Gelman Type AE are used for regular sampling; Gelman spectrograde or other filters may be used for special sampling. Dickson transducers should be equipped with chart paper as indicated by the chart # on the transducer; time from the chart may be estimated to the nearest 5 minutes.

B. Equipment

Calibrated Hi-volume sampler equipped with matched pressure transducer and chart paper.

Filter and/or filter cartridge.

Filter envelope.

Mailing envelope (outstate operator).

Timer

Ink

C. Procedure = Removal of exposed filter.

1. Observe the flow chart of the pressure transducer to verify that the sampler has run and that the chart has recorded the flow. If the pen did not ink or if the chart is not readable:

a) Open bottom housing door and turn on the motor using the on-off switch located either to the left of the timer face (Paragon) or below the timer face (Intermatic).

b) Allow the motor to run at least 5 minutes before reading the flow.

- c) Gently tap the recorder case and read the pen position; record the flow (to ± 0.5 cfm) in the "end flow" blank on the proper filter envelope.
 - d) Estimate from the chart the time the sampler ran to the nearest 5 minutes and record in the "end time" blank. This should be 1440 minutes (24 hours).
 - e) Turn off motor.
2. Remove exposed filter.
- a) Loosen the four wing nuts holding the hold down frame in place.
 - b) Remove the hold down frame.
 - c) Carefully remove the exposed filter. Observe the "white band" around the perimeter of the upper surface of the filter. If the border is not distinct, the hold down frame is not tight enough which means the incoming air is leaking through the gasket.
 - d) Fold the filter in half (across the long side) and place it in proper envelope. The number on the filter and on the envelope must match.
 - e) If the hi-vol is equipped with a filter cartridge, replace the cartridge cover and loosen the wing nuts holding the cartridge in place. Take the cartridge to a sheltered location before performing b, c, and d.
 - f) Remove the chart from the flow recorder and insert in the envelope with the printed side facing away from the filter.
 - g) Contact the MPCA office (612-296-7278) if any operational difficulties occur; also, note these under "comments" on the filter folder. Record any significant meteorological information. Return the exposed filters promptly to the MPCA office either in person or in the self-addressed, stamped envelope provided.

D. Procedure: Placement of Clean Filter.

1. If a filter cartridge is not used proceed as follows
 - a) Loosen the four wing nuts holding the filter hold down frame in place. Remove the hold down frame. Check the gasket; if worn, return to the laboratory for replacement.
 - b) Remove clean filter from its envelope and place squarely on the screen of the holder assembly with the rough side of the filter facing up and the smoother side down. Do not tear or puncture the clean filter!
 - c) Replace hold down frame taking care not to move the filter out of alignment. Tighten the wing nuts enough to achieve a tight seal to prevent air leaks.
2. If a filter cartridge is used, the cartridge is fitted with the filter at a sheltered location. The cartridge allows easy installment and removal under adverse conditions. The cartridge unit has three parts: 1) screen plate and gasket
2) hold down plate and 3) cartridge cover.
 - a) Remove the filter from its envelope and place it squarely on the screen plate (the gasket is on the underside of the plate and will be placed on the hi-vol). The rough side of the filter should be face up.
 - b) Place the hold down plate on top of the filter and tighten the two screws located at the sides of the plate. Tighten enough to achieve a tight seal.
 - c) Finally, place the cartridge cover over the assembly to protect the filter. The unit is now ready to be placed on the hi-vol.
 - d) Place the assembled cartridge on the hi-vol unit. It fits directly over the screen attached to the hi-vol funnel.
 - e) Tighten the wing nuts enough to insure a leak proof seal.
 - f) Since the cartridge assembly has two gaskets, there are two chances for leaks. Be sure the seals are tight and the gaskets are in good shape. If there is any doubt

clock face back 24 hours. For example, if the sample was set to run from midnight Wednesday to midnight Thursday and you arrive at 10 A.M. Friday to change the sample, advance the timer to 10 A.M. Friday. This setting means that the timer will activate on the sixth day as required by the sampling schedule. If the new filter is not replaced until the day before the run, the long arrow of the timer would be set to say 10 A.M., of the day before the run or at whatever time the operator is at the site.

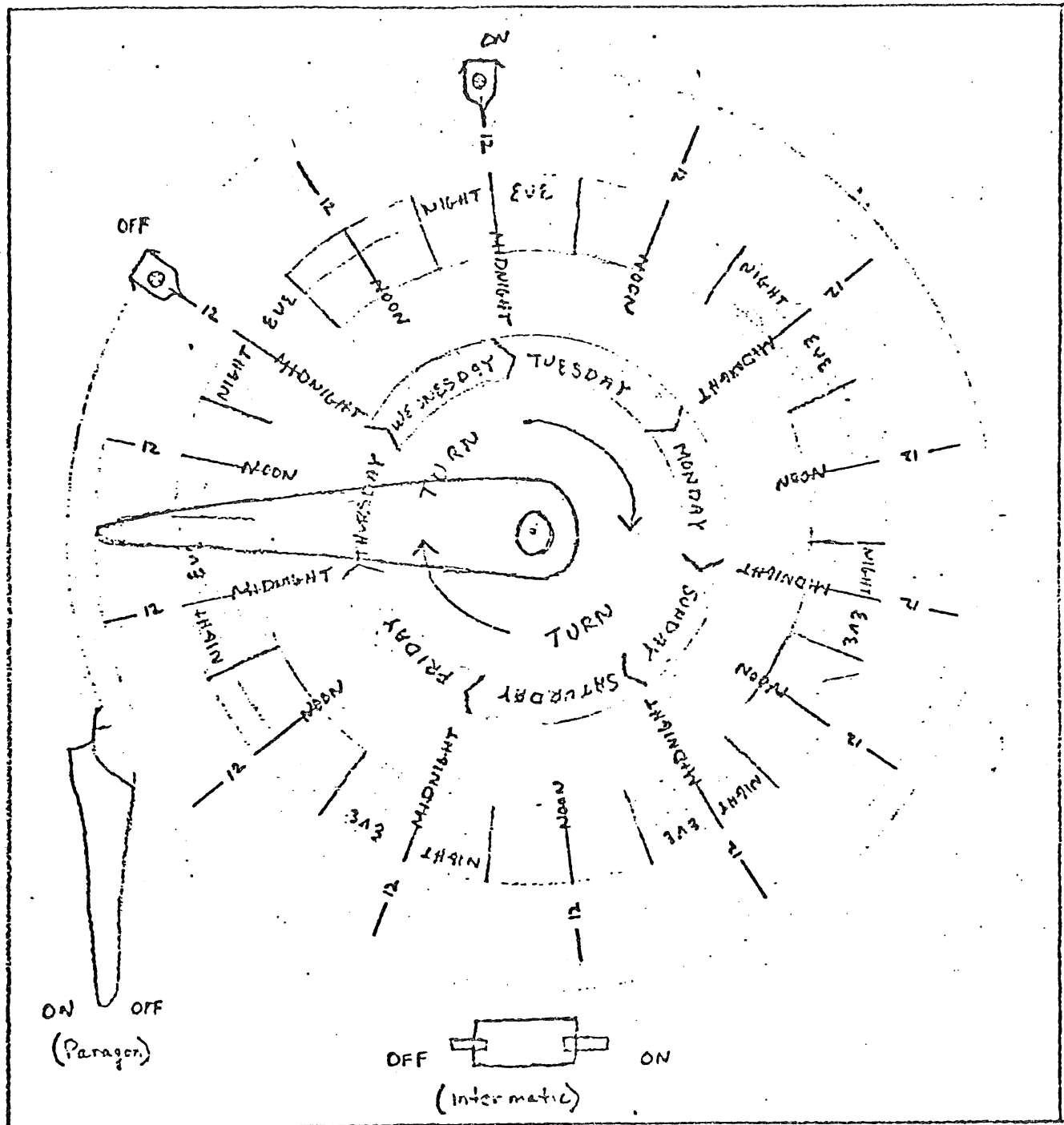
6. Dickson Recorder.

- a) To fill the "V" pen point.
 - i. lift the pen using pen lifter.
 - ii. place scrap of paper under pen point.
 - iii. gently squeeze a drop of ink into the top of the "V" point with the applicator bottle.
 - iv. move the paper against the pen point to start the flow of ink.
- b) To clean the "V" pen point.
 - i. lift the pen arm using the pen lifter.
 - ii. remove the pen point by slipping it downward, off the tab on the end of the pen arm.
 - iii. work the dried ink out of the point with the corner of a stiff piece of paper.
 - iv. if the point is excessively caked with dried ink, it should be soaked in alcohol or hot water.
 - v. dry the point completely before reusing it
- c) To install a chart.
 - i. lift pen using pen lifter.
 - ii. slip chart under raised pen arm and locate chart hole over hub (remove threaded knob if applicable).
 - iii. slip edge of chart under the chart guides and time index clip.
 - iv. push chart flat against dial plate.
 - v. with coin or screw driver, rotate chart hub until midnight of the time scale line on the chart coincides with the index clip; on instruments with

threaded hub, rotate the chart, not the hub, to the correct position and then tighten the knob securly.

- d) To remove a chart.
 - i. lift pen using pen lift.
 - ii. slip edge of chart out from under the chart clips.
 - iii. remove threaded knob (if applicable) and lift chart off hub.

FIGURE 1 TIMERS, PARAGON/INTERMATIC



Paragon Has Switch located on the Side
Intermatic Has Switch located on the Bottom

High-Volume Maintenance Procedure M-3

(motor, filter, holder, timer)

A. General

The high-volume samplers are maintained on a regular schedule; the maintenance interval is 5 months. At this time the motor, filter holders, transducers and visifloats are brought in from the field for maintenance. Timers are replaced when they malfunction. Maintenance for the high-volume motor consists primarily of replacing the brushes; if the armature is excessively worn the motor is replaced.

B. Equipment

Tools

White glue (for gasket replacement)

hi-vol motor

brushes

condensor

timers

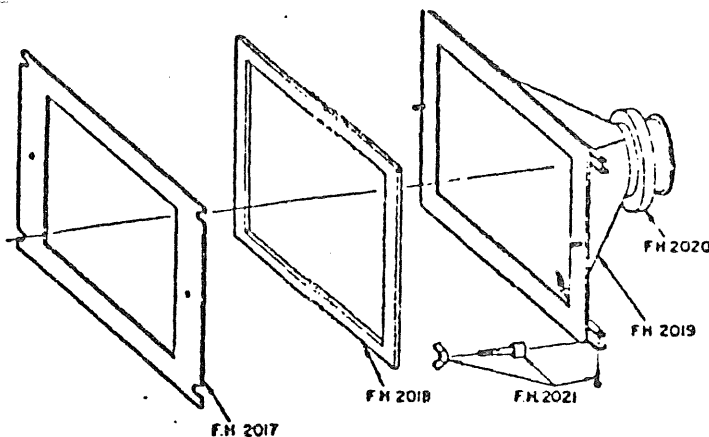
C. Procedure (refer to Figures 1 and 2 for parts)

1. Unscrew the 4 retaining screws from the mounting plate.
2. Remove the mounting plate; check the gasket of the plate and replace as needed.
 - a) To replace gasket; scrape off old gasket
 - b) File surface lightly
 - c) Apply white glue to gasket and cover plate
 - d) Position gasket on plate and allow to set
3. Slip motor out of housing, pulling power cord into housing to give enough clearance to work on the motor.
4. Examine armature. If the armature is badly scored the entire motor should be replaced. Obtain a new motor; check the motor for damage. If the bottom of the casing is bent, replace the bottom casing. Make sure the motor is turning freely and proceed to Step 6.

5. If the armature is not scored, unscrew the furl nuts and separate the power cord wires from the motor wires. At this point replace the brushes.
 - a) To do this simply loosen the clamps holding the brushes in place.
 - b) Remove the brushes and replace with new ones.
 - c) Since different suppliers of brushes are used, carefully check the alignment of brush and armature. The brush should be flush with the armature with no overhanging edges.
 - d) When the brushes are properly aligned, tighten the clamps to hold the brushes in place.
6. Remove the motor cushion and motor mounting ring. Check the cushion for wear and replace as necessary. Replace both cushion and ring before connecting motor to power cord. The cushion rests directly on the motor and the ring fits on top of the cushion.
7. Some motors have brackets for condensers; if the motor has a bracket, replace the old condensor with a new one.
8. Before wiring the motor to the power cord, check the power cord wiring. Replace worn power cords as necessary.
9. To rewire units without a condensor:
 - a) Connect the green ground wire of the power cord to the ground wire of the motor. Be sure to add a ground wire to the motor if it does not have one. DO NOT send ungrounded units to the field!
 - b) Attach the brush wires to the power cord wires. Color coding is not important at this point.
 - c) Use furl nuts to connect the wiring and be sure the connections are tight.
 - d) Tape wiring together as necessary to prevent danger of entanglement in the armature.
10. Replace motor into housing; pull power cord assembly out of the housing making sure it is taut and does not slip back into the housing.
11. Replace the mounting plate and tighten the retaining screws.

12. Timers. Replace timers that do not work properly.
13. Funnels, hold down plates, and cartridges. Check gaskets, franies, and studs for signs of wear. Replace these as needed.
14. Check all wiring and repair as needed.

Figure 1. Hi-vol Motor and Filter Holder Parts



MODEL FH-2100 FILTER HOLDER

| Part No. | Description |
|-----------|------------------------------|
| F.H. 2100 | Filter Holder Complete |
| F.H. 2017 | Aluminum Holddown Frame |
| F.H. 2018 | Rubber Gasket 8" x 10" |
| F.H. 2019 | Holder Assembly |
| F.H. 2020 | |
| F.H. 2021 | |
| F.H. 2021 | Wing Nut and Bolt with Rivet |

MODEL GMWL-2000H AIR SAMPLER REPLACEMENT PARTS

| Part No. | Description | Part No. | Description |
|------------|---------------------------------|----------|-------------------------------------|
| GMWL-2000H | Sampler Unit less filter holder | 2003-H | 1/16" Gasket Neoprene |
| GMW-808 | Calibration Slack Tube | 115250 | 0.6 H.P. Motor with special U-clips |
| | Manometer (Range 0-8") | 33252 | Motor Brushes Two Per Set |
| GMW-105 | Pressure Transducer with 50 | 215276 | Armature with bearings |
| | Charts and Ink | 2005-H | Motor Cushion |
| GMW-106 | Charts for Pressure | 2006-H | Motor Mounting Ring |
| | Transducer (106 C.F.M.) | 2007-H | Motor Housing |
| | Per 100 | 2011-H | Power Cord Assembly |
| GMW-107 | Recorder Ink | 2013-H | Bolt and Nut |
| 2001-H | 1/8" Gasket Neoprene | 2016-H | Tubing and Pressure Tap |
| 2002-H | Mounting Plate Motor Cover | | |

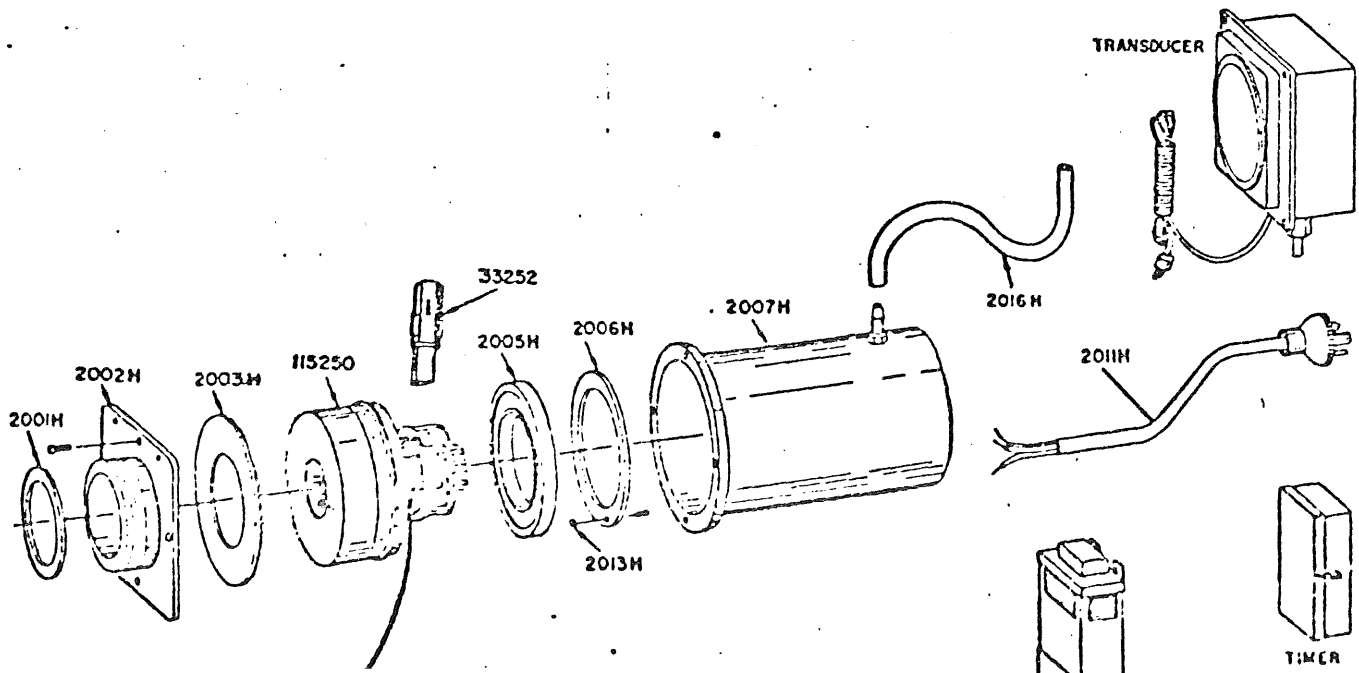
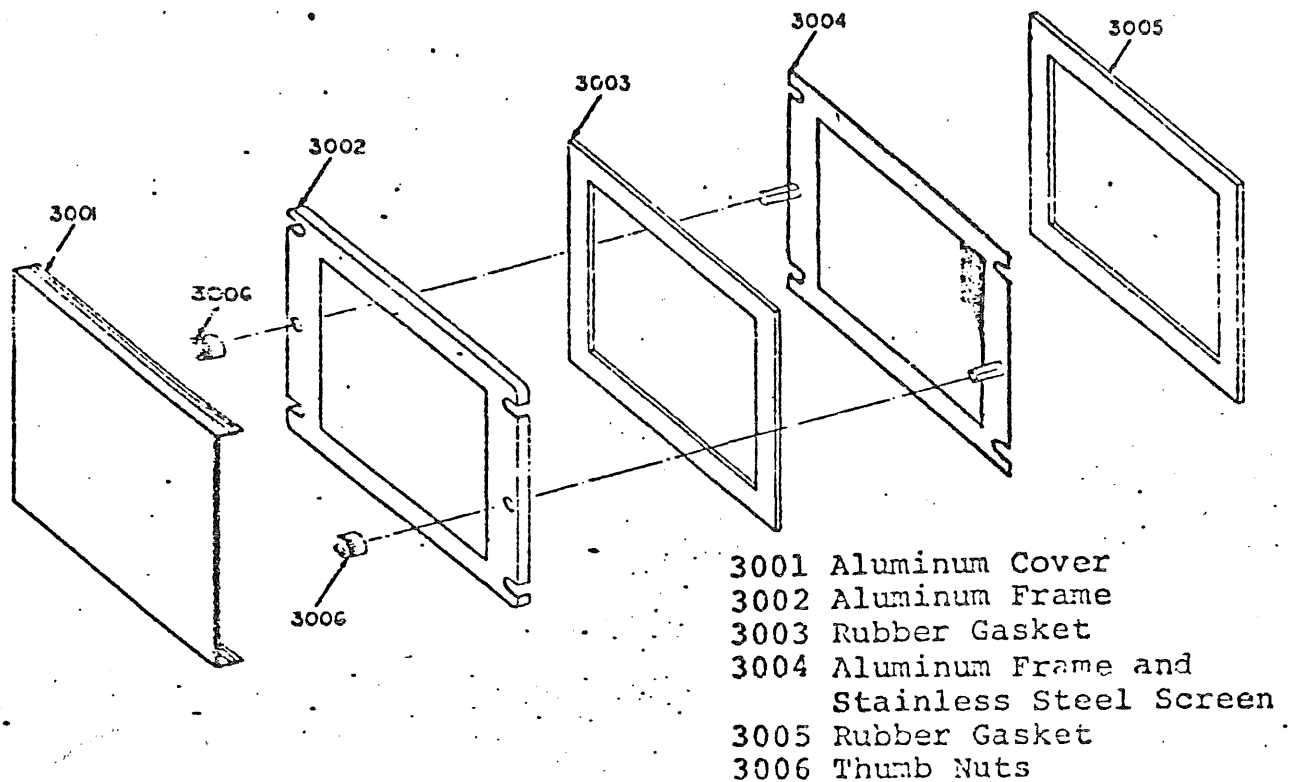


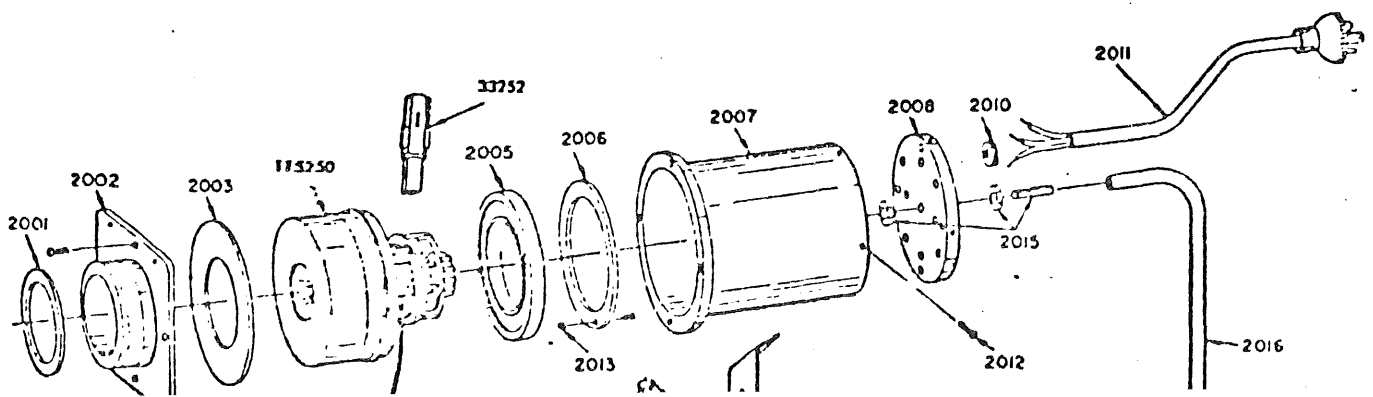
Figure 2. Hi-Vol Motor and Filter Cartridge Parts

**G.M.W. 3000 Filter
Paper Cartridge**



MODEL GMWL-2000 AIR SAMPLER REPLACEMENT PARTS

| Part No. | Description | Part No. | Description |
|----------|---|----------|--------------------------|
| GMWL2000 | Sampler Unit Less Filter Holder | 2007 | Motor Housing |
| 2001 | 1/8" Neoprene Gasket | 2008 | Orifice Plate |
| 2002 | Mounting Plate and Motor Cover | 2009 | Flowmeter No. 440 |
| 2003 | 1/16" Neoprene Gasket . | 2009-A | Flowmeter Mounting Plate |
| 2005 | Motor Cushion | 2010 | Grommet |
| 115250 | 0.6 H.P. Motor with special U-clip connectors | 2011 | Power Cord Assembly |
| 33252 | Motor Brushes | 2012 | Assembly Bolts and Nuts |
| 215276 | Armature With Bearings | 2013 | Bolt and Nut |
| 2006 | Motor Mounting Ring | 2015 | Pressure Tap Assembly |
| | | 2016 | Tubing |



CALIBRATION PROCEDURE 2

Hi-Volume Sampler Calibration Procedure

A. General

The air flow indicator (transducer or visifloat) of the hi-volume sampler system, must be calibrated against a system producing a known flow -- a calibrated orifice and water manometer. By measuring actual flow with a water manometer and calibrated orifice and simultaneously observing the value on the flow indicator, a curve for a given motor and indicator can be derived by plotting actual flow vs indicated flow.

B. Equipment

Calibration orifice with adaptor plate and five resistance plates. This system should have been calibrated on a Roots meter (Calibration Procedure 1).

- Sampler housing or stand

- Calibration curve for the orifice (Form GC-1)

- Hi-Vol motor, funnel, and flow indicator (transducer or visifloat)

- Variable transformer (Variac)

- Thermometer (°C)

- Water manometer (mmHg)

- Hi-Vol Sampler Calibration Data Sheet, Form C-2

- Hi-Vol Sampler Air Flow Calibration Curve, Graph CG-2

- RIC card

- Soap, Brush

C. Procedure

1. Set up equipment. Place repaired hi-vol motor in calibration stand or housing so that it is in an upright position. Clean dust from head plate of motor housing, with soapy water and a brush. Avoid getting water in the motor. Wipe with a damp rag, then a dry one. Attach funnel shaped filter holder to the motor with a gasket between motor and holder. Secure tightly with over-sized wrench. Attach orifice adaptor plate to the funnel, tightening the wing nuts securely. Attach the orifice canister

to the adaptor plate, inserting resistance plate #13 between the canister and adaptor plate. A gasket should be in contact with each side of the resistance plate. Secure tightly. Turn on variac, first setting it at 50V. Allow motor to run for 30 minutes to set brushes. (See Figure 1. Apparatus for seating Motor Brushes).

2. Clean flow measuring device while brushes are seating.

a. If the measuring device is a visifloat, disassemble it carefully being careful not to lose the red float in the bore. Wipe parts clean with a damp cloth and run a dry pipe cleaner through the bore. Reassemble the visifloat and check to see if the float moves freely in the bore by holding the visifloat horizontally and lifting each end alternately. If the float hangs up at any point, re-examine the bore. The visifloat should be discarded if it does not move freely in the bore.

b. If a transducer continuous recording indicator is used, it should be wiped with a damp cloth and checked for damage. The penholder should not be moveable in and out of the housing and should resist much lateral movement (less than 1 inch) if the hex nuts inside the case are tight.

c. Examine the hoses leading from the indicator to the motor. These should not be badly checked from exposure or have tears in them. Look for obstructions in the hose that might interfere with air flow to the indicator. Replace hoses as necessary.

3. Reset the voltage on the variac to 105V (field operating voltage) and run continuously for 5-10 minutes so the motor warms-up.

4. Zero the water manometer by sliding the manometer up or down; the water level changes as this is done and both sides of the manometer should read zero. After the manometer has been zeroed, attach the water manometer to the orifice port and the flow indicator to the motor exhaust port. The motor should remain on during this procedure. (see Figure 2 and Figure 3) The hi-vol motor/transducer units have exhaust ports on the side of the motor while the hi-vol motor/visifloat units have exhaust ports located

on the bottom of the motor.

5. Observe and record ambient barometric pressure and temperature.

6. Read inches of water to the nearest 0.05 inches on each side of the manometer (read the bottom of the meniscus) and add these values. Resistance plate #13 is in position and the voltage is 105 volts. Record this number in the manometer reading column in the Hi-Vol Calibration Data Sheet, Form C-2.

7. Refer to the appropriate orifice calibration curve to determine actual flow for the inches of water measured in step #6 and set the transducer or visifloat to match this actual flow to the nearest 0.5 CFM.

a. To adjust the visifloat, loosen lock nut at top of visifloat with small adjustable wrench. Then set flow with adjustment nut. Tighten lock nut tight enough to secure but not so tight as to distort plastic and threads.

b. The transducer is adjusted by simply turning the zero adjust screws on the lower right corner of the front panel. Before reading a transducer always give it a slight tap to compensate for any drag on pen caused by paper friction.

c. THIS IS THE ONLY POINT TO BE PRE-SET. Record the actual and indicated flow under the air flowrate and visifloat or transducer reading columns respectively on data sheet.

8. Turn off power and position resistance plate #7 at the bottom of the canister, with gaskets on either side, securing tightly. Turn on power with voltage still at 105V. Read the manometer, adding measured inches of water from both columns. Record this value next to plate #7 under Manometer Reading on the Calibration Data Sheet. Observe flow rate on visifloat or transducer. Read to nearest 0.5 CFM. Record on data sheet under visifloat or transducer reading. Repeat this procedure for plates #18, 5, and 10 in that order.

9. Remove orifice and adaptor plate, unplug motor.

10. Attach RIC card to motor housing, recording motor number on all three sections. Record date on "C" portion of card. Remove "C" portion and turn in to data analysis section later with data

sheet. Also attach sticker label to motor housing and transducer which indicates date of calibration and technician's initials. On the motor label record transducer number. On the transducer label record the motor number. A label does not need to be attached to the visifloat due to lack of space; however be sure that visifloat number is recorded on the motor sticker label.

11. Complete data sheet by recording actual flow values obtained from appropriate orifice curve for each resistance plate; the voltage during calibration, the date; motor # number; indicator number; and the orifice I.D..

12. Develop a calibration curve for the motor by plotting the actual flow against the indicated flow on the Hi-Vol Calibration Graph CG-2. Complete other blank items on the graph.

13. Submit graph, data sheet, and "C" portion of RIC card to data processing personnel. They will store data taken from the data sheet and keep the "C" portion of the RIC card.

14. Upon return of graph and data sheet to lab personnel this curve will be placed in numerical order by motor number.

FIGURE 2: APPARATUS FOR SEATING MOTOR
BRUSHES

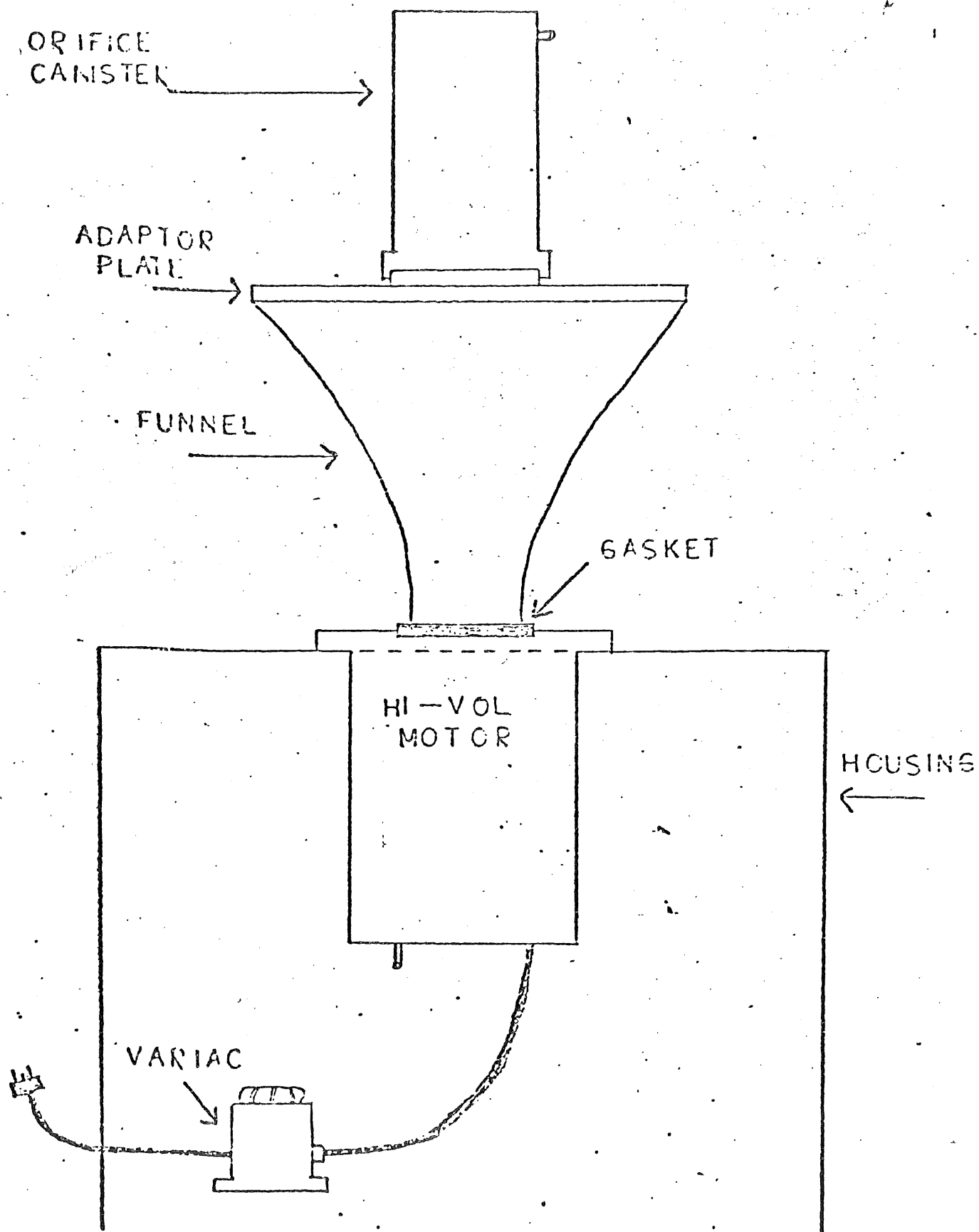


FIGURE 2: MOTOR / TRANSDUCER UNIT

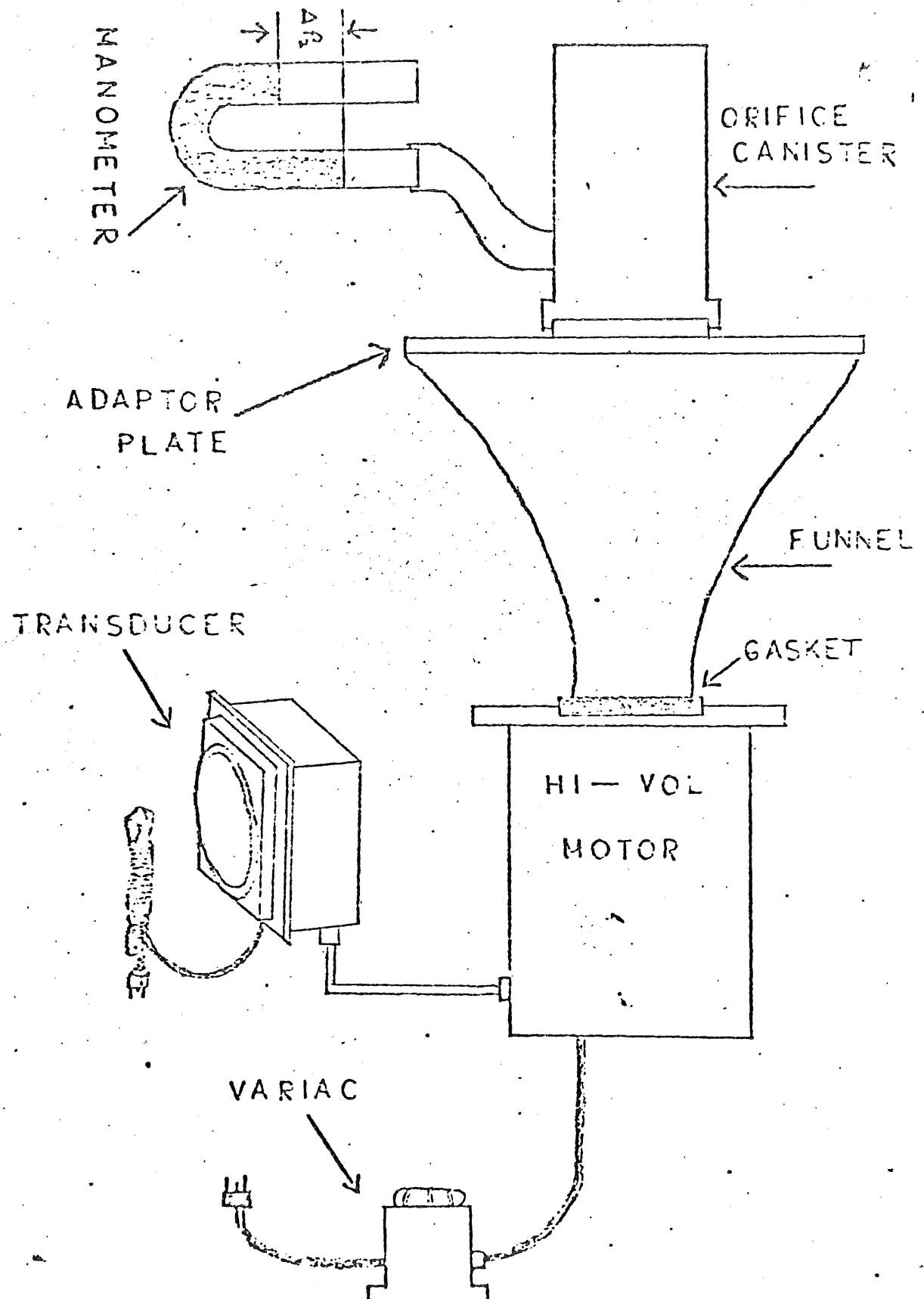


FIGURE 3: MOTOR/VISIFLOAT UNIT

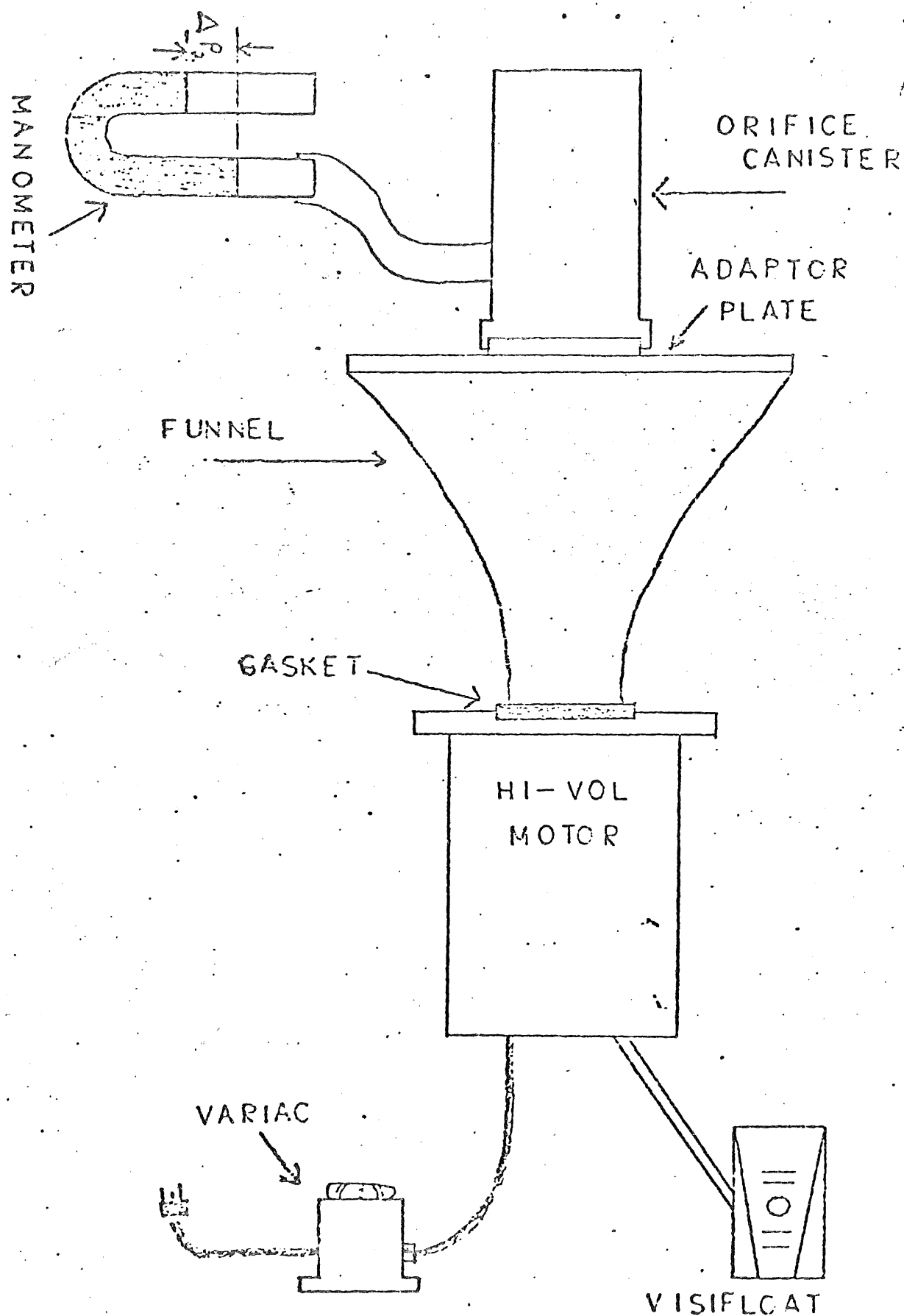
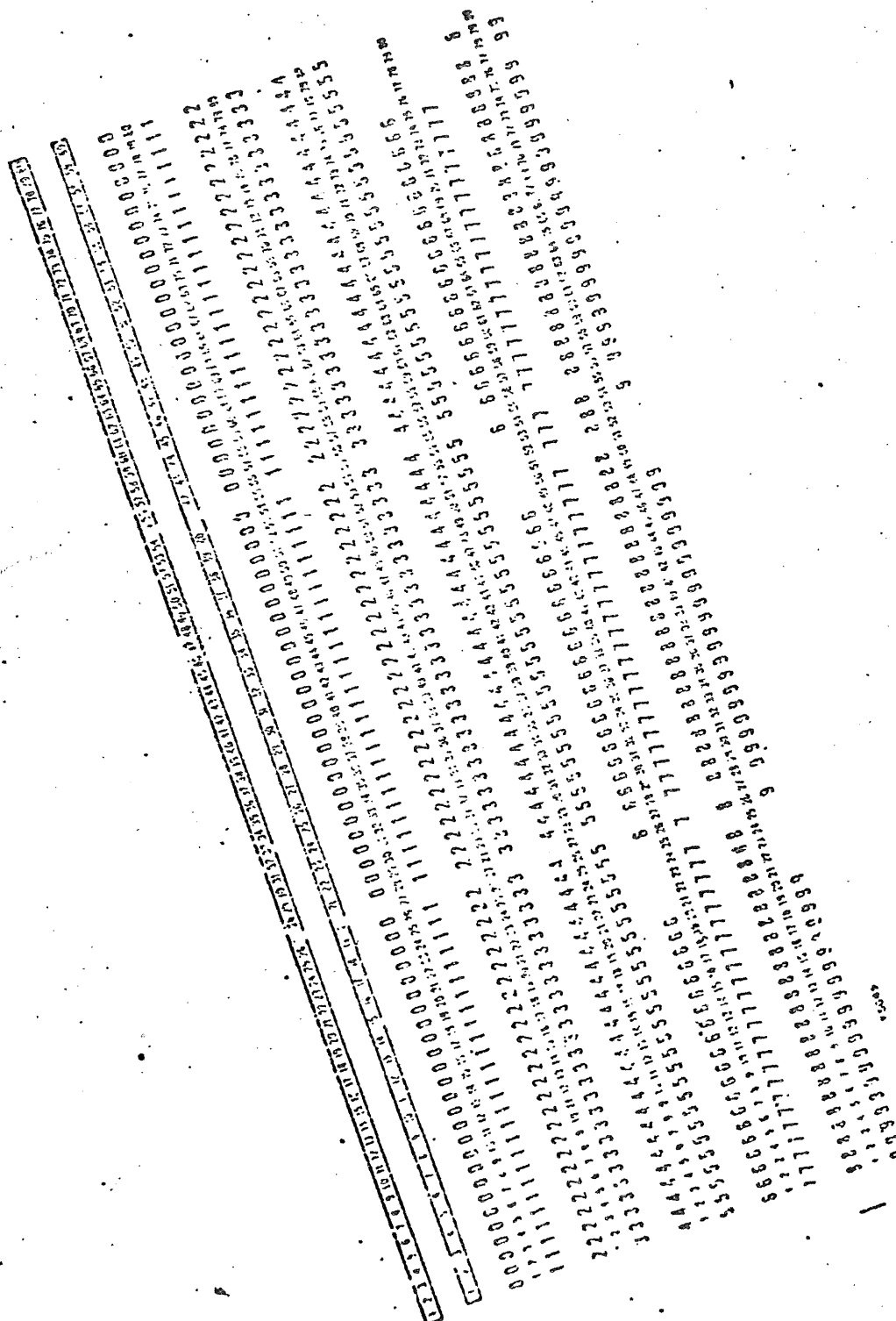


Figure 4. RIC Card



Minnesota Pollution Control Agency

Revised 10/28/80
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Data sheet, visifloat or transducer hi-vol calibration

Orifice # _____

Technician _____

Motor number (housing _____

Date _____

Visifloat or
transducer number* _____

Room temp. _____

Calibrating voltage _____

Room bar press _____

| Resistance Plates No. | Manometer Reading Inches of Water P ₂ | Visifloat or Transducer Reading | Air Flowrate Q ₂ CFM |
|-----------------------------|---|---------------------------------------|---------------------------------------|
| 5 | | | |
| ** (intermediate) | | | |
| 7 | | | |
| 10 | | | |
| 13 | | | |
| 18 | | | |

* Circle appropriate device

HI VOL AIR FLOW CALIBRATION CURVE

Date

Motor Type & #

Visifloat or transducer #

Room Temp. °C

Orifice #

Room B.P. mmHg

Calibrating Voltage

Technician

Actual M

70

60

50

40

30

20

10

CALIBRATION PROCEDURE 9.

Hi-Volume Field Sampler Calibration Procedure

A. General

The air flow indicator (transducer or visifloat) of the hi-volume sampler system must be calibrated against a system producing a known flow -- a calibrated orifice and water manometer. By measuring actual flow with a water manometer and calibrated orifice and simultaneously observing the value on the flow indicator, a curve for a given motor and indicator can be derived by plotting actual flow vs indicated flow. The field sampler calibration procedure differs slightly from Calibration Procedure 2 which is performed in the laboratory. Refer to Calibration Procedure 2 for equipment setup, data sheets and graphs.

B. Equipment

Hi-Vol unit

Field calibration kit:

calibration orifice

adaptor plate

resistance plates

field manometer

thermometer

barometer

Calibration Procedure 2

Calibration curve for the orifice, Form GC-1

Hi-Vol sampler calibration data sheet, Form C-2

Hi-Vol sampler air flow calibration curve, graph CG-2

RIC card

C. Procedure

1. Attach orifice adaptor plate to the funnel of the hi-vol, tightening the wing nuts securely and attach the orifice canister to the adaptor plate, inserting resistance plate #13 between the canister and adaptor plate. A gasket should be in contact with each side of the resistance plate. Secure tightly. Allow motor to run for 30 minutes to set brushes. If the brushes have been set in the laboratory this step may be omitted.

2. Clean flow measuring device while brushes are seating.

a. If the measuring device is a visifloat, disassemble it carefully being careful not to lose the red float in the bore. Wipe parts clean with a damp cloth and run a dry pipe cleaner through the bore. Reassemble the visifloat and check to see if the float moves freely in the bore by holding the visifloat horizontally and lifting each end alternately. If the float hangs up at any point, re-examine the bore. The visifloat should be discarded if it does not move freely in the bore.

b. If a transducer continuous recording indicator is used, it should be wiped with a damp cloth and checked for damage. The penholder should not be moveable in and out of the housing and should resist much lateral movement (less than 1 inch) if the hex nuts inside the case are tight.

c. Examine the hoses leading from the indicator to the motor. These should not be badly checked from exposure or have tears in them. Look for obstructions in the hose that might interfere with air flow to the indicator. Replace hoses as necessary.

3. Zero the water manometer by sliding the manometer up or down; the water level changes as this is done and both sides of the manometer should read zero. After the manometer has been zeroed, attach the water manometer to the orifice port and the flow indicator to the motor exhaust port. The motor should remain on during this procedure. The hi-vol motor/transducer units have exhaust ports on the side of the motor while the hi-vol motor/visifloat units have exhaust ports located on the bottom of the motor.

4. Observe and record ambient barometric pressure and temperature.

5. Read inches of water to the nearest 0.05 inches on each side of the manometer (read the bottom of the meniscus) and add these values. Resistance plate #13 is in position and the voltage is 105 volts or field voltage. Record this number in the manometer reading column in the Hi-Vol Calibration Data Sheet, Form C-2.

6. Refer to the appropriate orifice calibration curve to determine actual flow for the inches of water measured in step #6 and set the transducer or visifloat to match this actual flow to the nearest 0.5 CFM.

a. To adjust the visifloat, loosen lock nut at top of visifloat with small adjustable wrench. Then set flow with adjustment nut. Tighten lock nut tight enough to secure but not so tight as to distort plastic and threads.

b. The transducer is adjusted by simply turning the zero adjust screws on the lower right corner of the front panel. Before reading a transducer always give it a slight tap to compensate for any drag on pen caused by paper friction.

c. THIS IS THE ONLY POINT TO BE PRE-SET. Record the actual and indicated flow under the air flowrate and visifloat or transducer reading columns respectively on data sheet.

7. Turn off power and position resistance plate #7 at the bottom of the canister, with gaskets on either side, securing tightly. Turn on power with voltage still at 105V. Read the manometer, adding measured inches of water from both columns. Record this value next to plate #7 under Manometer Reading on the Calibration Data Sheet. Observe flow rate on visifloat or transducer. Read to nearest 0.5 CFM. Record on data sheet under visifloat or transducer reading. Repeat this procedure for plates #18, 5, and 10 in that order.

8. Remove orifice and adaptor plate, unplug motor.

9. Attach RIC card to motor housing, recording motor number on all three sections. Record date on "C" portion of card. Remove "C" portion and turn in to data analysis section later with data sheet. Also attach sticker label to motor housing and transducer which indicates date of calibration and technician's initials. On the motor label record transducer number. On the transducer label record the motor number. A label does not need to be attached to the visifloat due to lack of space; however be sure that visifloat number is recorded on the motor sticker label.

10. Complete data sheet by recording actual flow values obtained from appropriate orifice curve for each resistance plate; the voltage during calibration, the date; motor # number; indicator number; and the orifice I.D.

11. Develop a calibration curve for the motor by plotting the actual flow against the indicated flow on the Hi-Vol Calibration Graph CG-2. Complete other blank items on the graph.

12. Submit graph, data sheet, and "C" portion of RIC card to Data Analysis. For procedures on RIC cards see General Procedure I.4 of the Quality Assurance manual.

13. Local agencies should retain the motor curve for future reference; one copy should be submitted to the Calibration laboratory at MPCA.

DATA ANALYSIS PROCEDURE I
Hi-Vol Flow Table (DA #6) Procedure

A. General

When the air flow indicator for a hi-vol sampler is calibrated against a source of known flow, a curve showing actual flow versus indicated flow is obtained. It is necessary to adjust any subsequent measurements taken with the flow indicator using the curve obtained via calibration of the indicator. In order to facilitate adjusting indicated flow readings to actual flow units, a table giving indicated flow (in 1/2 cfm intervals) versus corresponding actual flow for the flow indicator motor pair is made.

B. Equipment.

PDP 8-E computer

Teletype

Line Printer

Hi-vol sampler Calibration Sheet, Form C-2 (Calibration Procedure Form DA-6

Form DA-8

RIC Card

C. Procedure

1. Completed Hi-vol Sampler Calibration Sheet (Form C-2) is submitted to Data Analysis personnel by calibration personnel.

2. Hi-vol flow curve program is executed on the PDP 8-E. Data from Form C-2 are entered into the computer via the teletype. Data include: a) date of calibration, b) motor I.D. number, c) calibration temperature and pressure, d) indicated flow, actual flow of the calibration points. After all calibration points have been entered a -9999 is entered to end data input. The computer fits line segments between calibration points, extending the segments at both ends, and prints on the line printer a table of indicated flows (from 0.5 cfm to 100 cfm by 0.5 cfm) and their corresponding actual flows by interpolating the appropriate line segment. Flow tables are designated by Form DA#6 and an example is shown. Form DA#36 lists temperature and pressure of calibration, site number, motor I.D.#,

calibration points and provides space for date installed, removed and calibrated. The date installed, removed and calibrated is obtained from the RIC card (Figure 2) as each portion of the card is given to Data Analysis. The "C" portion of the RIC card is given to Data Analysis along with the Form C-2 and this is the calibration date entered.

3. Flow tables are removed from the computer and filed. If the motor indicator pair is not currently in use, the flow table is filed by motor I.D.# in the "future" hi-vol calibration books. When the motor indicator pair is installed in the field the operator will give Data Analysis the "I" portion of the RIC card. At this time the site where the motor is installed and the date installed are recorded on DA-6. Next, the motor I.D.#, Indicator I.D.#, and date installed are recorded on Form DA-8 which is the Site Hi-Vol History. Then Form DA-6 is filed in the "current" hi-vol calibration book by site. As a hi-vol motor is removed from the field, the "R" portion of the RIC card is given to Data Analysis by the operator. The date removed is recorded on Forms DA-6 and DA-8 for the appropriate motor number. When DA-6 is completed with dates calibrated, installed and removed the form is filed in the "historic" hi-vol calibration book by motor number.

4. When a filter is received from a site, the average of the recorded starting and ending flow is used as the indicated flow. The flow table for the motor indicator pair at the site for the period which includes the sample run date is found either in the current or in the historic hi-vol calibration book. On this table opposite the indicated flow, the actual flow is read and recorded.

5. Temperature pressure corrections are not incorporated into the calculations in the flow table but they are recorded.

PRESSURE 1 729.1
TEMP. 1 24.3

INSTALLED 1
REMOVED 1
CALIBRATED 1 1/23/76

SITE #1
NO. 108 ID #1 5806

| | | | | | | | | | | | | | | | |
|------|---|------|---|------|---|------|---|------|---|------|---|-------|---|-------|---|
| 0.5 | = | -5.3 | 1 | 25.5 | = | 23.3 | 1 | 52.5 | = | 53.6 | 1 | 75.5 | = | 92.3 | 1 |
| 1.0 | = | -4.7 | 1 | 26.0 | = | 23.9 | 1 | 51.0 | = | 54.3 | 1 | 76.0 | = | 93.1 | 1 |
| 1.5 | = | -4.1 | 1 | 26.5 | = | 24.4 | 1 | 51.5 | = | 55.1 | 1 | 76.5 | = | 93.9 | 1 |
| 2.0 | = | -3.6 | 1 | 27.0 | = | 25.0 | 1 | 52.0 | = | 55.9 | 1 | 77.0 | = | 94.6 | 1 |
| 2.5 | = | -3.0 | 1 | 27.5 | = | 25.6 | 1 | 52.5 | = | 56.7 | 1 | 77.5 | = | 95.4 | 1 |
| 3.0 | = | -2.4 | 1 | 28.0 | = | 26.1 | 1 | 53.0 | = | 57.4 | 1 | 78.0 | = | 96.2 | 1 |
| 3.5 | = | -1.9 | 1 | 28.5 | = | 26.7 | 1 | 53.5 | = | 58.2 | 1 | 78.5 | = | 97.0 | 1 |
| 4.0 | = | -1.3 | 1 | 29.0 | = | 27.3 | 1 | 54.0 | = | 59.0 | 1 | 79.0 | = | 97.7 | 1 |
| 4.5 | = | -0.7 | 1 | 29.5 | = | 27.9 | 1 | 54.5 | = | 59.8 | 1 | 79.5 | = | 98.5 | 1 |
| 5.0 | = | -0.1 | 1 | 30.0 | = | 28.4 | 1 | 55.0 | = | 60.5 | 1 | 80.0 | = | 99.3 | 1 |
| 5.5 | = | 0.4 | 1 | 30.5 | = | 29.0 | 1 | 55.5 | = | 61.3 | 1 | 80.5 | = | 100.1 | 1 |
| 6.0 | = | 1.0 | 1 | 31.0 | = | 29.6 | 1 | 56.0 | = | 62.1 | 1 | 81.0 | = | 100.8 | 1 |
| 6.5 | = | 1.6 | 1 | 31.5 | = | 30.1 | 1 | 56.5 | = | 62.9 | 1 | 81.5 | = | 101.6 | 1 |
| 7.0 | = | 2.1 | 1 | 32.0 | = | 30.7 | 1 | 57.0 | = | 63.6 | 1 | 82.0 | = | 102.4 | 1 |
| 7.5 | = | 2.7 | 1 | 32.5 | = | 31.3 | 1 | 57.5 | = | 64.4 | 1 | 82.5 | = | 103.2 | 1 |
| 8.0 | = | 3.3 | 1 | 33.0 | = | 31.9 | 1 | 58.0 | = | 65.2 | 1 | 83.0 | = | 103.9 | 1 |
| 8.5 | = | 3.9 | 1 | 33.5 | = | 32.4 | 1 | 58.5 | = | 66.0 | 1 | 83.5 | = | 104.7 | 1 |
| 9.0 | = | 4.4 | 1 | 34.0 | = | 33.0 | 1 | 59.0 | = | 66.7 | 1 | 84.0 | = | 105.5 | 1 |
| 9.5 | = | 5.0 | 1 | 34.5 | = | 33.6 | 1 | 59.5 | = | 67.5 | 1 | 84.5 | = | 106.3 | 1 |
| 10.0 | = | 5.6 | 1 | 35.0 | = | 34.2 | 1 | 60.0 | = | 68.3 | 1 | 85.0 | = | 107.0 | 1 |
| 10.5 | = | 6.1 | 1 | 35.5 | = | 34.8 | 1 | 60.5 | = | 69.1 | 1 | 85.5 | = | 107.8 | 1 |
| 11.0 | = | 6.7 | 1 | 36.0 | = | 35.4 | 1 | 61.0 | = | 69.8 | 1 | 86.0 | = | 108.6 | 1 |
| 11.5 | = | 7.3 | 1 | 36.5 | = | 36.0 | 1 | 61.5 | = | 70.6 | 1 | 86.5 | = | 109.4 | 1 |
| 12.0 | = | 7.9 | 1 | 37.0 | = | 36.6 | 1 | 62.0 | = | 71.4 | 1 | 87.0 | = | 110.1 | 1 |
| 12.5 | = | 8.4 | 1 | 37.5 | = | 37.1 | 1 | 62.5 | = | 72.2 | 1 | 87.5 | = | 110.9 | 1 |
| 13.0 | = | 9.0 | 1 | 38.0 | = | 37.7 | 1 | 63.0 | = | 72.9 | 1 | 88.0 | = | 111.7 | 1 |
| 13.5 | = | 9.6 | 1 | 38.5 | = | 38.3 | 1 | 63.5 | = | 73.7 | 1 | 88.5 | = | 112.5 | 1 |
| 14.0 | = | 10.1 | 1 | 39.0 | = | 38.9 | 1 | 64.0 | = | 74.5 | 1 | 89.0 | = | 113.2 | 1 |
| 14.5 | = | 10.7 | 1 | 39.5 | = | 39.5 | 1 | 64.5 | = | 75.3 | 1 | 89.5 | = | 114.0 | 1 |
| 15.0 | = | 11.3 | 1 | 40.0 | = | 40.1 | 1 | 65.0 | = | 76.0 | 1 | 90.0 | = | 114.8 | 1 |
| 15.5 | = | 11.9 | 1 | 40.5 | = | 40.7 | 1 | 65.5 | = | 76.8 | 1 | 90.5 | = | 115.6 | 1 |
| 16.0 | = | 12.4 | 1 | 41.0 | = | 41.3 | 1 | 66.0 | = | 77.6 | 1 | 91.0 | = | 116.3 | 1 |
| 16.5 | = | 13.0 | 1 | 41.5 | = | 41.8 | 1 | 66.5 | = | 78.4 | 1 | 91.5 | = | 117.1 | 1 |
| 17.0 | = | 13.6 | 1 | 42.0 | = | 42.4 | 1 | 67.0 | = | 79.1 | 1 | 92.0 | = | 117.9 | 1 |
| 17.5 | = | 14.1 | 1 | 42.5 | = | 42.9 | 1 | 67.5 | = | 79.9 | 1 | 92.5 | = | 118.7 | 1 |
| 18.0 | = | 14.7 | 1 | 43.0 | = | 43.4 | 1 | 68.0 | = | 80.7 | 1 | 93.0 | = | 119.4 | 1 |
| 18.5 | = | 15.3 | 1 | 43.5 | = | 43.9 | 1 | 68.5 | = | 81.5 | 1 | 93.5 | = | 120.2 | 1 |
| 19.0 | = | 15.9 | 1 | 44.0 | = | 44.5 | 1 | 69.0 | = | 82.2 | 1 | 94.0 | = | 121.0 | 1 |
| 19.5 | = | 16.4 | 1 | 44.5 | = | 45.0 | 1 | 69.5 | = | 83.0 | 1 | 94.5 | = | 121.8 | 1 |
| 20.0 | = | 17.0 | 1 | 45.0 | = | 45.5 | 1 | 70.0 | = | 83.8 | 1 | 95.0 | = | 122.5 | 1 |
| 20.5 | = | 17.6 | 1 | 45.5 | = | 46.1 | 1 | 70.5 | = | 84.6 | 1 | 95.5 | = | 123.3 | 1 |
| 21.0 | = | 18.1 | 1 | 46.0 | = | 46.6 | 1 | 71.0 | = | 85.3 | 1 | 96.0 | = | 124.1 | 1 |
| 21.5 | = | 18.7 | 1 | 46.5 | = | 47.4 | 1 | 71.5 | = | 86.1 | 1 | 96.5 | = | 124.9 | 1 |
| 22.0 | = | 19.3 | 1 | 47.0 | = | 48.1 | 1 | 72.0 | = | 86.9 | 1 | 97.0 | = | 125.6 | 1 |
| 22.5 | = | 19.9 | 1 | 47.5 | = | 48.9 | 1 | 72.5 | = | 87.7 | 1 | 97.5 | = | 126.4 | 1 |
| 23.0 | = | 20.4 | 1 | 48.0 | = | 49.7 | 1 | 73.0 | = | 88.4 | 1 | 98.0 | = | 127.2 | 1 |
| 23.5 | = | 21.0 | 1 | 48.5 | = | 50.5 | 1 | 73.5 | = | 89.2 | 1 | 98.5 | = | 128.0 | 1 |
| 24.0 | = | 21.6 | 1 | 49.0 | = | 51.2 | 1 | 74.0 | = | 90.0 | 1 | 99.0 | = | 128.7 | 1 |
| 24.5 | = | 22.1 | 1 | 49.5 | = | 52.0 | 1 | 74.5 | = | 90.8 | 1 | 99.5 | = | 129.5 | 1 |
| 25.0 | = | 22.7 | 1 | 50.0 | = | 52.8 | 1 | 75.0 | = | 91.5 | 1 | 100.0 | = | 130.3 | 1 |

CALIBRATION POINTS:

(27.00, 25.00) (34.00, 33.00) (41.00, 41.32) (46.00, 45.60)
(50.00, 52.80)

FIGURE 2. RIC CARD

Date Removed
 Site (Motor ID)
 Initials
 Date Installed
 Site (Motor ID)
 Initials
 Date Calibrated
 Site (Motor ID)
 Initials

SITE HI-VOL HISTORY

MPCA SITE #

LOCATION _____

[illegible]

DATA ANALYSIS PROCEDURE 2

High Volume Data Analysis Procedure

A. General

The high volume data analysis procedure details the steps involved in data handling from ordering the filters to final editing of data.

B. Equipment

Clean filters

Laboratory Data Sheet for clean, weighed filters

Stamped envelope

Form DA#5, Filter Distribution Log

Form DA#1, Hi-Vol Filter Log Sheet

Form DA#6, High Volume Motor Calibration Curve

Form DA#7, High Volume Sample Coding Sheet

Form DA#3, Coding Log Sheet

Form DA#4, Laboratory Sample and Accounting Record

C. Procedure

1. Filters are ordered by Air Monitoring Unit.

2. Clean, boxed filters are taken to the lab by Data Analysis Unit (usually semi-annually).

3. Each month, the lab processes clean filters required for the next month's operation as follows:

a) The clean filters are removed from the box and the identifying number, which is stamped on both sides of the filter, is typed using a teletype into the computer.

b) The filter is weighed on the electronic balance to get the tare weight.

c) The filter number and the corresponding tare weight along with temperature and relative humidity are stored by the computer. Standard weights are used to check the balance before weighing and 10% of the filters are reweighed for quality control.

d) When the entire box of filters has been weighed, all filters and two copies of the data sheet containing each filter's identifying number, tare, weight and the lab

humidity, temperature and quality control data are placed in the box. The laboratory also retains a copy of the filter tare weight data.

4. The Data Analysis Unit retrieves the clean, weighed filters from the laboratory and provides the Quality Assurance Unit with one copy of the data sheet.

5. Data Analysis prepares ~~sample~~ envelopes (without clasps) by stamping a 9" x 12" ~~mail~~ envelope with a rubber stamp. The stamp has spaces for recording tare weight, loaded weight, filter number, date and site of run, start and end time of run and start and end flow. (Figure 1).

6. Data Analysis removes each individual filter from the box, packages it in a sample envelope, and records the filter number and tare weight in the spaces provided on the sample envelope.

7. Clean filters are provided to the operators as follows:

a) Metropolitan sampling - site operators secure filters from Data Analysis Section as they are needed.

b) Outstate sampling - enough clean filters to sustain the next month's sampling are mailed or dispatched with MPCA air monitoring personnel monthly.

c) Local agencies - currently purchase and use their own filters.

d) Form DA#5 is completed as the filters are dispatched.

As the log sheet is completed it is sequentially assigned a page number in the upper right corner and the sheet is filed in the log book. Form DA#5 identifies where the filters are dispatched.

8. High volume sample is run, starting and ending flow, sampling site and date, and starting and ending time are recorded on the sample envelope; the folded filter and transducer chart if used are placed in the sample envelope.

9. Samples are returned to the MPCA as follows:

a) Outstate monitors - samples are mailed back to the Data Analysis Unit on a sample-by-sample basis.

b) Metropolitan area samples are returned to the Data Analysis Unit as they are run.

10. As samples are returned from the field, date of run, site of run, and filter number are recorded on the Hi-Vol Filter Log Sheet (Form DA#1, 1-15-76). Sample exposure time (minutes) is calculated from the starting and ending times on the sample envelope. Filters are visually inspected for holes, flows out of range or other conditions which invalidate the sample. Filters are also checked to be sure that the ID number of the filter matches that recorded on the sample envelope. Form DA#1 is reviewed to be sure that a sample from the site and date has not previously been received. Inconsistencies from these checks are recorded on Form DA#1; 1-15-76. If the filter validity is questioned and if the filter is not invalidated for physical reasons an attempt is made to correct data believed to be in error (e.g., to determine on what date a filter actually ran in the case of a duplicate site and date).

If the filter was physically damaged an error code is assigned to the sample and recorded on the log sheet (Form DA#1; 1-15-76). If physical damage appears to be consistent from a particular site, the site and nature of the problem are reported to the Air Monitoring Unit.

The error codes include:

- 1 -- no analysis
- 2 -- PCA
- 3 -- laboratory
- 4 -- operator
- 5 -- vandalism
- 6 -- natural (rain, wind)
- 7 -- equipment failure
- 8 -- generated by computer, quality assurance

The laboratory may assign codes -2 or -3; operators may assign any code except -3 or -8; -8 is a quality assurance code and can only be assigned by the computer.

If the sample appears to be valid but is excessively loaded, the Engineering and Enforcement Sections are notified.

Along with logging in the filters, site number, date of run, tare weight and calculated exposure time in minutes are recorded on HI-VOL DATA Form DA#7; 3-16-76. True flow rate is determined by averaging the starting flow and ending flow logged on the sample envelope. This average number is then located on the appropriate high volume motor calibration curve (DA#6; 1-16-76) shown in Figure 2.

Each page of data form DA#7 is sequentially assigned a sheet number (starting value is taken from the last coding sheet log form DA#3; 1-15-76. This sheet number is also logged on the high volume filter log sheet (DA#1; 1-15-76).

11. On Tuesday and Friday mornings all data sheets (DA Form#7; 3-16-76) which are ready to be sent to the laboratory are logged (by date) on the coding sheet log (DA#3; 1-15-76). The sheet number of each coding sheet used and the date the coding sheets and corresponding filters will be taken to the laboratory are logged in the appropriate columns of the coding sheet log and a description of "high volume samples" is entered in the description column.

Data sheet page numbers and total number of filters are logged on a laboratory sign-in sheet (DA#4; 1-15-76). This form is filled out in duplicate and the laboratory must sign for the samples; the laboratory keeps one copy and the other is returned to MPCA.

12. On Tuesday and Friday afternoons all coding sheets logged to the laboratory along with corresponding filters are taken to the laboratory.

13. The laboratory acknowledges the receipt of the filters and coding forms by signing the laboratory sign-in sheet (DA#4; 1-15-75).

14. The laboratory weighs the loaded filters on the electronic balance; standard weights and 10% audit samples are also weighed. The laboratory provides two computer printouts of the results.

15. Data Analysis retrieves all data sheets completed by the laboratory and logs the data returned in the "Date From Lab" column of the coding sheet log (DA#3) for that coding sheet

page number. One of the two copies is sent to Quality Assurance. In addition all data sheets which have been in the lab more than 3 weeks are reported to Quality Assurance.

16. Local agencies send MPCA completed coding sheets.

17. Data sheets are manually edited to remove irregularities in coding and reporting of data. Invalidated data points are checked and assigned an appropriate error code.

18. All coding sheets which have been completed and edited are logged out to keypunch in the "DATE TO" column of the coding sheet log for that coding sheet page number (DA#3) and are taken to keypunch on Tuesday and Friday afternoons.

19. All data sheets (DA#7) are keypunched on given stripped cards.

20. All keypunched cards and the corresponding data sheets (DA#7) are retrieved from keypunch, returned to the MPCA, and the date returned is logged on the keypunch "DATE FROM" column for that coding sheet page number on the coding sheet log (DA#3; 1-15-76).

21. Form DA#1 is checked to indicated that the filter has been returned to MPCA and Form DA#1 is then filed by site and date.

22. Keypunched cards are edited via the PDP8/E computer. Edit checks are made for illegal characters on the card, date within specified range, number of parameters must be equal 7, time between 1320 and 1560 minutes (22 and 26 hours), flow between 32 and 72 cfm, tare weight between 3 and 5 grams, total weight between the tare weight and 5 grams, and calculated high volume results between 5 and 300 ug/m^3 . The card and calculated results are printed out on the line printer, errors are flagged with the word "check." Calculated results in excess of 150 ug/m^3 are single starred, and those in excess of 260 ug/m^3 are doubled starred. A detailed list of all cards in error and appropriate error messages are printed out on the console teletype.

23. Keypunch errors are corrected as found. Coding of values in error is verified, and if possible, corrected. A listing of results for each local agency is dispatched to that agency for error checking and result verification. An attempt is made to

correct every error, if possible, or if not possible to assign an appropriate error code.

Figure 1. Hi-vol data stamped on 9" x 12" envelope without clasps.

| | | |
|------------------|---------------------------------|----------------|
| LOCATION _____ | | MONTH _____ |
| START FLOW _____ | | DAY _____ |
| END FLOW _____ | START TIME _____ | END TIME _____ |
| NET WT _____ | TOTAL WT _____ | |
| NET WT _____ | NETALS <input type="checkbox"/> | |
| NET WT _____ | TOTAL WT _____ | |
| COMMENTS: | | |

FILTER DISTRIBUTION LOG

[illegible]

[illegible]

HIGH VOLUME SAMPLE CODING SHEET

[illegible]

VII.2

Figure 2. High Volume Motor Calibration Curve (Flow Table).

PRESSURE : 732.4 INSTALLED : SITE # :
TEMP. : 24.0 REMOVED : MOTOR ID # : H 7779
CALIBRATED : 3/29/76

| | | | | | | | | | | | | | | | |
|------|---|-----|---|------|---|------|---|------|---|------|---|------|---|------|---|
| 0.5 | = | 4.1 | 1 | 25.5 | = | 22.6 | 1 | 50.5 | = | 49.3 | 1 | 75.5 | = | 78.1 | 1 |
| 1.0 | = | 3.6 | 1 | 26.0 | = | 23.1 | 1 | 51.0 | = | 49.9 | 1 | 76.0 | = | 78.7 | 1 |
| 1.5 | = | 3.0 | 1 | 26.5 | = | 23.6 | 1 | 51.5 | = | 50.5 | 1 | 76.5 | = | 79.2 | 1 |
| 2.0 | = | 2.5 | 1 | 27.0 | = | 24.2 | 1 | 52.0 | = | 51.1 | 1 | 77.0 | = | 79.8 | 1 |
| 2.5 | = | 2.0 | 1 | 27.5 | = | 24.7 | 1 | 52.5 | = | 51.6 | 1 | 77.5 | = | 80.4 | 1 |
| 3.0 | = | 1.4 | 1 | 28.0 | = | 25.2 | 1 | 53.0 | = | 52.2 | 1 | 78.0 | = | 81.0 | 1 |
| 3.5 | = | 0.9 | 1 | 28.5 | = | 25.8 | 1 | 53.5 | = | 52.8 | 1 | 78.5 | = | 81.5 | 1 |
| 4.0 | = | 0.4 | 1 | 29.0 | = | 26.3 | 1 | 54.0 | = | 53.4 | 1 | 79.0 | = | 82.1 | 1 |
| 4.5 | = | 0.2 | 1 | 29.5 | = | 26.8 | 1 | 54.5 | = | 53.9 | 1 | 79.5 | = | 82.7 | 1 |
| 5.0 | = | 0.7 | 1 | 30.0 | = | 27.4 | 1 | 55.0 | = | 54.5 | 1 | 80.0 | = | 83.3 | 1 |
| 5.5 | = | 1.2 | 1 | 30.5 | = | 27.9 | 1 | 55.5 | = | 55.1 | 1 | 80.5 | = | 83.8 | 1 |
| 6.0 | = | 1.8 | 1 | 31.0 | = | 28.4 | 1 | 56.0 | = | 55.7 | 1 | 81.0 | = | 84.4 | 1 |
| 6.5 | = | 2.3 | 1 | 31.5 | = | 29.0 | 1 | 56.5 | = | 56.2 | 1 | 81.5 | = | 85.0 | 1 |
| 7.0 | = | 2.8 | 1 | 32.0 | = | 29.5 | 1 | 57.0 | = | 56.8 | 1 | 82.0 | = | 85.6 | 1 |
| 7.5 | = | 3.4 | 1 | 32.5 | = | 30.0 | 1 | 57.5 | = | 57.4 | 1 | 82.5 | = | 86.1 | 1 |
| 8.0 | = | 3.9 | 1 | 33.0 | = | 30.6 | 1 | 58.0 | = | 58.0 | 1 | 83.0 | = | 86.7 | 1 |
| 8.5 | = | 4.4 | 1 | 33.5 | = | 31.1 | 1 | 58.5 | = | 58.5 | 1 | 83.5 | = | 87.3 | 1 |
| 9.0 | = | 5.0 | 1 | 34.0 | = | 31.6 | 1 | 59.0 | = | 59.1 | 1 | 84.0 | = | 87.9 | 1 |
| 9.5 | = | 5.5 | 1 | 34.5 | = | 32.2 | 1 | 59.5 | = | 59.7 | 1 | 84.5 | = | 88.4 | 1 |
| 10.0 | = | 6.0 | 1 | 35.0 | = | 32.7 | 1 | 60.0 | = | 60.3 | 1 | 85.0 | = | 89.0 | 1 |
| 10.5 | = | 6.6 | 1 | 35.5 | = | 33.2 | 1 | 60.5 | = | 60.8 | 1 | 85.5 | = | 89.6 | 1 |
| 11.0 | = | 7.1 | 1 | 36.0 | = | 33.8 | 1 | 61.0 | = | 61.4 | 1 | 86.0 | = | 90.2 | 1 |
| 11.5 | = | 7.6 | 1 | 36.5 | = | 34.3 | 1 | 61.5 | = | 62.0 | 1 | 86.5 | = | 90.7 | 1 |
| 12.0 | = | 8.2 | 1 | 37.0 | = | 34.8 | 1 | 62.0 | = | 62.6 | 1 | 87.0 | = | 91.3 | 1 |
| 12.5 | = | 8.7 | 1 | 37.5 | = | 35.4 | 1 | 62.5 | = | 63.1 | 1 | 87.5 | = | 91.9 | 1 |
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LABORATORY SAMPLE AND ACCOUNTING RECORD

THE ANALYTICAL LABORATORY SECTION OF THE MINNESOTA HEALTH DEPARTMENT
ACKNOWLEDGES RECEIPT OF:

_____ SO₂ BUBBLER SAMPLE(S)
_____ NO₂ BUBBLER SAMPLE(S)
_____ HIVOL FILTER SAMPLE(S)
_____ METALS

AND THE CORRESPONDING DATA SHEETS FOR THE ABOVE:

DATA SHEET #

DATA SHEET #

DATA SHEET #

ON THIS DATE OF _____ BY _____

RESULTS DUE OUT BY _____

PLEASE FILL OUT THIS FORM IN DUPLICATE

Procedure:

A. TARE WEIGHT

1. Determine the tare weights of the clean, numbered 8" x 10" glass fiber filters. This is to be done only after the relative humidity in the laboratory has been under 50% for at least 24 hours.

B. GROSS WEIGHT

1. Allow a desiccation period of 24 hours during which the R.H. is below 50% after the exposed filters are brought into the lab before final weighing.
2. Inspect filters for holes, missing pieces of filter, loading extending beyond margins and over the filter edge, and record as an invalid sample any filter with one or more of the above defects.
3. Weigh to the nearest .1 mg and record.

Quality Control

PRECISION:

- a) At least 10% of each box of 100 clean numbered, tare weighted filters are independently reweighed.
- b) At least 5% of each batch of filters which are weighed for total weight are independently reweighed.

ACCURACY:

Weights which have been calibrated with Class S weights are used to check and adjust the balance prior to and after each batch weighing.

In addition, a polonium source is used to retard the effects of static charge on the filters.

SAMPLE HANDLING PROCEDURE

The following procedure is followed for air quality samples by the Laboratory staff.

- 1) Upon receipt of samples (gas and particulate), the accompanying data sheets are given a laboratory control number, dated, and entered into the Receiving Desk Log Book.
- 2) The gas samples, if not immediately analyzed, are placed into the Receiving Desk storage cooler which is maintained at 40° F.
- 3) Filters are analyzed after the required dessication period has elapsed. They are boxed and returned each week.
- 4) Upon completion of all analyses requested on each data sheet, the sheets are forwarded to the office staff for tallying and duplication.
- 5) Data sheet originals are placed in the appropriate box for pickup by PCA personnel.
- 6) Filters will be placed in the same appropriate box to be picked up with the data sheet originals.

OPERATION PROCEDURE 9

Brushless Hi-Volume Sampler Operation Procedure (Magnehelic System)

A. General

Brushless Hi-Volume samplers are operated once per six days from midnight to midnight. Units operating with magnehelic gages are equipped with Intermatic timers which measure time to ± 15 minutes; Gelman Type AE filters are generally used for regular sampling; other filters may be used for special sampling. Brushless Hi-vols are equipped with elapsed timers for measuring actual running time.

B. Equipment

Calibrated Brushless Hi-volume sampler equipped with magnehelic gage and elapsed timer.

Filter and/or filter cartridge.

Filter envelope.

Mailing envelope (if used).

Timer (mounted on Hi-Vol).

Magnehelic gage

Magnehelic operation bulletin

Elapsed timer (mounted on top of Hi-Vol).

C. Procedure: Removal of exposed filter.

1. Verify magnehelic calibration versus a water manometer before each days use. Zero with set screw. If upscale reading does not match refer to magnehelic operation bulletin.

2. Observe the elapsed timer reading to verify that the Hi-Vol has run the necessary 24 hours (1440 min).

a. Open the bottom housing door and turn on the motor using the on/off switch located below the timer face.

b. Remove the port cap and attach the magnehelic hose to the port located by the filter screen and record the reading on the filter envelope in the "final flow" heading. Replace the port cap.

c. Record the elapsed timer reading on the filter envelope in the "ending time" heading.

- d. Turn off the motor.
3. Remove exposed filter.
 - a. Loosen the four wing nuts holding the hold down frame in place.
 - b. Remove the hold down frame making sure the filter does not stick to the frame.
 - c. Carefully remove the exposed filter. Observe the "white band" around the perimeter of the upper surface of the filter. If the border is not distinct, the hold down frame is not tight enough which means the incoming air is leaking through the gasket.
 - d. Fold the filter in half (to form a small rectangle) and place it in the proper envelope. The number on the filter and on the envelope must match.
 - e. If the hi-vol is equipped with a filter cartridge, replace the cartridge cover and loosen the wing nuts holding the cartridge in place. Take the cartridge to a sheltered location before performing b, c, and d.
 - f. Record operational difficulties or meteorological conditions under "comments" on the filter envelope. Return the exposed filters promptly to the MPCA office either in person or in the self-addressed, stamped envelope provided.

D. Procedure: Placement of clean filter.

1. If a filter cartridge is not used proceed as follows.
 - a. Loosen the four wing nuts holding the filter hold down frame in place. Remove the hold down frame. Check the gasket; if worn, replace it.
 - b. Remove clean filter from its envelope and place squarely on the screen of the holder assembly with the rough side of the filter facing up and the smoother side down. Do not tear or puncture the clean filter.
 - c. Replace hold down frame taking care not to move the filter out of alignment. Tighten the wing nuts enough to achieve a tight seal to prevent air leaks.
2. If a filter cartridge is used, the cartridge is fitted

with the filter at a sheltered location. The cartridge allows easy installment and removal under adverse conditions. The cartridge unit has three parts: 1. screen plate and gasket, 2. hold down plate and 3. cartridge cover.

a. Remove the filter from its envelope and place it squarely on the screen plate (the gasket is on the underside of the plate and will be placed on the hi-vol). The rough side of the filter should be face up.

b. Place the hold down plate on top of the filter and tighten enough to achieve a tight seal.

c. Finally, place the cartridge cover over the assembly to protect the filter. The unit is now ready to be placed on the hi-vol.

d. Place the assembled cartridge on the hi-vol unit. It fits directly over the screen attached to the hi-vol funnel.

e. Tighten the wing nuts enough to insure a leak proof seal.

f. Since the cartridge assembly has two gaskets, there are two chances for leaks. Be sure the seals are tight and the gaskets are in good shape. If there is any doubt, replace with another cartridge.

g. Remove the cartridge cover from the assembly. After the filter has been properly placed, ready the system for the next run.

3. Turn on the motor and allow a few minutes warm up before reading the flow off the magnehelic gage. The wing nuts and cartridge retaining nuts should be rechecked at this point.

a. Record site number, location and date filter will run on the filter envelope. Record the start time in the "start time" block (obtained from the elapsed timer).

b. Record the magnehelic reading on the filter envelope under "initial flow."

4. Set the clock so the sampler will turn on at midnight of

the day indicated on the sampling schedule. Samples should run exactly 24 hours. Once set, the timers actuate themselves. The timed indicators should be separated by 24 hours; they should be set from midnight to midnight. Since the timer is set up for a seven day period and sampling is once every six days, it doesn't matter on which day of the week the indicators are set. The indicators are pre-set and should not require further setting. The clock face turns clockwise in the direction of the "turn" arrows. The long arrow marked "do not turn" or "time" remains stationary and should not be removed. To set the timers after the 24 hour sampling period has been completed simply turn the clock face back 24 hours. For example, if the sample was set to run from midnight Wednesday to midnight Thursday and you arrive at 10 a.m. Friday to change the sample, advance the timer to 10 a.m. Friday. This setting means that the timer will activate on the sixth day as required by the sampling schedule. If the new filter is not replaced until the day before the run, the long arrow of the timer would be set to say 10 a.m., of the day before the run or at whatever time the operator is at the site.

CALIBRATION PROCEDURE 11

Brushless Hi-Volume Sampler Calibration Procedure

A. General

The air flow indicator (magnehelic gage) of the brushless hi-volume sampler system, must be calibrated against a system producing a known flow -- a calibrated orifice and water or oil manometer. By measuring actual flow with a manometer and calibrated orifice and simultaneously observing the value on the flow indicator, a curve for a given motor and magnehelic gage can be derived by plotting actual flow vs indicated flow. Brushless hi-vols, because of their weight and inability to remove the motor from the housing, are calibrated in the field.

B. Equipment

Field calibration kit, including adaptor plate, orifice, manometer and five resistance plates. This system should have been calibrated on a Roots meter (Calibration Procedure 1).

Brushless hi-vol

Calibration curve for the orifice (Form CG-1)

Magnehelic gage

Magnehelic operation bulletin

Meter for monitoring line voltage

Thermometer

Barometric pressure indicator - if available

Hi-vol sampler calibration data sheet, Form C-11

Hi-vol sampler air flow calibration curve, Graph CG-11

RIC card (see fig. 4)

C. Procedure

1. Attach orifice adaptor plate to the funnel of the hi-vol, tightening the wing nuts securely and attach the orifice canister to the adaptor plate, inserting resistance plate #18 between the canister and the adaptor plate. Secure tightly. Allow motor to warm up for a few minutes. As there are no brushes to set, a few minutes should be sufficient.

2. Before using magnehelic, verify calibration versus a water manometer. If zero requires adjustment, use front meter set screw. If upscale readings are inaccurate, refer to the magnehelic operations bulletin. Attach the magnehelic gage hose to the port on top of the hi-vol being careful that the gage is kept level.

3. Zero the manometer by sliding the scale up or down; the water level changes as this is done and both sides of the manometer should read zero. After the manometer has been zeroed, attach the manometer to the orifice port. The motor should remain on during this procedure. (see fig. 3)

4. Observe and record ambient barometric pressure, temperature and line voltage on form C-11.

5. Read inches of water to the nearest 0.05 inches on each side of the manometer (read the bottom of the meniscus) and add these values. Record this number in the "manometer reading" column on the hi-vol Calibration Data Sheet, form C-11.

6. Being careful that the magnehelic gage is level record the value in the "magnehelic reading" column on form C-11.

7. Refer to the appropriate orifice calibration curve to determine actual flow (CFM) for the inches of water measured in step #6. Read inches of water yielding CFM.

8. Turn off power and position resistance plate #13 at the bottom of the canister, with gaskets on either side, securing tightly. Turn on power and read the manometer, adding measured inches of water from both columns. Record this value next to plate #13 under "manometer reading" on the Calibration Data Sheet. Record on data sheet under "magnehelic reading" the magnehelic reading.. Repeat this procedure for plates #10, #7, #5. Plate #5 may not have sufficient vacuum to read from the orifice curve therefore it may be eliminated.

9. Remove the orifice and adaptor plate, unplug motor.

10. Attach RIC card (see fig. 4) to the motor housing, recording motor number on all three sections. Record date on "C" portion of card. Remove "C" portion and turn in to data analysis section later with the data sheet (refer to Sec. I.4

for procedures on RIC cards). Also attach a sticker label to the hi-vol with date of calibration and technician's initials.

11. Complete data sheet by recording actual flow values obtained from appropriate orifice curve for each resistance plate; the line voltage during calibration; the date; motor number; magnehelic number; and the orifice I.D..

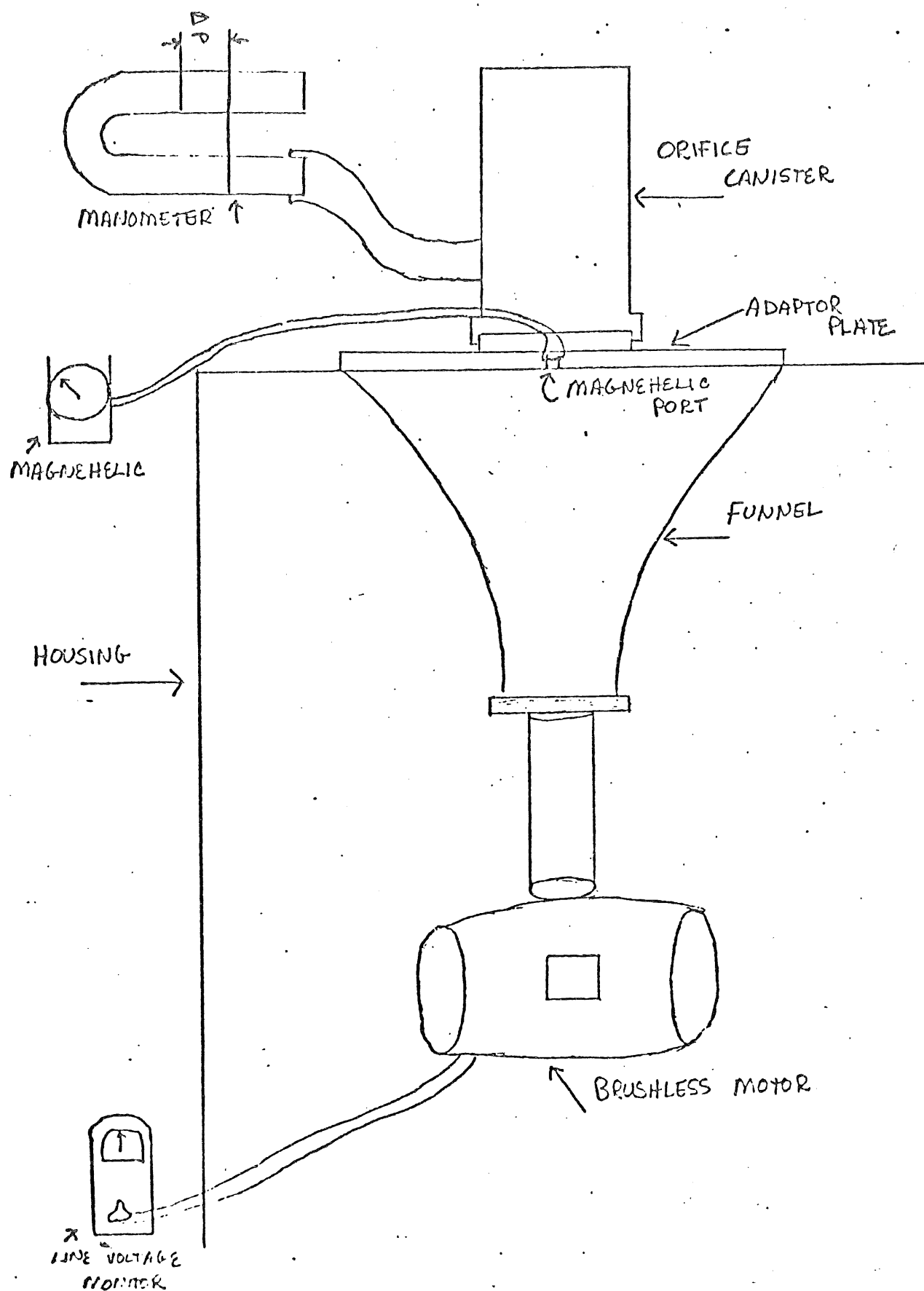
12. Develop a calibration curve for the motor by plotting the actual flow (readings from the orifice curve) against the indicated flow (magnehelic gage readings) on the hi-vol Calibration Graph CG-11. Complete other blank items on the graph.

13. Submit graph, data sheet, and "C" portion of RIC card to data processing personnel. They will store data taken from the data sheet and keep the "C" portion of the RIC card.

14. Curves and data should be kept on file by motor number by the operator.

FIGURE 3: Brushless Hi-Vol Magnehelic Unit

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Data Sheet, Brushless Hi-Vol Calibration

Orifice # _____

Technician _____

Motor # _____

Date _____

Magnehelic # _____

Temp _____

Calibration Voltage _____

Bar Press _____

| Plate No. | Manometer Reading | Magnehelic Reading | CFM (orifice calcve) |
|-----------|-------------------|--------------------|----------------------|
| 18 | | | |
| 13 | | | |
| 10 | | | |
| 7 | | | |
| 5 | | | |

Brushless Hi-Vol Calibration Curve

Date _____

Motor Number _____

Magnehelic No. _____

Temp _____

B.P. mmHg _____

Orifice No. _____

Line Voltage _____

Technician _____

Actual \dot{M} (from orifice curve)

40

30

20

10

0

10

20

30

40

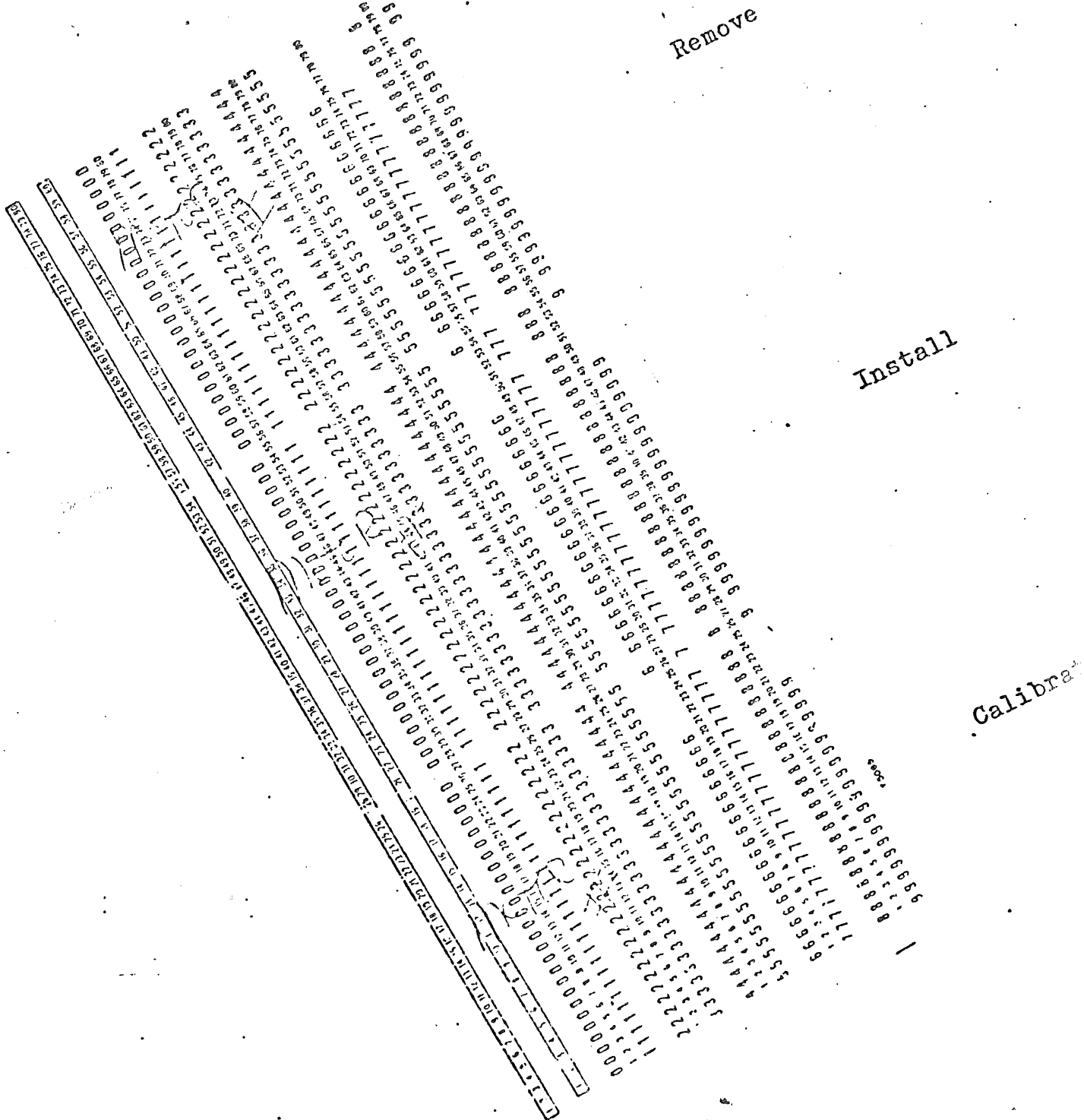
50

60

70

Graph CG-11
7/14/76

FIGURE 4. RIC Card



APPENDIX A-3

RAC MEMBRANE SAMPLER OPERATIONAL
AND CALIBRATION PROCEDURES

Operation Procedure

Calibration Procedure

Sample Transfer — *missing*

OPERATION PROCEDURE 10
Operation of the Membrane Sampler

A. General:

The Membrane Sampler is used for taking high volume samples of suspended particulate matter. The unit consists of a carbon vane pump, a filter cartridge, a bonnet, and attached magnehelic gauge. The membrane sampler is housed in a weather-proof container.

B. Equipment:

Teflon Tweezers

Spare Filter Cartridge (if available)

Spare Filter Container

Clean Filter

Tool Kit

C. Procedure:

1. Turn on the motor by using the on-off switch located on the timer. Allow the motor to run at least 5 minutes before reading the flow.
2. Zero magnehelic by depressing the zero button. (If the magnehelic does not read zero, adjust the set screw located on the bottom of the face. If a reading of zero is still not obtained, the magnehelic should be removed and checked out in the lab.)
3. Depress the test button, this will give you the indicated flow, the actual flow is read off the Calibration Curve. This procedure is done at least twice to insure proper readings. Record this information on the proper form. (Stickers to be placed on the filter container)
4. Detach entire filter holder and stem and proceed to a sheltered area to change the filter.
5. Remove the bonnet.
6. Carefully loosen the retaining nuts.
7. Carefully remove the metal retaining ring being careful the filter does not stick to it. (If filter does stick, carefully remove with teflon tweezers.)

8. Observe the location of the thick teflon gasket normally found located on the top of the filter. If it is stuck to the filter remove with teflon tweezers.

9. Remove filter with teflon tweezers being extremely careful not to damage the filter in any way.

NOTE: Lower thin teflon gasket may stick - if so remove.

10. Place exposed filter in appropriate container and fill out information on the container labels.

PROCEDURE: Placement of a clean filter.

1. Place the thin teflon lower gasket in place - checking to make sure filter holder is free of debris.

2. Using teflon tweezers remove a clean filter from box and place it on the filter holder.

NOTE: Be sure blue filter backing is not attached to filter.

3. Place upper thicker teflon gasket followed by metal retaining ring; tighten the retaining nuts as evenly as possible.

NOTE: Do not over-tighten; finger tight is sufficient.

4. Before replacing bonnet, set the filter holder in place assuring a proper seal at the base; with the motor on, check the filter for cracks. Replace filter if damaged.

5. Replace bonnet on cartridge.

6. Take initial flow, and record on label.

7. If membrane sampler coincides with the hi-vol, check the timer setting to assure proper running day.

CALIBRATION PROCEDURE 12Membrane Sampler Calibration ProcedureA. General

The membrane sampler flow is measured by the pressure drop that occurs across an orifice. Pressure drop is read from a Magnehelic gauge. The individual samplers are calibrated using a calibrated hot wire mass flowmeter. The hot wire mass flowmeter has the advantage of automatic compensation for pressure and temperature, making it suitable for field use.

B. Equipment

Membrane Sampler

Thermal anemometer and throttle valve assembly

Digital voltmeter

AC source

Membrane sampler calibration data sheet, Form CG-12

Rootsmeter (optional)

C. Procedure:

1. Set up equipment in configuration shown in Figure 1. Remove membrane sampler head. Insert anemometer - throttle valve assembly into tygon connector above critical orifice. Connect digital voltmeter to "+ -" terminals on electronics box of the flowmeter. Plug both anemometer and voltmeter into a 115 VAC source.
2. Turn on sampler and voltmeter. Allow sampler to run 10 minutes to reach operating temperature.
3. Read Magnehelic gauge as follows: First, press "zero" button, then adjust zero with adjusting screw on front of gauge while holding "zero" button in. Next, read upscale valve by pressing and holding "span" button. NOTE: zero meter before reading each upscale valve.
4. Adjust throttle valve so that that Magnehelic gauge reads approximately 20 in/H₂O. Note D.C. voltage reading on voltmeter. When voltage stabilizes record gauge and voltmeter readings.



5. Repeat step 4 setting the gauge to readings of approximately 15 and 10 in/H₂O. Record voltmeter and Magnehelic readings.
6. Obtain true flow readings (CFM) by referring to anemometer calibration curve stappled to inside of anemometer cover.
7. Draw sampler calibration curve by plotting true flow values and Magnehelic readings on graph on data sheet. Use best fit straight line to describe plotted points. All future flow readings are obtained by reference to this line. Fill out remaining blanks on data sheet. NOTE: keep copy of curve in station logbook or at station; return one copy to central office.
8. Rootsmeter Calibration. To calibrate sampler or anemometer with Rootsmeter, follow hook-up diagram in Figure 1, use Magnehelic settings of 20, 15, 13, 10 and 8 in/H₂O. Time the passage of a volume of air (20 cubic feet for 20, 15 and 13 in/H₂O, 10 cubic feet for 10 and 8 in/H₂O) with a stop watch. Record all data on data sheet, calculate True CFM by dividing volume of air by elapsed time (min), and plot data on graph.

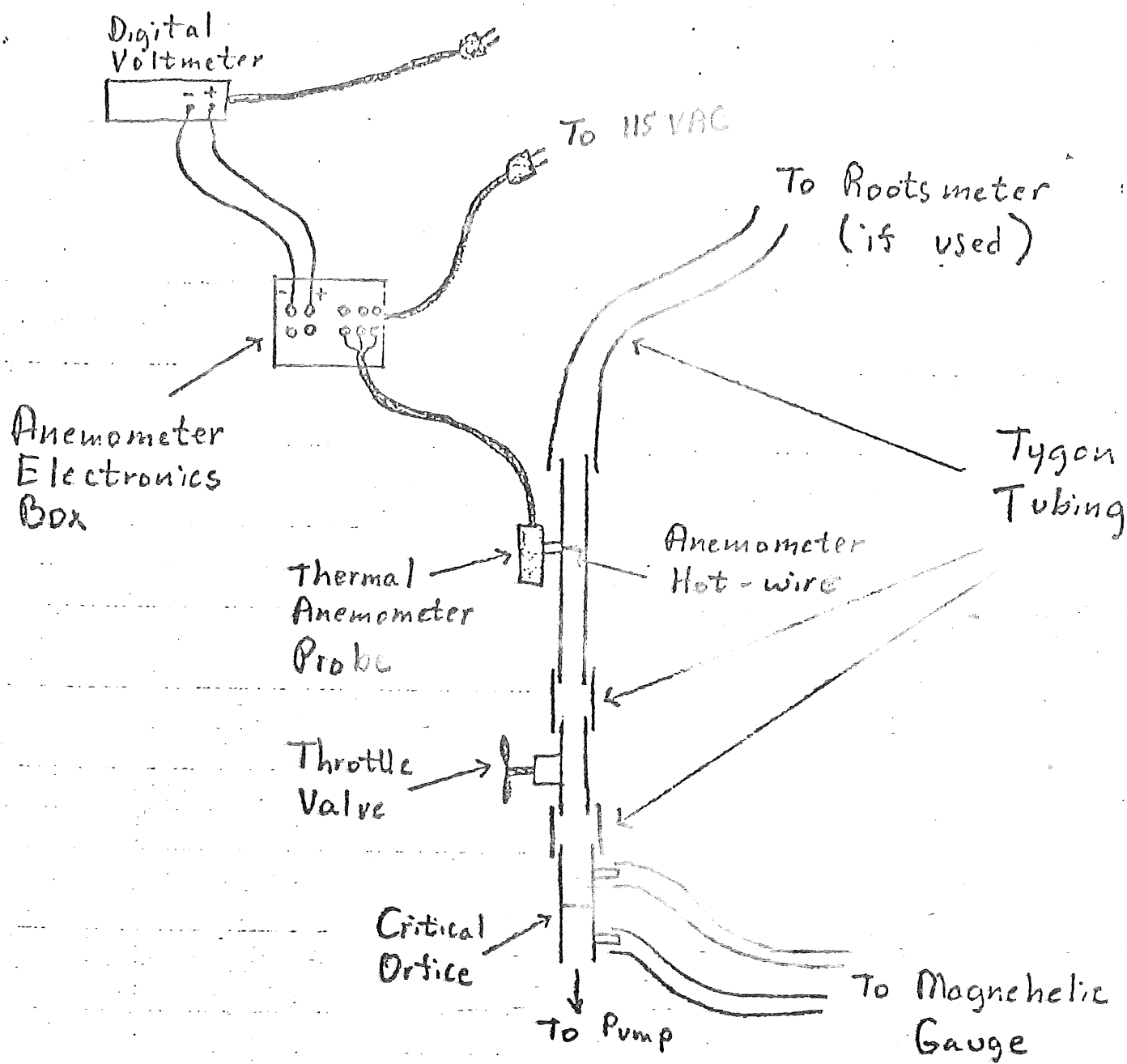


Figure 1.

102 mm Membrane Sampler Calibration

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Graph CG-12
10/12/76

APPENDIX A-4

NO₂ AND SO₂ 24-HOUR BUBBLER OPERATIONAL AND CALIBRATION PROCEDURES

SO₂ and NO₂ Bubbler Operation

~~NO₂~~ SO₂ and NO₂ Maintenance

Critical Orifice Calibration

NO₂ Laboratory Procedure

SO₂ Laboratory Procedure

Data Analysis Procedure

OPERATION PROCEDURE 1

Operation of the Bubbler (RAC and MISCO) Units

A. General

The bubbler units are operated once per six days. Units operated directly by MPCA or local agency personnel are prepared for field operation one day before the sampling period or on the same day. Outstate volunteer operators are provided bubbler tubes with absorbing solution and calibrated orifices by MPCA personnel.

B. Equipment

RAC or MISCO Bubbler Units with color-coded tubes

Distilled water

50ml volumetric pipette

Calibrated critical orifices

Bubbler data card #628

Absorbing solutions (SO_2 -- Potassium Tetrachloromercurate (TCM); NO_2 -- Sodium Hydroxide-Sodium Arsenite)

Pump and timer (usually hi-vol)

Rubber bands, paper envelopes

C. Preparation for field operation

1. Rinse polypropylene absorbing tubes with distilled water
2. Rinse pipette with distilled water
3. Pipette 50ml of absorbing solution into the color-coded tubes (SO_2 -red, NO_2 -blue)

4. Calibrate critical orifices on the calibrated flowmeter in the lab (refer to Calibration Procedure 3, Section II. 3).

The orifices must be between 190-210 cc/min. DISCARD any that fall outside this range. Label orifices with flow. Orifices and bubbler tubes are ready for field use.

5. Prepare bubbler tubes and critical orifices for volunteer operators and local agencies in sufficient quantity as outlined above. Be sure to include enough data cards (#628), See Figure 1.

D. Field Operation

1. Remove bubbler unit from case. Check to see if strip heater is working.
2. Observe timer and note start and finish time on data card, along with location, date and pollutant. (Bubblers run from midnight to midnight, a 24 hour period).
3. Turn pump on. Observe bubbler unit for bubbling solution. Turn pump off. If bubbling is absent, note on data card and determine cause.
4. Remove the exposed tubes from the rack and replace with unexposed tubes (match color-coded tubes).
5. Remove critical orifices and replace with new orifices that were calibrated in the lab. The old orifices will be returned to the lab and will be re-calibrated so identify them with site number and parameter (envelopes work well).
6. Turn pump on. If solution is bubbling, turn pump off. If solution is not bubbling, check all connections to assure leak proof system. Continue trouble shooting until system is bubbling.
7. Replace bubbler unit in case.
8. Set timer to operate on the next specified sampling date (usually six days from the previous run date). To set timer refer to Hi-Vol Operation Procedure 3.
9. Be sure probe inlet is clean and free from snow and ice.
10. Attach the data card to the bubbler tube with rubber band or tape.
11. Return exposed solution tubes to laboratory or home base. Pour exposed solutions into glass tubes and mark the glass tubes with site number and date. Also, color code the tubes for the appropriate solution (SO_2 -red, NO_2 -blue).
12. Recalibrate the critical orifices and record the flow rate on the data card. It is assumed that this flow is the same as the initial flow.
13. Complete the data card and add any comments about weather, problems with the sampling period and so forth. Initial the card.
14. Place exposed tubes in the refrigerator as soon as possible.
15. Samples should be exposed to a minimum of light during and after each run.

16. Agency personnel should submit data card #628 to the data analysis unit.

17. Outstate operators should place exposed tubes and data cards in the refrigerator until MPCA personnel pick up the tubes.

Figure 1. Data Card

LOCATION _____

DATE _____

POLLUTANT _____

MINUTES FINISH _____

START _____

TOTAL _____

COMMENTS _____

MAINTENANCE PROCEDURE 1

Bubblers (RAC and MISCO Units) Maintenance Procedure

A. General

The total bubbler maintenance procedure should be performed on a quarterly basis. Changing of filters or glass fiber plugs may be required at shorter intervals.

B. Equipment

RAC or MISCO Bubbler Units

Membrane filters and backings

Calibrated critical orifices

Glass wool or foam plugs

Rubber septums

Spare tygon, glass and flexible teflon tubing

Thermometer

Test tube brushes, detergent

Distilled water

Bubbler Maintenance Form M-1

Vacuum pump

C. Procedure

1. Record date, operator, site number, bubbler serial number on Form M-1.

2. Remove bubbler unit from case. Remove rubber band (if present) that holds absorber tubes in rack. Remove any heat shrink tape from filter assemblies and bubbler tubes.

3. Clean glass manifold and tubing as follows:

a) Disconnect rubber septum and trap bubbler tube assembly from critical orifices (see Figure 1 for parts), remove these critical orifices (needles) and septums. Discard septums. Also remove any needles and caps that are acting as plugs for unused assembly spaces.

b) If needles are bent, discard them. If not, at the end of the bubbler maintenance check flow of needles using a calibrated flowmeter. Refer to Calibration Procedure 3.

If the flow is in the range 190-210 cc/min, the needles may be reused; otherwise, they are discarded.

c) Detach flexible teflon tubing from glass manifold.

Remove any rubber septums acting as plugs from the glass manifold. Next, remove glass manifold from the housing by removing retaining clamps and screws at either end of the glass manifold. The glass manifold will slip out of position and is then ready for washing along with rubber septums that were acting as plugs.

d) The collection bubbler tube assembly may be dismantled as follows. Remove tygon tubing and flexible teflon tubing from the 2-port polypropylene cap. Also, disconnect the glass bubbling tube from the 2-port cap. The flexible teflon tubing, 2-port cap, glass bubbling tube and polypropylene bubbler tube are now ready for washing.

e) Detach the remaining section of tygon tubing from the 2-port cap on the trap bubbler tube. This tubing is now ready for washing.

f) Detach the 2-port cap from the trap bubbler tube. Remove the glass wool or foam plug and discard. Detach the polypropylene tube from the cap and wash both the polypropylene tube and bubbler tube.

g) Detach the elbow glass tube and straight glass tube from the filter assembly and 2-port cap along with sections of tygon tubing. Wash 2-port cap and tubing.

h) Separate the filter assembly and discard filter and backing. Wash assembly.

i) All items should be washed in hot soapy water, thoroughly rinsed first with tap water and then with distilled water. Rinse 3 times with distilled water and allow all parts to dry before reassembly.

j) Check Form M-1 "clean manifold, clean tubing."

4. Reassemble bubbler. The procedure is the reverse of the steps outlined above. Tubes are color-coded; red tubes are for SO₂ and blue tubes are for NO₂.

a) Trap bubbler assembly and filter assembly. Place a new filter and backing in the filter assembly.

Backing should be placed next to the outlet and filter next to the inlet. Check Form M-1 under "change filter."

b) Reassemble the elbow glass tube above the filter assembly and the straight glass tube below, using the appropriate tygon tubing. Plug the top end of the elbow tube with a rubber septum.

c) Place one end of the straight glass tubing (with tygon tubing) into the top of the 2-port cap. Replace a section of tygon tubing (about 6 inches) on the remaining port of the cap. Replace the straight polypropylene tube into the bottom of the 2-port cap opposite the 6 inch length of tygon tubing.

d) Insert a fresh glass wool or foam plug into the polypropylene bubbler tube. Insert the assembled 2-port cap into the bubbler tube.

e) The assembled trap bubbler tube and filter are placed in the carrier rack across from the exhaust manifold ports. Replace calibrated critical orifices in the appropriate taps. Plug unused taps with needles and caps.

f) Absorber Assembly. Attach the remaining end of the 6 inch tygon tubing to the appropriate port of the color-coded 2 port cap. Attach one end of the flexible teflon tubing to the remaining port. Replace the constricted glass tube into the port beneath the flexible teflon tubing. Replace the 2-port cap over the absorber tube.

g) Insert bubbler absorber tube in the carrier rack opposite the glass inlet manifold and attach the remaining end of the flexible teflon tube to the inlet tap of the glass inlet manifold. Replace rubber band to hold tubes in place.

h) Plug unused taps of the glass inlet manifold with rubber septums.

i) Carefully insert calibrated critical orifices into the rubber septums.

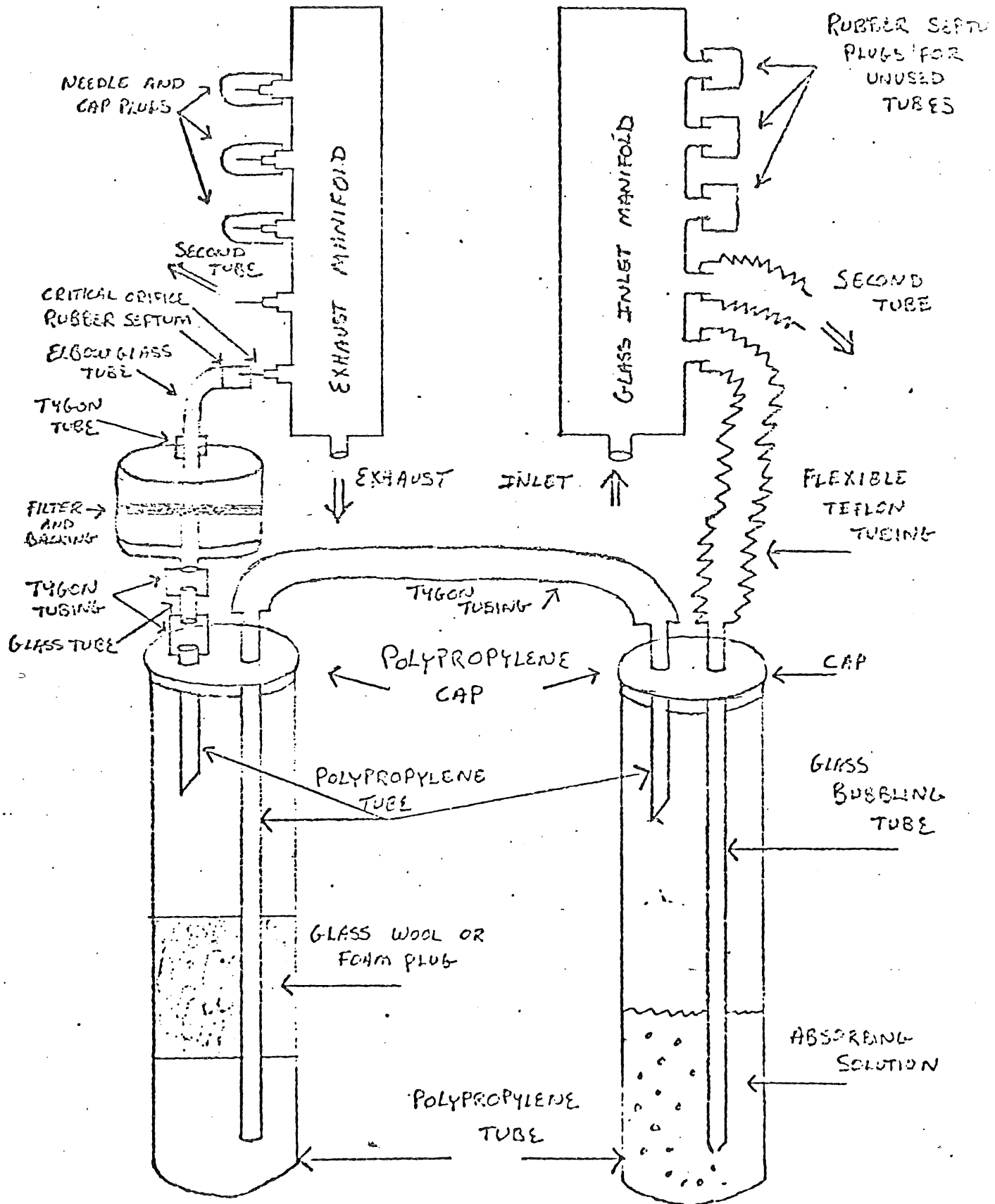
5. Clean case by wiping with damp sponge. Dry. Check Form M-1 under "clean housing."

6. System Checks. These checks should be performed before the

unit is sent to the field.

- a) Temperature: Plug case containing heating pad into outlet. Insert thermometer into the case but not on top of pad and allow 10-15 minutes for reaching temperature. The MISCO and RAC units are equipped with pads preset to 90°F. Observe and record the temperature on Form M-1. If the temperature in the case falls below 80°F, replace the pad.
- b) Flow: Fill bubbler tubes with 50 ml of water or absorbing solution. Make sure all connections have been made. Connect the exhaust manifold of the bubbler assembly to a vacuum pump and observe the flow. If the solution in the bubbler tubes is bubbling, the system is assumed to be functioning. If the solution is not bubbling or bubbling slowly, the system has a leak. Heat shrink tape may be required around the filter assemblies or the absorber tube/cap joints. Re-check all connections. Units should not be sent to the field until they have demonstrated flow.

FIGURE 1: Bubbler assembly.



Bubbler Maintenance Form
for RAC and MISCO units

10/1/75

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[illegible]

CALIBRATION PROCEDURE 3

Critical Orifice Calibration Procedure

A. General

Critical orifices for bubbler units are calibrated by measuring flow through the orifice ~~using a~~ calibrated rotometer (flowmeter). Critical orifices are calibrated before each sampling period.

B. Equipment

Calibrated rotometer (flowmeter), tygon tubing

Rotometer calibration curve

Vacuum pump; tygon tubing with adaptor

Rubber septum

Tygon tubing

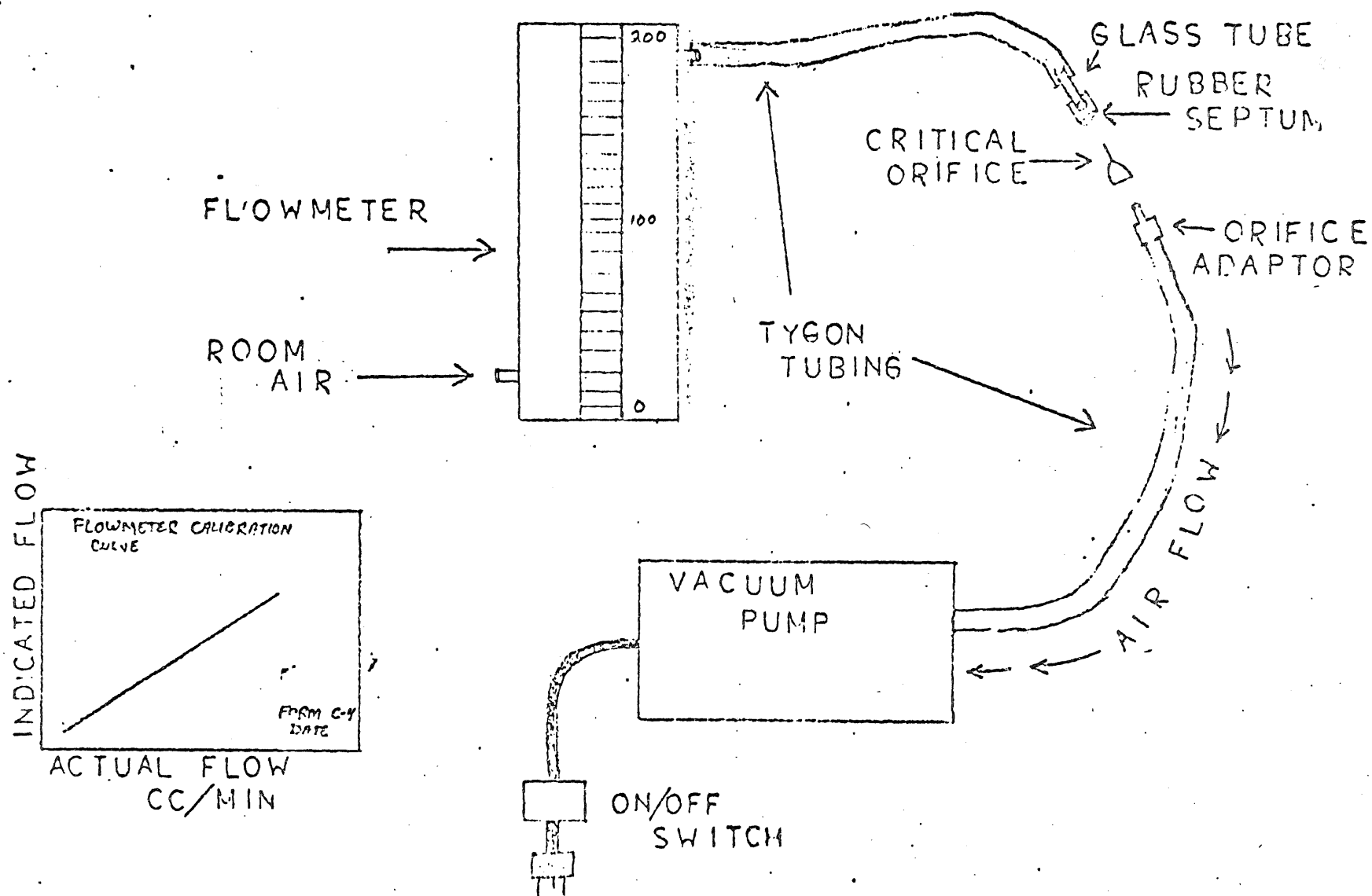
Glass tubing

Agency data sheet, bubbler identification card (#628)

C. Procedure

1. Assemble the apparatus as shown in Figure 1. Attach the critical orifice to the tygon tubing coming from the pump (an adaptor is required) and carefully insert the needle of the orifice into the septum.
2. Turn pump on.
3. Observe the indicated flow on the calibrated flowmeter. This air flow is converted to actual air flow using the flowmeter calibration curve.
4. Make sure the flowmeter I.D. number on the curve matches the flowmeter used. Locate the indicated flow on the vertical axis of the graph; follow this number horizontally until it intersects the drawn curve. At this point drop a perpendicular line to the horizontal axis. The point of intersection on the horizontal scale is the actual air flow rate (cc/min).
5. Discard needles not falling into the flow range 190 cc/min - 210 cc/min.
6. Record actual flow rates for each orifice on the appropriate form or card if the orifices are being sent to the field.

FIGURE 1: APPARATUS FOR CALIBRATING
CRITICAL ORIFICE



NITROGEN DIOXIDE

I. METHOD

Arsenite, 24-hour Sampling Reference Method.

II. PRINCIPLE

Nitrogen dioxide is collected by bubbling air through a sodium hydroxide-sodium arsenite solution to form a stable solution of sodium nitrite. The nitrite ion produced during sampling is reacted with phosphoric acid, sulfanilamide, and N-1-naphthylethylenediamine dihydrochloride to form an azo dye and then determined colorimetrically. The analysis range is 0.02 to 2.0 $\mu\text{g NO}_2/\text{mg}$. The addition of hydrogen peroxide before analysis eliminates the sulfur dioxide interference of azo dye formation.

III. PROCEDURE

1. Replace any water lost by evaporation during sampling by adding distilled water to bring the volume to 50 ml.
2. Pipet 5.0 ml of sample into reaction tube.
3. Add 0.5 ml H_2O_2 , 5.0 ml sulfanilamide, and 0.7 ml NEDA solution to each sample and mix.
4. Prepare a blank in the same manner with 5.0 ml absorbing reagent.
5. Prepare standards using 5.0 ml of absorbing reagent spiked with 50, 100, 150, etc. μl of the 50.0 $\mu\text{l}/\text{ml}$ standard.
6. After a 10 minute color-development interval, measure the absorbance at 540 nm on the spectrophotometer.
7. Calculate the $\mu\text{g NO}_2/50 \text{ ml}$ from the standard curve.
8. Dilute, with absorbing solution, samples having an absorbance greater than 2 $\mu\text{g}/\text{ml}$ (100 $\mu\text{g}/50 \text{ ml}$).
9. Plot the accuracy and precision data.

IV. REAGENTS

1. Absorbing Reagent: Dissolve 4.0 g NaOH in about 700 ml distilled water, add 1 g NaAsO₂ and dilute up to 1 liter.
2. Hydrogen Peroxide: Dilute 0.2 ml of 30% H₂O₂ to 250 ml distilled water. Refrigerate, stable for one month.
3. Sulfanilamide: Dissolve 20 g in 700 ml distilled water. Add 50 ml conc. Phosphoric acid, dilute to 1 liter. Stable for 1 month at 40° F.
4. NEDA Solution: Dissolve 0.5 g NEDA in 500 ml distilled water. Stable for one month if refrigerated and protected from light.
5. Standard Nitrite Solution: (1000 µg/ml) Dissolve 1.5464 g NaNO₂ in distilled water, dilute to 1 liter.
6. Working Standards: 25, 50, 75, 100 µg/50 ml are prepared for the calibration curve.

V. CALCULATIONS

Read the blank corrected absorbances and determine the concentration in µg/50 ml NO₂ from the standard curve.

VI. INSTRUMENTS

Spectrophotometer, Beckman ACTA IV.

Settings: Wavelength - 540 nm

Absorbance = 0. - 1.0

Slit Width = 1.0 to 1.5

Mode = DB Servo

VII. METHOD SOURCE

Federal Register, Volume 38, Number 110, Friday, June 8, 1973.

Pages 15174-15177.

SULFUR DIOXIDE

I. Principle - Reference Method

Sulfur dioxide will be absorbed when a measured air sample is bubbled through a solution of sodium or potassium tetrachloromercurate. The formation of a dichlorosulfitomercurate complex resists oxidation by air, thereby allowing delay time for sample transportation to the laboratory for analysis.

The colorimetric analysis is facilitated by the formation of a highly colored pararosaniline methyl sulfonic acid upon the addition of a bleached pararosaniline dye. The sulfonic acid complex behaves as a pH indicator. The presence of the sulfonic acid complex is then measured by a spectrophotometer.

II. Procedure

- 1) Bring samples up to volume with TCM absorbing solution.
- 2) Transfer 4 ml of samples (4 ml of TCM for blanks and standards) to reaction tubes.
- 3) Prepare standards and spiked samples by adding sulfite standard using Eppendorf pipet (50, 100 ml).
- 4) Add .4 ml 0.6% sulfamic acid -- wait 10 minutes
- 5) Add .8 ml 0.2% Formaldehyde solution.
- 6) Add 2.0 ml Pararosaniline dye.
- 7) Add 2.8 ml distilled water and mix.
- 8) After 30 minutes and before 60 minutes, determine absorbances on a Spectrophotometer.

SULFUR DIOXIDE (Continued).

III Reagents

1) Absorbing Reagent (0.04 M TCM)

Dissolve 10.86 g mercuric chloride, 0.066 g EDTA and 6.0 g potassium chloride in water and bring up to volume of 1 liter.

2) Sulfamic Acid (0.6%)

Dissolve 0.6 g sulfamic acid in 100 ml distilled water. Prepare fresh for each batch analysis.

3) Formaldehyde (0.2%)

Dilute 0.5 ml of 36-38% formaldehyde solution up to 100 ml with distilled water. Prepare fresh for each batch analysis.

4) Pararosaniline Working Dye

To a 500 ml volumetric flask, add 40.0 ml of stock pararosaniline solution and 50 ml of 3 M phosphoric acid. Mix. Dilute to volume with distilled water. The maximum absorbance must be at 540 nm in a .1 M sodium acetate-acetic acid buffer.

5) Sulfite Standard

Prepare the stock sodium sulfite (Na_2SO_3) solution and standardization as per Federal Register, Vol. 36, No. 84, Friday, April 30, 1971 (6.2.8).

SULFUR DIOXIDE (continued)

IV Calculations

Prepare a standard curve using the standards analyzed with the sample set. The slope must be in the range of 0.030 ± 0.002 absorbance units/ $\mu\text{g SO}_2$.

Report results in $\text{SO}_2/50 \text{ ml.}$

V Instruments

1. Spectrophotometer, Beckman ACTA MIV

SETTINGS: Wavelength = 548 nm.

Absorbance = 0. - 1.0

Slit width = 1.0 to 1.5

Mode = DB SERVO

DATA ANALYSIS PROCEDURE 3
Bubbler (SO₂ and NO₂) Procedure

A. General

The bubbler data analysis procedure details the steps involved in bubbler data handling from dispensing samples to final editing of the data.

B. Equipment

Color coded bubbler tubes and solution

Data log card #628

Form DA #9, Bubbler Analysis Coding Sheet

Form DA #3, Coding Sheet Log

Form DA #2, Bubbler Log Sheet

Form DA #4, Laboratory Sample and Accounting Record

C. Procedure

1. Bubbler solutions are obtained each month from the MDH laboratory in color coded tubes (red tubes - SO₂; blue tubes - NO₂) containing 50 ml of the appropriate absorbing reagent. Tubes are stored in a cupboard in the MPCA laboratory.
2. Color coded bubbler tubes are dispensed from MPCA to the local agencies as needed; a month's supply of tubes is delivered to outstate volunteers while local agencies pick up their tubes each month. Metro personnel deliver tubes to the site as scheduled (1 time per 6 days).
3. a) Bubbler tubes and calibrated critical orifices are dispatched to the monitoring site; the screw on cap is removed and the color coded tube is inserted into the proper sampling train position; the critical orifice is installed. The bubbler is ready for sampling on the once per 6 day schedule.

b. The bubbler tube which has run for the 24 hour sampling period is removed as soon as possible after the run and capped. Light exposure should be minimized.

c. Sampling site number, operator initials and date of run are recorded on both the data log card #628 and the bubbler tube. Pollutant flow and time of exposure are recorded on the data log card as well as any comments about the sample (e.g., equipment failure, frozen samples, etc.) Critical orifice is calibrated after each run; start and finish flow are averaged for final flow.

4. The data log card is attached to the tube and the sample is returned to MPCA under refrigeration as follows:

1) Metro personnel - deliver directly to MPCA after each sample run.

2) Local agencies - store bubblers in refrigerator no longer than 30 days before returning to MPCA.

3) Volunteers - Store bubblers in refrigerator no longer than 30 days before MPCA personnel picks up bubblers for return to MPCA.

5. At MPCA samples are immediately placed in the calibration room refrigerator; data log cards (#628) are returned to the Data Analysis Section.

6. a) At MPCA, site number, date of run, time of exposure and flow are copied from the data log card (#628), to Form DA #9, Bubbler Analysis Coding Sheet.

b) At local agencies the items listed in 6.a) are copied onto Form DA #9 which is submitted to MPCA along with the bubblers at the end of each month.

7. If the data log card has noted any problems encountered during the course of the sampling run an error code may be assigned as follows:

- 2 MPCA personnel
- 3 laboratory
- 4 equipment/operator error
- 5 vandalism
- 6 natural (rain, wind)
- 7 equipment failure
- 8 generated by computer, quality assurance

The laboratory may assign codes -2 or -3; operators may assign and code except -3 or -8; -8 is a quality assurance code and can only be assigned by the computer.

8. Data cards are filed for future reference.

9. Each page of the Bubbler Analysis Coding Sheet, Form DA #9 is assigned a sequential sheet number (the starting value is taken from the last coding sheet log, Form DA #3). The sheet number is then copied to the Bubbler Log Sheet, DA #2 for the appropriate site along with sampling date, time and flows for SO₂ and NO₂ samples, error codes, and any additional comments about the sample.

10. On Tuesday and Friday mornings all data sheets (DA #9) which are ready to be sent with the bubbler samples to the laboratory are logged on the coding sheet log (DA #3). Sheet number are date samples will be taken to the laboratory are entered in the coding sheet log with the description "bubbler samples."

Data sheet numbers and total number of samples are logged

on the Laboratory Sample and Accounting Record, Form DA #4 is completed in duplicate.

11. On Tuesday and Friday afternoons all coding sheets logged to the laboratory and their corresponding samples are taken to the laboratory. The laboratory verifies the Laboratory Sample and Accounting Record, signs both copies, retains one and the other to the MPCA.

12. The laboratory analyzes the bubblers and records SO₂ and NO₂ concentration in ug/50 ml on Form DA #9.

13. All Form DA #9 sheets completed by the laboratory are returned to the MPCA and logged on the coding sheet log (DA #3) in the "Date from Lab" column for that coding sheet number. DA #9 data sheets are manually edited to remove irregularities in coding and reporting of data. Invalidated data points are assigned an appropriate error code enumerated in Step #7.

14. All completed, DA #9 edited coding sheets are logged out in the "date to keypunch" column for that coding sheet number. All sheets are taken to keypunch on Tuesday and Friday afternoons.

15. Bubbler samples are keypunched on brown stripped cards.

16. All completed cards and DA #9 coding sheets are retrieved from keypunch, returned to the MPCA and logged in under the "date from keypunch" column for the coding sheet number on the coding sheet by (DA #3). Form DA #9 is filed by month and location.

17. Keypunched cards are edited via the PDP 8/E computer.

Edit checks are made for illegal characters on the card, date within specified range, number of data items on the card either 6 or 7, time between 1320 and 1560 minutes, and flow between 180 and 220 cc/min. Calculated values for SO₂ and NO₂ are computed and printed out with the card. Cards with edit errors are flagged with the word check next to the results. A detailed list of all cards in error and appropriate error description is printed on the line printer.

18. Key punch errors are corrected as found. Coding of values in error is verified and if possible corrected. A listing of results for each local agency is dispatched to that agency for error checking and result verification.

LOCATION _____

DATE _____

POLLUTANT _____

MINUTES FINISH _____

START _____

TOTAL _____

COMMENTS _____

Flow start _____
finish _____
ave. _____

Initials

628

Page 7 of 1

BUBBLER ANALYSIS CODING SHEET

[illegible]

BUBBLER SITE #

Page 8 of 1

KHM

[illegible]

LABORATORY SAMPLE AND ACCOUNTING RECORD

THE ANALYTICAL LABORATORY SECTION OF THE MINNESOTA HEALTH DEPARTMENT
ACKNOWLEDGES RECEIPT OF:

_____ SO₂ BUBBLER SAMPLE(S)
_____ NO₂ BUBBLER SAMPLE(S)
_____ HIVOL FILTER SAMPLE(S)
_____ METALS

AND THE CORRESPONDING DATA SHEETS FOR THE ABOVE:

DATA SHEET #

DATA SHEET #

DATA SHEET #

ON THIS DATE OF _____ BY _____

RESULTS DUE OUT BY _____

PLEASE FILL OUT THIS FORM IN DUPLICATE

APPENDIX A-5

INSTRUMENT MANUALS AND PRODUCT INFORMATION

Because of its size, the Philips Model 9700 instrument manual is not included here. Please ask for this manual separately or see a Philips salesperson to see how you may obtain a copy. Copies are available for inspection at the Minnesota Pollution Control Agency or the Ely office of the Regional Copper-Nickel Study.



ANALYTICAL EQUIPMENT

SO₂ Monitor PW 9700

for air pollution monitoring

Air pollution is one of the biggest problems facing industrial countries in the coming decade. It can be cured. But before it can be cured economically it must be traced accurately.

The Philips monitor PW 9700 does just that. SO₂ is universally acknowledged to be the best tracer for general air pollution. This is because it is usually present in the fumes of combustible materials such as oil and coal. Moreover it is offensive to the human nose and readily forms corrosive sulphuric acid. Therefore Philips have concentrated on the accurate and economic detection and measurement of SO₂. The resultant monitor

PW 9700 is easy to install and to service and provides remotely controlled, unattended operation for 3-month periods. It can be used in simple, single monitor installations or in complex, multiple detector systems. And in this latter area Philips have the hardware, software and experience to provide complete air pollution monitoring and control systems.

3 months automatic, unattended operation

Remotely controlled calibration using built-in SO₂ source

Highly selective

Scientifically designed air intake

Suitable interface for telemetry data transmission

Multiple installations easily incorporated into data handling systems

Easy to install - easy to service

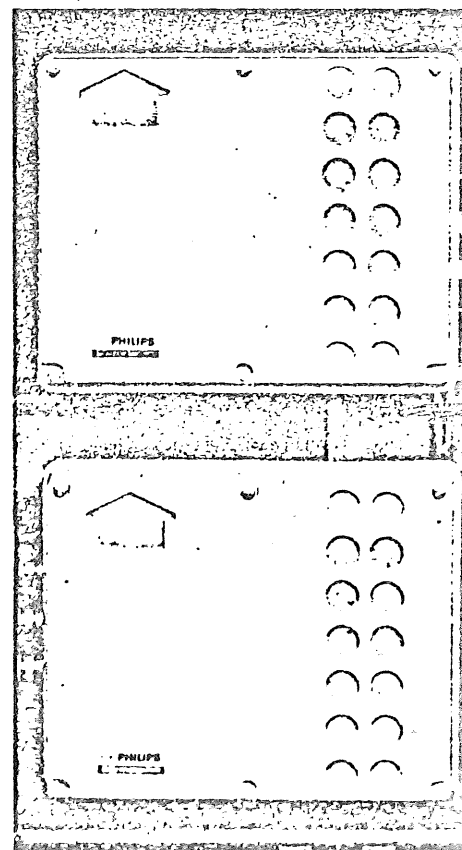
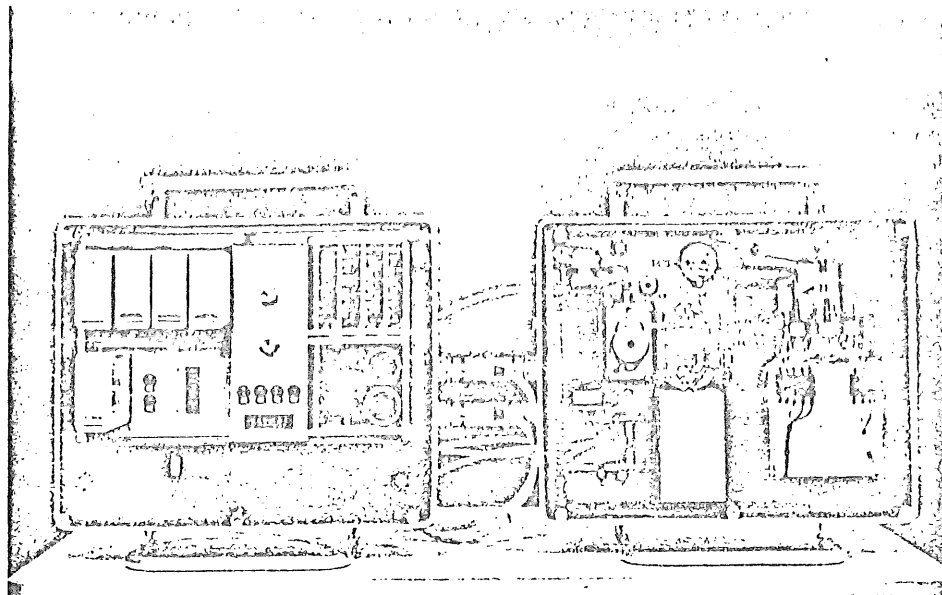


Fig. 1. The PW 9700 is arranged in two modules, electronics on the left and chemistry on the right.



Automatic operation

The PW 9700 has been designed to give trouble-free, automatic operation for 3-month periods. Calibration and zero checks must therefore be made automatic, and this condition is met by a remote controlled three-way valve. (Manual operation inside the monitor is also possible).

With the valve switched to the "zero check" position the air from the intake flows through an activated charcoal filter (see Fig. 2) to remove the SO_2 and then passes to a measuring cell free of SO_2 . The resultant signal from the generator electrodes then represents the zero level.

With the valve switched to the "calibration" position the air passes through the same charcoal filter, then through an internal SO_2 source (see Fig. 3) and then to the measuring cell. This internal SO_2 source delivers a constant flow per unit of time and the resultant electrical signal will thus provide a calibration level.

With the valve in the normal "measurement" position the active coal filter is bypassed and the air only passes through the series filter. In this other filter the air comes in contact with a heated silver wire which eliminates any hydrogen sulfide, ozone and Cl_2 that would otherwise interfere with the SO_2 reading.

How it works

The purpose of the monitor is to convert the local SO_2 air concentration into an electrical signal. This can then be read in situ or transmitted to a central point for reading, analysis, storing, etc.

The first requirement is to purify the air from dust, ozone, hydrogen sulfide and other interfering substances. These filters have been described earlier. The purified air is then passed at a rate of about 150 ml/min to an aqueous solution of KBr , Br_2 and H_2SO_4 .

With the aid of two electrodes in this solution the concentration of free bromine is converted

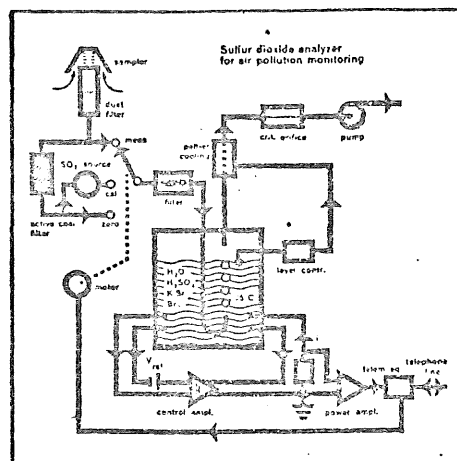


Fig. 2. Schematic of the monitoring system. Note the arrangement of programmed switching for calibration and zero point check in order to allow for unattended operation.

ed into a redox potential which is compared with a known voltage. The difference between both voltages is converted by electronic means into an electrical current through two other electrodes (the generator electrodes). This current converts bromide ions into free bromine.

This system keeps the concentration of free bromine constant, because when the concentration comes below a certain level new bromine is generated. The current needed for this reaction is directly proportional to the quantity of used bromine, while the consumption of the bromine depends on the quantity of SO_2 which is led through the cell and reacts with bromine. The above-mentioned current through the generator electrodes defines the output signal which is directly proportional to the quantity of SO_2 . The air-stream is kept constant with the aid of a critical orifice, and a vacuum pump.



Fig. 3. Close up of "chemistry" module shows measuring cell on the right, SO_2 internal source on the left.

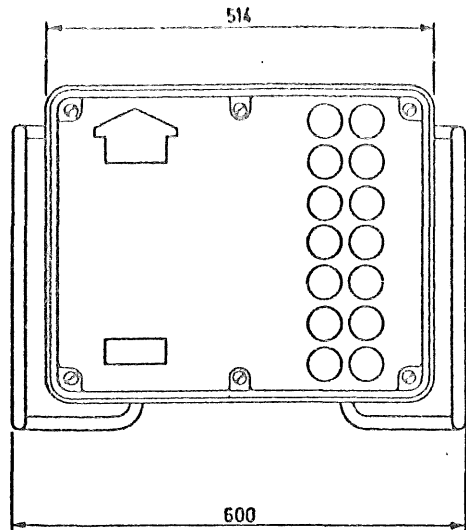
Maintenance of water level

The level of the electrolyte could sink to an inadmissible level because of water evaporation from the measuring cell. Whenever the level of the liquid in the cell goes below a certain limit, a cooling device, located just above the cell, is activated, cooling the air and causing the water vapour to condense and drip back into the cell.

Separate air intake

As can be seen in Fig. 4 the air intake is separate to the actual monitor. It can be fitted to the top of, a streetlamp if this is more convenient.

The intake is provided with a glass fibre filter to remove dust and heated to avoid SO_2 absorption. On the outside, a steel gauze cover prevents the intake of large dust particles and insects.



Dimensions in mm

TECHNICAL SPECIFICATIONS

Design

The chemical part is contained in a portable glass-fibre-reinforced polyester box. This box stands on the ground or is hung on a wall. In this "chemical" box the highest electric potential is less than 36 volts, for safety reasons.

The electronics, pump and telemetering system are built in a similar box. The two boxes are interconnected by means of water-tight tubes and jacks. The dust filter and the suction lead form a separate flexible unit which can be connected easily to the measuring instrument.

Measuring range

0-3 mg/m³ (1.15 ppm). Other ranges between 0-1 and 0-10 mg/m³ can easily be realised.

Output signal (before telemetry)

0-20 mA, into a resistance of 0-300 ohm.

Response time

Approx. 1½ minutes (63% of final value).

Approx. 3 minutes (95% of final value). It is possible to change the time constant to larger values.

Accuracy (overall, absolute)

Better than 15% of the measuring signal, or better than 0.01 ppm (25 µg/m³ for a SO₂ concentration smaller than 0.07 ppm (200 µg/m³) SO₂ (provided that a calibration cycle is performed once a day). This accuracy depends to a large extent on the accuracy of the wet chemical calibration of the SO₂ source (West & Gaeke Method).

Reproducibility

Better than 2% of the measuring signal.

Detection limit

Smaller than 10 µg/m³ SO₂ (4 ppb).

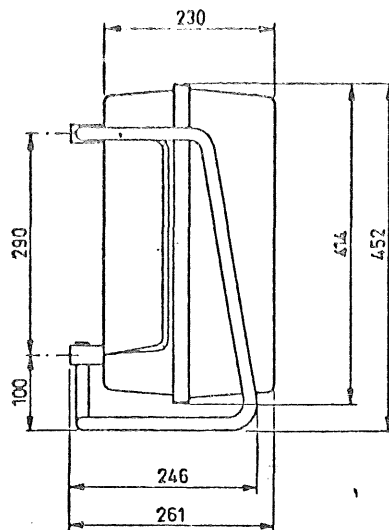


Fig. 4. The PW 9700 lends itself to installation in typical roadside housings for unobtrusive operation.

Size of zero-current

Same as a measuring signal in the order of 100 µgSO₂/m³.

Drift of the zero signal

Smaller than 25 µg/m³ a day, not cumulative.

Influence of 10% mains variation

Negligible.

Climatological influence

The zero-current variation per 10°C is smaller than a measuring signal corresponding to 25 µg/m³ SO₂ (between 0 and +35° C.).

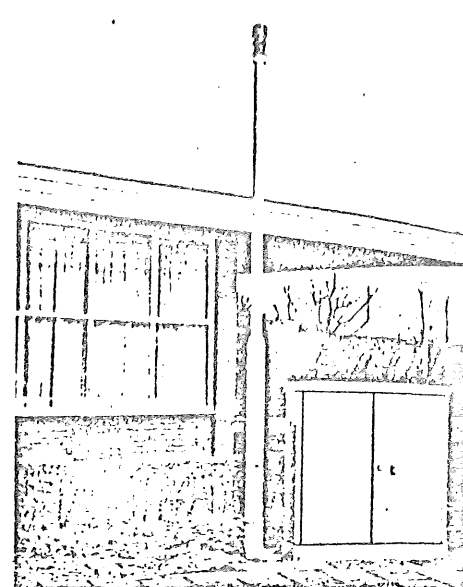
Selectivity

This is defined by $S = \frac{\text{interference sensitivity}}{\text{signal 0.5 ppm SO}_2} \times 100\%$

$$\frac{\text{signal 0.5 ppm X}}{\text{signal 0.5 ppm SO}_2} \times 100\%$$

| X | S |
|---------------------|----------|
| NO ₂ | < 5% |
| O ₃ | < 1% |
| H ₂ S | < 1% |
| Methyl mercaptans | > 100% + |
| Ethene | < 2% |
| Cl ₂ | < 2% |
| NO | < 1% |
| Aldehydes | < 1% |
| Benzene, chloroform | < 1% |
| CS ₂ | < 1% |

+ The large mercaptan interferences give no practical problem because of the extreme low average concentrations in the air.



Calibration and zero point check

Periodically the zero-current can be remotely checked. Air, free from SO₂, passes through the measuring cell for a period of time. Calibration can then be performed with the aid of an SO₂ source. This source delivers an exactly known amount of SO₂ which is added to the clean air.

The amount of SO₂ coming from the source does not decrease more than 5% over 3 months.

An example:

15 min. zero current check, 15 min. calibration, 12½ hour measuring. This cycle can be performed remotely controlled or by hand.

Weight

Complete 65 kg.

Power supply

110, 125, 145, 220, 235 or 250 (± 10%) V, 47-63 Hz, 125-150 VA.

Maintenance

3 months of continuous operation without the need for service and/or maintenance.

ORDERING INFORMATION

A complete SO₂ monitor can be ordered under type number PW 9700/00. It consists of

| | |
|--|----------------|
| 1 chemical unit | PW 9710/00 |
| 1 electrical unit | PW 9720/00 |
| 1 sampling unit with approx. 5 metres of teflon tubing | PW 9730/00 |
| 1 bottle with 800 cm ³ electrolyte | PW 9711/00 |
| 1 SO ₂ calibration source | PW 9740/00* |
| 1 box with 100 glass fibre filters | 4022 198 03590 |
| 1 service documentation connection cables, tubing and other accessories. | |

* For low measuring ranges PW 9740/10
For high measuring ranges PW 9740/20

SO₂ MONITOR PW 9700 MEETS ALL SYSTEMS REQUIREMENTS

Fig. 5. Schematic of simple installation having direct links to recorder.

Fig. 6. A more complex telemetry system using commercial telephone lines.

Fig. 7. A highly sophisticated network using telemetry transmission to a central computer.

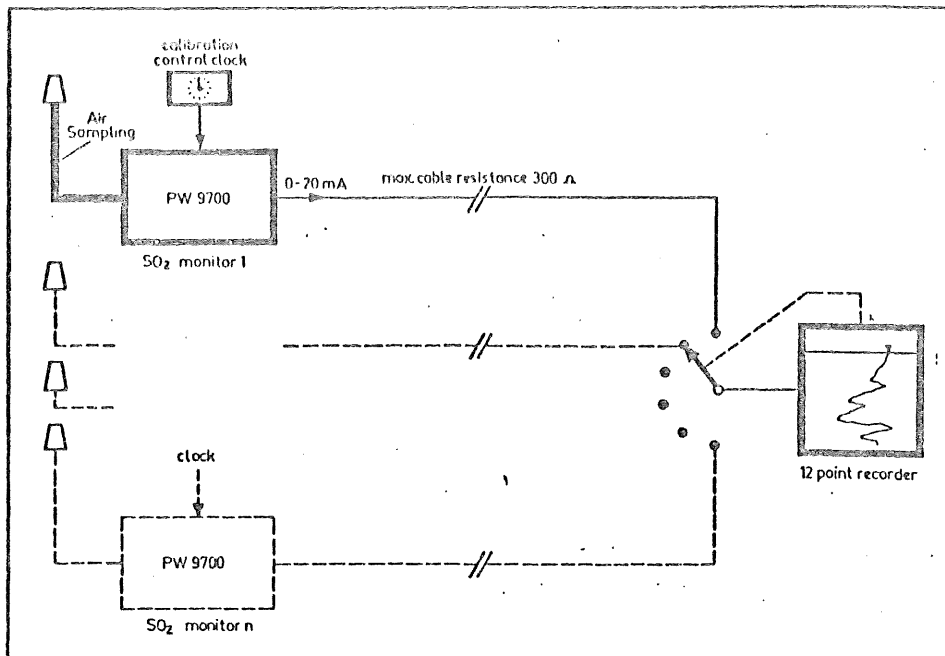


Fig. 5

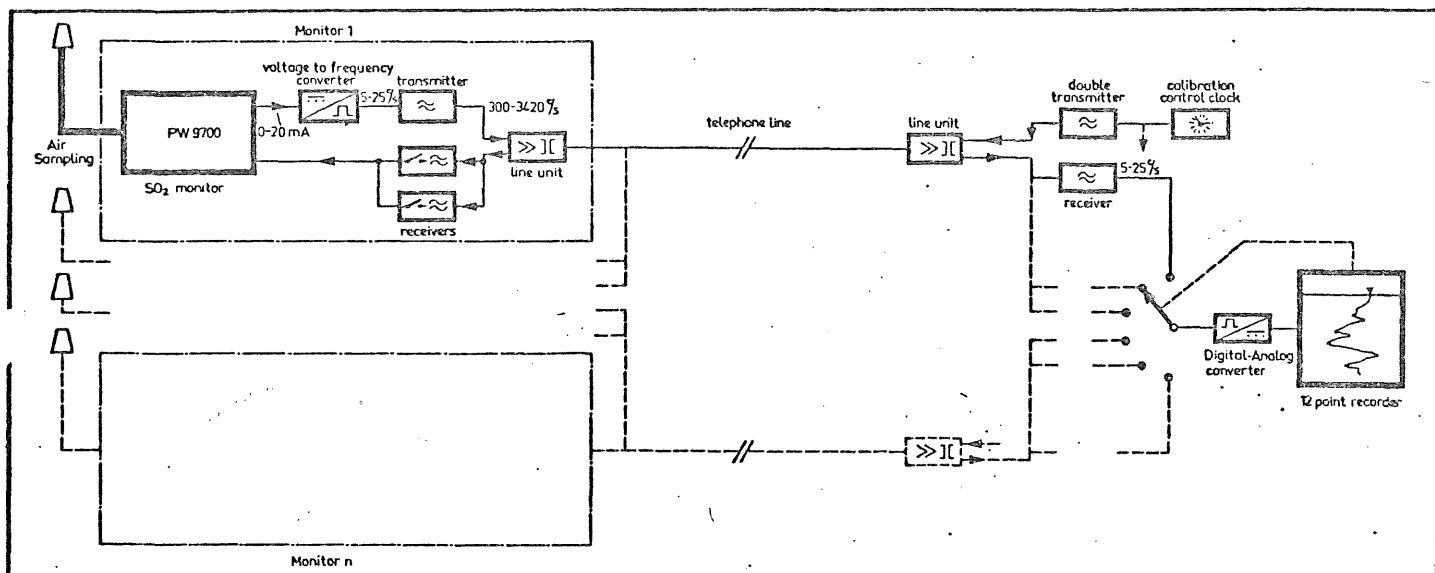


Fig. 6

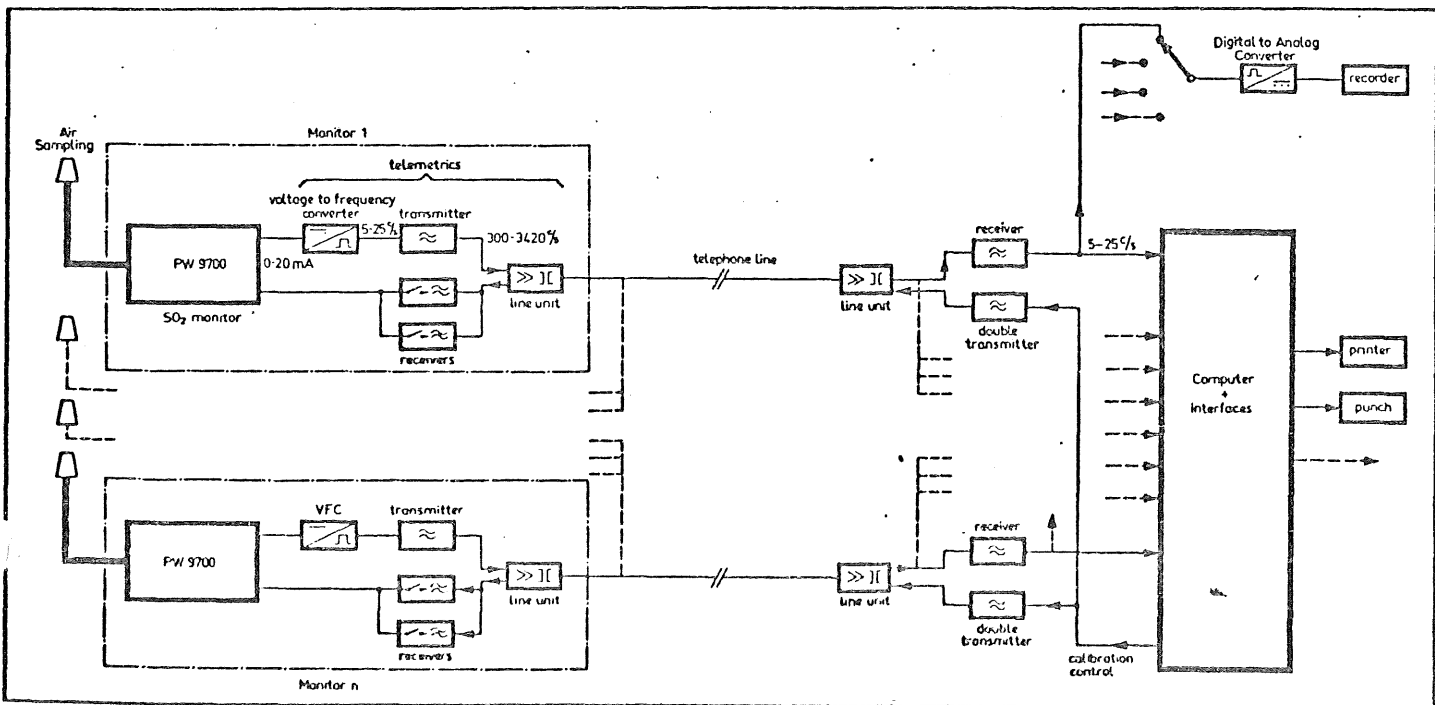
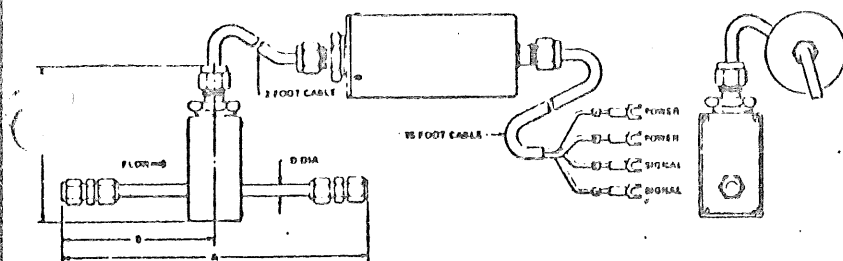


Fig. 7

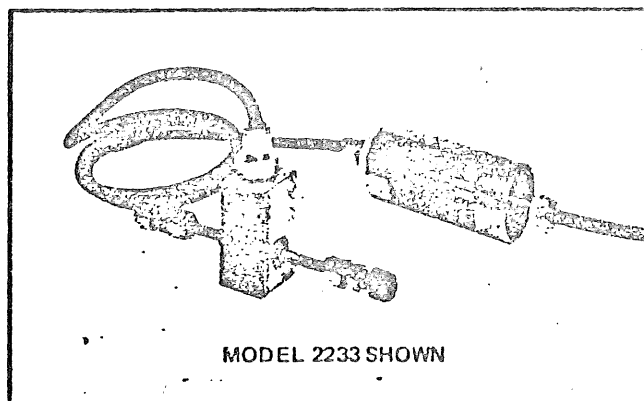


MODEL 2231-2234

- 1) Flow body construction of 300 Series stainless steel.
- 2) Finish: Flow tube is sand blasted and meterhousing is vinyl clad.

| Model | A | B | C | D | Throat Diameter | Swagelok Fitting Supplied |
|-------|-----|-----|-----|------|-----------------|---------------------------|
| 2231 | 6.4 | 3.2 | 3.2 | 1/8" | 0.013 | 1/8" |
| 2232 | 6.4 | 3.2 | 3.2 | 1/8" | 0.02 | 1/8" |
| 2233 | 6.6 | 3.4 | 3.2 | 1/4" | 0.06 | 1/4" |
| 2234 | 9.5 | 5.8 | 3.2 | 1/2" | 0.188 | 1/2" |

Dimensions in Inches



MODEL 2233 SHOWN

GROUP 2230

MODELS
2231 thru 2234

FAST RESPONSE
QUARTZ HOT FILM SENSOR

TRANSIENT FLOW AND
LOW FLOW APPLICATIONS

GENERAL DESCRIPTION

Models in this group utilize TSI proven hot film sensors as the thermal element. These yield faster response than metal sheathed elements; however, they are not as rugged. Therefore, it is recommended that the flow stream be filtered to remove particulate matter. The small element size allows manufacture in sizes for extremely low flows.

SPECIFICATIONS:

Input voltage: 11.2 to 15V DC or TSI 1605 Power Pack or Type 62, 64, 67, 70 conditioners.

Input current: 250 ma max.

Output voltage: 0.3 to 2.5V (approximate)

For linear voltage or current output, see signal conditioners Models 62, 64, 67 & 70.

Output impedance: 100 ohm

Accuracy: $\pm 2\%$ reading $\pm 0.05\%$ F.S.

Repeatability: $\pm 0.1\%$ of reading $\pm 0.01\%$ F.S.

Rangeability: 100:1

Response time: 5 ms

Fluid Temperature Range: 0-200°F (-18 to 100°C)

Environmental Temperature Range: 0-130°F (-18 to 50°C)

Flow Media: Air and most other gases (5m filtration recommended)

Standard Calibration Range: Each meter is supplied with calibration of 15 points over the full scale range. Calibration pressure is 1 atmosphere (15 psia) and 21°C (70°F).

Temperature Compensation Range: 32°-150°F (0-65°C)
Other ranges on request.

Pressure Compensation Range: 15 \pm 3 psia (0.8-1.2 atmosphere)

Standard Equipment: Each unit is supplied with calibration data, 15 foot power/output cable and instruction manual.

Flow Connections: Standard units in the Group 2230 are supplied with compression type connections.

APPLICATIONS

- Gas flow metering in semi-conductor manufacture.
- Gas flow meter calibration stands
- Air gauging of carburetor jets and venturis
- Leakage flow measurement
- Transient flow research

| Model | Flow Range (1) | | Pressure Rating (2) (Atmospheres) | Pressure Drop (3) (Inch H ₂ O) |
|-------|----------------|---------------|--------------------------------------|--|
| | SCFM | SCCM | | |
| 2231 | 0.00015-0.015 | 5-500 | 70 | 10 |
| 2232 | 0.0003-0.03 | 10-1000 | 70 | 10 |
| 2233 | 0.003-0.3 | 100-10,000 | 70 | 10 |
| 2234 | 0.03-3.0 | 1,000-100,000 | 70 | 2 |

(1) Range at one atmosphere and 0°C. See chart for sizing at other pressures.

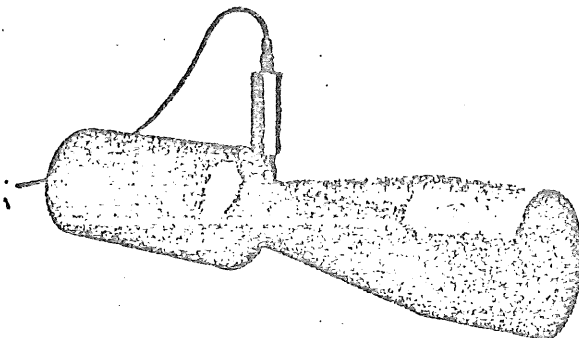
(2) Maximum safe working pressure at room temperature.

(3) For air at one atmosphere and full scale flow.

• See accuracy discussion

LINEAR OR NON-LINEAR OPERATION

SERIES 2000 FLOWMETERS MAY BE USED ALONE
PROVIDING A NON-LINEAR OUTPUT



FOR A LINEAR OUTPUT, SELECT ONE OF
FOUR CONVENIENT SIGNAL CONDITIONERS TO
ACCOMPANY YOUR SERIES 2000 METER

ALSO AVAILABLE

NON-LINEAR OUTPUTS

Any Series 2000 Flow Meter may operated in the non-linear mode with additional circuitry.

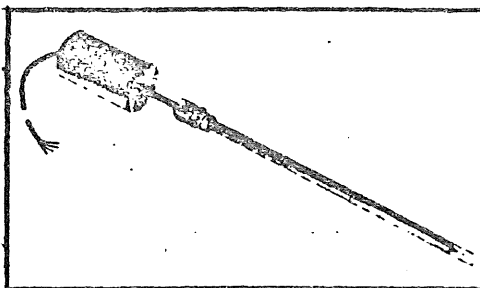
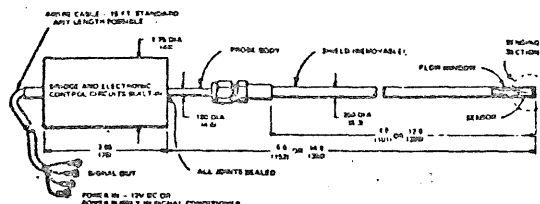
It is only necessary to supply power (11.2-15V DC). The impedance, high level PDM output may conveniently monitored on a digital, analog panel meter or chart recorder.

LINEAR OUTPUTS

Connect your Series 2000 Flow Meter to one of these 4 signal conditioners for direct reading and linear analog electrical outputs.

These conditioners also supply power to the transducer. Rear barrier strip terminals make hook-up easy.

Cable length between meter and conditioner is not critical. Up to 500 feet without modification.



MODEL 1610

AN INSERTION PROBE

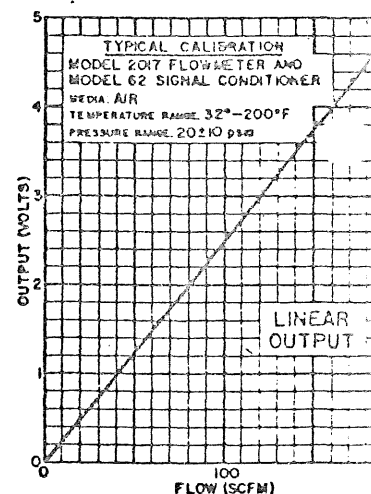
GENERAL DESCRIPTION

Model 1610 immersion probes utilize the same sensor and control circuit design as group 2010. When placed into a large duct or pipe, these probes provide an electrical signal proportional to the density-velocity (DV) product at the probe tip. Therefore, by traverse, a calibration curve relating pipe mass flow (total SCFM) versus output voltage can be established.

SPECIFICATIONS

Electrical: Same as Group 2010
Range: Standard range 0-200 ft/sec
Calibration: Each probe supplied with air calibration of 0-200 ft/sec @ 1 atmosphere. Other ranges on request.
Dimensions: Diameter: 0.25"
Length: Model 1610-4 is for 4"
Model 1610-12 is for 12"

Cable: 15' standard
Environmental Conditions:
Sensor Section: Temperature 20°C to 100°C
Pressure 0.1 to 500 psia
Electronics Section: 0-70°C



SPECIFICATIONS COMMON TO ALL LINEAR CONDITIONERS PICTURED

Power Input: 110/230 VAC, 0.5 ampere
Output: linear & non-linear
Range: 0-5V DC
Impedance: 50 ohm
Connections: Barrier strip type - 5 terminals
Linearity: $\pm 1\%$ reading $\pm 0.05\%$ FS
Response: Same as Series 2000 Flow Meter.
Controls: Zero and Span (internal)
Temperature Stability: $\pm 0.025\%/^{\circ}\text{C}$
Temperature Range: 0 to 120°F (M 62: -20 to 120°F)
Each linear conditioner is factory calibrated for a particular Model 2000 Flow Meter.

POWER SUPPLIES

In the non-linear mode you may supply your own power to the transducer. The transducer requires a DC voltage of 11.2 - 15V input. Power requirement 5 watts maximum.

or

TSI MODEL 1605 POWER SUPPLY



110° VAC
Input Handy
connections
for flow meter
and signal.

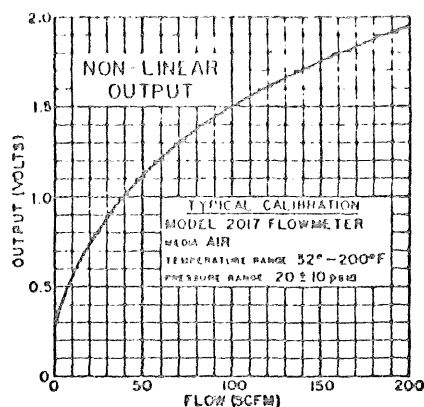
*Model 1606 for 230VAC.

APPLICATIONS

A typical non-linear output voltage calibration is pictured to the right.

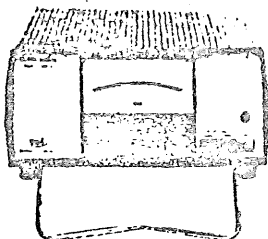
Applications include:

1. Flow situations where calibration curve look up is feasible for the operator.
2. Control applications where one set point is desired to be maintained.
3. Computer acquisition where the computer can convert this voltage to flow values.



TYPICAL NON-LINEAR

MODEL 64



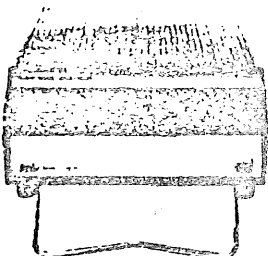
DESCRIPTION

Model 64 provides a visual analog output with two scales. Switch chooses 10% or 100% full scale ranges. Rugged aluminum cabinet is suitable for bench operation in laboratory or factory.

SPECIFICATIONS

Meter: 3" mirrored
Ranges: Switch selectable, 10 & 100% FS
Transducer Input/Power: Rear barrier strip
Outputs: Rear 0-5V linear, 50 ohm impedance
Housing: Extruded Aluminum black anodized
Weight: 6.5 pounds
Size: 8.5" w x 3.5" h x 11" d

MODEL 67



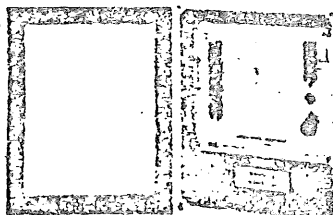
DESCRIPTION

Model 67 provides a direct reading digital output of flow rates from any Series 2000 transducer. Analog output voltage for recording is provided. Package is suitable for laboratory or factory bench operation and can be rack mounted.

SPECIFICATIONS

Meter: 3 1/2 digit readout
Meter Accuracy: .01% FS ± 1 digit
Ranges: Direct reading on digital meter in flow units for transducer selected.
Transducer Input/Power: Rear barrier strip
Outputs: Rear 0-5V linear, 50 ohm impedance
Housing: Extruded aluminum black anodized
Weight: 6.5 pounds
Size: 8.5" w x 3.5" h x 11" d

MODEL 62



DESCRIPTION

Model 62 features a rugged industrial enclosure housing the linearization circuitry. This "no control" package is recommended for remote readout applications. Standard output is analog voltage (0-5V). Options commensurate with industrial requirements available including 1-5V, 4-20 milliamperes and 10-50 milliamperes.

SPECIFICATIONS

Transducer Input/Power: Rear barrier strip
Outputs: 0-5V linear over flow range (consult factory for current and live zero options)
Housing: Vinyl clad welded steel gasketed enclosure. Mounting lugs for installation as shown.
Service connections: Via industrial compression fittings to accept # 12 Neoprene transducer cable, power cable and signal output cable.
Weight: 11.2 pounds
Size: 8.5" w x 11.5" h x 4.4" d

MODEL 70/71

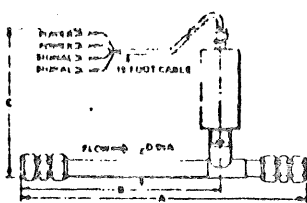


DESCRIPTION

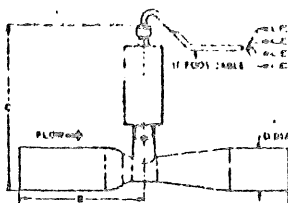
Model 70/71 - These models provide multi channel linearizing capability for the 2000 Series Flow Meters. Model 70 has no readout - Model 71 has digital readout and channel selector switch. One chassis holds up to 12 linearizing circuits via convenient slides behind front panel. All transducer power and signal connections are on industrial rated rear barrier strip.

SPECIFICATIONS

Meter: Model 70 - none
Model 71 - meter similar to Model 67 above
Meter selection switch: Model 70 - none
Model 71 - 12 position
Transducer Input/Power: Rear barrier strip - Screw terminals
Outputs: 0-5V rear barrier strip
Linearizer circuit boards: slide in circuit board behind front panel - up to 12 possible.
Input Power: 110/230 VAC, 400 watts with 12 flow meters
Weight: 16.5 Pounds
Size: 17.7" w x 5.25" h x 13.5" d
Options: High/low limit allowance, totalizer and current output boards available - consult factory.
Hardware available for standard 19" instrument rack



MODEL 2011-2012

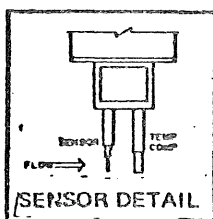


MODEL 2013-2019

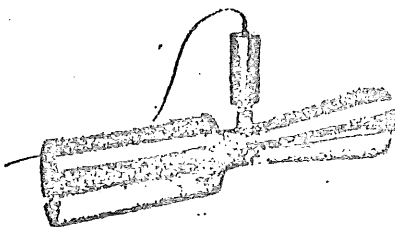
- 1) Flow body construction of 300 Series stainless steel.
- 2) Finish: Passivated.

| Model | A | B | C | D | Throat Diameter | Wall Thickness |
|-------|------|------|------|------|-----------------|----------------|
| 2011 | 7.5 | 5.7 | 6.2 | 0.5 | 0.22 | 0.049 |
| 2012 | 10.9 | 8.4 | 6.5 | 0.75 | 0.34 | 0.049 |
| 2013 | 14.2 | 11.0 | 6.5 | 1.0 | 0.50 | 0.049 |
| 2014 | 10.2 | 5.2 | 7.2 | 1.5 | 0.75 | 0.065 |
| 2015 | 12.4 | 5.5 | 7.5 | 2.0 | 1.0 | 0.065 |
| 2016 | 17.2 | 8.0 | 8.2 | 3.0 | 1.5 | 0.065 |
| 2017 | 22.7 | 10.5 | 9.0 | 4.0 | 2.0 | 0.065 |
| 2018 | 33.0 | 15.3 | 10.5 | 6.0 | 3.2 | 0.065 |
| 2019 | 42.8 | 20.5 | 12.2 | 8.0 | 4.5 | 0.065 |

All Dimensions in Inches



SENSOR DETAIL



MODEL 2016 SHOWN

GROUP 2010

MODELS
2011 thru 2019

LOW RESPONSE
METAL CLAD SENSOR

INDUSTRIAL AND GENERAL
GASEOUS FLOW MEASUREMENT

GENERAL DESCRIPTION

These models feature a drawn tubular nickel sheath over the sensing element. This construction has the appearance and durability of a hypodermic needle. All units of this series are easily disassembled for routine sensor cleaning. Flow tubes are stainless steel.

SPECIFICATIONS:

Input voltage: 11.2 to 15V DC or TSI 1605 Power Pack or Type 62, 64, 67, 70 conditioned.

Output current: 250 ma max.

Output voltage: 0.3 to 2.5V DC (approx)

For linear voltage or current output, see signal conditioners Models 62, 64, 67 & 70.

Output impedance: 100 ohm

Accuracy: $\pm 2\%$ reading $\pm 0.05\%$ FS *

Repeatability: $\pm 0.1\%$ of reading $\pm 0.01\%$ F.S.

Rangeability: 100:1

Response Time: 100 ms **

Fluid Temperature Range: 0-200°F (-18 to 100°C)

Environmental Temperature Range: 0-130°F (-18 to 50°C)

Flow Media: Air and most other gases.

Standard Calibration Range: Each meter is supplied with calibration of 15 points over the full scale range. Calibration pressure is 1 atmosphere (15 psia) and 21°C (70°F).

Temperature Compensation Range: 32°-150°F (0-65°C) Other ranges on request.

Pressure Compensation Range: 20 \pm 10 psia (0.5-2 Atmosphere)

Standard Equipment: Each unit is supplied with calibration data, 15 foot power/output cable and instruction manual.

Flow Connections: Standard units in the Group 2010 are supplied with plain tube connections. Optional fittings include compression pipe thread and flange. Consult price list.

* See accuracy discussion.

** A 5 ms response time model is also available. Specify model 22__. All dimensions similar to 20__ units. Group 2210 units are alumina coated hot-films and are more fragile than Group 2010 Meters.

APPLICATIONS

- Engine inlet air flow test stands
- Cooling air flow
- Compressor monitoring
- Flow meter calibration stands
- Carburetor testing

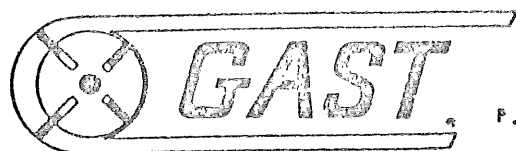
| Model | Flow Range (1) | | Pressure Rating (2) | Auxiliary Pressure Taps (3) | Pressure Drop (4) |
|-------|----------------|------------|---------------------|-----------------------------|-----------------------|
| | SCFM | SLPM | (Atmospheres) | | Inch H ₂ O |
| 2011 | 0.02-2.0 | 0.6-60 | 100 | No | 2 |
| 2012 | 0.05-5.0 | 1.5-150 | 100 | No | 2 |
| 2013 | 0.1-10 | 3.0-300 | 50 | No | 2 |
| 2014 | 0.2-20 | 6.0-600 | 50 | No | 2 |
| 2015 | 0.5-50 | 15.0-1500 | 50 | No | 2 |
| 2016 | 1.0-100 | 30-3000 | 20 | Yes | 2 |
| 2017 | 2.0-200 | 60-6000 | 20 | Yes | 2 |
| 2018 | 5.0-500 | 150-15,000 | 5 | Yes | 2 |
| 2019 | 10.0-1000 | 300-30,000 | 5 | Yes | 2 |

(1) Range at one atmosphere and 0°C. See chart for sizing at other pressures.

(2) Maximum safe working pressure at room temperature. Type of fitting connection will often govern.

(3) Female 1/8" NPT taps positioned upstream and at throat

(4) For air at one atmosphere and full scale flow.



MANUFACTURING CORPORATION

P. O. BOX 97, BENTON HARBOR, MICHIGAN 49022

PHONE 616-926-6171

PARTS LIST and OPERATING and MAINTENANCE INSTRUCTIONS FOR MODELS 0822-V103 , 1022-V103 0822-P102 , 1022-P102

CAUTION: NEVER LUBRICATE THIS DRY "OIL-LESS" AIR PUMP. This carbon vanes and grease packed motor bearings require no oil.

CONSTRUCTION: The outer end plate, body, rotor and mounting bracket are all cast iron. Consequently any moisture that accumulates in the pump will tend to corrode the interior when pump stands idle. The vanes are made of hard carbon and are precision ground. They should last 5,000 to 10,000 hours depending upon the degree of vacuum or pressure at which the pump is run.

STARTING: If the motor fails to start or hums, pull the plug and check the current rating shown on the motor nameplate. Examine the plug and switch also. Some motors (upon specification) are equipped with overloads that turn the current off automatically when the motor heats up due to mechanical or electrical overload. If the pump is extremely cold, bring to room temperature before starting. If anything appears to be wrong with the motor return the entire assembly.

VANE REPLACEMENT: The four vanes can be replaced simply by removing the end plate and exchanging new for worn or broken vanes. Use compressed air to clean out the pump chamber especially if the vane has broken. Do this prior to inserting new vanes.

Sometimes when a vane breaks, a piece will edge between the top of the rotor and the body, opening the top clearance. The top clearance should be .002". This can be checked with a feeler gauge. The rotor should be turned while checking clearance so that all points on the circumference of the rotor will clear. To reduce the top clearance to .002" tap "LIGHTLY" on the top of the body with a miniature hammer.

DO NOT at any time remove the rotor. **DO NOT** loosen the bolts on either the body or mounting bracket as this will destroy the preset clearance between the rotor and these parts.

CLEANING: If the pump is permitted to run with a dirty filter or no filter at all, excessive dirt, foreign particles, moisture, and possibly even oil (from vapors in surrounding air) could accumulate in the chamber. Any of these could cause the vanes to act "sluggish" or even break. **FLUSHING** the pump should take care of these situations, but if not, remove the end plate for further examination.

FLUSHING is accomplished by removing the filter assemblies and adding several teaspoons full of *solvent at the intake while the pump is running. Repeat the **FLUSHING** procedure again and after all the solvent has passed thru the pump replace the filters. **FLUSH** the pump several times a year.

To clean the filter and muffler felts, brush off excess dirt, lint, etc. Wash in cleaning solvent and dry before again installing.

*Recommended solvents are "Loctite Safety Solvent, Inhibisol Safety Solvent, Dow Chemical Chlorothane or equivalent solvents. **DO NOT USE KEROSENE.**

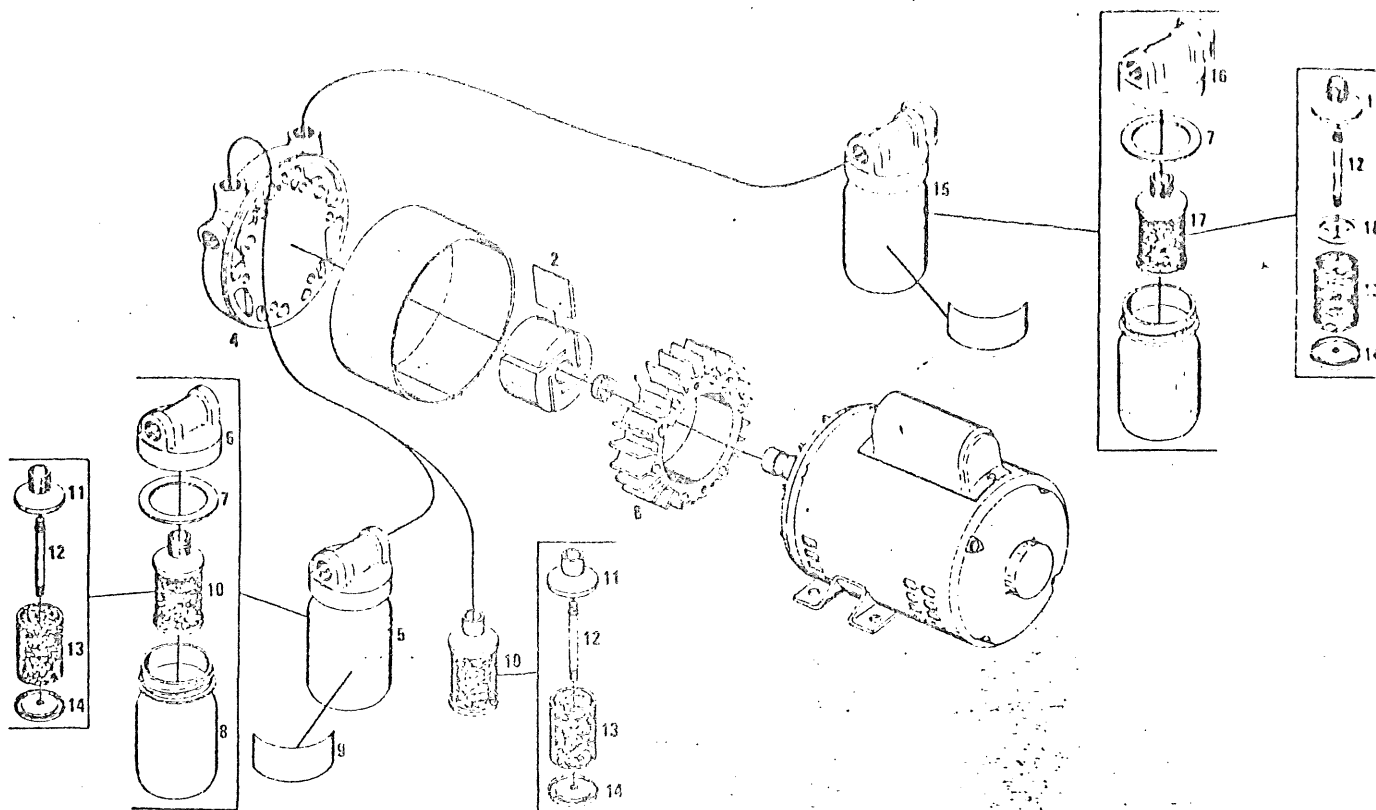
Authorized service facilities are located at:

Brenner-Fiedler and Associates
16210 Gundry Avenue
Paramount, CA 90723
213/636-3206

Gast Manufacturing Corporation
515 Washington Avenue
Carlstadt, NJ 07072
201/933-8484

Gast Manufacturing Corporation
2300 M-139
Benton Harbor, MI 49022
616/926-6171

DANGER: To avoid explosive hazard, **DO NOT** pump combustible liquids or vapors with these units.



SERVICE KITS

IF YOU ARE UNABLE TO RETURN YOUR GAST UNIT TO AN AUTHORIZED SERVICE CENTER, YOU MAY WANT TO KEEP ONE OR TWO SERVICE KITS ON HAND. THESE SERVICE KITS CONTAIN ALL PARTS WHICH SHOULD BE REPLACED WHEN SERVICING YOUR GAST UNIT, SUCH AS VANES, FILTERS AND GASKETS.

Use K223 SERVICE KIT for both the 0822 & 1022 oil-less units.

• Indicates parts included in SERVICE KIT.

| REF. NO. | DESCRIPTION | PART NO. | VACUUM PUMP 0822-V103 | COMPRESSOR 0822-P102 | VACUUM PUMP 1022-V103 | COMPRESSOR 1022-P102 |
|----------|------------------------|----------|--------------------------|-------------------------|--------------------------|-------------------------|
| 1 | BODY | AB978 | 1 | 1 | | |
| 1 | BODY | AB887 | | | 1 | 1 |
| •2 | VANE | AB992B | 4 | 4 | 4 | 4 |
| 3 | SHROUD | AB981 | 1 | 1 | 1 | 1 |
| 4 | END PLATE | AB982 | 1 | 1 | 1 | 1 |
| 5 | INTAKE FILTER ASSEMBLY | AB599 | 1 | | 1 | |
| 6 | COVER | AV805A | 1 | | 1 | |
| •7 | COVER GASKET | AA405 | 1 | | 1 | |
| 8 | JAR 1 PINT | AA805 | 1 | | 1 | |
| 9 | INSTRUCTION LABEL | AB678 | 1 | | 1 | |
| 10 | FILTERING ELEMENT | AC433 | 1 | | 1 | |
| 10 | FILTER ASSEMBLY | AC432 | | 1 | | 1 |
| 11 | COUPLING | AC390 | | 1 | | 1 |
| 11 | COUPLING | AC391 | 1 | | 1 | |
| 12 | STUD | AC396 | 1 | 1 | 1 | 1 |
| •13 | CARTRIDGE | AC393 | 1 | 1 | 1 | 1 |
| 14 | END CAP | AC394 | 1 | 1 | 1 | 1 |
| 15 | EXHAUST MUFFLER | AB599B | 1 | | 1 | |
| 16 | COVER & ELBOW ASSEMBLY | AV806 | 1 | | 1 | |
| 17 | MUFFLER ELEMENT | AC434 | 1 | | 1 | |
| 18 | PLATE-MUFFLER | AC395 | 1 | | 1 | |

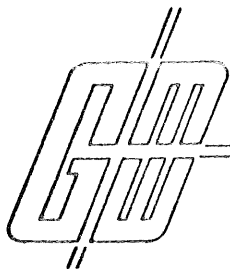
OPERATORS MANUAL

MODEL GMWL 2000
and
MODEL GMWL 2000 H



GENERAL METAL WORKS INC.

8369 BRIDGETOWN ROAD / CLEVELAND, OHIO 44102 / TEL. 513-941-2229



ACKNOWLEDGEMENT

General Metal Works Inc., extends its sincere gratitude to the many individuals and organizations whose efforts have been instrumental in the development of the high volume air sampler to its present state. We especially wish to commend the personnel of the United States Environmental Protection Agency whose efforts and investigations have contributed significantly to the definition and operation of this equipment.

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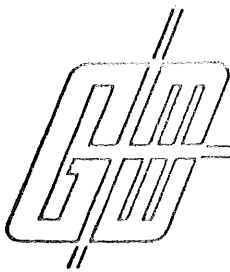
INTRODUCTION

The High Volume Air Sampler is the recommended instrument for sampling large volumes of air for the collection of suspended particulate matter. The physical design of the sampler is based on aerodynamic principles which result in the collection of particles of 100 microns (Stokes Equivalent Diameter) and less. The Sampler consists of a blower/motor unit and a supporting screen for the filter ahead of the blower/motor unit. During the sampling operation, the sampler is supported in a protective shelter so that the 8" x 10" surface of the filter is in a horizontal position. In its basic configuration (Model GMWL 2000) a flow meter is connected to a pressure tap at the exhaust end of the motor. The sampler may be modified (Model GMWL 2000 H) to incorporate a continuous flow device for recording the air flow over the entire sampling period.

It is the intent of this manual to instruct the user in the operating techniques of these two models. For information on air sampling principles, procedures and requirements, contact the local E.P.A. office serving your area.

Various applications for this equipment include:

- Ambient air monitoring to determine suspended particulate levels relative to air quality standards.
- Impact of a specific source on ambient levels of suspended particulates by incorporating a "wind-direction-activation" modification which permits the sampler to operate only when conditions are such that a source-receptor relationship exists.
- Monitoring of enclosed environments for relatively high levels of particulate matter, particularly toxic materials.
- Monitoring of emissions from large diameter vents where physical conditions preclude the use of conventional stack-testing equipment.



UNPACKING PROCEDURE GMWL-2000 AND GMWL-2000-H

- A. Place box in upright position. (Note Arrows)
- B. Carefully open the top flaps of the carton to expose the top of the sampler and shelter.
- C. Remove the front support piece and the two corner pieces.
- D. With the aid of another person, carefully lift sampler and shelter together up and out of carton.
- E. Remove the shelter lid in the bottom of the carton.
- F. Cut away the cross brace from the top of the filter holder.
- G. Disconnect the power cord of the sampler motor/blower unit from the transformer (GMWL-2000-H only).
- H. Lift the filter holder and motor/blower unit straight up and out through the opening in the sampler support pan.
- I. Lift the sampler support pan out of the shelter to expose the cardboard motor shipping support and remove.
- J. Replace sampler support pan and filter holder with motor/blower unit.
- K. Refer to "Shelter Assembly" instructions for lid and catch placement.

SHELTER ASSEMBLY

AFTER REMOVAL FROM THE SHIPPING CARTON ASSEMBLE SHELTER AS FOLLOWS:

- A. Locate the package that contains the front and rear catches. This bag also contains the rear lid hasp and an aluminum strip for securing the lid in an open or closed position.
- B. Secure the front catch, (See Figure A), to the shelter using the two flat head screws and nuts.
- C. Secure the rear catch, (See Figure A), to the shelter using one truss head screw and nut.
- D. Secure the rear lid hasp, (See Figure A), to the lid using two truss head screws and nuts.
- E. (NOTE: These three catches may need adjustment after the shelter lid is installed.)
- F. Attach the lid to the shelter by placing the hinge bolt plates on the "inside" of the shelter top and tighten nuts.
- G. Adjust the front and rear catches to be sure that the lid slot lowers over the front catch when closing the lid. The slot at the rear of the lid should align with the rear catch when the lid is open.
- H. The lid can now be secured in an open or closed position with the aluminum strip or a padlock.

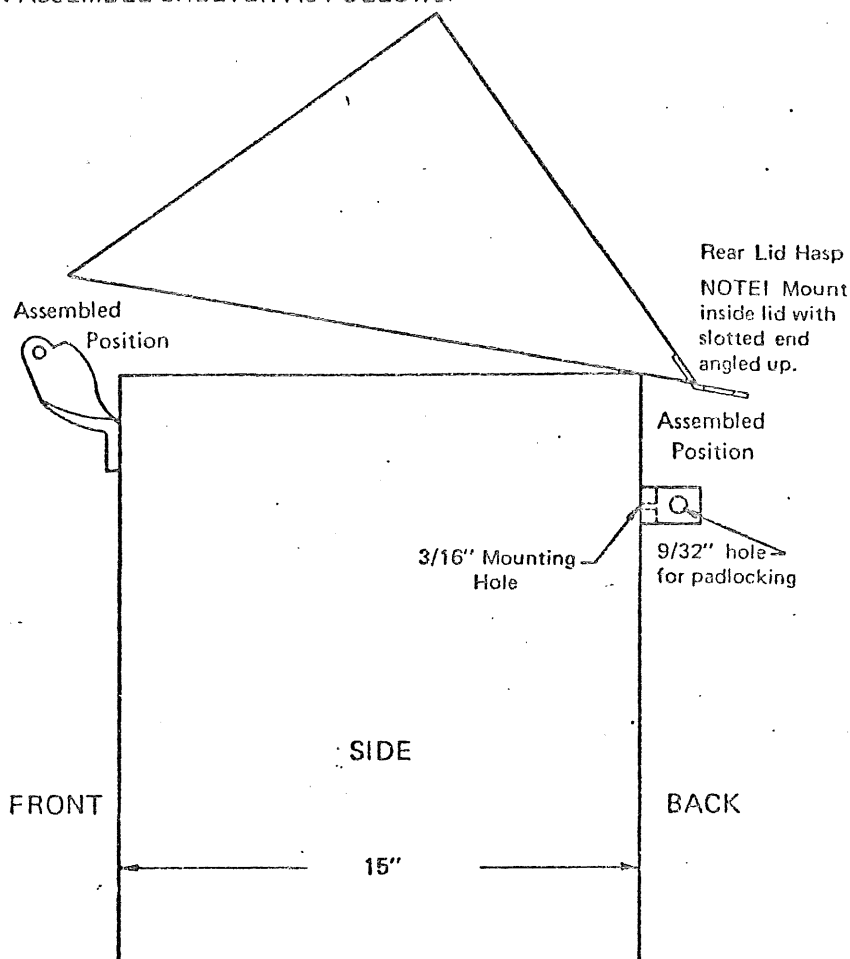
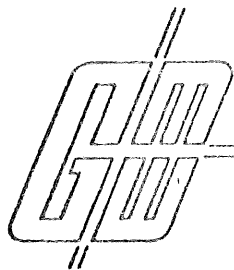


FIGURE A

SAMPLER LOCATION

The sampler should not be placed more than 50 feet above ground level nor in a location adjacent to higher structures. Strong wind eddies induced by movement around such structures may result in recirculation of previously sampled air. Public buildings such as schools, fire stations and libraries are favorable sampler sites because of their security and accessibility.



MODEL GMWL-2000

HIGH VOLUME AIR SAMPLING SYSTEM

MODEL GMWL-2000 AIR SAMPLER

This basic unit is widely used by government and industry to collect and accurately measure airborne particulate matter by monitoring large volumes of air. Utilizing paper media, the Model GMWL-2000 traps particles as small as .01 micron in size.

Designed and built for continuous, 24-hour a day sampling, the heavy duty turbine type blower with high-speed motor is contained in a rugged but light-weight plastic housing. Four bolts, easily accessible, permit motor removal for periodic brush replacement. Special U-clip connectors facilitate brush changing and prevent damage to the internal leads.

The air flow rate is measured by a variable orifice meter which must be calibrated periodically to maintain on-site accuracy.

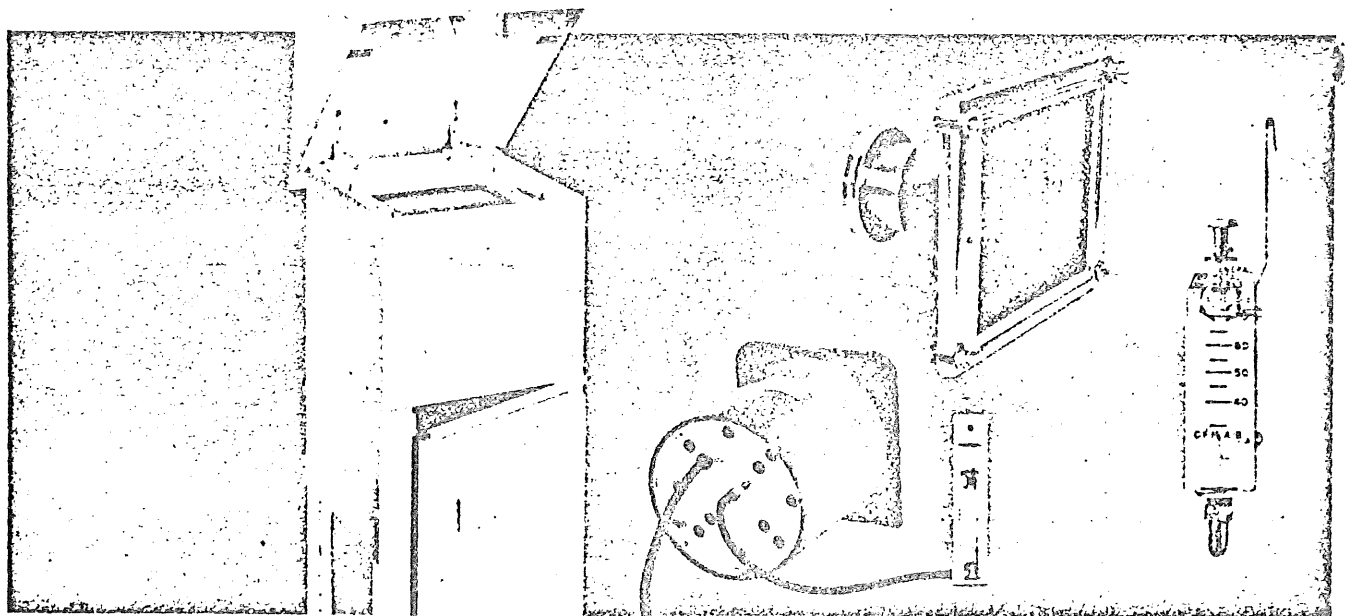
A precision bored flow meter, Model GMW 2009-2, may be substituted optionally. Encapsulated in durable acrylic, the deluxe flow meter is designed to withstand extended field service.

MODEL FH-2100 FILTER HOLDER

Designed to accommodate 8" x 10" filter paper, the Model FH-2100 Filter Holder is made of Type 304 stainless steel for maximum strength and durability. Its heavy duty seamless construction is leakproof and conical in shape for maximum support. Furnished complete with support screen and neoprene gasket for positive seal, the Model FH-2100 Filter Holder also accommodates the Model GMW-3000 Filter Paper Cartridge without modification. The filter holder attaches to the sampler with a threaded ring and gasket for easy assembly.

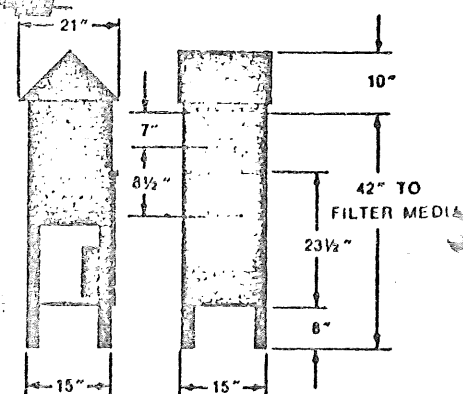
MODEL GMW-8500 ALUMINUM SHELTER.

Heavily reinforced, the shelter is constructed of .080" aluminum anodized for outdoor service. The gable roof and large door are equipped with heavy duty aluminum hinges affording complete access to the components housed within. A horizontal baffle prevents sampler exhaust dust and aluminum hasps facilitate locking the gable roof in either the open or closed position.



Specifications:

Motor Hp — 0.6
 Speed — 18,250 R.P.M.
 Amperage — 6.25
 Wattage — 745
 Max. Flow Rate — 60 C.F.M.
 Min. Flow Rate — 20 C.F.M.
 Power Source — 115V, 1 phase, 60 Hertz (other electrical characteristics available on request)
 Net Weight — 53 lbs.
 Shipping Weight — 60 lbs.
 Complies with Federal Register Vol. 36, No. 84 dated April 30, 1971



SAMPLER CALIBRATION GMWL - 2000

EQUIPPED WITH FLOW METER

The high volume air sampler may be calibrated by means of a standard positive displacement rotary type meter. Although this is an accurate calibration method, it requires considerable time.

A much simpler procedure utilizes a calibrating orifice assembly and water manometer. (Model GMW - 25) The orifice and manometer unit are factory calibrated against the positive displacement meter and a calibration curve is drawn from the air-flow versus static pressure data.

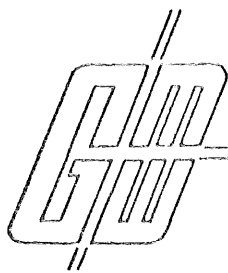
The GMW - 25 Calibration Orifice is used for calibration of the high volume air sampler and the procedure is as follows:

- A. Remove the motor/blower filter holder assembly from the shelter by lifting it up and out through the rectangular hole in the support pan.
- B. Remove the filter holder from the motor/blower unit.

NOTE: Use of the Calibration Adapter Plate GMW - 35 allows the operator to attach the calibration orifice to the motor/blower unit without removing the filter holder and motor/blower unit from the shelter.

- C. Replace the filter holder with the orifice calibrator using the Number 18 Resistance Plate, supplied with the orifice calibrator, to approximate the resistance of a clean filter (GMW-810).
- D. Connect the flow meter to the pressure tap at the exhaust end of the motor/blower unit using the supplied length of tubing. (Tubing is connected to bottom of flow meter).
- E. Connect a water manometer to the pressure tap of the calibration orifice.
- F. Plug sampler into 110V. 60 Hz. source and let it stabilize for approximately 5 minutes.
- G. Read the manometer pressure in inches of water and convert to actual flow rate using the curve supplied with calibration orifice.
- H. Set the flow meter to the actual flow rate (widest part of the float) by adjusting the brass hexagon nut on top of the flow meter. Once adjusted, tighten the lock nut and seal to prevent the setting from changing.
- I. Use the remaining resistance plates (using the one with the next fewer number of holes first), until the actual flow rates and the flow meter relationship have been established.
- J. Using the readings established with the above procedure, plot a curve which represents the actual flow rate versus the flow meter readings.
- K. This new calibration curve is used as a direct reference to obtain the actual flow rate.

The sampler flow meter should be calibrated at least every six months and after every motor and brush change to maintain air volume accuracy.



SAMPLER OPERATION GMWL - 2000

1. Place sampler and filter holder in the servicing position by raising both the sampler motor/blower unit and filter holder up until the filter holder is above the top level of the shelter. Then rotate the unit one-quarter turn so that the filter holder hangs in the rectangular hole in the sampler support pan.
2. Remove faceplate by loosening the four wing nuts allowing the swing bolts to swing down out of the way.
3. Carefully center a new filter, rougher side up, on the supporting screen. Properly align the filter on the screen so that when the faceplate is in position the gasket will form an airtight seal on the outer edges of the filter.
4. Secure the filter with the faceplate and four brass swing bolts with sufficient pressure to avoid air leakage at the edges.
5. Rotate and lower the filter holder and blower/motor assembly to its normal operating position.
6. Wipe any dirt accumulation from around the filter holder with a clean cloth.
7. Close lid carefully and secure catch with aluminum strip or padlock.
8. Plug motor/blower unit into a 110V., 60Hz. source and allow sampler to warm up for 5 minutes.
9. Connect the flow meter calibrated with the sampler to the brass pressure tap at the bottom of the motor/blower unit.
10. Hold flow meter at eye level in a vertical position and read the widest part of the float.
11. Flow measurements are taken at the beginning and end of the sampling period. Disconnect flow meter during sampling period to prevent excessive clogging.
12. After sampling period, disconnect motor/blower unit from the power source.
13. Place the sampler in the servicing position and remove the faceplate to expose the filter.
14. Carefully remove the exposed filter from the supporting screen by holding it gently at the ends (not at the corners). Fold the filter lengthwise so that sample touches sample.
15. If GMW - 70 Timer is being used on Model GMWL - 2000, refer to timer instructions on page 14 under Model 2000 H operation step 11.

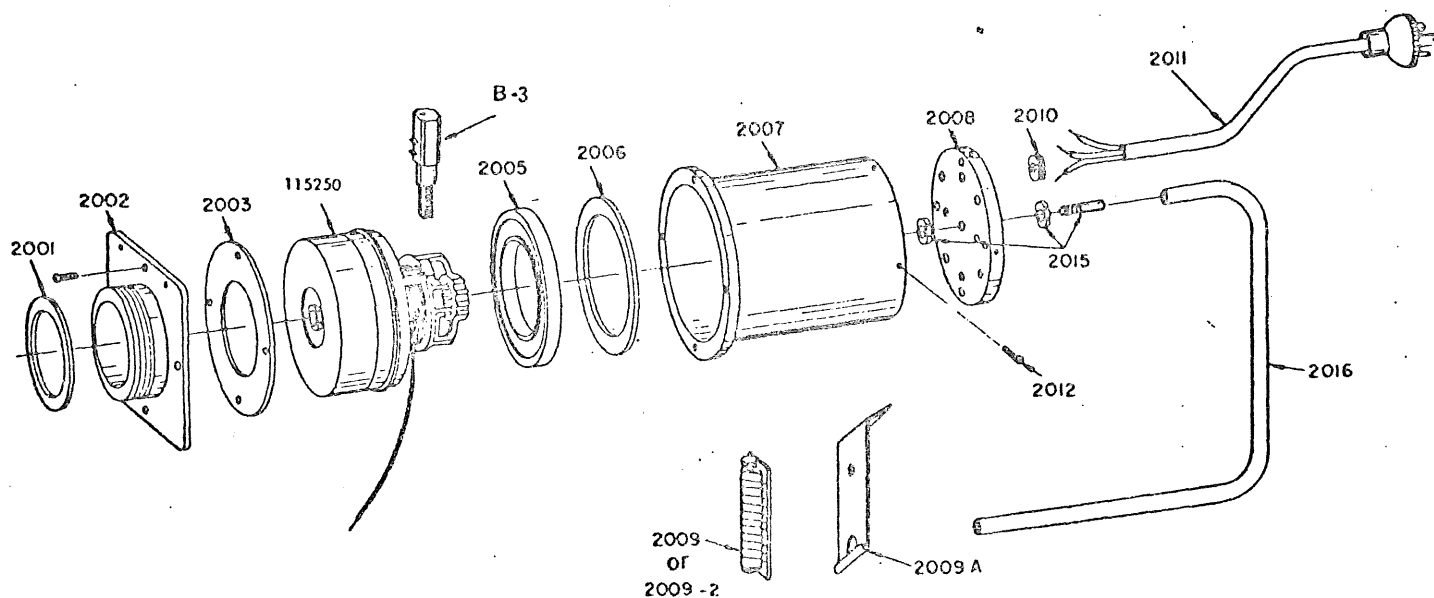
CLEANING FLOW METER — MODEL GMW - 2009

- A. Remove the screw at the bottom of the flow meter and carefully let the float slide from the flow meter tube.
- B. Clean out the flow meter tube using a pipe cleaner wet with carbon tetrachloride, gasoline, etc. Do not use acetone or alcohol. The float may be cleaned by wiping with a cloth or cleaning tissue moistened with water.
- C. Do not change orifice adjustment at the top of the flow meter.
- D. Check for particles being lodged in the orifice of the flow meter prior to each flow meter reading.

BLOWER/MOTOR REPLACEMENT PARTS GMWL-2000

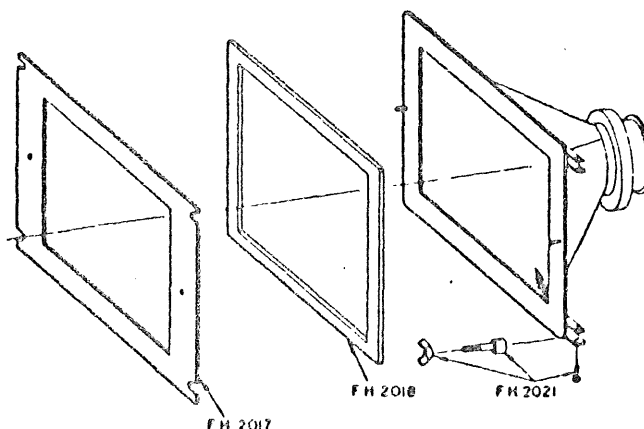
| Part No. | Description |
|----------|---|
| 2000 | Blower/Motor Assembly Complete less filter holder |
| 2001 | Neoprene Gasket |
| 2002 | Mounting Plate Motor Cover |
| 2003 | Neoprene Gasket |
| 2005 | Motor Cushion |
| 115250 | 0.6 H.P. Motor with special U-clip connectors |
| 215276 | Armature with Bearings |
| 2006 | Motor Mounting Ring |
| B-3 | Motor Brushes Per Set of Two |
| 2007 | Motor Housing |

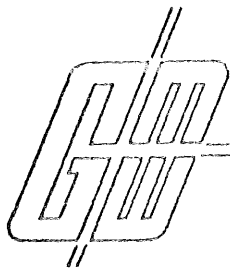
| Part No. | Description |
|----------|--|
| 2008 | Orifice Plate |
| 2009 | Flowmeter No. 440 Graduated 10 to 70 Cubic Feet per Minute |
| 2009-M | Flowmeter Graduated 0.0 to 2.0 Cubic Meters per Minute |
| 2009-A | Flowmeter Mounting Plate |
| 2009-2 | Precision Bored Flowmeter |
| 2010 | Grommet |
| 2011 | Power Cord Assembly |
| 2012 | Assembly Bolts and Nuts |
| 2015 | Pressure Tap Assembly |
| 2016 | Tubing |



MODEL FH-2100 FILTER HOLDER

| Part No. | Description |
|----------|----------------------------|
| F.H.2100 | Filter Holder Complete |
| F.H.2017 | Aluminum Hold Down Frame |
| F.H.2018 | Rubber Gasket 8"x10" |
| F.H.2021 | Wing Nut & Bolt with Rivet |





MODEL GMWL-2000 H

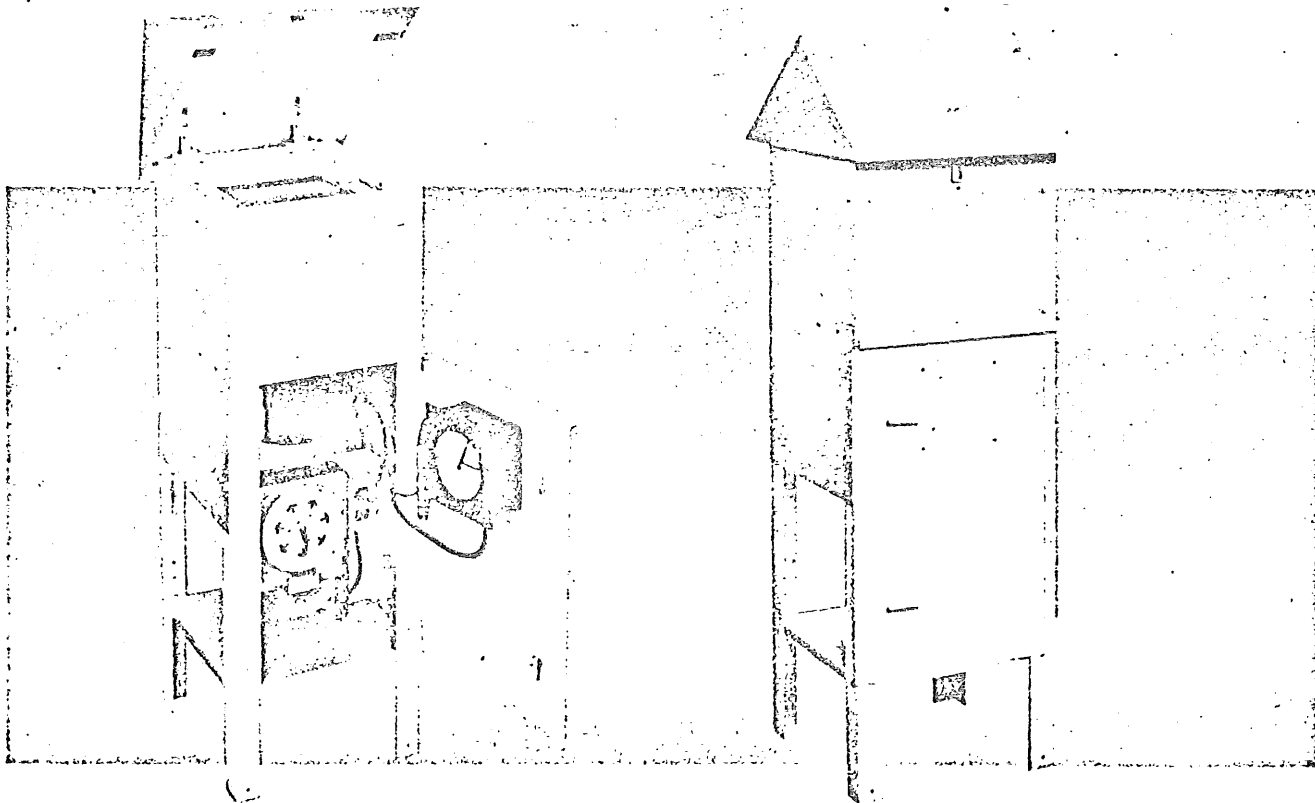
HIGH VOLUME AIR SAMPLING SYSTEM

Designed for continuous operation in an all weather environment, the Model GMWL-2000 H is a complete monitoring station for the collection of suspended particulate matter with precise measurement capability. All instruments and components are mounted within the anodized aluminum shelter for protection. The hinged roof facilitates filter media exchange.

The Model GMWL-2000 H is complete with high volume sampler, seamless stainless steel filter holder, pressure transducer recorder, 50 charts, ink and 90-volt protective transformer all housed in the aluminum shelter ready to operate. A seven day regular timer Model GMW-70 is included as standard equipment. The timer/programmer Model GMW-800 is optional.

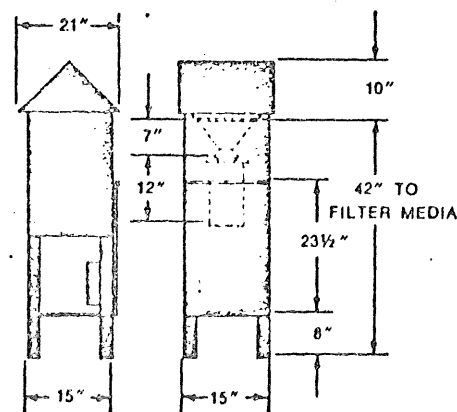
The sampler is a heavy duty turbine type blower with high speed motor arranged with a fixed orifice on the discharge end. Although factory calibrated against a water manometer, recalibration is suggested to suit barometric conditions at the site. Air flow is accurately measured by the pressure transducer which provides a permanent record of every sample.

Four bolts, easily accessible, permit motor removal for periodic brush replacement. Special U-clip connectors facilitate brush changing and prevent damage to the internal leads. The 90-volt transformer reduces the operating voltage to approximately triple normal brush and motor life.



Specifications:

Motor HP — 0.6
 Speed — 13,500 R.P.M.
 Amperage — 4.9
 Wattage — 440
 Max. Flow Rate — 52 C.F.M.
 Min. Flow Rate — 20 C.F.M.
 Power Source — 115 V, 1 phase, 60 Hertz (other electrical characteristics available on request)
 Net Weight — 68 lbs.
 Shipping Weight — 75 lbs.
 Complies with Federal Register Vol. 36, No. 84 dated April 30, 1971



SAMPLER CALIBRATION GMWL - 2000 - H

EQUIPPED WITH PRESSURE RECORDER

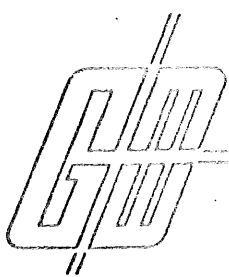
The high volume air sampler may be calibrated by means of a standard positive displacement rotary type meter. Although this is an accurate calibration method, it requires considerable time.

A much simpler procedure utilizes a calibrating orifice assembly and water manometer. (Model GMW - 25) The orifice and manometer unit are factory calibrated against the positive displacement meter and a calibration curve is drawn from the air-flow versus static pressure data.

The GMW - 25 Calibration Orifice is used for calibration of the high volume air sampler and the procedure is as follows:

1. Remove the motor/blower filter holder assembly from the shelter by lifting it up and out through the rectangular hole in the support pan.
2. Remove the filter holder from the motor/blower unit and replace it with the Orifice Calibrator (GMW - 25) using the Number 18 Resistance Plate supplied with the orifice calibrator to approximate the resistance of a clean filter (GMW - 810).

Note: Use of Calibration Adapter Plate GMW-35 allows the operator to attach the Calibration Orifice to the motor/blower unit without the removal of the filter holder and motor/blower unit from the shelter.
3. Connect the pressure recorder to the pressure tap on the side of motor/blower unit.
4. Connect the water manometer to the pressure tap of the calibration orifice.
5. Install a clean Recorder Chart (# 106) and prepare pressure recorder as follows:
 - A. Remove pressure recorder from door of shelter and remove the back plate exposing the electric chart drive motor and bellows assembly.
 - B. Rotate zero adjustment screw from the front side counter-clockwise to the extreme position.
 - C. At the top of the bellows assembly is a slotted arm extending to the left of the pen arm shaft. This slotted arm has a slotted screw.
 - D. Loosen the slotted screw and move it and the vertical arm (which is directly attached to the bellows) toward the pen arm shaft to its farthest position and tighten screw.
6. Connect sampler directly to a 120V source by-passing the transformer if it is normally used. Let the sampler run for a few minutes.
7. Read the differential pressure as indicated by the manometer and record it on your data sheet. Convert the inches of water reading to CFM using the calibration curve supplied with the calibration orifice.



8. While holding the pressure recorder in a near vertical position, adjust the span of the recorder so that the recorder pen is indicating the correct flow rate from calibration curve.

The suggested method for adjusting the span is as follows:

- A. Hold the slotted arm firmly with one hand while gently deflecting the pen arm to the correct flow rate with the other hand. Be careful not to bend pen arm. Holding the pen arm toward the top, near the pen arm shaft, will prevent bending.
 - B. Release pressure to the recorder (turn off sampler.)
 - C. Check zero and reset using the zero adjustment screw on the front of the recorder case.
 - D. Reapply pressure and check recorder deflection for proper flow reading.
 - E. Repeat steps A - B - C until no span or zero adjustments are required. Record the recorder chart deflection on your data sheet.
9. Change the resistance plate in the calibration orifice to the one with the next fewer number of holes (# 13).
 10. Turn sampler on and convert the differential pressure indicated by the manometer to the corrected flow rate.
 11. Record the manometer pressure in inches of water, the actual flow rate from the calibration curve, and the recorder deflection on your data sheet.

Repeat steps 9, 10 and 11 for the remaining resistance plates.

Using the readings established with the above procedures, plot a calibration curve representing the actual flow rate versus the recorder deflection.

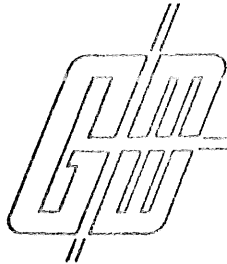
This new calibration curve is used as a direct reference to obtain the actual flow rate.

SAMPLER OPERATION GMWL - 2000 - H

1. Place sampler and filter holder in the servicing position by raising both the sampler motor/blower unit and filter holder up until the filter holder is above the top level of the shelter. Then rotate the unit one-quarter turn so that the filter holder hangs in the rectangular hole in the sampler support pan.
2. Remove faceplate by loosening the four wing nuts allowing the swing bolts to swing down out of the way.
3. Carefully center a new filter, rougher side up, on the supporting screen. Properly align the filter on the screen so that when the faceplate is in position the gasket will form an airtight seal on the outer edges of the filter.
4. Secure the filter with the faceplate and four brass swing bolts with sufficient pressure to avoid air leakage at the edges.
5. Rotate and lower the filter holder and blower/mower assembly to its normal operating position.
6. Wipe any dirt accumulation from around the filter holder with a clean cloth.
7. Close lid carefully and secure with the aluminum strip or padlock.
8. Plug all cords into their appropriate receptacles as follows:
 - A. Motor/blower unit male to transformer female.
 - B. Transformer male to timer female (left female cord set).
 - C. Recorder transducer male to duplex receptacle beside timer.
 - D. Regular Timer GMW-70 male to 110V., 60Hz. source (if timer is being used.)

If the GMW-800 Timer/Programmer is used, then modify procedure as follows:

- A. Motor/blower unit male to transformer female.
 - B. Transformer male to timer/programmer female (left hand cord set.)
 - C. Recorder transducer male to timer/programmer female (right hand cord set.)
 - D. Timer/Programmer male to 110V. 60Hz. source.
9. Connect rubber tubing between the orifice on the sampler and the connector on the bottom of the recorder transducer. Be careful not to pinch tubing when closing shelter door.



10. Prepare Recorder Transducer as follows:

- A. Clean any excess ink and moisture on the inside of recorder by wiping with a clean cloth.
- B. Depress pen arm lifter to raise pen point and carefully insert a fresh chart in the recorder.
- C. Carefully align the center tab of the chart to the drive hub of the recorder and press gently with thumb to lower chart center onto hub. Make sure chart is placed under the chart guide clip and the time index clip so it will rotate freely without binding.
- D. With the pen arm lifter depressed, fill pen point reservoir with the ink provided. Place ink bottle nipple squarely against pen point reservoir and squeeze gently. Release pen arm lifter and let the pen point fall to the fresh chart. Move the pen arm laterally a few times to make sure the pen point will ink during the sampling period.
- E. Check to see that the pen point rests on zero (i.e. the smallest diameter circle on the chart.) If it does not, tap the recorder case lightly to make certain the pen arm is free. Adjust to zero with the zero adjustment screw if necessary.
- F. When recalibration becomes necessary, refer to "Recorder Calibration" on pages 11 and 12.

11. Prepare the GMW - 70 Timer as follows:

- A. To set the "on" time, assemble a knurled screw to the "on" side of a tripper and place tripper firmly against dial edge with "on" marking visible. Set or slide tripper point at the Day-Of-Week and Time-Of-Day when the "on" operation is desired. Tighten knurled screw firmly by hand. (Do not use pliers)
- B. To set the "off" time, assemble a knurled screw to the "off" side of a tripper and place tripper to the Day-Of-Week, Time-Of-Day when the "off" operation is desired.
- C. To set clock dial to the actual time, turn dial "counter-clockwise" and align the exact Day-of-Week and Time-Of-Day (AM or PM) on dial to the time pointer.
- D. To operate switch manually, press down the lever on the "right" of the name plate to turn circuit "on". Press down the lever on the "left" of the name plate to turn circuit "off".
- E. Note: Minimum "on" time is one hour. Minimum "off" time is two hours. There must be at least 6 hours between any two "off" trippers.

12. Manually trip timer switch on to determine if sampler is operating properly and the recorder is inking correctly.

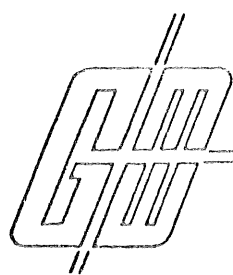
13. When it has been determined the unit is operating properly, turn unit off, reset timer, close timer door, close recorder door, and close shelter door being careful not to pinch the recorder tubing.

14. At the end of the sampling period place the sampler motor/blower filter holder assembly in the service position.

15. Remove the face plate to expose the filter. Carefully remove the exposed filter from the supporting screen by holding it gently at the ends (not at the corners). Fold the filter lengthwise so that sample touches sample.

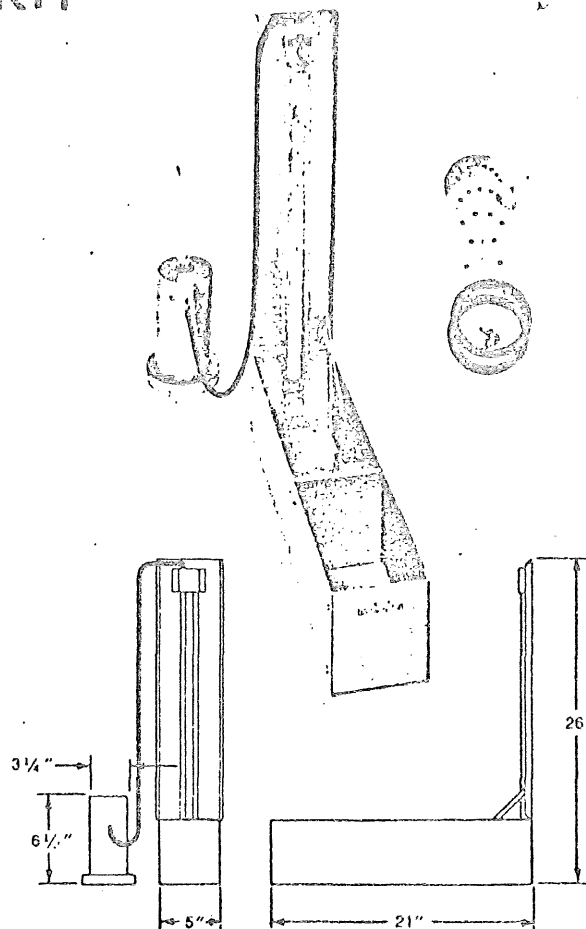
| Part No. | Description |
|----------|--|
| 2000H | Blower/Motor Assembly Complete less filter holder |
| GMW-808 | Calibration Slack Tube Manometer (Range 8"-0-8") |
| 2001-H | Neoprene Gasket |
| 2002-H | Mounting Plate Motor Cover |
| 2003-H | Neoprene Gasket |
| 115250 | 0.6 H.P. Motor with special U-clip connectors |
| B-3 | Motor Brushes — Two Per Set |
| 215276 | Armature with bearings |
| 2005-H | Motor Cushion |
| 2006-H | Motor Mounting Ring |
| 2007-H | Motor Housing |
| 2010-H | Cord Retainer |
| 2011-H | Power Cord Assembly |
| 2016-H | Tubing and Pressure Tap |

9K



GMW - 25 CALIBRATION KIT

1. After removal of the all aluminum carrying case from the shipping carton, open the lid by pressing the button on the handle and lifting gently.
2. Remove all packing materials from inside the carrying case.
3. Prepare the manometer as follows:
 - A. Unroll the manometer and secure it to the square metal pads one each on the lid and case.
 - B. Add the $\frac{3}{4}$ oz. bottle of fluorescein green concentrate to one quart of distilled water.
 - C. Remove one tubing adaptor and hex plug assembly from the manometer and fill to mid point level. Shake gently to remove air bubbles and slide scale so zero is in line with the meniscus of the two columns. (For readings in inches of mercury, fill manometer with 9 ozs. of mercury)
 - D. Replace tubing adaptor and hex plug assembly. Both tubing adaptor and hex plug assemblies must be screwed only half way in when taking pressure readings. To stow away, both tubing adaptors and hex plug assemblies must be screwed all the way in to prevent fluid loss.
 - E. To read the manometer when a pressure vacuum or differential pressure is imposed, add the number of inches one column travels up to the amount the other column travels down. Should one column travel further than the other, due to minor variations in tube I. D. or pressure imposed the accuracy of the reading thus obtained is not impaired.
4. Connect one end of the length of tubing provided to one leg of the manometer and the other to the pressure tap on the orifice calibrator.
5. Select one of the five resistance plates and place it inside the threaded ring of the calibration orifice.
6. The calibration orifice can now be secured to the motor/blower unit to be calibrated.
7. For calibration procedures refer to "Unit Calibration" for models GMWL-2000 and GMWL-2000-H.



AVERAGE CALIBRATION CURVE FOR GMW CALIBRATION ORIFICE

PRESSURE = 29.6
TEMPERATURE = 68°

INCHES OF
MANOMETER
H₂O

| ACTUAL CU. FT. AIR | INCHES OF WATER MANOMETER |
|-----------------------|---------------------------------|
| 65 | 13.6" |
| 60 | 11.6" |
| 55 | 9.7" |
| 50 | 8.0" |
| 45 | 6.5" |
| 40 | 5.1" |
| 35 | 3.9" |
| 30 | 2.9" |

30

35

40

45

50

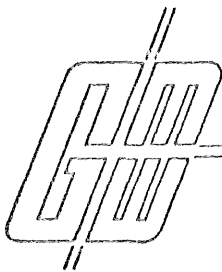
55

60

65

70

CUBIC FEET OF AIR



MOTOR BRUSH REPLACEMENT

MODEL GMWL-2000

1. Remove Orifice Plate (part # 2008) from sampler by removing four 6-32 bolts and nuts. Slide power cord through the rubber grommet to gain access to brushes.
2. Remove the brush holder clamp and release the expended brush.
3. Release the special U-Clip connector from the brass sleeve of the expended brush and mount it on a new brush.
4. Place the new brush in the motor casting so as to register on the boss of the casting. (Refer to Figures 1 & 2 for your particular style motor)
5. Replace brush holder clamp on the brush and secure to motor with the screws.
6. Use the procedure as defined above for the other brush.
7. The model B3 (formerly # 33252) motor brush set is designed for brush replacement in either style motor supplied with GMW-Hi-Vol Samplers.

MODEL GMWL-2000-H

1. Remove the mounting plate-motor cover (part # 2002-H) by removing the four hex-head bolts. This will expose the motor.
2. Release the power cord by turning the cap of the power cord connector (part #2010-H) counter-clockwise.
3. Carefully let the motor slide from the housing exposing brushes.
4. Refer to steps 2 to 6 of the "GMWL-2000 Brush Replacement" section:
5. Assemble motor after brush replacement by placing the housing over and down on the motor, being careful not to pinch any motor wires beneath the motor Mounting Ring (part #2006-H).
6. Replace the mounting plate motor cover.
7. Gently pull the power cord back out of sampler housing and secure it with the connector cap.

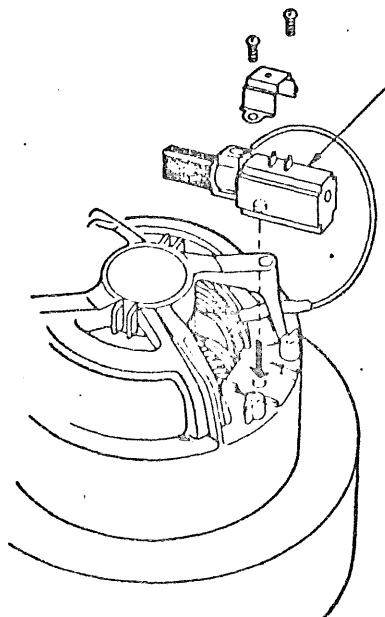


Fig. 1

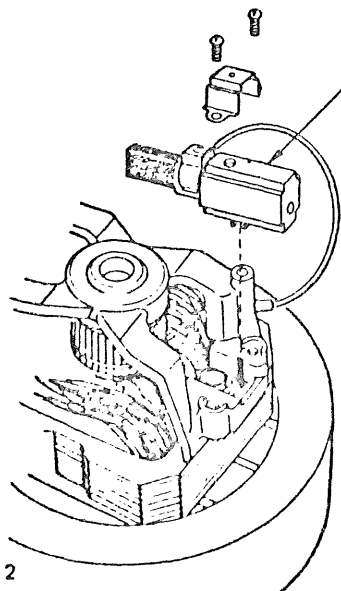


Fig. 2

MOTOR BRUSH SEATING PROCEDURE

The brushes should be changed before the brush shunt touches the commutator.

On reassembly and handling, the lead wires must be kept away from rotating parts and motor frame.

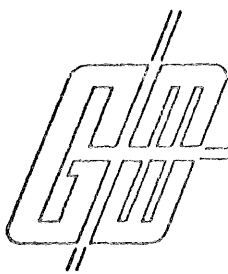
To achieve best performance, the new brushes should be seated on the commutator before full voltage is applied.

After brush change apply approximately 50% voltage for thirty minutes to accomplish this seating. The motor will return to full performance after thirty to forty-five minutes running at full voltage.

(Caution) — Direct application of full voltage after changing brush will cause arcing, commutator pitting, and reduce overall life.

Use of the Model GMW - 900 Voltage Variator provides the reduced voltage needed for brush seating.

If reduced voltage is unavailable, connect two motors of similar rating in series for thirty minutes to accomplish the brush seating.



REWIRING OF TIMER GMW - 70

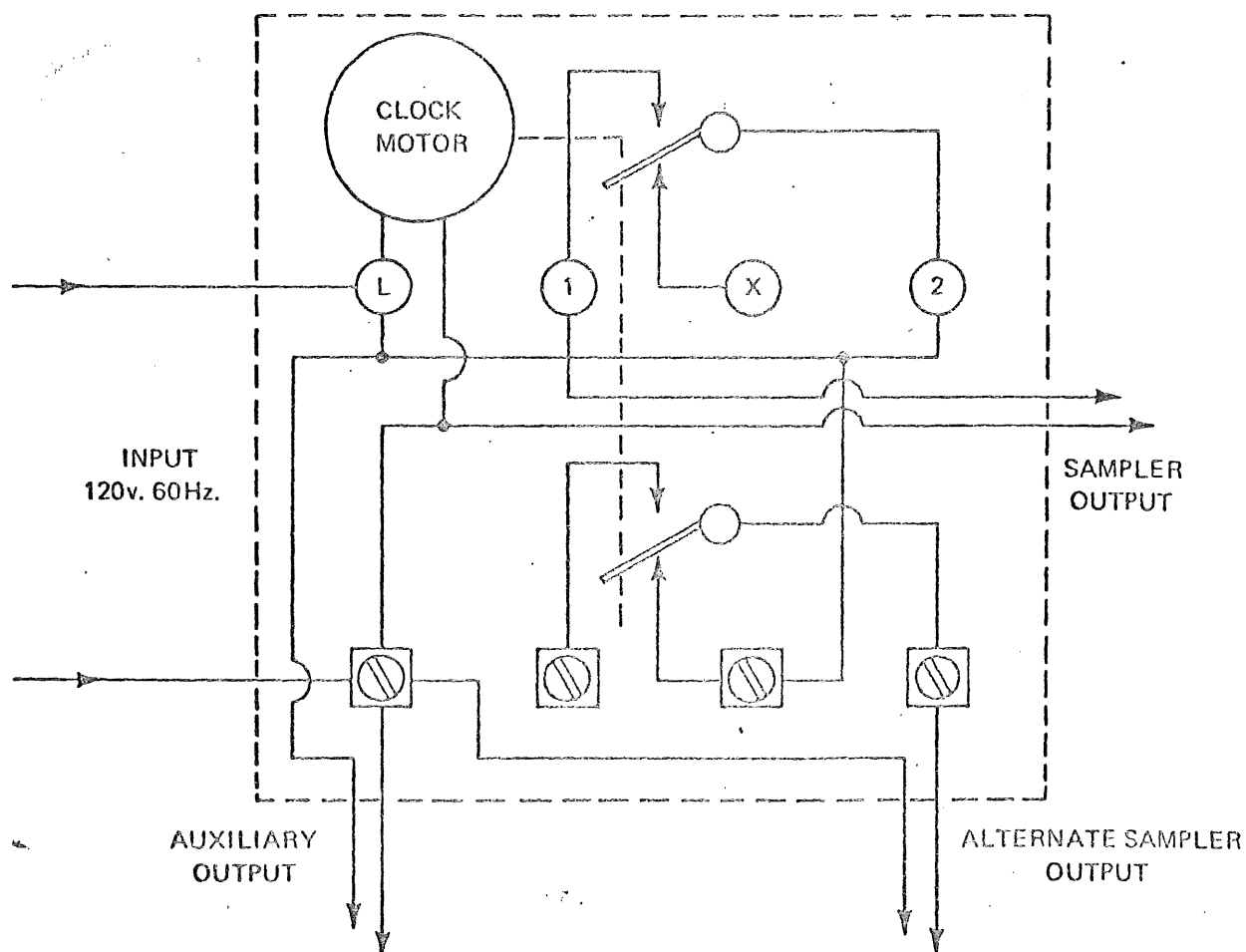
The GMW-70 7 Day Skip Timer is factory wired with one output to operate a Hi-Vol and a second output to operate a second Hi-Vol or gas bubbler on alternate days.

If it is desirable to operate both Hi-Vol and gas bubbler the same day, the timer must be rewired as follows:

- A. Open timer and remove paper insulator.
- B. Locate the jumper wire that is connected to terminal "5" on the bottom set of terminals. Disconnect this jumper wire from terminal "5" and reconnect it to terminal "3" on the bottom set of terminals.
- C. This will enable both female cords to be hot at the same time. Contact rating is 40 amps per pole.
- D. Replace paper insulator after all connections are tight.

GMW - 70 TIMER

FACTORY WIRING SCHEMATIC

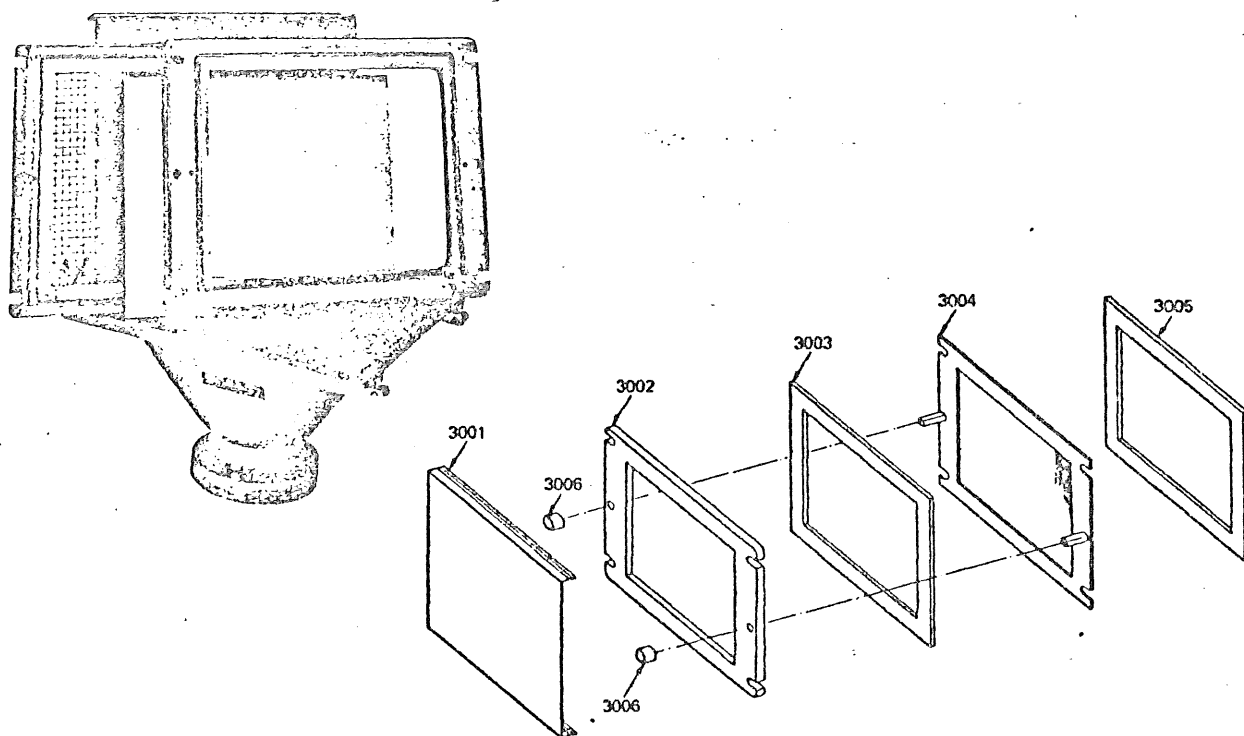


UNIT OPERATION GMW - 3000

The GMW - 3000 FILTER PAPER CARTRIDGE protects the sample while in transit to and from the lab.

In the lab the filter paper cartridge is prepared as follows:

- A. Release the snap cover by applying pressure with both thumbs to the long side of the filter paper cartridge.
- B. Remove the two thumb nuts to release the hold down frame.
- C. Center a clean filter, rough side up, on the supporting screen.
- D. Replace the hold down frame and secure it with the thumb nuts.
(NOTE: It is not necessary to over tighten the thumb nuts because the swing bolts and wing nuts of the filter holder will sufficiently create a good seal.)
- E. Replace the snap cover while making sure that it is centered properly.
- F. The loaded filter paper cartridge is now ready for transport to the sampling site where it can be placed on the filter holder. Remove the snap cover and retain for replacement upon completion of the sampling period.



G.M.W. 3000 Filter Paper Cartridge Complete

3001 Aluminum Cover

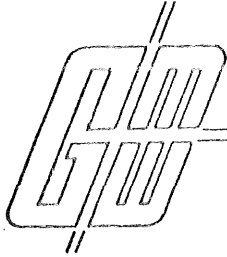
3002 Aluminum Frame

3003 Rubber Gasket

3004 Aluminum Frame and Stainless Steel Screen

3005 Rubber Gasket

3006 Thumb Nuts (2 required per set)



MODEL GMW-800 SIXTH DAY TIMER/PROGRAMMER OPERATING INSTRUCTIONS

The model GMW-800 timer/programmer provides three distinct programming modes, 24 hour, episode and sixth day sampling. For all modes the real time clocks "A&B" are set to the actual time of day.

The ON and OFF tabs of clock "A" are set at midnight. The function of clock "A" is to sequentially advance the indicator light every 24 hrs. Thus while passing through three switch positions or days with only the second day switch in the up position will give a 24 hour sampling period.

NOTE: The ON and OFF tabs of clock "A" are secured together under the clock face and must be moved together. The OFF tab of clock "A" must never be permitted to swing around in front of the ON tab. This will result in a burn out of the stepping mechanism coil.

The ON and OFF tabs of clock "B" are needed only while in the episode sampling mode. The function of clock "B" is to act as a series switch to the output according to the setting of the ON and OFF tabs on the face of clock "B".

NOTE: By placing the toggle switch between clocks "A" and "B", in the right hand position, allows the series switch of clock "B" into the circuit.

Both clocks rotate together clockwise with the up position of the power switch.

The indicator lights are wired in parallel and indicate the day or position of the stepping mechanism. As a result it is possible for more than one indicator light to light up when the timer output is activated. To reset the indicator light all seven day switches must be in the down position.

This timer is arranged with three cord sets extending down from the bottom of the timer. The male cord set is plugged into the source voltage (120 V, 60 Hz). The left hand female cord set is the timed output. The right hand female cord set is an auxiliary output which is not timed.

24 HOUR SAMPLING

With all seven day switches and the 6TH DAY SAMPLE switch in the DOWN position, reset the indicator light to the present day by sequentially pressing the DAY RESET switch. The toggle switch between clocks "A" and "B" is set in the left hand position. The desired sampling day switches are placed in the UPWARD position. The sampling period is from midnight to midnight.

EPISODE SAMPLING

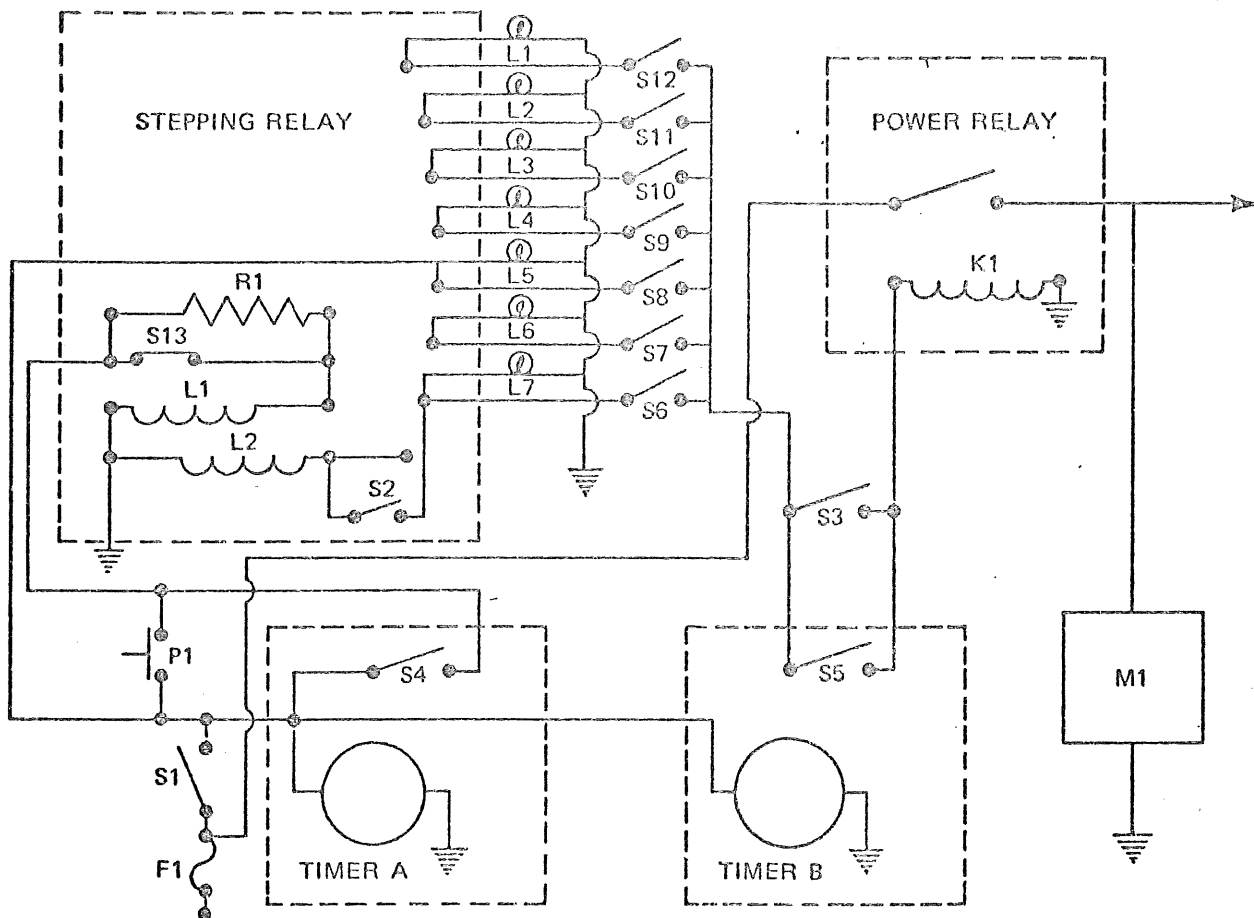
With all seven day switches and the 6TH DAY SAMPLE switch in the DOWN position, reset the indicator light to the present day by sequentially pressing the DAY RESET switch. The toggle switch between clocks "A" and "B" is set in the right hand position. The desired sampling day switches are placed in the UPWARD position. The ON and OFF tabs on clock "B" can then be set for any sampling period within 24 hours.

SIXTH DAY SAMPLING

NOTE: When in the sixth day sampling mode disregard day of the week nomenclature. The days of the week should be regarded as positions and not Monday, Tuesday, etc.

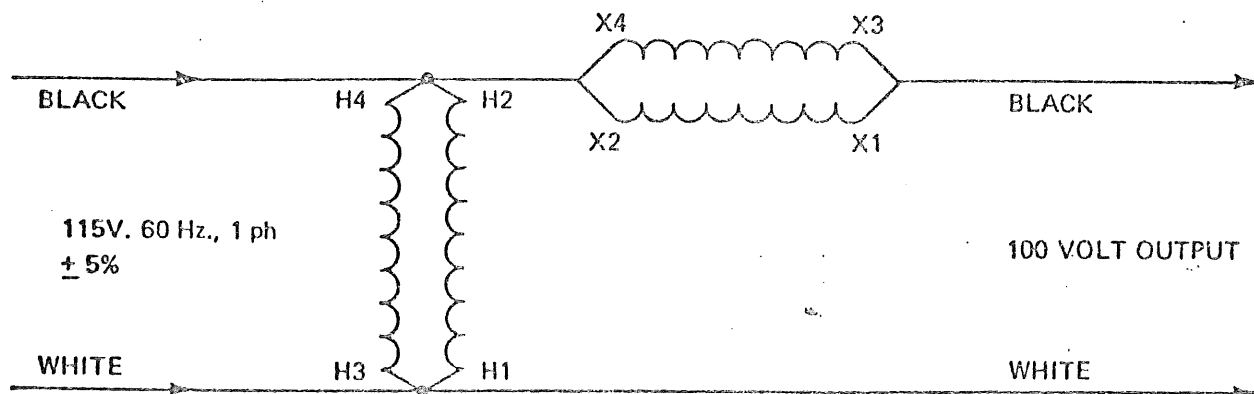
With all seven day switches in the DOWN position, reset the indicator light to the fifth from the left position (Thursday) by sequentially pressing the DAY RESET switch. Place the 6TH DAY SAMPLE switch and the sixth from the left day switch (Friday) in the UP position. Set the toggle switch between clocks "A" and "B" to the left hand position. The sampling period is from midnight to midnight the following day or position and every six days thereafter.

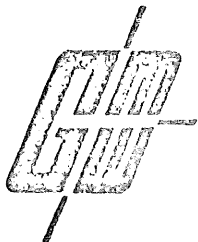
SCHEMATIC MODEL GMW-800



GMW-90 TRANSFORMER FACTORY WIRING SCHEMATIC

(Effective June 1, 1976)





GENERAL METAL WORKS INC.

8368 BRIDGETOWN ROAD / CLEVELAND, OHIO 44102 / TEL. 513-941-2229

RESEARCH APPLIANCE COMPANY

Route 8

Gibsonia, PA 15044

Phone: (412) 443-5935

OPERATING INSTRUCTIONS

for

5 - Gas Collecting Sampler
Catalog No. 2333-A

RESEARCH APPLIANCE COMPANY

Route 8

Gibsonia, PA 15044

Instructions: '5 - Gas Collecting Sampler Cat. No. 2333-A

1. Preliminary Inspection: Upon unpacking, please inspect all parts for damage in shipment. If damage has occurred, please notify carrier immediately. Save all packing material for their inspection.
2. Factory Guarantee: You are protected by a one year factory guarantee against defective material or workmanship, subject to inspection and replacement F.O.B. factory. If the unit appears defective, whether new or old, it should be returned to the factory for inspection. This is less expensive than unauthorized field repairs, which may void the guarantee or render minor parts replacement impossible due to damage to major parts.
3. A General Explanation of the Unit: The basic sampling unit consists of a bubbler, which is connected through a critical or limiting orifice to a pump. A filter connected between the bubbler and orifice reduces plugging of the orifice by entrained absorbing reagent. Use of manifolds permits connection of five sampling units in parallel and simultaneous sampling for as many as five different gases.

Ambient air enters through a polypropylene funnel connected to a polypropylene probe. This funnel prevents precipitation from being drawn through the probe into the sampler. Particulate matter is removed by a membrane filter before the air enters the glass inlet manifold. This inlet filter must be changed every three months or sooner if the unit is placed in an area of high particulate pollution. The glass manifold divides the air stream into five parallel branches, each leading to a collecting unit consisting of a polypropylene centrifuge tube fitted with a two-hole cap.

A section of glass tubing, constricted at one end to a diameter of 14 ± 2 mls (0.35 ± 0.05 mm) or a fritted bubbler is held in one of the holes of the two hole cap and disperses the air through the absorbing reagent in the collecting unit. After the air is bubbled through the absorbing reagent, it is exhausted through a section of vinyl tubing connected to the second hole of the cap. The air then passes through another plastic tube filled with a demister and a second membrane filter, which removes any entrainment. The purpose of this dual trap is to prevent plugging of the limiting orifice used to control flow and from contaminating the vacuum pump. This membrane filter must be changed every six months.

A hypodermic needle inserted through a serum stopper attached to the down-stream side of the second filter serves as a limiting orifice. This needle fits onto an adaptor attached to a brass manifold. The portion of the sampling system between and including the two manifolds is housed within the box.

The air sample contacts the plastic funnel, polypropylene probe, membrane prefilter, glass manifold and connecting tubing, polypropylene butt-connectors. Teflon and polypropylene are generally regarded as suitable for use in probes for a wide variety of pollutants; however, pollutant contact with Tygon and rubber is sometimes undesirable and is held to a minimum. The membrane prefilters were adopted with some reservations because the filter itself, or particulate matter that collects thereon, may affect gaseous pollutants passing through the inlet system. These prefilters are replaced periodically to minimize such effects.

4. Unpacking: Remove the gas bubbler rack from its cabinet. A two-foot length of polypropylene tubing is wrapped around the top

portion of this rack. If your 5-Gas Sampler is supplied in an all-weather shelter, release the quick disconnect located in the tubing connecting the pump to the metal manifold before taking the rack out of the shelter. Note that for shipment certain parts of the sampling train are left unassembled. Please find the following parts between the bubbler tubes. The simplest way to remove these parts is to unhook the elastic retainer from in front of the first bubbler and move the bubbler up out of the way.

1. Two feet of rubber tubing; not supplied with units in all-weather shelters.
2. Polypropylene funnel.
3. Package of five closures.
4. Plastic bag containing:
 - A. Inlet filter assembly
 - B. $\frac{1}{2}$ " polypropylene sleeve
 - C. 2" polypropylene sleeve
 - D. Package of five orifice needles
 - E. Fritted bubbler tube
5. Setting Up: There are three different configurations used as an inlet probe, any one of which may be used; they are as follows.
 1. Remove the vinyl sleeve on the inlet side of the inlet filter assembly and connect the outlet side of the filter to the glass manifold on the rack by means of the vinyl sleeve on this end. Make sure connection is butt to butt. Assemble probe by placing the funnel outlet into one end of the two-foot piece of polypropylene tubing and placing the other end over the inlet of the filter.

2. To assemble the inlet without the polypropylene tubing, connect the inlet filter as above; however, leave the vinyl sleeve on the inlet to the filter. Use this sleeve to connect the funnel to the filter. Make sure all connections are butt to butt.
3. If you desire, the inlet filter may be eliminated by using the two-inch piece of polypropylene tubing, mentioned previously, as a sleeve to connect the funnel to the glass manifold.

Note: The I.D. of polypropylene tubing is by nature out of round; therefore, some enlargement may be necessary to use this sleeve in the manner indicated.

The orifice needles may now be inserted into the red rubber serum stopper through the circle indicated on the face of the stopper and the plastic end placed on the bibs on the metal manifold. Make sure this last connection is tight. The flow rate through the matched orifices is indicated on the sheet accompanying the orifices. Flow may range from 175 to 200 ml/min. for any given set. Orifices should be cleaned and recalibrated often in order to insure correct flow. (Orifice Calibration Unit available from Research Appliance Co., Cat. #2346.)

6. 5-Gas Sampler with External Pump: The two-foot piece of black rubber tubing mentioned previously is connected between the metal manifold and the pump. Exit from the bubbler rack is through the opening indicated on the cabinet. When the pump is plugged in, the sampler will draw air through the bubbler tubes at the rate indicated on the orifice calibration sheet. When the power cord supplied with the unit is plugged into the recessed male receptical

on the bubbler rack cabinet and an external outlet, the heaters in the cabinet will be activated. The temperature in the cabinet should stabilize near 90°F ($+3^{\circ}$) when the heaters are used.

7. 5-Gas Sampler in the All-Weather Shelter: This unit is supplied with the pump enclosed in a shelter. Without the timer option the pump and heater are connected as in section above. With either 24 hour or 7 day skip timers included, the pump and heater are plugged into female recepticals emanating from the timer box located on the cabinet lid. The timer then is plugged into an outlet and the timer set for desired operation. See included sheets for instructions explaining timer operation.

8. Some Additional Notes: A fritted bubbler tube has been supplied with the sampler. This tube is substituted for the constricted bubbler tube in any of the bubblers when it is desired to sample for NO_2 . This is done by removing the constricted tube and replacing it with the fritted tube using the $\frac{1}{2}$ " polypropylene sleeve to make the connection. A method for determining the exact frit pore size is included with the sampling procedures for NO_2 . Pore size is nominally 70 microns.

Note: The I.D. of polypropylene tubing is by nature out of round; therefore, some enlargement may be necessary to use this sleeve in the manner indicated.

The five closures supplied are leakproof and are normally used when transporting the sampling reagents to and from the lab.

Procedures are included for sampling and analysis of some of the more common pollutants.

24-HOUR TIMER
PROGRAM TIME SWITCH

Single pole, double throw or
Single pole, single throw

SWITCH RATING: 20 AMPS; $\frac{1}{2}$ HP; 125 VOLTS A.C.

CLOCK MOTOR RATING: 125 VOLTS; 60 CYCLES

HOW TO SET TIME SWITCH

1. Pull tripper out, away from dial, to turn Load Circuit #2 ON for 15 minutes. Push tripper in when no switching is desired. (Trippers are usually at "IN" position.) Pull out two adjacent trippers for continuous 30 minute ON period. 3 for 45, etc.
2. To set time, turn dial in clockwise direction only until actual time of day is opposite time arrow on insulator.
3. To turn normally open circuit ON permanently (thus skipping all closed circuit OFF operations until reset), push manual lever up. For automatic operation push manual lever down.
4. To remove mechanism, depress spring grasp, dial and pull outward. To replace mechanism, slide bottom end of plate between lower pairs of projecting ears inside case. Push mechanism into place.

IMPORTANT!

*Supply circuit voltage and cycles must correspond to ratings shown above.

*Turn dial clockwise direction only to avoid stripping gears.

WIRING INSTRUCTIONS Wire in accordance with suggested wiring in the Bulletin.

TO SET TRIPPERS Place A (Bright) trippers at time 1 and 3 load circuits should close (2 and 4 load circuits open). Place B (Dark) trippers at time 2 and 4 load circuits should close (1 and 3 load circuits open). Extra trippers and bridges may be found in envelope. Trippers must be tight against dial rim. Tighten tripper screws with fingers only.

TO SET TIME Grasp dial and rotate CLOCKWISE ONLY until correct day and time of day appear at time pointer.

DO NOT TURN TIME POINTER

TO REMOVE MOVEMENT FROM CASE Remove terminal insulator and depress spring locking tab at top of case. Grasp dial and lift outward and upward.

TO REPLACE MOVEMENT Slide terminal board into the grooves provided. Press at top of plate and movement will snap in.

THIS TIME SWITCH CONTROLS

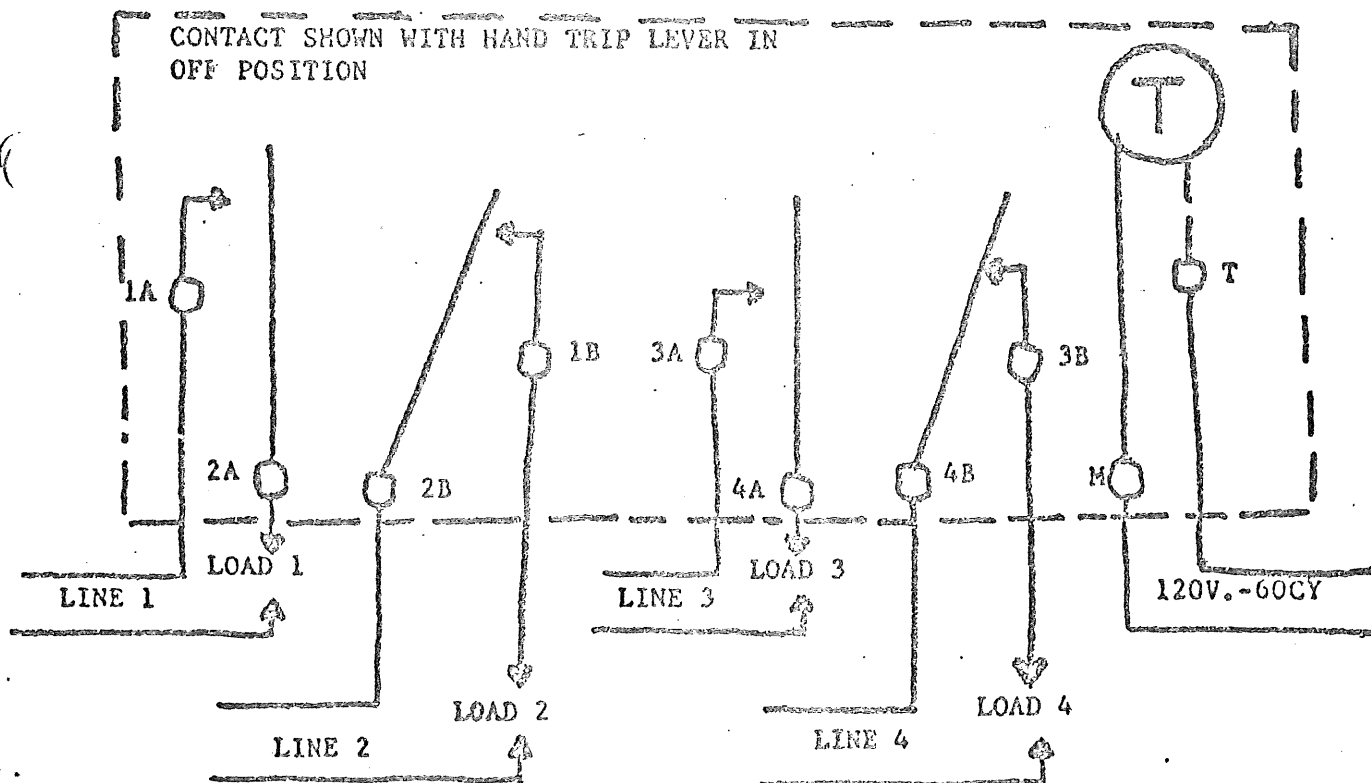
Load 1

Load 2

Load 3

Load 4

CONTACT SHOWN WITH HAND TRIP LEVER IN
OFF POSITION



**MAXIMUM LOAD RATING
Per Pole**

40 Amp.
1 H.P. (1 Pole Only)
690 V.A. Pilot Duty

120 - 277 Volt AC
120 or 208-240 Volt AC
120 - 277 Volt AC

Timing Motor 120V.-60 CY.

MADE IN THE U.S.A. by:

Paragon Electric Company, Inc.
1600 12th St. Two Rivers, Wisconsin 54211
Subsidiary of AMF Incorporated

RESEARCH APPLIANCE COMPANY
Route 8, Gibsonia, PA 15044
Phone: (412) 443-5935

METHOD FOR THE DETERMINATION OF SULFUR DIOXIDE
IN THE ATMOSPHERE (PARAROSANILINE METHOD), E.P.A. PROCEDURE

1. PRINCIPLE AND APPLICABILITY

A. Sulfur dioxide is absorbed from air in a solution of potassium tetrachloromercurate (TCM). A dichlorosulfitomercurate complex, which resists oxidation by the oxygen in the air, is formed.^{1, 2} Once formed, this complex is stable to strong oxidants (e.g. ozone, oxides of nitrogen). The complex is reacted with the pararosaniline and formaldehyde to form intensely colored pararosaniline methyl sulfonic acid³. The absorbance of the solution is measured spectrophotometrically.

B. The method is applicable to the measurement of sulfur dioxide in ambient air using sampling periods up to 24 hours.

2. RANGE AND SENSITIVITY

A. Concentrations of sulfur dioxide in the range of 25 to 1048 $\mu\text{g}/\text{m}^3$ (0.01 to 0.40 ppm) can be measured under the conditions given. One can extrapolate to concentrations below 25 $\mu\text{g}/\text{m}^3$ by sampling larger volumes of air, but only if the absorption efficiency of the particular system is first determined. Higher concentrations can be analyzed by using smaller gas samples, a larger collection volume, or a suitable aliquot of the collected sample. Beer's law is followed through the working range from 0.03 to 1.0 absorbance units (0.8 to 27 μg of sulfite ion in 25 ml final solution computed as SO_2).

B. The lower limit of detection of sulfur dioxide in 10 ml TCM is 0.75 μg (based on twice the standard deviation) representing a concentration of 25 $\mu\text{g}/\text{m}^3$ SO_2 (0.01 ppm) in an air sample of 30 liters.

3. INTERFERENCES

A. The effects of the principal known interferences have been minimized or eliminated. Interferences by oxides of nitrogen are eliminated by sulfamic acid,^{4, 5} ozone by time-delay,⁶ and heavy metals by EDTA (ethylenediaminetetraacetic acid, disodium salt) and phosphoric acid^{4, 6}. At least 60 μg Fe (III), 10 μg Mn (II), and 10 μg Cr (III) in 10 ml absorbing reagent can be tolerated in the

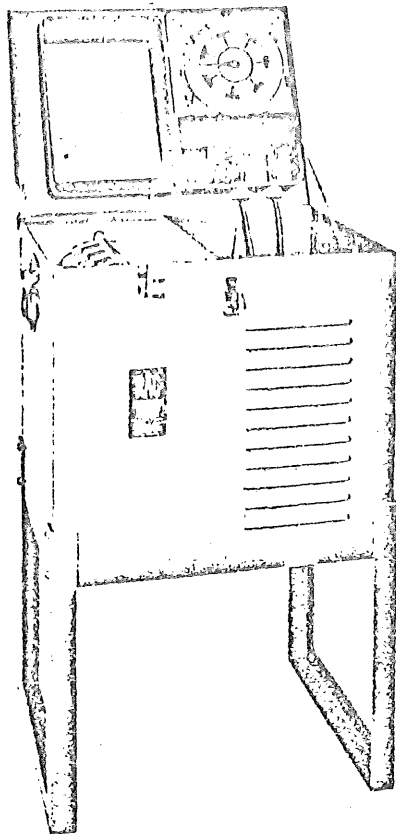


FIGURE 2

All-Weather Shelter Model in operating configuration, with top open to show installation of optional 7-day timer; air inlet tube (see Fig 1) connects to manifold through slot.

ing a weather- and corrosion-resistant finish. Sampling train compartment is insulated and equipped with thermostat-controlled heater. Pump compartment has ventilating louvers to dissipate heat, and is separated from the sampling compartment by a partition to minimize overheating or evaporation of absorbing solutions in bubblers.

Shelter's sturdy angle-iron legs—which can be attached flush with the cabinet for carrying/transporting—are securely mounted in both extended and retracted positions by steel bolts in predrilled holes. (See Fig 2 & 3)

Two optional timer mechanisms can be installed in the all-weather shelter model. The 24-hour timer (shown in Fig 3) has permanently attached trippers that provide up to 96 on-off cycles, in 15-min increments, over a 24-hr period. The alternate 7-day skip-timer mechanism (see Fig 2) permits settings one week in advance, and has 14 trippers that will provide minimum sampling cycles of 3 hours and a maximum cycle of 7 days. Both timers are attached to shelter's hinged top and positioned in the pump compartment.

All-weather shelter model of the RAC 5-Gas Collecting Sampler weighs 58 lbs complete, without a timer installed (24-hr timer weighs 3 lbs; 7-day timer, 6 lbs). With the legs raised for carrying/transporting, this model measures 17½"W x 16"H x 13¼"D. Height is 29" with legs extended.

• operation

Vacuum pump draws ambient air in through inlet funnel and tube. (Funnel is installed inverted to prevent precipitation from entering sampling train.) Particulate matter entrained in the air sample is trapped in a membrane-type filter before air enters the inlet manifold. Air stream then is divided into five equal parts by inlet manifold and directed through parallel branches into the bubblers. Each 100 ml bubbler has a 2-hole cap with a standard glass bubbler tube, either constricted or fritted, on the inlet port. The air to be sampled passes through these tubes into 50 ml quantities of reagent (absorbing solution) contained in each bubbler.

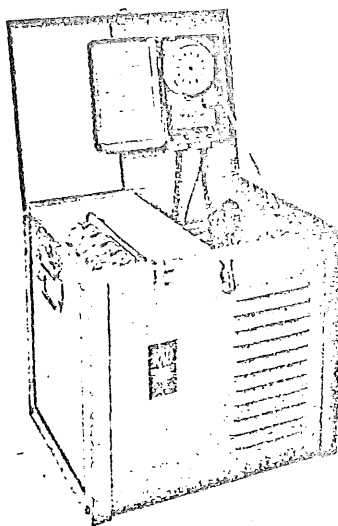


FIGURE 3

Shelter Model in carrying configuration; top raised to show optional 24-hr timer installation (air inlet tube not shown).

After bubbling through the reagent, the air exhausts through a length of vinyl tubing connected to outlet port in the 2-hole cap. Each air stream then passes through another polypropylene bubbler containing a demistor and a second membrane filter. (This dual-trap arrangement protects the critical/limiting orifices from moisture or other entrainments, and helps to maintain continuous full-flow operation for optimum sampling efficiency.) The five sampled, scrubbed air streams then are collected by the exhaust manifold and discharged through the pump.

After a sampling cycle is completed, the sampling train assembly is removed from the carrying case (or shelter). The bubblers in which gas samples have been absorbed by reagents are disconnected, and the 2-hole caps are replaced with the threaded, solid, leak-tight closures. Bubblers then are taken to a laboratory for an analysis of contents according to appropriate procedures. (NOTE: Sampling/analyzing procedures for some pollutant gases are included in the operating instructions furnished with RAC 5-Gas Collecting Samplers.)

• specifications

Vacuum Pump
1/6 hp, 1.8 cfm free flow, 29" Hg vac, continuous duty, overload protection

Electrical
115 v, 60 Hz, 3.4 amp

Dimensions
STANDARD MODEL:
12"W x 12¾"H x 7¾"D
SHELTER MODEL:
17½"W x 29"H x 13¼"D w/legs extended
(16"H w/legs raised)

VACUUM PUMP:
11¾"L x 5¾"W x 8½"H

Weights
STANDARD MODEL:
15¾ lbs (without pump)
SHELTER MODEL:
58 lbs including pump (w/o timer installed)

24-HOUR TIMER: 3 lbs
7-DAY TIMER: 6 lbs
VACUUM PUMP: 18 lbs

• ordering information

Both the standard and all-weather shelter models of the RAC 5-Gas Collecting Sampler are furnished complete and ready-to-use. The standard model, including the vacuum pump and power cord, is the basic system. It contains all the components listed in the Design section of this bulletin. The all-weather shelter assembly and the two alternate timer mechanisms are available on an optional basis.

Specify all units, including optional arrangements, by full name and catalog number. Unit prices and the catalog numbers of the individual system components are furnished on separate sheets.

RAC 5-Gas Collecting Sampler, Standard Model, Complete CAT. #2333-A
Includes heated steel carrying case, complete sampling train, vacuum pump, 3-wire power cord, all necessary tubing & connections, pack of orifices (5), pack of filters & back-up discs (5 ea).

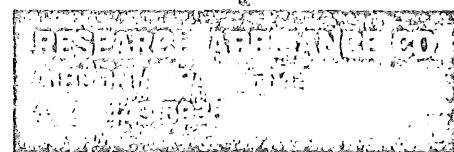
RAC 5-Gas Collecting Sampler, All-Weather Shelter Model, Complete CAT. #2333-S
Substitutes a 2-compartment, louvered, weather-resistant steel shelter for carrying case; includes same train, pump & components as Standard Model.

RAC 5-Gas Collecting Sampler, All-Weather Shelter Model with 24-Hour Timer, Complete CAT. #2333-24
Same components as regular all-weather model with addition of a timer that provides up to 96 on-off operations, in 15-min increments, within 24-hr cycle.

RAC 5-Gas Collecting Sampler, All-Weather Shelter Model with 7-Day Skip Timer, Complete CAT. #2333-7
Only difference is optional 14-trip timer that provides min. sampling cycles of 3 hrs, max cycle of 7 days; permits setting 7 days in advance.

• other sampling equipment

Research Appliance Company manufactures and supplies a wide variety of precision instruments and systems designed for sampling/monitoring environmental air, water, and sound pollution. Write for details on other RAC sampling equipment.





versatile

5-GAS SAMPLER

compact, portable bubbler system collects up to five different pollutant gases from ambient air in one sampling cycle

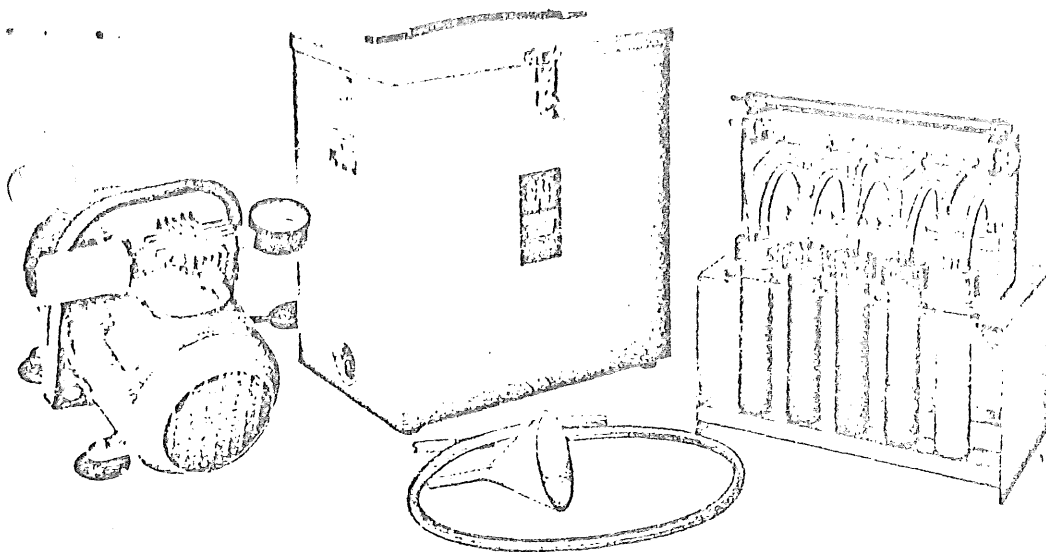


FIGURE 1

Standard Model, RAC 5-Gas Collecting Sampler (system's 3-wire power cord & 5 solid bubbler caps are not illustrated).

• features

- Performance & reliability proved by years of use by governmental agencies & industry
- Meets EPA specs for sampling SO_2 & NO_2 in ambient air
- Both standard & all-weather models are lightweight, fully portable
- All-weather unit available with 24-hr or 7-day timer mechanisms (optional)
- Integral limiting orifices give 200 ml/min flow rate (approx) to bubblers
- All orifices protected by inline filters & demistors to prevent clogging & flow reduction
- Polypropylene bubblers have threaded interchangeable caps (2-hole unit for sampling, solid unit for carrying)
- Sampler cabinets equipped with thermostatically-controlled heater
- Bubblers & closures supplied in 5 colors; demistors-traps in natural plastic

• application

The RAC 5-Gas Collecting Sampler is a wet-chemical system that will sample ambient air for any pollutant gas for which there is a suitable chemical reagent (absorbing solution). It tests for sulfur dioxide (SO_2), nitrogen dioxide (NO_2), hydrogen sulfide (H_2S), ammonia (NH_3), aliphatic aldehydes (CHO), and other gases reactive to specific chemical solutions. This versatile instrument can be used to accurately sample either a single gas or up to five different gases simultaneously. Simplified design, ease of assembly, and modular components permit easy changes in sampling train configuration to meet variable sampling requirements.

The concept for this multi-gas system was evolved by NAPCA, the predecessor to the Environmental Protection Agency (EPA), and the original design has been continually improved

by RAC over a period of years. This system is being used for area surveillance by numerous state, county, and municipal governments as well as federal government stations involved in the Community Air Monitoring Program (CAMP) and the Community Health Air Monitoring Program (CHAMP). It also is used in many industries for plant perimeter surveys and interior air quality monitoring or evaluation. In fact, the RAC 5-gas instrument is one of the most widely used systems for sampling gaseous pollutants in ambient air.

• design

RAC's 5-gas sampling system is supplied in standard and all-weather shelter models that are furnished complete and ready-to-operate.

The standard model can be used to sample either indoor or outdoor air. When used for outdoor sampling, the funnel-equipped inlet tube is passed through any convenient opening or connected to an air inlet duct. This model's sampling case and vacuum pump should be shielded from inclement weather at all times.

The all-weather shelter model is designed primarily for outdoor applications. It is fabricated from heavy-gauge steel, has a heavy-duty baked enamel finish, and is suitable for use under all climatic conditions.

Standard Model—consists of an insulated steel carrying case with an integral heating element; a preassembled, removable, complete sampling train; an external $\frac{1}{2}$ hp vacuum pump; and a 3-wire power cord. (See Fig 1)

The RAC sampling train assembly includes a polypropylene inlet tube with a detachable funnel, a membrane-type inlet filter for particulates, a 5-branch glass inlet manifold, 5 polypropylene

100 ml bubblers with interchangeable threaded closures (2 hole & solid caps), 5 constricted glass bubbler tubes, 1 fritted glass bubbler tube, 5 polypropylene demistor-entrainment traps, 5 limiting/critical orifices, and a 5-branch nickel-plated exhaust manifold. All components between and including the two manifolds are preassembled and can be removed as a subassembly for filling, cleaning, or change in sampling train configuration.

The flow-regulating critical orifices can be either the stainless steel needle type or sections of precision-bore glass tubing encased in vinyl. Both types provide a 200 ml/min flow rate (approx) to all bubblers, are easily cleaned in small RAC ultrasonic baths.

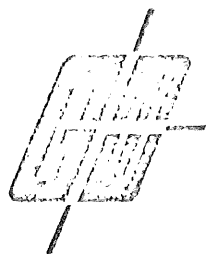
The sampling cabinet's thermostat-controlled heating element maintains a uniform internal temperature of 90°F ($\pm 3^\circ$) to assure continuous sampling/operating efficiency.

Threaded closures for the polypropylene bubblers are a 2-hole inlet & outlet design that is used during sampling operations, and a solid leak-tight cap used to transport bubblers filled with reagents, both before and after sampling cycles.

The 100 ml bubblers and their closures are supplied in five colors: red, yellow, blue, green, and orange; one set in each color. Demistors-traps are furnished only in natural plastics.

The standard model measures 12"W x 12 $\frac{3}{4}$ "H x 7 $\frac{3}{4}$ "D and weighs 15 $\frac{1}{2}$ lbs. The vacuum pump provides 1.8 cfm free flow and 29" Hg vacuum. It 11 $\frac{1}{2}$ "L x 5 $\frac{1}{2}$ "W x 8 $\frac{1}{4}$ "H, weighs 18 lbs., operates on 115 v, 60 Hz, 3.4 amp.

All-Weather Shelter Model—has all the above sampling train components and the same vacuum pump installed in a 2-compartment steel shelter fea-



MODEL GMWL-2000 H

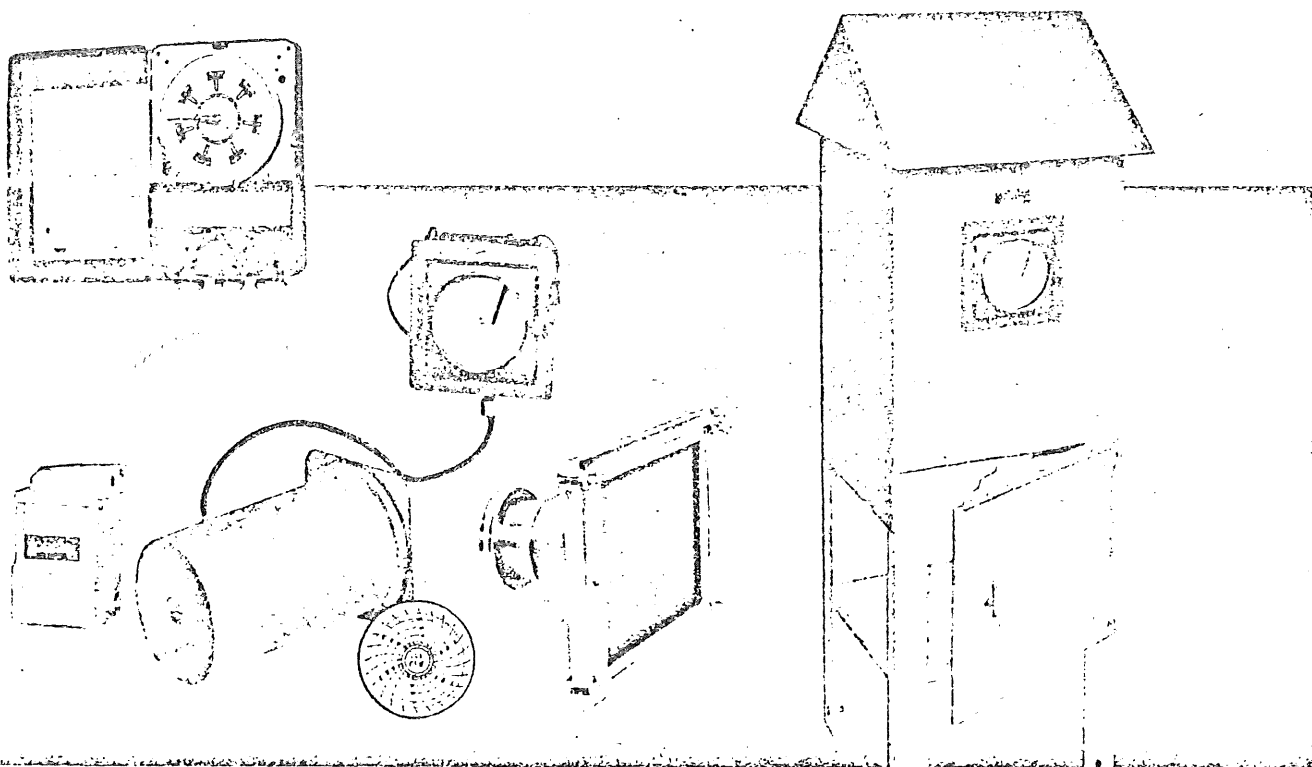
High Volume Air Sampler

Designed for continuous operation in an all weather environment, the Model GMWL-2000 H is a complete monitoring station for the collection of suspended particulate matter with precise measurement capability. All instruments and components are mounted within the aluminum shelter for complete protection. The hinged roof facilitates filter media exchange.

The Model GMWL-2000 H is complete with high volume sampler, seamless stainless steel filter holder, pressure transducer recorder, 50 charts, ink and 90-volt protective transformer all housed in the aluminum shelter ready to operate. A seven day regular timer Model GMW-70 is included as standard equipment. The timer/programmer Model GMW-80 is optional.

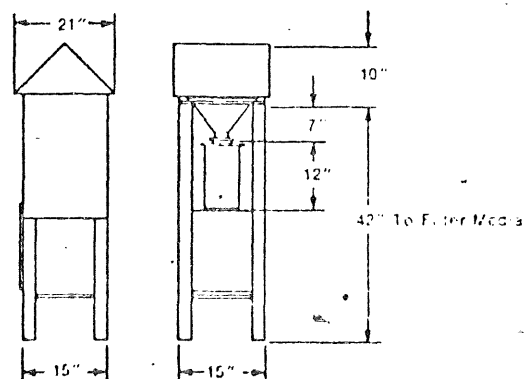
The sampler is a heavy duty turbine type blower with high speed motor arranged with a fixed orifice on the discharge end. Although factory calibrated against a water manometer, recalibration is suggested to suit barometric conditions at the site. Air flow is accurately measured by the pressure transducer which provides a permanent record of every sample.

Four bolts, easily accessible, permit motor removal for periodic brush replacement. Special U-clip connectors facilitate brush changing and prevent damage to the internal leads. The 90-volt transformer reduces the operating voltage to approximately triple normal brush and motor life.



Specifications:

Motor HP — 0.6
 Speed — 13,500 R.P.M.
 Amperage — 4.9
 Wattage — 440
 Max. Flow Rate — 52 C.F.M.
 Min. Flow Rate — 20 C.F.M.
 Power Source — 115 V, 1 phase, 60 Hertz (other electrical characteristics available on request)
 Net Weight — 53 lbs.
 Shipping Weight — 65 lbs.
 Meets all Federal performance and dimensional specifications including Federal Register Vol. 36, No. 84 dated April 30, 1971





MODEL GMW-65-000

Particle Sizing Head/Anderson 2000 Inc.

Now for the first time, high volume particle sizing can be performed in industrial hygiene applications with this special head. High flow rate (20 CFM) reduces sampling time. Tedious microscopic counting and sizing are eliminated. Respirable and non-respirable fractions of particulates can be quickly and easily separated.

The head is designed and built to meet E.P.A. specifications for ambient air sampling. It gives sizing data in five micro ranges: 0.0 to 1.1; 1.1 to 2.0; 2.0 to 3.3; 3.3 to 7; 7 and above. According to E.P.A. tests, the Model GMW-65-000 Particle Sizing Head is compatible for use with all GMW Hi-Vol air samplers and aluminum shelters without modifications.

The Model GMW-6500 Aluminum Shelter is especially recommended for use with the head because of its design characteristics. The entire unit can be

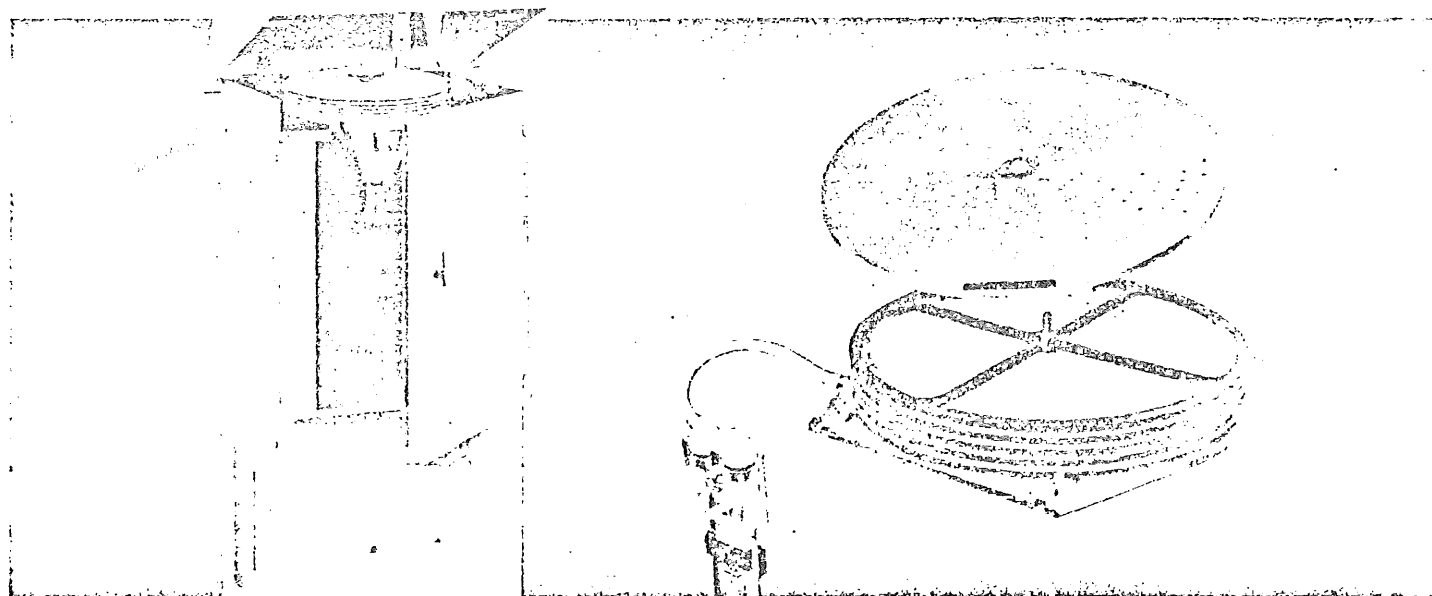
removed through the large door in the front of the shelter.

The air flow of the sampler when equipped with the particle sizing head must be maintained at 20 CFM. A variable voltage transformer Model GMW-625 is, therefore, required to reduce the operating voltage to approximately 50 volts.

Standard Equipment includes interface adapter to fit existing 8" x 10" filter holders, 5 jet plates, 5 gaskets, special washer, speedball handle, water manometer and 1/4" rubber tubing.

Optional Equipment: Complete Collection Kit No. GMW-660 includes: 50 sets (200 sheets) of perforated glass fiber (non-hygroscopic) Type A collection discs and 100 glass fiber backup filters.

Model GMW-625 Variable Voltage Transformer for air flow regulation.



Specifications:

Anderson 2000 Inc. (Head Only)

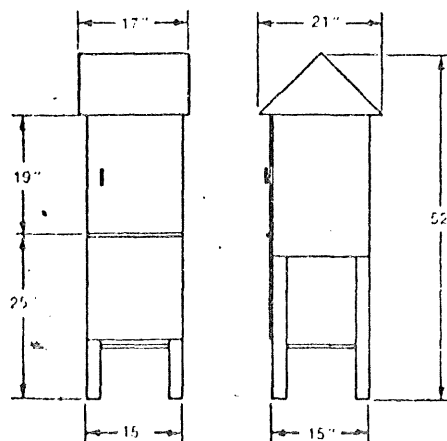
Maintained flow rate — 20 C.F.M.

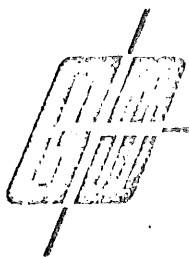
Approximate Diameter — 12"

Overall height, including handle — 5" (approximately)

Net weight — 19 lbs.

Shipping weight — 23 lbs.





MODEL GMWR-5000

Brushless High Volume Air Sampler

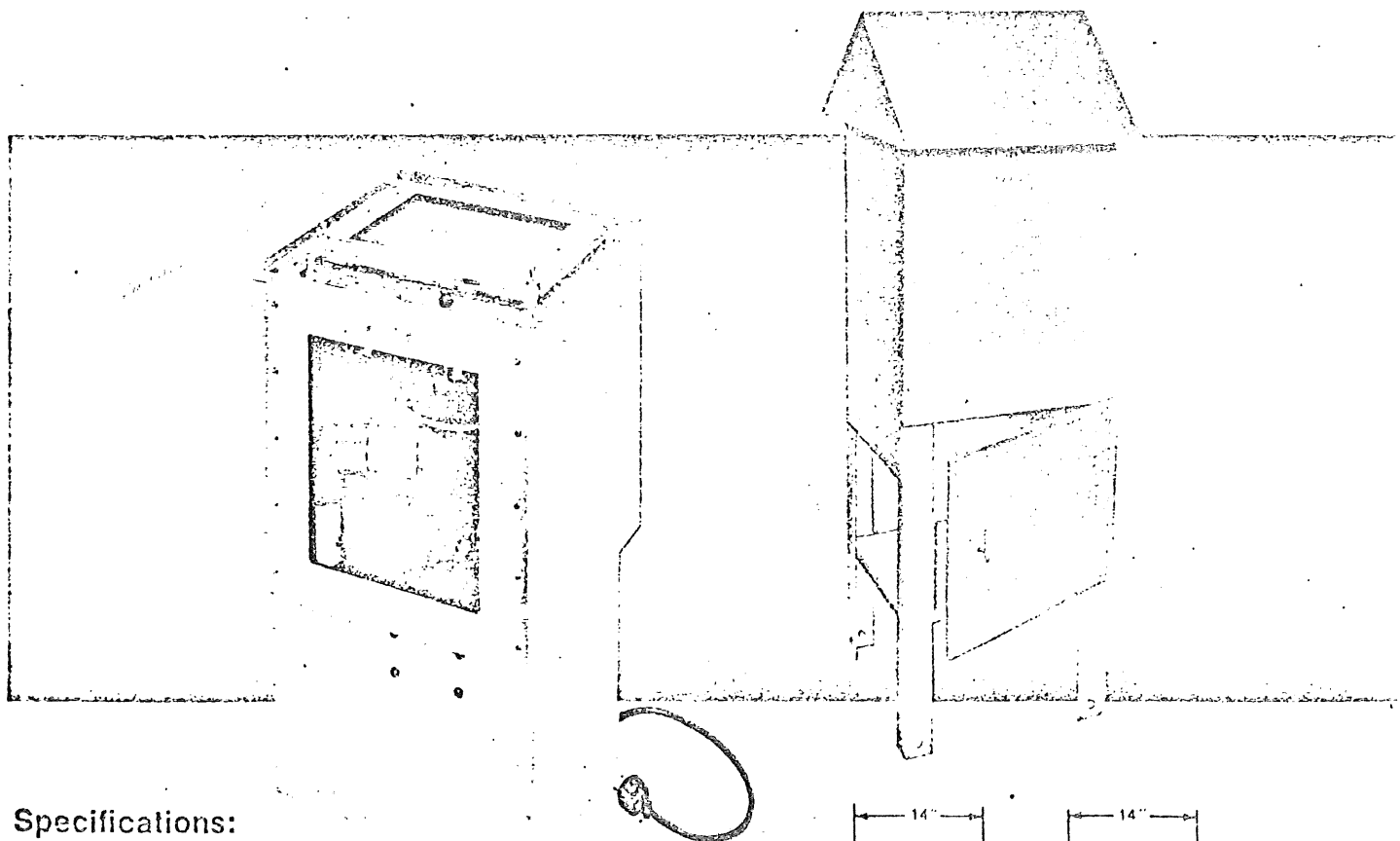
The ultimate in air sampling performance and unit reliability is guaranteed in the Model GMWR-5000. Designed and developed to provide extended life and maintenance free operation, this brushless high volume air sampler has operated for over three years under actual field conditions without malfunction.

The Model GMWR-5000 is a complete monitoring station, providing 24-hour a day sampling of airborne particulate matter. It includes the Brushless High Volume Air Sampler, and FH-2100 Filter Holder housed in a Model-5500 Aluminum Shelter. A fused digital counter to indicate elapsed unit running time is included as standard equipment.

The brushless sampler is mounted in an aluminum

housing which is integral with the upper support plate. The filter holder attaches to the sampler with a threaded ring and gasket. This entire sub-assembly may be removed from the shelter at the top through the hinged shelter roof. The air flow rate is measured by a variable orifice meter which must be calibrated periodically to maintain on-site accuracy.

The Brushless High Volume Air Sampler is also available as a conversion kit to replace existing GMWL-2000 units. The kit consists of the brushless sampler mounted in the aluminum housing with integral upper support plate. The conversion kit will fit existing Model GMW-5500 shelters by simple exchange of the present upper support plate with the kit assembly.



Specifications:

Motor HP — 0.8

Speed — 3300 R.P.M.

Max. Flow Rate — 45 C.F.M.

Min. Flow Rate — 20 C.F.M.

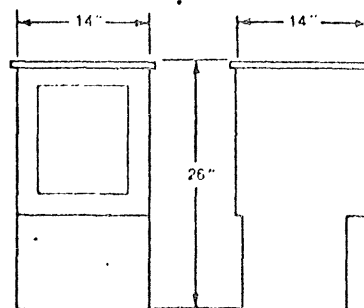
Power Source — 115 V, 1 phase, 60 Hertz (other electrical characteristics available on request)

Net Weight — 75 lbs.

Shipping Weight — 87 lbs.

Conversion Kit Shipping Weight — 57 lbs.

Meets all Federal performance and dimensional specifications including Federal Register Vol. 36, No. 84 dated April 30, 1971





GMW-4000 VERTICAL ELUTRIATOR

Cotton Dust Sampler

The Cotton Dust Sampler is designed to entrap in the filter all fine dust except cotton lint. The sample thus approximates a respiratory criteria which includes tracheal deposition.

The principle of operation is the production of a slow lamina up-flow of air that equals the falling speed of some size particle at the upper end of the respiratory range. Particles with greater falling speed, such as cotton lint fibers, will not be carried to the filter at the outlet and hence not sampled.

OPERATION

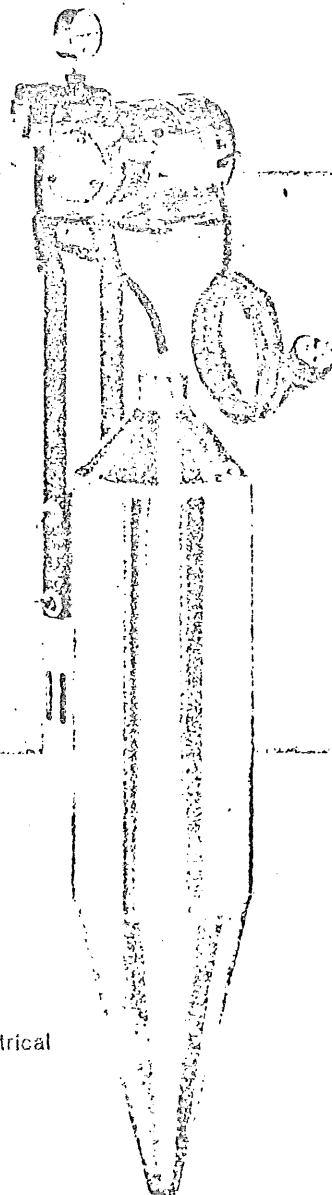
In operation, the unit is hung vertically or otherwise

suspended with the motor on top and the inlet on the bottom at approximately breathing level. On and off times are recorded and the concentration calculated thus:

$$\text{Concentration—mg/m}^3 = \frac{(\text{Final Wt.} - \text{Tare Wt.}) \times 1000}{\text{Time in minutes} \times 7.4}$$

MAINTENANCE

The motor requires no lubrication. After every run, lint should be blown out of the motor and elutriator. Clean the relief valve screen and adjust the relief valve to hold vacuum between 15" and 18" Hg. Check calibration of the critical orifice and vacuum gauge periodically or if malfunction is suspected.



Specifications:

Motor HP — 0.1

Speed — 3450 R.P.M.

Max. Flow Rate — 1.5 C.F.M.

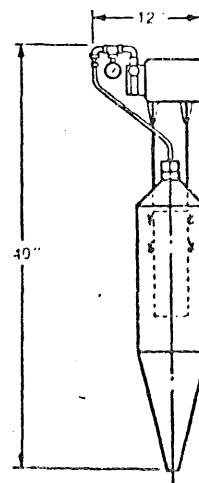
Actual Flow Rate — 7.4 L.P.M. with orifice

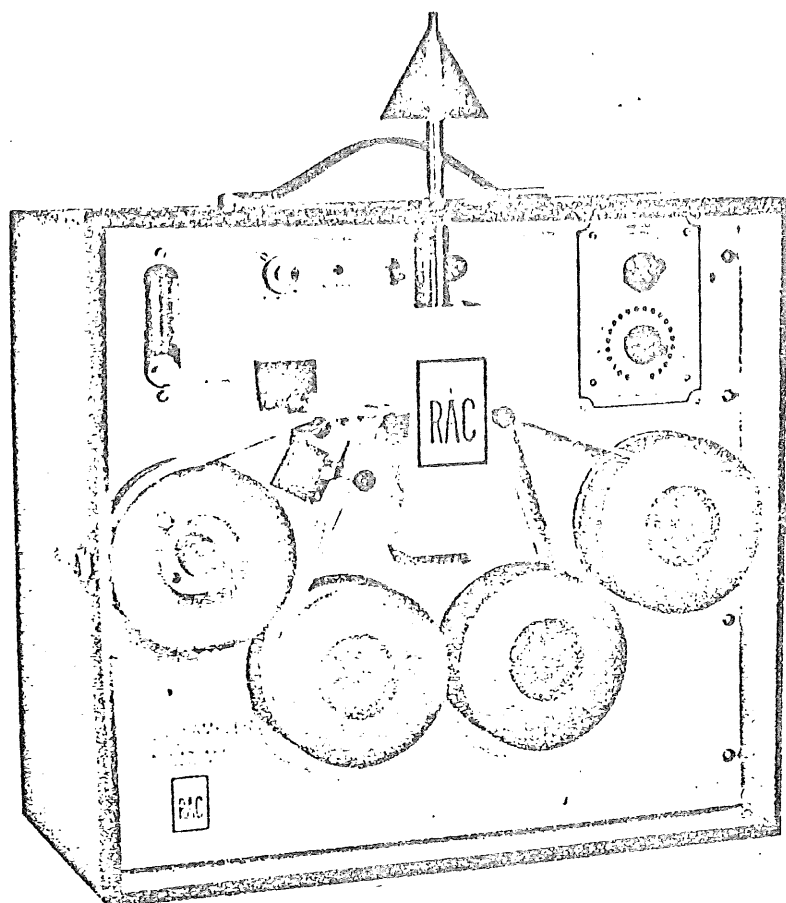
Power Source — 115 V, 1 phase, 60 Hertz (other electrical characteristics available on request)

Net Weight — 20 lbs.

Shipping Weight — 22 lbs.

Meets all Federal performance and dimensional specifications.





FLUORIDE SAMPLER

model G2DT

dual filter tape system provides simultaneous automatic sampling of particulate and gaseous fluorides in ambient air

• application

This rugged self-contained precision sampler provides, with automatic sequential sampling, long term operation and simultaneous collection of particulate and gaseous fluoride concentrations, using two specially treated filter tapes. The samples permit accurate determination of changes in fluoride concentration, and the direction and rate of change.

• operation

Two different types of specially-treated filter paper tape are fed simultaneously through the sampling nozzle. The oil-less vacuum pump draws the sample air through both tapes. The upper tape (#2356-52) collects particulate fluoride, and the lower tape (#2356-4) collects gaseous fluoride in the sample. Samples are evaluated analytically, giving quantitative results. Contamination of tapes in the unit (by ambient fluoride) is effectively prevented by filtering the vacuum pump's exhaust air and using this fluoride-free air to pressurize the front compartment.

• specifications

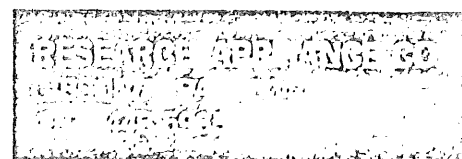
Power
110 v, 60 Hz; 220 v, 50 Hz
Timer
10 min. to 3½ hr cycles, in 10-min. increments (also available: ½, 1, 2, and 4 hr cycle timer)
Pump
1.1 cfm @ 0" Hg, continuous, rotary, carbon vane, oil-less
Flow Meter
0.1 - 1.0 cfm, push to test
Size
20¾"W x 23¾"H x 12"D
Case
Steel, 18 gauge, baked enamel finish
Cover
Aluminum & clear acrylic plastic
Weight
45 lbs

• ordering information

Specify: Fluoride Sampler (Dual Tape Type) Catalog No. 2356, and voltage desired. Treated Tapes for Fluoride Particulate (100 feet) Catalog No. 2356-52. Treated Tapes for Fluoride Gas (100 feet) Catalog No. 2356-4.

• features

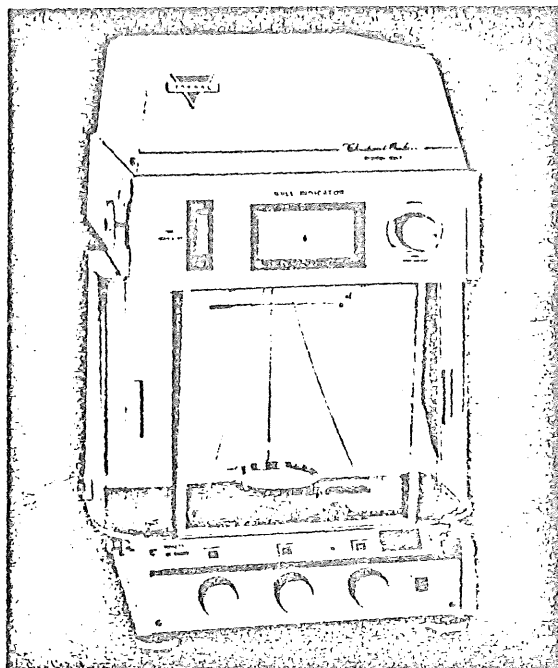
- Direct in top sampling . . . minimizes loss due to impingement
- Range & Sensitivity: For HF, 2 to 75 µg/m³ from 10 to 180 minutes. For F particulate concentrations up to 57 µg/m³ have been tested. Particle size was 1.2 microns.
- Each tape has individual motor drive and indexing control switch
- 600 samples per tape roll (approx.)
- New positive design timer . . . no accumulated time error
- Timer and nozzle are modular
- Unit operates unattended for long intervals
- Oil-less continuous duty vacuum pump
- Push-to-test flow meter permits quick monitoring and/or adjustment of flow rates
- Unit designed for either cabinet or 19-inch rack mounting





TORBAL EA-1-AP ANALYTICAL BALANCE

DESIGNED FOR AIR POLLUTION ANALY
NEW EASE AND ACCURACY IN ANALYTICAL WEIGHINGS



- No beam-arrestment required
- All weighing controls on lower console for convenient operation
- Large weighing chamber for 8" x 10" filter sheets
- Special easel support for 8" x 10" filter
- Easy access to pan by either right or left handed person (dual doors)
- Removable weighing pan allows easy use of other commodity holders (permits increasing tare capacity)
- Substitution weighing principle
- Removable top cover gives access to entire weighing mechanism

Analytical Balance gives friction-free performance because fulcrum is composed of torsion bands instead of knife edges or friction pivots. No movement of parts over one another and dust or foreign material cannot affect results. Gives digital presentation of weight for better readability, accuracy, and reproducibility. No optical system, micrometer, or vernier are used. Torsion balances retain initial high sensitivity and balance for twenty years or more.

SPECIFICATIONS

Capacity—160 g.

Precision (Standard Deviation)— ± 0.03 mg.

Readability—0.05 mg.

Built-in Set of Weights
(Class S or better)—0-159.9 g.

Taring System

Continuous tare—0-8 g.

Replacement of stainless steel pan with
aluminum pan—20 g. approx.

Removal of aluminum pan—20 g. approx.

Total tare without use of internal weights—48 g.
approx.

Tare using internal weight set—159.9 g.

Total tare available—207.9 g.

Weighing System—Torsion (no knife edge construction)
Substitution
Single Pan

Damping—Silicone fluid

Built-in Set of Weights—Stainless steel non-magnetic

Pan—Special easel for supporting large filter sheets
and matched standard pan and bow assembly for
regular analytical use

Pan Bow Height—7½"

Weighing Chamber Base Dimensions—12½" wide x 6"
deep • Height—8¾"

Balance Housing—Metal; mounting plate of weighing
system aluminum alloy casting

Overall Dimensions—12½" x 17½" x 20" High
Net Weight 42 lbs. • Shipping Weight 50 lbs.

Power Supply—110-120V A.C., 60 cycle (220 V A.C. •
special order)

ORDERING INFORMATION

Please specify Torbal EA-1-AP Analytical Balance Catalog No. 2336

RESEARCH APPLIANCE CO., Gibsonia, Pa., U.S.A. 15044 (412) 443-5935

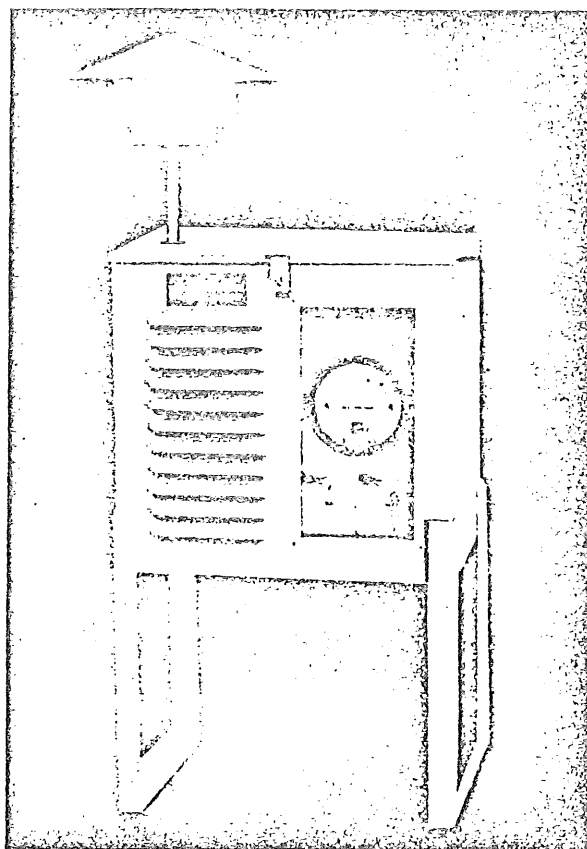
TOTAL PARTICULATE MEMBRANE SAMPLER

Reliable Accurate Control



BULLETIN 2349

THIS SAMPLER IS IDEAL FOR TAKING HIGH VOLUME SAMPLES OF SUSPENDED PARTICULATE MATTER. THE USE OF MEMBRANE FILTER MEDIA MAKES THIS UNIT IDEAL FOR ANALYSIS REQUIRING MEASUREMENT OF RADIOACTIVITY, FOR MICROSCOPIC ANALYSIS, FOR ANALYSIS OF TRACE MINERALS AND ALLOWS REMOVAL OF SAMPLE FROM MEDIA WITHOUT CONTAMINATION BY FILTER MEDIUM ITSELF. IDEAL FOR SAMPLING FOR SILICA, ALKALIES, CATIONS ANIONS AND METALS WHICH MAY NOT BE EASILY MEASURED WHEN USING PAPER OR GLASS FILTER MEDIA.



Ready to Operate

FEATURES

- WEATHERPROOF • DURABLE-18 GA STEEL PRIMED AND 2 COATS BAKED ENAMEL • WELL VENTILATED • RAIN PROOF CAP PROTECTS FILTER
- STAINLESS STEEL ORIFICE • MAGNAHELIC ΔP GAUGE ACROSS ORIFICE FOR FLOW DETERMINATION • PUSH TO TEST VALVES FOR CHECKING ΔP
- LEGS FIT ON ENDS AND FILTER HEAD FITS INSIDE FOR COMPACT SHIPPING • QUIET • CALIBRATED CURVE SUPPLIED.

SPECIFICATIONS

CARBON VANE PUMP Oil-less— $\frac{1}{2}$ HP 115/230V—60 Cycle—7.8 Amp. @ 115V—3.9 Amp. @ 230V 7.2 CFM free flow 5.5 CFM through 3.0 Micron Membrane.

MAGNAHELIC GAUGE—0-40 inches of water Operates between 22 and 29 inches H_2O when 3.0 Micron Filter Membrane is used.

PUSH TO TEST VALVES—Used to read ΔP on gauge and to zero gauge when unit is operating.

9 ft. 2 wire and ground power cord

FILTER HEAD—Anodized aluminum—4" dia. media. $3\frac{5}{8}$ " dia. effective area—Stainless Steel support screen—Teflon and "O" ring gaskets—"O" ring fit rain cap (anodized aluminum)

Weight—81 lbs.

Size—Packed $16\frac{1}{2}$ " x $12\frac{1}{2}$ " x $15\frac{3}{4}$ "

Size—Set-up $16\frac{1}{2}$ " x $12\frac{1}{2}$ " x 38"

SET-UP AND OPERATION

Remove legs from side of cabinet and place on lower part of cabinet as pictured, open cover take out filter head and cap, remove plastic pipe cap from end of orifice, place power cord out through slot, close lid, push filter head pipe through grommet in lid and into sleeve at end of orifice, carefully place weighed filter membrane onto filter support screen, place teflon gasket on top, place frame over studs and tighten thumb nuts evenly and snug by hand—Do Not Use Pliers—Place rain cap down tight on shoulder, plug in cord, push "test" button, read gauge—Push "zero" button and your operating.

WHEN ORDERING SPECIFY

TOTAL PARTICULATE MEMBRANE SAMPLER Cat. No. 2349 115/230 Volt 60 Cycle (50 cycle also available)

3 MICRON 4" DIA. MEMBRANE FILTERS

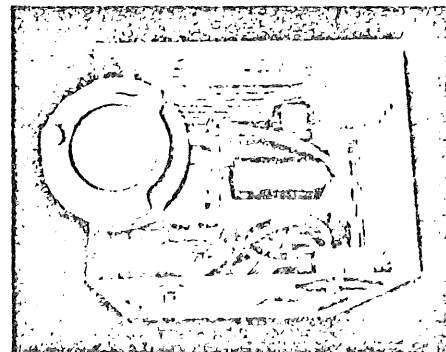
Box of 100

Cat. No. WS-100

OPTIONAL

mer—7 day skip—30 min. increments Cat. No. 2338-T

Glass fiber and cellulos paper filters also available.



Top View—Open

RESEARCH APPLIANCE CO., Gibsonia, Pa., U.S.A. 15044 (412) 443-5935

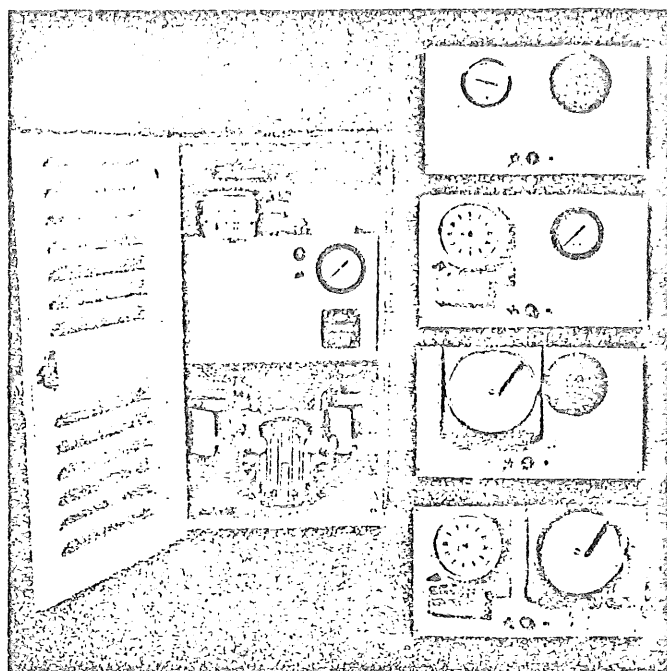


UNIVERSAL SAMPLER

MODELS 51068-A, B, C & D

The Universal Sampler is ideal for continuous sampling where accurate measurements of time, volume and vacuum are essential. The high capacity 4 CFM Free Flow Carbon Vane Pump permits the use of up to 4" dia. filter holders, Greenburg-Smith Impingers or Gas Collecting Bubbler Trains. Flow is controlled by use of built-in Limiting Orifices.

Available in four models with Vacuum Gauge and Time Totalizer, Vacuum Gauge and Program Timer, Vacuum Recorder and Time Totalizer or Vacuum Recorder and Program Timer.



- 115 Volt, 60 Cycle
- Carbon Vane Oilless Vacuum Pump
- 1/4 H.P. Motor
- 6 Amps
- 9ft. 3-Conductor Grounded Detachable Line Cord
- On-off Switch—fuse
- Flow Rates, 1, 2, 5, 14, 28 & 50 LPM with limiting Orifices supplied
- Dry Gas Meter accurate to 1/1000 cu. ft.
- Quick Disconnect for attaching Sampling Sensors
- Net Weight 59 Lbs.
- 13 1/2" x 12 1/2" x 21 1/2"
- Weather Resistant Baked Enamel Steel Case—Louvered
- Carrying Handles
- Key Locked to prevent tampering
- Program Timer 1/2 to 24 Hours
- Vacuum Recorder—24 Hour Circular Chart
- Control Panels interchangeable
- Easy access to Pump Head for service

OPERATION

Place desired Critical Orifice for Flow Control in the line, attach Sampling System to quick disconnect, set Program Timer (if used) take reading on Gas Meter and then turn switch on.

ORDERING INFORMATION. Specify Universal Sampler:

| | |
|---|--------------------------------------|
| With Vacuum Gauge and Time Totalizer..... | Model 51068-A, Catalog Number 2344-A |
| With Vacuum Gauge and Program Timer | Model 51068-B, Catalog Number 2344-B |
| With Vacuum Recorder and Time Totalizer | Model 51068-C, Catalog Number 2344-C |
| With Vacuum Recorder and Program Timer | Model 51068-D, Catalog Number 2344-D |
| Vacuum Gauge and Time Totalizer Control Panel Only | Catalog Number 44-A |
| Vacuum Gauge and Program Timer Control Panel Only | Catalog Number 44-B |
| Vacuum Recorder and Time Totalizer Control Panel Only | Catalog Number 44-C |
| Vacuum Recorder and Program Timer Control Panel Only | Catalog Number 44-D |

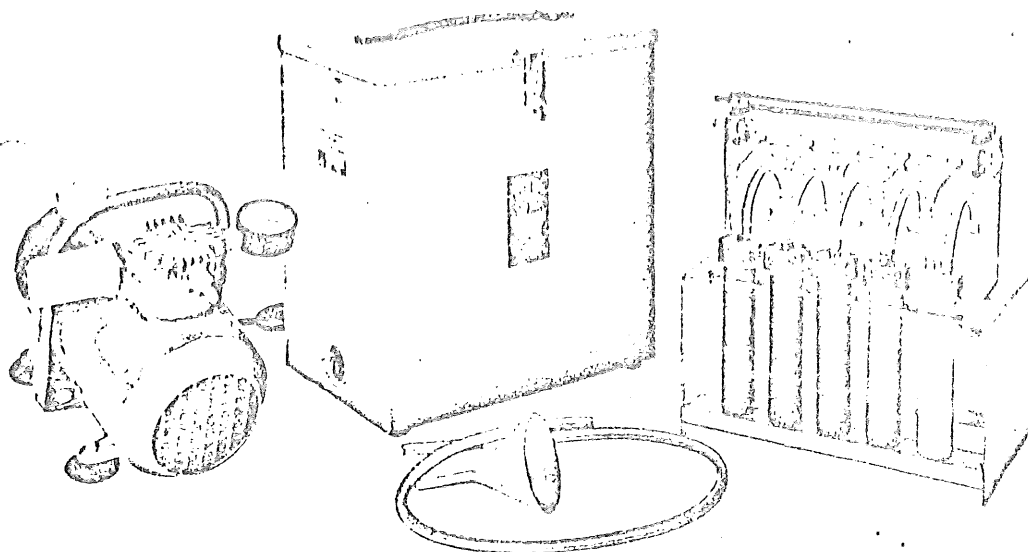


FIGURE 1

Standard Model, RAC 5-Gas Collecting Sampler (system's 3-wire power cord & 5 solid bubbler caps are not illustrated).

versatile 5-GAS SAMPLER

compact, portable bubbler system collects up to five different pollutant gases from ambient air in one sampling cycle

• features

- Performance & reliability proved by years of use by governmental agencies & industry
- Meets EPA specs for sampling SO_2 & NO_2 in ambient air
- Both standard & all-weather models are lightweight, fully portable
- All-weather unit available with 24-hr or 7-day timer mechanisms (optional)
- Integral limiting orifices give 200 ml/min flow rate (approx) to bubblers
- All orifices protected by inline filters & demistors to prevent clogging & flow reduction
- Polypropylene bubblers have threaded interchangeable caps (2-hole unit for sampling, solid unit for carrying)
- Sampler cabinets equipped with thermostatically-controlled heater
- Bubblers & closures supplied in 5 colors; demistors-traps in natural plastic

• application

The RAC 5-Gas Collecting Sampler is a wet-chemical system that will sample ambient air for any pollutant gas for which there is a suitable chemical reagent (absorbing solution). It tests for sulfur dioxide (SO_2), nitrogen dioxide (NO_2), hydrogen sulfide (H_2S), ammonia (NH_3), aliphatic aldehydes (CHO), and other gases reactive to specific chemical solutions. This versatile instrument can be used to accurately sample either a single gas or up to five different gases simultaneously. Simplified design, ease of assembly, and modular components permit easy changes in sampling train configuration to meet variable sampling requirements.

The concept for this multi-gas system was evolved by NAPCA, the predecessor to the Environmental Protection Agency (EPA), and the original design has been continually improved

by RAC over a period of years. This system is being used for area surveillance by numerous state, county, and municipal governments as well as federal government stations involved in the Community Air Monitoring Program (CAMP) and the Community Health Air Monitoring Program (CHAMP). It also is used in many industries for plant perimeter surveys and interior air quality monitoring or evaluation. In fact, the RAC 5-gas instrument is one of the most widely used systems for sampling gaseous pollutants in ambient air.

• design

RAC's 5-gas sampling system is supplied in standard and all-weather shelter models that are furnished complete and ready-to-operate.

The standard model can be used to sample either indoor or outdoor air. When used for outdoor sampling, the funnel-equipped inlet tube is passed through any convenient opening or connected to an air inlet duct. This model's sampling case and vacuum pump should be shielded from inclement weather at all times.

The all-weather shelter model is designed primarily for outdoor applications. It is fabricated from heavy-gauge steel, has a heavy-duty baked enamel finish, and is suitable for use under all climatic conditions.

Standard Model—consists of an insulated steel carrying case with an integral heating element; a preassembled, removable, complete sampling train; an external $\frac{1}{2}$ hp vacuum pump; and a 3-wire power cord. (See Fig 1)

The RAC sampling train assembly includes a polypropylene inlet tube with a detachable funnel, a membrane-type inlet filter for particulates, a 5-branch glass inlet manifold, 5 polypropylene

100 ml bubblers with interchangeable threaded closures (2 hole & solid caps), 5 constricted glass bubbler tubes, 1 fritted glass bubbler tube, 5 polypropylene demistor-entrainment traps, 5 limiting/critical orifices, and a 5-branch nickel-plated exhaust manifold. All components between and including the two manifolds are preassembled and can be removed as a subassembly for filling, cleaning, or change in sampling train configuration.

The flow-regulating critical orifices can be either the stainless steel needle type or sections of precision-bore glass tubing encased in vinyl. Both types provide a 200 ml/min flow rate (approx) to all bubblers, are easily cleaned in small RAC ultrasonic baths.

The sampling cabinet's thermostat-controlled heating element maintains a uniform internal temperature of 90°F ($\pm 3^\circ$) to assure continuous sampling operating efficiency.

Threaded closures for the polypropylene bubblers are a 2-hole inlet & outlet design that is used during sampling operations, and a solid leak-tight cap used to transport bubblers filled with reagents, both before and after sampling cycles.

The 100 ml bubblers and their closures are supplied in five colors: red, yellow, blue, green, and orange; one set in each color. Demistors-traps are furnished only in natural plastics.

The standard model measures $12\frac{1}{2}''$ W x $12\frac{3}{4}''$ H x $7\frac{3}{4}''$ D and weighs 15 $\frac{3}{4}$ lbs. The vacuum pump provides 1.8 cfm free flow and 29" Hg vacuum. It is $11\frac{1}{2}''$ L x $5\frac{1}{2}''$ W x $8\frac{1}{4}''$ H, weighs 16 lbs, operates on 115 v, 60 Hz, 3.4 amp.

All-Weather Shelter Model—has all the above sampling train components and the same vacuum pump installed in a 2-compartment steel shelter tea

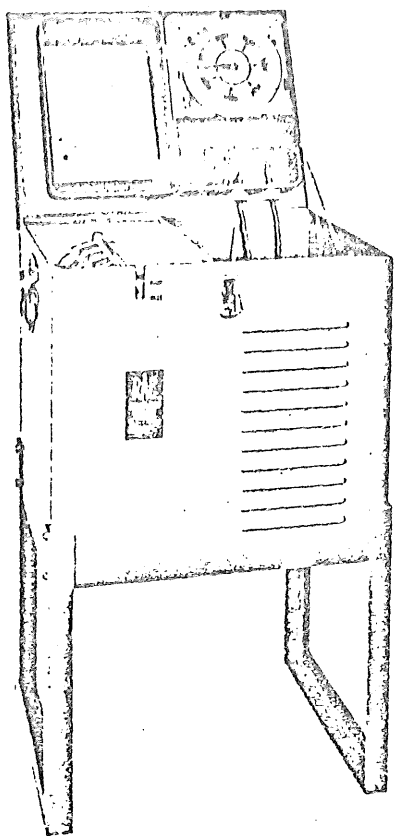


FIGURE 2

All-Weather Shelter Model in operating configuration, with top open to show installation of optional 7-day timer; air inlet tube (see Fig 1) connects to manifold through slot.

turing a weather- and corrosion-resistant finish. Sampling train compartment is insulated and equipped with thermostat-controlled heater. Pump compartment has ventilating louvers to dissipate heat, and is separated from the sampling compartment by a partition to minimize overheating or evaporation of absorbing solutions in bubblers.

Shelter's sturdy angle-iron legs—which can be attached flush with the cabinet for carrying/transporting—are securely mounted in both extended and retracted positions by steel bolts in predrilled holes. (See Fig 2 & 3)

Two optional timer mechanisms can be installed in the all-weather shelter model. The 24-hour timer (shown in Fig 3) has permanently attached trippers that provide up to 96 on-off cycles, in 15-min increments, over a 24-hr period. The alternate 7-day skip-timer mechanism (see Fig 2) permits settings one week in advance, and has 14 trippers that will provide minimum sampling cycles of 3 hours and a maximum cycle of 7 days. Both timers are attached to shelter's hinged top and positioned in the pump compartment.

All-weather shelter model of the RAC 5-Gas Collecting Sampler weighs 58 lbs complete, without a timer installed (24-hr timer weighs 3 lbs; 7-day timer, 6 lbs). With the legs raised for carrying/transporting, this model measures 17½"W x 16"H x 13¼"D. Height is 29" with legs extended.

• operation

Vacuum pump draws ambient air in through inlet funnel and tube. (Funnel is installed inverted to prevent precipitation from entering sampling train.) Particulate matter entrained in the air sample is trapped in a membrane-type filter before air enters the inlet manifold. Air stream then is divided into five equal parts by inlet manifold and directed through parallel branches into the bubblers. Each 100 ml bubbler has a 2-hole cap with a standard glass bubbler tube, either constricted or fritted, on the inlet port. The air to be sampled passes through these tubes into 50 ml quantities of reagent (absorbing solution) contained in each bubbler.

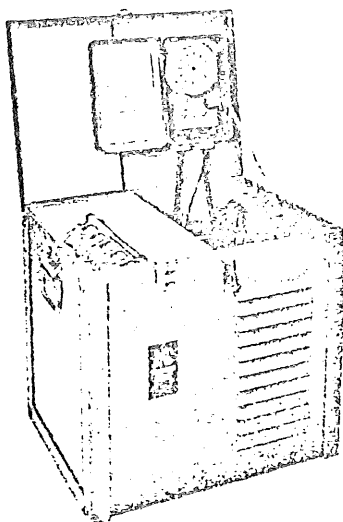


FIGURE 3

Shelter Model in carrying configuration; top raised to show optional 24-hr timer installation (air inlet tube not shown).

After bubbling through the reagent, the air exhausts through a length of vinyl tubing connected to outlet port in the 2-hole cap. Each air stream then passes through another polypropylene bubbler containing a demistor and a second membrane filter. (This dual-trap arrangement protects the critical/limiting orifices from moisture or other entrainments, and helps to maintain continuous full-flow operation for optimum sampling efficiency.) The five sampled, scrubbed air streams then are collected by the exhaust manifold and discharged through the pump.

After a sampling cycle is completed, the sampling train assembly is removed from the carrying case (or shelter). The bubblers in which gas samples have been absorbed by reagents are disconnected, and the 2-hole caps are replaced with the threaded, solid, leak-tight closures. Bubblers then are taken to a laboratory for an analysis of contents according to appropriate procedures. (NOTE: Sampling/analyzing procedures for some pollutant gases are included in the operating instructions furnished with RAC 5-Gas Collecting Samplers.)

• specifications

Vacuum Pump

1/6 hp, 1.8 cfm free flow, 29" Hg vac, continuous duty, overload protection

Electrical

115 v, 60 Hz, 3.4 amp

Dimensions

STANDARD MODEL:

12"W x 12¾"H x 7¾"D

SHELTER MODEL:

17½"W x 29"H x 13¼"D w/legs extended (16"H w/legs raised)

VACUUM PUMP:

11½"L x 5½"W x 8½"H

Weights

STANDARD MODEL:

15¾ lbs (without pump)

SHELTER MODEL:

58 lbs including pump (w/o timer installed)

24-HOUR TIMER: 3 lbs

7-DAY TIMER: 6 lbs

VACUUM PUMP: 18 lbs

• ordering information

Both the standard and all-weather shelter models of the RAC 5-Gas Collecting Sampler are furnished complete and ready-to-use. The standard model, including the vacuum pump and power cord, is the basic system. It contains all the components listed in the Design section of this bulletin. The all-weather shelter assembly and the two alternate timer mechanisms are available on an optional basis.

Specify all units, including optional arrangements, by full name and catalog number. Unit prices and the catalog numbers of the individual system components are furnished on separate sheets.

RAC 5-Gas Collecting Sampler, Standard Model, Complete CAT. #23

Includes heated steel carrying case, complete sampling train, vacuum pump, 3-wire power cord, all necessary tubing & connections, pack of orifices (5), pack of filters & back-up discs (5 ea).

RAC 5-Gas Collecting Sampler, All-Weather Shelter Model, Complete . . . CAT. #2333-S

Substitutes a 2-compartment, louvered, weather-resistant steel shelter for carrying case; includes same train, pump & components as Standard Model.

RAC 5-Gas Collecting Sampler, All-Weather Shelter Model with 24-Hour Timer, Complete CAT. #2333-24

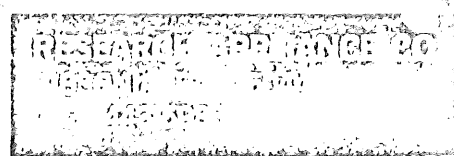
Same components as regular all-weather model with addition of a timer that provides up to 96 on-off operations, in 15-min increments, within 24-hr cycle.

RAC 5-Gas Collecting Sampler, All-Weather Shelter Model with 7-Day Skip Timer, Complete CAT. #2333-7

Only difference is optional 14-trip timer that provides min. sampling cycles of 3 hrs, max cycle of 7 days; permits setting 7 days in advance.

• other sampling equipment

Research Appliance Company manufactures and supplies a wide variety of precision instruments and systems designed for sampling / monitoring environmental air, water, and sound pollution. Write for details on other RAC sampling equipment.



APPENDIX A-6

PHILIPS MODEL 9700
OPERATIONAL AND CALIBRATION PROCEDURES

Operation Procedure
Calibration Procedure
Maintainance Procedure
Strip Chart Reading Procedure

OPERATION PROCEDURE 5

Philips 9700 SO₂ Analyzer Operation Procedure

A. General

The Philips 9700 SO₂ Analyzer requires little day to day attention; the analyzer is equipped with internal zero and span modes that are automatically operated. Any problems that cannot be handled "on-site" should be reported to the Air Monitoring Unit Leader.

B. Equipment

Philips SO₂ Monitor PW9700 Manual (2nd ed., Dec. 1972)
recorder ink, paper
roll pack tool kit

C. Procedure

1. Disconnect unit from Data Acquisition system if instrument is on telemetry and notify Data Analysis Section of time.
2. Record zero value during last 24 hr. period from the chart.
3. Record span value during last 24 hr. period from the chart.
4. Record span pot setting (location on back of recorder).
5. To obtain correct ppm value of recorder trace:
 - a) Determine zero base line using past two zero-span cycles in % of scale (A).
 - b) Determine difference (in % of scale) between last zero and last span (B).
 - c) Look up ppm equivalent of span from last calibration (C).
 - d) Determine hourly percent of scale readings (D).
6. Record reference voltage setting. Should be 760 - if it is not then reset and notify the Air Monitoring Unit Leader.
7. Observe recorder trace for signs of atypical operation such as excess noise, negative spiking, baseline drift.
8. Remove cover from chemical unit and observe cell for proper electrolyte level and bubbling in inner cell.
9. Reconnect Data Acquisition system and notify Data Analysis Section if applicable; also report daily information to the data section.

10. Be sure sample inlet is securely attached to analyzer.

11. Record the following information in the log book:

- a) date, time, site
- b) last zero, last span
- c) reference voltage
- d) span pot setting
- e) operations performed (change filter, chart paper etc.)
- f) abnormalities observed
- g) corrective actions needed (e.g., recorder noise greater than 2%)
- h) operator initials

12. Record the following information on the chart:

- a) date, time, site
- b) any operations that disturb normal chart tracing

13. Check the following for the recorder:

- a) paper supply
- b) ink supply
- c) telemetry if applicable

14. As charts are used they should be stored after they have been read.

15. Refer to the instrument manual for assistance in trouble shooting and notify the Air Monitoring Section (612) 296-7282.

CALIBRATION PROCEDURE 6

Philips 9700 SO₂ Calibration Procedure

A. General

The calibration procedure is to be used with the Monitor Labs (ML) permeation device. The ML usually has a range of 200 ppb, higher ranges may be available. The ML should be left running at least overnight in order for it to come to the proper operating temperature.

B. Equipment

ML and manual with calibration information included

Teflon tube to connect ML to monitor

Calibration Data Sheet, Form C-4 and SO₂ Calibration Curve,

CG-3 (see Calibration Procedure 4 for Graph CG-3)

Tools

Voltmeter

Flowmeter

C. Procedure

1. Be sure the ML has been running overnight and that the Philips has been running 4-8 hours. After arriving at the site plug in ML and wait at least 1/2 hour for it to warm up. If you traveled further than the Metro area more time will be needed.

a) The amber light on the ML should light up immediately upon plugging it in. If it does not, there may be insufficient line voltage at the site.

b) The ML is at its operating temperature when the amber light starts to pulsate. However, if the pulse rate is very fast then operating temperature has not yet been reached.

2. Before starting the multipoint calibration measure the flow before the measuring cell. To do this separate the air tube between the selectivity filter and the cell inlet and insert flowmeter. With analyzer in measure mode, "M" in window, record flow. This is the sample flow. If the flow differs by more than ± 15 ml/min from stated flow on instrument a leak should be suspected. Trace leak (refer to Maintenance Procedure 4) before proceeding.

3. Observe the electrolyte level and indicate "OK, high or low" on the Calibration Data Sheet. Observe the noise band on the chart and indicate "% of scale" on the data sheet. Record analyzer I.D. number, location and calibration device model and I.D. number. Record this on Form C-4.
4. Zero the analyzer by detaching the cable to the automatic timer and pressing the red button on the chemical unit until "Z" appears in the window. Allow 15 minutes to stabilize.
5. If a change in span range or zero offset is desired, use pot on rear of recorder to change span and zero control inside recorder to change zero offset. If a correct offset (5%) cannot be obtained with this pot, the reference voltage control on the electrical unit can be used. Turn the control only one position in either direction -- wait 15-30 minutes for baseline to restabilize before additional adjustments are made.
6. Multi-point Calibration. Once the ML has reached proper temperature, connect the teflon tube of the calibrator to the inlet of the chemical unit. Be sure you have the system hooked up so you are operating with the SO₂ section of the ML and the system is leak free.
7. At this point, using a voltmeter, check the signal from instrument and recorder for agreement. Attach the leads from the voltmeter to the appropriate plugs on the monitor and zero at 5% of scale. Adjust as necessary.
8. Set the flowmeter on the ML to read the desired ppb output by using the calibration curve in the manual. Be sure the curves in the manual have been corrected for temperature and pressure before using them.
 - a) A good starting point would be around 50 ppb (look up appropriate ppb on the ML curve for flowmeter setting).
 - b) Be sure the instrument is on "sample." Observe the recorder for correct response which will vary depending on the operational scale of the instrument. Example: 50 ppb on the 0-500 scale would be 50/500 or 10% plus a 5% zero offset for a total recorder reading of 15% of scale, or 15mv if the voltmeter is hooked up.
 - c) Allow to equilibrate until you see a steady trace

on the recorder. If the trace is not at the theoretical % of scale adjust the pot on the rear of the recorder until you get the proper response. Record the responses on the Calibration Data Sheet, in the Log Book and on the recorder strip chart.

d) At least 5 points should be run covering the full range of the ML. If excessive time is required for each point to equilibrate then one may suspect that the monitor requires service. (The response should be stable within about 15 minutes.)

8. After five points have been run to ensure good instrument function, draw a "field copy" of the instrument calibration curve and leave it at the site. Data should be recorded both on the recorder strip chart and the instrument log book.

A sticker should be placed on the monitor with the date of calibration, name of person performing the calibration and the value of the flow. The calibration data sheet and another copy of the calibration curve should be brought back to the lab for storage.

9. After calibration is completed, zero the monitor.

10. Internal Span. Span the unit using the internal source by pressing red button until "C" appears in window. Allow span to stabilize (15-30 minutes).

11. Check permeation rate of source.

a) Determine ppm output of internal source using the slope of the curve from analyzer just calibrated with the external source.

$$SO_2 \text{ ppm} = \text{slope of curve} \left(\frac{\text{PPM}}{\% \text{ of scale}} \right) \times \text{recorder deflection} \quad (\% \text{ of scale})$$

Record this value on Form C-4.

b) Back calculate permeation rate of source using air flow measured in Step 2.

$$SO_2 \text{ permeation rate (ug/min)} = \frac{\text{Flow (ml/min)}}{382.3} \times \text{ppm}$$

12. Compare this rate to the permeation rate given on the source.

13. After calibration is complete zero the monitor.

14. Before leaving the site make the following spot checks:
- a) Monitor is on "on" and "measure."
 - b) Intake probe has been replaced and free from obstruction.
 - c) Automatic timer is attached to monitor.
 - d) Copy of the calibration curve is left with the monitor and entries have been made in the log book and the appropriate stickers have been left.

PHILIPS SO₂ CALIBRATION DATA SHEET

Analyzer I.D. Number: _____

Location: _____

If the analyzer received a quarterly maintenance in the last 48 hrs.,
does the zero drift appear normal? _____ yes _____ no

Noise band: _____ % of scale

Sample Flow: _____

Electrolyte level: _____ OK _____ HIGH _____ LOW

Calibration device (model and I.D. number): _____

| Cal pts. | Flow | Input ppb | Theoretical % scale | Actual % scale | Flow adj. (if necessary) |
|----------|------|--------------|------------------------|-------------------|-----------------------------|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |

Internal source span: _____ % of scale

_____ ppm

Permeation rate calc. from external source (A): _____ ug/min

Permeation rate listed on internal source (B): _____ ug/min

Difference = $\frac{A-B}{A} \times 100\%$: _____ %

MAINTENANCE PROCEDURE 4

Philips 9700 SO₂ - H₂S Maintenance Procedure

A. General

The Philips 9700 analyzer is a coulometric device to continuously measure SO₂ or H₂S in ambient air. The analyzer, when connected to a recorder will have a full scale range adjustable to a maximum of 1.1 ppm. The analyzer is normally operated with a range of .5 or 1ppm full scale. Maintenance procedures are performed on a quarterly and yearly basis. If quarterly and annual maintenance occur together, perform the yearly maintenance first.

External calibration of the SO₂ units is performed using a portable calibrator. H₂S units must be brought to the laboratory for a wet chemical calibration.

B. Equipment

Beckman SO₂ service kit

Philips Service kit

selective scrubber replacement

charcoal recharge

package of glass fiber filters

lubricating oil

vacuum gauge

ground glass fitting grease, Apiazon

bubbler oil

replacement capillaries

fuses, connectors, sleeves, O-rings

extender (feedback) board

plug in electrical cable

Electrolyte and waste jar

Calibrated rotameter (to measure \approx 300ml/min)

Digital voltmeter

Distilled water

Kimwipes

Monitor Labs calibrator with calibration curve, teflon tubing

Philips 9700 manual (2nd edition, Dec. 1972)

Philips 9700 Maintenance Form M-3

SO₂ Calibration Curve Graph, CG-3 (see Calibration Procedure 2)
SO₂ Calibration Data Sheet, Form C-3 (see Calibration Procedure 2)
Oscilloscope (annual only)

C. Procedure - Annual (refer to Figures 1 and 2) Complete Form M-3

1. Remove blue vacuum tube and measure pump vacuum, it should be at least 400 mmHg (7psi).
2. Check whether or not pump runs smoothly. Check for excessive free-play in bearings.
3. Check whether or not spindle of stirrer motor fits correctly.
4. Replace capillaries if not changed within one year.
5. Replace charcoal in the zero scrubber.
6. Refer to the attached procedure and check operation of amplifiers (Print 3 and 4).

NOTE: This adjustment may affect calibration.

D. Procedure - Quarterly

The following steps should be done with the analyzer off. Consult the manual for location of parts. Check procedures on Form M-3.

1. a) If unit is equipped with silver gauge selectivity filter, remove connecting fittings and examine filter, if black stain is over 1/2 of the way down the filter, replace filter and renew old filter according to manual directions.
b) If unit is equipped with a chemical selectivity filter, remove connecting fittings and replace filter. Discard old filter.
2. Remove electrical connecting plugs on Peltier cooling fan. Loosen mounting screws. Lubricate bearings of fan. Check bearings for excessive free-play. Replace fan.
3. Remove cover of source carrier (box at bottom center of chemical unit). Remove filter cover by removing three outer screws. Remove old filter and mount new filter. Mount cover making certain of good connection between filter cover and capillary.
4. Replace measuring cell electrolyte (Refer to manual Figure 32, 33 and 34. Caution: electrolyte is corrosive - do not spill.) Do not touch inner parts of cell with fingers. Avoid contamination.

- a) Disconnect lower plugs from terminal strip on outside of cell.
- b) Loosen quick fit couplings where air inlet and outlet attach to cell.
- c) Loosen hold down rubber rings on sides of cell.
- d) Remove cell and container, putting front of cell up so rear air fitting will clear connector.
- e) Disconnect plugs from upper side of terminal strips.
- f) Loosen quick fit nuts and remove electrodes carefully. Rinse electrodes with distilled water. Do not contaminate electrodes.
- g) Loosen hold down springs on inner vessel. Remove inner cell by drawing upward and twisting. Caution: Allow inner vessel to drain before removing from cell.
- h) Empty inner and outer vessel. Check whether inner nozzle is clear. If nozzle is plugged, air flow will be lowered or stopped.
- i) Rinse inner vessel inside and out with distilled water: Do not rinse greased ground glass fitting. Rinse outer cell. Drain all water from cell.
- j) Pour entire bottle of PW9711 measuring solution into outer cell.
- k) Fit inner cell into outer cell with twisting motion to seat ground glass fitting. If additional grease is needed on fitting use only small amount Apiazon grease. Attach hold down springs.
- l) Fit electrodes into cell carefully. Do not overtighten fittings.
- m) Reconnect electrical leads from electrodes to upper side of terminal strips (refer to Figure 34).
- n) Carefully fit assembled cell into chassis. Attach rubber hold down rings. Connect air fitting quick connects. Do not overtighten. The tension and exact positioning of these fittings is critical. If even slightly over or under tightened, air leaks will result. It may be necessary to measure the flow through the cell while tightening the fittings

- to assure correct tension (refer to step 10).
- o) Re-connect lower plugs. The color of upper wire connecting to lower wire should be identical.
 - p) Electrolyte level should be at blue line on outer vessel.
5. a) Replacement of vacuum pump diaphragm. Disconnect air tubes from inlet and outlet of vacuum pump located in electronics unit. Remove diaphragm cover. Loosen screw attaching diaphragm to position and remove diaphragm. Replace diaphragm and reassemble.
- b) Loosen screws on plate clamping inlet and outlet fittings to cover. Remove clamping plate and remove inlet and outlet fittings. Outlet diaphragm is now visible and can be removed with tweezers. Remove gauze in inlet pipe and replace inlet diaphragm. Assemble in reverse order.
6. Replace particulate filter in heated sampling head.
7. Check oil in backflow control bubbler. Level should reach to blue line.
8. The following steps should be performed with the analyzer ON.
9. Block air inlet temporarily at outside of case, bubbling should occur in oil tube, if no bubbling occurs there is an air leak. Determine location of leak and remedy.
10. Separate air tube between selectivity filter and cell inlet and insert flowmeter. Flowmeter outlet should be connected to cell inlet and flowmeter inlet should be connected to selectivity filter. With analyzer on measure, record flow, this is the sample flow. The flow should be approximately 150 ml/min, if flow is different from this value a leak is suspected downstream, likely at the quick fit fitting directly below the Peltier cooler element. Another likely source of reduced flow is a blocked sample capillary. If blockage is suspected, replace sample capillary located in source carrier housing.
11. If sample flow is OK measure total inlet flow by removing teflon sample inlet and attaching flowmeter. Record flow. Total flow should be approximately 300 ml/min. If much lower than 300 ml/min a blocked purge capillary is suspected. Replace

purge capillary and remeasure flow. Note: Purge and sample capillaries are physically identical.

12. Perform electronics check by plugging service cable into terminals or front panel of electronics unit. Measure voltages with voltmeter and record on maintenance checksheet. Note: Heater voltages will vary over indicated range, depending on exterior temperature and length of time unit has been operating.

13. Run analyzer after electrolyte replacement for 4-8 hours to stabilize output.

14. Perform a multipoint calibration for SO_2 using the portable ML calibrator (Calibration Procedure 5). The wet chemical method is used to calibrate units measuring H_2S .

a) First zero analyzer by detaching cable to automatic timer and pressing red button on chemical unit until "Z" appears in window. Allow trace to stabilize.

b) Connect calibrator to chemical unit air inlet, refer to Calibration Procedure 5 and perform a multipoint calibration with the analyzer in the measure mode, "M" in window.

c) If it is desired to change span range or zero offset, use pot on rear of recorder to change span and zero control inside recorder to change zero offset. If a correct offset cannot be obtained with this pot, the reference voltage control on the electrical unit can be used. Turn the control only one position in either direction, wait 15-30 minutes for baseline to restabilize before additional adjustments are made.

15. After the multipoint calibration has been performed and Forms C-4, CG-3 completed, span the unit using the internal source by pressing the red button until "C" appears in window. Allow span to stabilize (15-30 minutes).

16. Check permeation rate of internal source.

a) Determine ppm output of internal source using slope of the curve from analyzer just calibrated with external source.

$$\text{SO}_2 \text{ ppm} = \text{slope of curve} \left(\frac{\text{ppm}}{\% \text{ of scale}} \right) \times \text{recorder deflection} (\% \text{ of scale})$$

Record this value on Form C-4 and M-3

b) Back-calculate permeation rate of source using air flow measured in Step 10.

$$\text{SO}_2 \text{ permeation rate} = \frac{\text{Flow (ml/min)}}{382.3} \times \text{ppm}$$

Record on Forms C-4, M-3.

H₂S permeation rate may be calculated by:

$$\text{H}_2\text{S permeation rate (ug/min)} = \frac{\text{Flow (ml/min)}}{719} \times \text{ppm}$$

c) Compare this rate to rate given on source. Also compare with perm. rates determined previously. If rate has dropped significantly (≈ 10%) the source should be replaced. If rate has dropped significantly it is also imperative to inform the Agency taking data so that corrections may be applied.

17. Reconnect all fittings and place analyzer "on-line."
Record maintenance procedures and findings on form M-4 and in log book. Record pertinent information on chart recorder paper. Complete Calibration Forms C-4, CG-3; leave one copy of CG-3 with the analyzer. Return all forms to the laboratory.
18. Report any problems or abnormalities to the Air Monitoring Unit Leader (612) 296-7282.

Philips 9700 Maintenance Form

Annual

- _____ 1. Check vacuum pump: _____ psi or _____ mmHg.
- _____ 2. Check stirrer motor.
- _____ 3. Check amplifier operation.
- _____ 4. Replace charcoal in zero scrubber.
- _____ 5. Replace capillaires.

Quarterly

- _____ 1. Replace filter in heated sampling head.
- _____ 2. Replace aerosol filter protecting flow regulating capillary.
- _____ 3. Replace chemical selective scrubber or examine silver gauge selective scrubber and replace if necessary.
- _____ 4. Check lubricate peltier cooling fan.
- _____ 5. Replace measuring liquid.
- _____ 6. Replace diaphragm and valves in vacuum pump.
- _____ 7. Check oil line in suction tube.
- _____ 8. Measure and record flow through sample capillary,
_____ cc/min.
- _____ 9. Measure and record flow through purge capillary,
_____ cc/min.
- _____ 10. Check SO₂ (H₂S) source output and calibrate unit at four
upscale points. Internal Source = _____ ppm.
- _____ 11. Perform electronics check and record values in chart below.

| | | Corrected Voltage | Measured Voltage |
|----------|---------------------------------|----------------------|---------------------|
| terminal | 1 | +30V | |
| | 2 | +16V | |
| | 3 (Peltier) off 6.6V | On 3.2V | |
| | 4 (Supply Peltier) off 0.0V | On 2.3V | |
| | 5 SO ₂ source heater | 0-30V | |
| | 6 Measuring cell heater | 0-30V | |
| | 7 Output Amp I | 0-15V | |
| | 8 12V Supply | 12V | |
| | 9 Recorder Output | 0-100mV | |

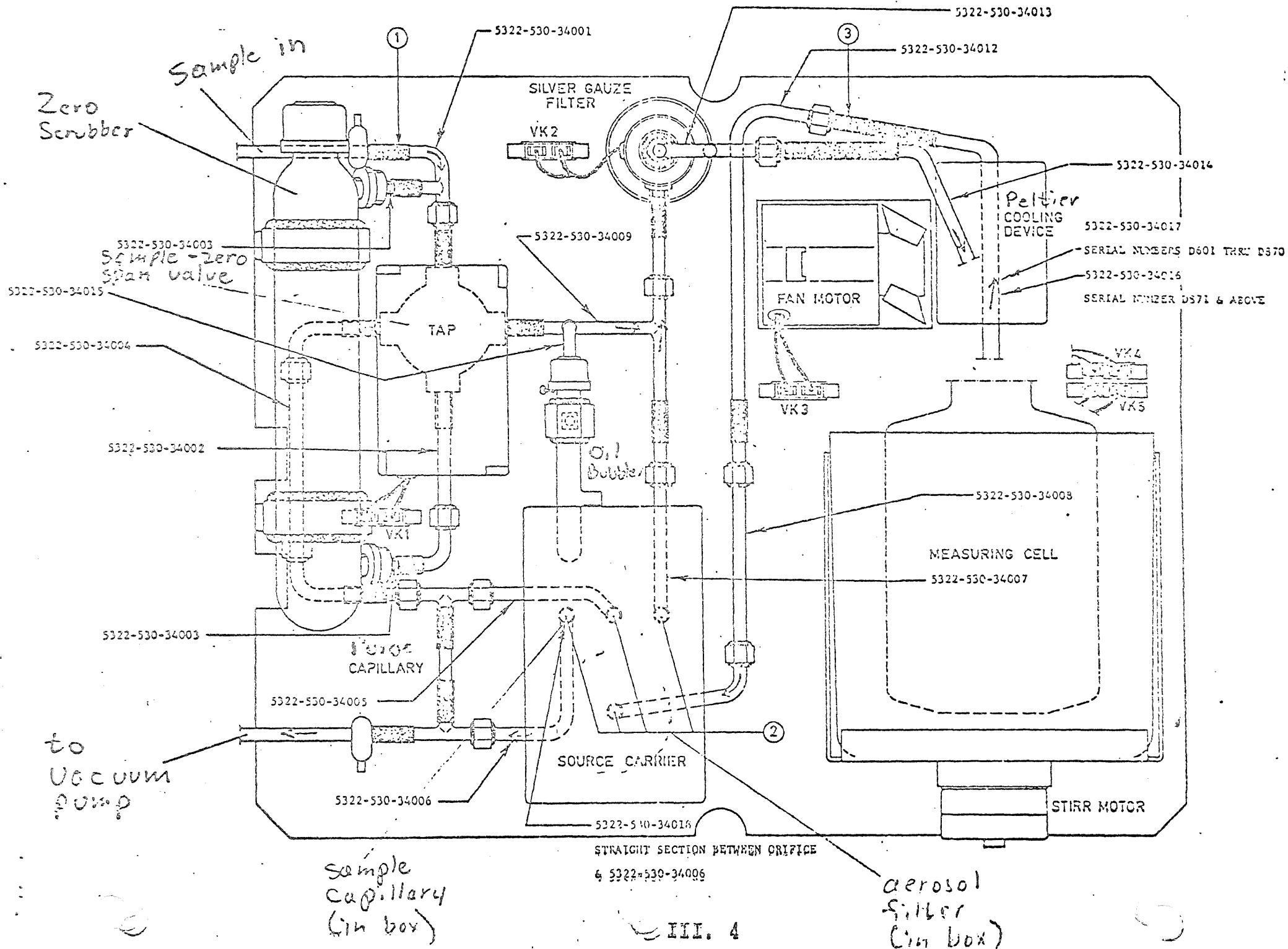
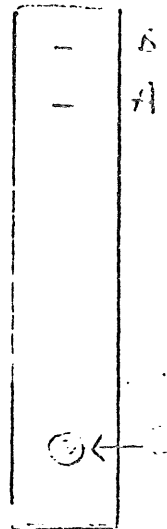
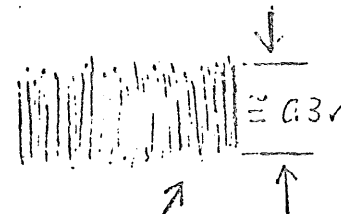


Figure 2. ADJUSTMENT OF PW 9720 AMPLIFIERS

1. Remove lower interconnecting cable between PW 9710 & 9720.

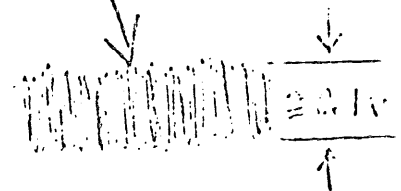
2. PCB #3

- a) Ground connector pin #22
- b) Scope between Pin A & ground
- c) Adjust C_1 to give min^m signal (about 0.3V peak - peak.).
- d) If recorder is connected (9) Time Base to MP1 reading should be about 10MV
- e) Signal at Pin A should stay small if ground connection is removed from pin 22. Phasing may be incorrect if it doesn't.



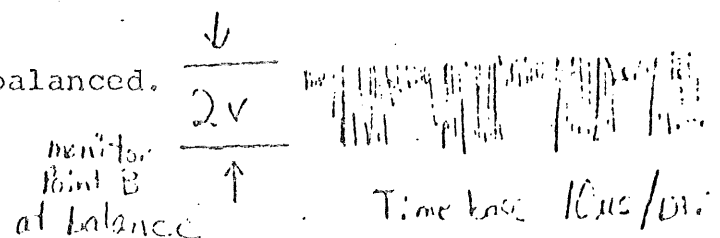
3. PCB #4

- a) Short connector pins 6 and 22 to each other
- b) Connect meter (0-15V DC) to MP1 (7)
- c) Scope between Pin A and ground
- d) Adjust C_1 for minimum signal Trim to give 0.5V on MP1 (7)



NOTE: Scope signal should not appreciably change as C_1 is varied such that MP1 (7) varies between 0.5 - 15V

Both amplifiers are now correctly balanced.
Reconnect lower cable



DATA ANALYSIS PROCEDURE 1

Strip Chart Reading Procedure

A. General

The following procedure for reading strip charts is a general procedure and may vary depending on the type of recorder in use and adaptations such as signal averagers.

B. Equipment

Pen or pencil
Straight Edge
Strip charts
Data coding form

C. Procedure

To determine the hourly average concentration from a strip chart record, the following procedures are used:

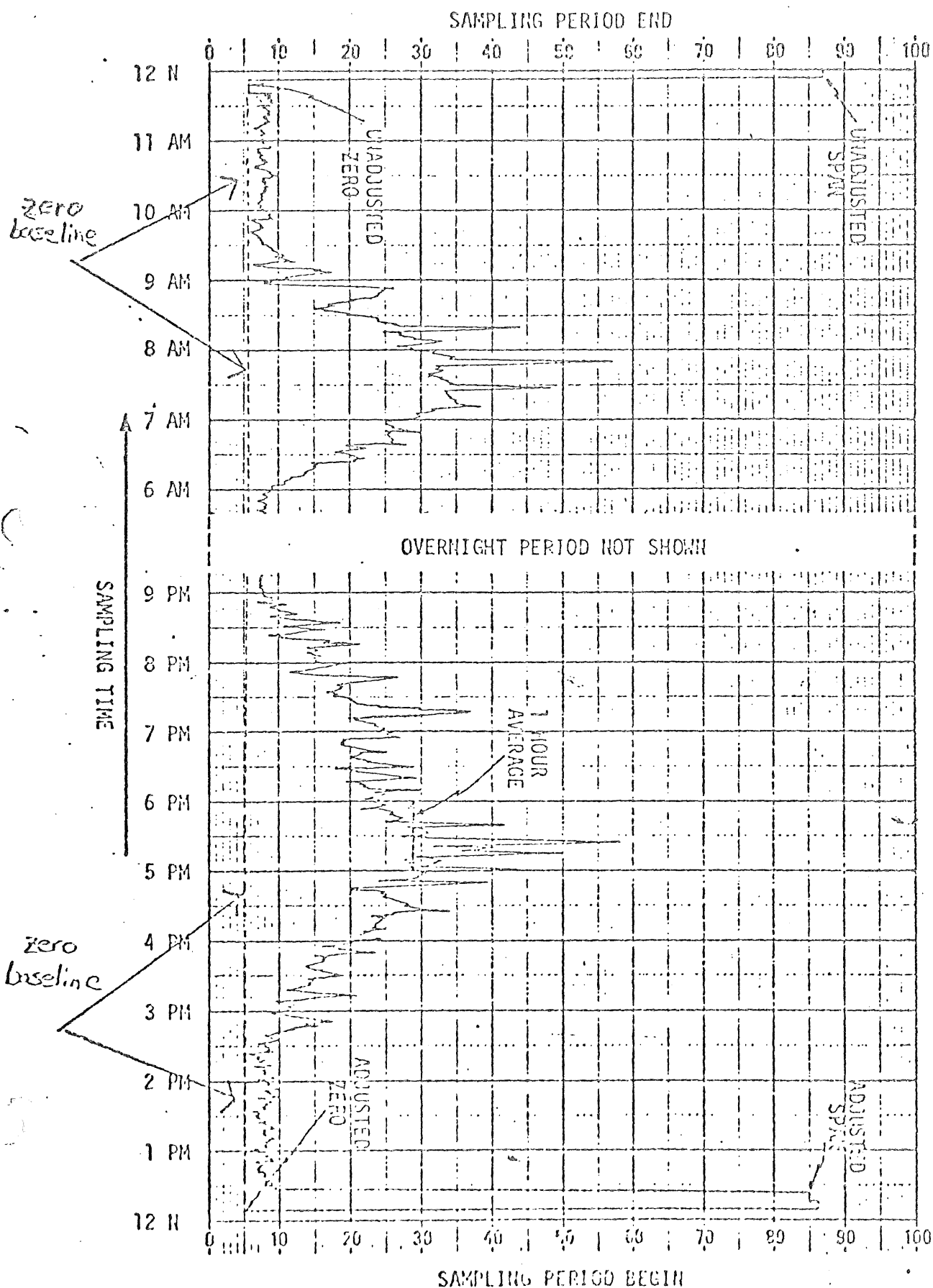
1. Obtain the strip chart record for the sampling period in question. The record must have adjusted span (if applicable) and zero traces at the beginning of the sampling period and unadjusted span and zero traces at the end of the sampling period.
2. Fill in the identification data called for on the coding sheet being used.
3. Using a straight edge, draw a straight line from the adjusted zero at the start of the sampling period to the unadjusted zero at the end of the sampling period as illustrated in Figure 1. This line represents the zero baseline to be used for the sampling period.
4. Coding forms in use should be completed only with the final zero adjusted concentration, which is determined as follows:
 - a) Read the zero baseline in percent of chart at the mid-point of each hour interval and record the value on the chart.
 - b) Determine the hourly averages by using a transparent object, such as a piece of clear plastic with a straight edge. A clear plastic ruler with a single line down the length of the ruler works best. Place the straight edge parallel to the horizontal chart division lines.

For the interval of interest between two vertical hour lines, adjust the straight edge between the lowest and highest points of the trace in that interval, keeping the straight edge parallel to the chart division lines, until the total area above the straight edge bounded by the trace and the hour lines is estimated to equal the total area below straight edge bounded by the trace and hour lines. See Figure 1 for an illustrated example.

Repeat the above procedure for all the hour intervals needed and which have not been marked invalid. Record all values on the chart.

- c) Subtract the zero baseline value from the reading value.
- d) Convert percentage chart values to concentration in ppm using a calibration conversion table developed from the calibration curve. Record the ppm values on the coding form.

Figure 1. Sample Strip Chart Trace of 24-Hour Sampling Period with Zero and Span Calibrations



APPENDIX A-7

FLUORIDE TAPE SAMPLER OPERATIONAL
AND CALIBRATION PROCEDURES

Operation Procedure
Calibration Procedure
Maintenance Procedure
Data Transfer Procedure

} missing

APPENDIX A-8

CALIBRATION, OPERATION, AND AUDIT SCHEDULE

update
this schedule
as needed

(especially
past calibration
& audit
dates)

Get from Dave Kels

AQ Schedules

MONTHLY SCHEDULE

FOR

All

(LOCATION)

FOR

September-1976

(MONTH)

X = Date of Sample Run

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|--------|--------|---------|-----------|----------|--------|----------|
| | | | 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 | | |

Circled site numbers indicate calibration - maintenance

Boxed site numbers indicate audits

S = continuous SO₂
 B = SO₂-NO₂ bubbler
 HV = High volume sampler

M = 4" membrane sampler
 F = Fluoride sampler

MONTHLY

SCHEDULE

FOR

All
(LOCATION)

FOR

October-1976
(MONTH)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|----------|--------------|---------|-----------|-----------------------|-----------------------|----------|
| | | | | | 1 9-12-23-14 HV | 2 |
| 3 X | 4 | 5 | 6 | 7 | 8 6-9-10 B | 9 X |
| 10 | 11 | 12 | 13 | 14 7-11-15-16 M | 15 X | 16 |
| 17 | 18 | 19 | 20 | 21 X | 22 | 23 |
| 24 31 | 25 1 S | 26 | 27 X | 28 | 29 | 30 |

MONTHLY

SCHEDULE

FOR

(LOCATION)

FOR

(MONTH)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|---------|---------------------|---------|----------------------|------------------------------------|---------------------------------------|----------|
| | 1 6-7-8-10 HV | 2 X | 3 | 4 | 5 5-7-11 B | 6 |
| 7 | 8 X | 9 | 10 | 11 | 12 | 13 |
| 14 X | 15 | 16 | 17 6-8-10-17 M | 18 15-16-11 7-9-10 B S | 19 15-16-10 15-16-11 HV M | 20 X |
| 21 | 22 | 23 | 24 | 25 8-12 F | 26 X | 27 |
| 28 | 29 | 30 | | | | |

MONTHLY

SCHEDULE

FOR

All
(LOCATION)

FOR

December 1970
(MONTH)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|---------|------------------|-----------------|------------------|--------------|--------|----------|
| | | | 1 1-2-3 HV | 2 X | 3 | 4 |
| 5 | 6 | 7 2-3-4 B | 8 X | 9 | 10 | 11 |
| 12 | 13 1-4-5 M | 14 X | 15 | 16 | 17 | 18 |
| 19 | 20 X | 21 | 22 | 23 1 5 | 24 | 25 |
| 26 X | 27 | 28 | 29 | 30 | 31 | |

MONTHLY

SCHEDULE

FOR

All

(LOCATION)

FOR

January 1977

(MONTH)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|--------|-----------------|------------------------|-----------------------|----------|--------|----------|
| | | | | | | 1 X |
| 2 | 3 | 4 | 5 9-12-13-14 HV | 6 | 7 X | 8 |
| 9 | 10 | 11 | 12 6-9-10 B | 13 | 14 | 15 |
| 16 | 17 | 18 12-11-15-16 M | 19 X | 20 | 21 | 22 |
| 23 | 24 8-12 F | 25 X | 26 | 27 | 28 | 29 |
| 30 | 31 X | | | | | |

MONTHLY SCHEDULE

FOR All (LOCATION) FOR February 1977 (MONTH)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|--------|--------|---------|----------------|------------------------|---------------------|----------|
| | | 1 | 2 | 3 (6-7-8-10) HV | 4 | 5 |
| 6 X | 7 | 8 | 9 | 10 | 11 (5-7-11) B | 12 X |
| 13 | 14 | 15 | 16 | 17 (6-8-10-17) M | 18 X | 19 |
| 20 | 21 | 22 | 23 (1) S | 24 X | 25 | 26 |
| 27 | 28 | | | | | |

MONTHLY SCHEDULE

FOR March 1977 (MONTH)

FOR A11 (LOCATION)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|---------|----------------|-----------------|-----------|-----------------|----------------|----------|
| | | 1 (1-2-3 HV) | 2 X | 3 | 4 | 5 |
| 6 | 7 (2-3-4 B) | 8 X | 9 | 10 | 11 | 12 |
| 13 | 14 X | 15 | 16 | 17 (1-4-5 M) | 18 | 19 |
| 20 X | 21 | 22 | 23 | 24 | 25 (8-12 F) | 26 X |
| 27 | 28 | 29 | 30 | 31 | | |

MONTHLY

SCHEDULE

FOR

All

(LOCATION)

FOR

April 1972

(MONTH)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|--------|------------------------|-------------------|---------------------|----------|--------------|----------|
| | | | | | 1 | 2 |
| | | | | | X | |
| 3 | 4 | 5 | 6 9-12-14 HVC | 7 X | 8 | 9 |
| 10 | 11 | 12 6-9-10 B | 13 X | 14 | 15 | 16 |
| 17 | 18 12-11-15-16 M | 19 X | 20 | 21 | 22 1 5 | 23 |
| 24 | 25 X | 26 | 27 | 28 | 29 | 30 |

MONTHLY SCHEDULE

FOR Al (LOCATION) IFOR May 1977 (MONTH)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|--------|---------------------------|------------------------------------|------------------------|-------------------|---------|----------|
| 1 X | 2 | 3 | 4 (6-7-8-10) HV | 5 | 6 | 7 X |
| 8 | 9 | 10 | 11 | 12 (5-11) B | 13 X | 14 |
| 15 | 16 2-3-4-5-6 B 3 | 17 2-3-6 HV 5 1-4 M | 18 (6-8-10-17) M | 19 X | 20 | 21 |
| 22 | 23 | 24 (8-12) F | 25 X | 26 | 27 | 28 |
| 29 | 30 | 31 X | | | | |

MONTHLY SCHEDULE

FOR

All

(LOCATION)

FOR

June 1977

(MONTH)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|---------|--------|---------|-----------|--------------|------------------|----------|
| | | | 1 | 2 | 3 1-2-3 HV | 4 |
| 5 | 6 X | 7 | 8 | 9 | 10 2-3-4 B | 11 |
| 12 X | 13 | 14 | 15 | 16 | 17 1-4-5 M | 18 X |
| 19 | 20 | 21 | 22 | 23 1 S | 24 X | 25 |
| 26 | 27 | 28 | 29 | 30 X | | |

MONTHLY

SCHEDULE

FOR

A1

(LOCATION)

FOR

July 1977

(MONTH)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|--------|--------|---------|-----------|----------|--------|----------|
| | | | | | 1 | 2 |
| 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 31 | | | | | | |

MONTHLY

SCHEDULE

FOR

All

(LOCATION)

FOR

August 1977

(MONTH)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|--------|----------|----------------------|---------------------|----------|--------|----------|
| | 1 | 2 | 3 6-7-8-10 HV | 4 | 5 X | 6 |
| 7 | 8 | 9 | 10 5-7-11 B | 11 X | 12 | 13 |
| 14 | 15 | 16 6-8-10-17 M | 17 X | 18 | 19 | 20 |
| 21 | 22 15 | 23 X | 24 | 25 | 26 | 27 |
| 28 | 29 X | 30 | 31 | | | |

MONTHLY

SCHEDULE

FOR

All

(LOCATION)

FOR

September 19

(MONTH)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|--------|--------|---------|-----------|----------|--------|----------|
| | | | | 1 | 2 | 3 |
| 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 | |

MONTHLY

SCHEDULE

FOR

All

(LOCATION)

FOR October 197

(MONTH)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|--------|--------|---------|-----------|----------|--------|----------|
| | | | | | | 1 |
| 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| 30 | 31 | | | | | |

MONTHLY SCHEDULE

FOR

All

(LOCATION)

FOR

November 1977

(MONTH)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|---------|-----------------------------|-------------------------|----------------------------|---|---|----------|
| | | 1 | 2 <u>6-7-8-10</u> HV | 3 X | 4 | 5 |
| 6 | 7 | 8 <u>5-7-11</u> B | 9 X | 10 | 11 | 12 |
| 13 | 14 <u>6-8-10-12</u> m | 15 X | 16 | 17 <u>7-9-10</u> <u>11-15-16</u> B | 18 <u>12-13-14</u> <u>17-11</u> HV m | 19 |
| 20 | 21 X | 22 | 23 | 24 <u>8-12</u> <u>21-5</u> | 25 | 26 |
| 27 X | 28 | 29 | 30 | | | |

MONTHLY SCHEDULE

FOR

H1

(LOCATION)

FOR

December 1971

(MONTH)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|--------|--------|---------|------------|------------|-------------|----------|
| | | | | 1 | 2 | 3 |
| | | | | | 1-2-3 H1 | X |
| 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | | | 2-3-4 0 | X | |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| | | | 1-4-5 M | | | |
| 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| | | | X | | | |
| 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| | 1 S | X | | | | |

APPENDIX A-9

STUDY STAFF RESUMES

might wish to
add L. King's
B. Enders's
J. Bowman's
names

RESUME

Mary Beth West
4110 Kentucky Avenue North
Crystal, Minnesota 55427

612-537-7547

EDUCATION

Sept. 1972-
Nov. 1974

Hennepin Technical Center
Eden Prairie, Minnesota
Pollution Control

Sept. 1971-
June 1972

Neil Armstrong Sr: High
Plymouth, Minnesota

EXPERIENCE

Jan. 1976-
Present

Regional Copper-Nickel Study

Minnesota Pollution Control
Agency in conjunction with
the Minnesota Environmental
Quality Council, St. Paul,
Minnesota

Primary responsibilities involved formulation and design of the air monitoring program for the Copper-Nickel study area. Secondary responsibilities included the selection of the monitoring sites and procurement of monitoring equipment. As field representative of the program, further responsibilities included the coordination of this program with the meteorology and the plant pathology studies and the writing of the air monitoring portion of the Field Operations Manual.

May 1975-
Jan. 1976

Technical Services Section Division of Air Quality

Minnesota Pollution Control
Agency, Roseville, Minnesota

RESUME

Mary 'Beth West
4110 Kentucky Avenue North
Crystal, Minnesota 55427

EXPERIENCE - cont.

May 1975-
Jan. 1976

Primary responsibilities involved setting up and maintaining high volume samplers, gas collecting samplers and tape spot analyzers throughout the City of St. Paul. Special studies included the summer Ozone Project and the Highway Department Carbon Monoxide Project.

Sept. 1974-
May 1975

Data Analysis Section
Division of Air Quality

Minnesota Pollution Control
Agency, Roseville, Minnesota

Calculate and publish the daily Minnesota Air Quality Index.
Administer the out-state hi-vol filters distribution and collection.

July 1974-
Sept. 1974

Noise Section
Division of Air Quality

Minnesota Pollution Control
Agency, Roseville, Minnesota

Primary responsibilities included conducting noise surveys and investigating complaints. Setting up the cross reference between the filing and metropolitan map.

REFERENCES

Personal

Provided upon request

Born: Minneapolis, MN 10/21/54
Height: 5'9" Weight: 130
Marital Status: Single

RESUME

JOHN S. SELTZ

2067 Goodrich Ave.
St. Paul, MN 55105

WORK EXPERIENCE

1967-1971 City of Minneapolis Air Pollution Control

Part time conducting air monitoring surveys, answering public complaints, and compiling emission inventory of sources.

1971-1973 Minnesota Pollution Control Agency

Conducting air monitoring operations including equipment deployment, maintenance, calibration, and laboratory operations.

1973-Present Minnesota Pollution Control Agency

Supervise air monitoring unit.

Oversee operations and deployment of state network.

EDUCATION

B.S. University of Minnesota IT (Chemistry)

One year Dental School, University of Minnesota

M.S. University of Minnesota School of Public Health (Environmental Health)--expected Fall '76.

PROFESSIONAL AFFILIATIONS

Midwest Chapter Air Pollution Control Association.

PUBLICATIONS

"Planning Control Strategies to Reduce Carbon Monoxide Concentration--Minnesota's Experience", Ingrid Ritchie and John Seltz. Presented at the Third Joint Conference on Sensing Environmental Pollutants, Las Vegas, Nevada, Sept., 1975.

INVOLVEMENT

Primary senior staff contact for air monitoring study. Responsible for design of study and deployment and operation of network.

1968/9111 25
RESUME

GARY S. ECKHARDT

5028 West 70th Street
Edina, Minnesota 55435

EXPERIENCE:

Chief, Technical Services

Minnesota Pollution Control Agency, Air Quality Division, 1973 to present. Responsible for all State ambient air monitoring, quality control, and data acquisition and analysis of all ambient air data. Responsible for acquiring air quality data in order to determine air quality standards compliance, to determine the existence of air episodes, to provide information for planning and administrative functions, to determine long term pollutant concentration trends, and to detect the presence of newly defined air contaminants.

Unit Leader, Air Monitoring

Minnesota Pollution Control Agency, Air Quality Division, Technical Services Section, 1971 to 1973. Responsible for all air monitoring activities throughout the State. Responsible for procuring siting, maintaining and calibrating, instrumentation used to monitor criteria pollutants (SO_2 , NO_2 , HC, CO, O_3 and TSP).

Senior Member Technical Staff

Control Data Corporation, Edina Space and Defense Systems and Research Division, 1968 to 1971. Redesigned analog circuitry for detection of weak signals in presence of noise. Very high input impedance charge to voltage converters were designed as well as special active filters. Evaluate photodetectors for use in starmappers. Photodetectors utilized were photomultipliers, channel multipliers, solid state detectors and image converters.

Logic design of special peripheral equipments associated with the Automated Proper Motion Machine (scanning microdensitometer) built for NASA and the University of Minnesota to study proper motions of stars. Design included modification of standard type synchronizer incorporating TTL integrated circuits. A special digital algorithm to modify data was designed utilizing MSI circuitry.

Member Technical Staff

Control Data Corporation, Research Division, 1966 to 1968. Designed Star Data Formatter for interface with NASA ground support equipment which received data from the attitude sensor aboard the ATS-C satellite. Responsible for systems electronics design of the electro-optical sensor for the ATS satellite experiment.

Circuit and packaging design for the Star Occultation Photometer which was flown on Gemini 7 and 10 missions.

Checkout and Installation of Polaris MK 84 fire control system.
Initial checkout of analog and digital equipments within the
Digital Geoballistic computer system.

Technical Writer

Control Data Corporation, 1961. Technical writing and schematic
layouts for Polaris fire control system.

EDUCATION:

A.D. in Journalism, Scottsbluff College (Nebraska Western), 1956.
B.S. and M.S. in Electrical Engineering, University of Nebraska,
1961 to 1962 respectively. Control Data internal courses including
digital communications, digital computer applications, and CDC3600
hardware course.

PROFESSIONAL ORGANIZATION MEMBERSHIP:

Upper Midwest Air Pollution Control Association

PAPERS PUBLISHED:

"A Survey of Microwave Stripline Directional Couplers"
"An Operational Urban Air-Monitoring Data Acquisition System:
Experience and Applications"

COPPER-NICKEL INVOLVEMENT

Executive Director of Air Program

RESUME OF: David A. Kelso

VITAL STATISTICS: Born on May 17, 1946, in New York, New York. Lived in Duluth, MN, from 1947 to 1975. Height: 5' 4"; weight: 155; single and residing at 2201 Albert in Roseville, MN.

EDUCATION: Attended the University of Minnesota, Duluth, from 1966-1969 and 1973 to 1974 receiving a BS degree in Earth Science and teaching credentials for Secondary Education. Attended EPA course #435 (atmospheric sampling).

EMPLOYMENT: July 1975 to present: Employed by the Environmental Protection Agency as a Federal Assignee with the Minnesota Pollution Control Agency in the Division of Air Quality. Duties are concentrated in the Quality Assurance program for the Technical Services Section.

January 1975 to June 1975: Employed by the Duluth Board of Education as a Special Education Coordinator where I was responsible for coordinating students working in the community and their classrooms at the various schools.

March 1974 to January 1975: Student at UMD and working part time for the Department of Geology as a geologic technician where I prepared rock samples as thin sections for microscopic use.

October 1973 to March 1974: Employed by a California firm and stationed in the Antarctic where responsibilities included being a shift leader for a labor crew and a technician in the geology laboratory.

December 1971 to October 1973: Student at UMD and working part time for the Department of Geology in the soils laboratory as a soils technician.

February 1969 to December 1971: Military

September 1966 to February 1969: Student at UMD

MILITARY: Enlisted in the Army on February 19, 1969 and was released from active duty with an honorable discharge on December 17, 1971. I attended Artillery Ballistic Meteorological School but was later assigned as a personnel specialist in California.

ACTIVITIES: Past Board member for the UMD alumni Association, amateur photographer, singer and outdoor enthusiast.

My involvement with the copper nickel project will begin full time this Sept. when I will take over as the operator of the Air Quality Network.

APPENDIX A-10

FEDERAL REFERENCE METHODS FOR SUSPENDED PARTICULATES,
SULFUR DIOXIDE, AND NITROGEN DIOXIDE

NITROGEN DIOXIDE 24-HR. BUBBLER

TEMPERATURE CANDIDATE METHOD FOR THE DETERMINATION OF NITROGEN DIOXIDE IN THE ATMOSPHERE (24-HOUR SAM- PLING METHOD)

1. *Principle and applicability.*—1.1 Nitrogen dioxide is collected by bubbling air through a sodium hydroxide-sodium arsenite solution to form a stable solution of sodium nitrite. The nitrite ion produced during sampling is reacted with phosphoric acid, sulfanilamide, and N-1-naphthylethylenediamine dihydrochloride to form an azo dye and then determined colorimetrically.

1.2 The method is applicable to collection of 24-hour samples in the field and subsequent analysis in the laboratory.

2. *Range and sensitivity.*—2.1 The range of the analysis is 0.02 to 2 $\mu\text{g NO}_2/\text{ml}$ (Beers law is obeyed through this range). Above 2.0 $\mu\text{g NO}_2/\text{ml}$ dilutions are needed. With 50 ml absorbing reagent

and a sampling rate of 200 cm^3/min for 24 hours, the range of the method is 5 to 750 $\mu\text{g}/\text{m}^3$ (0.003 to 0.4 p.p.m.) nitrogen dioxide.

2.2 A concentration of 0.01 $\mu\text{g NO}_2/\text{ml}$ will produce an absorbance of 0.02 with 1 cm cells.

3. *Interferences.*—3.1 The interference of sulfur dioxide with the azo dye formation in the colorimetric determination is eliminated by converting it to sulfate ions with hydrogen peroxide before analysis.¹

3.2 A slight positive NO interference has been observed at NO_2 levels above 100 $\mu\text{g}/\text{m}^3$ when the NO to NO_2 mole ratio is 3:1 or greater. Studies have shown that NO can increase the NO_2 response by 3 to 15 percent at high NO and NO_2 levels.²

4. *Precision, accuracy, and stability.*—

4.1 Relative standard deviation of 5 percent and 6 percent can be expected at nitrogen dioxide concentrations of 40 $\mu\text{g}/\text{m}^3$ and 60 $\mu\text{g}/\text{m}^3$, respectively, based on an automated analysis of samples collected from a standard test atmosphere. Precision would probably be different when the analysis is performed manually.

4.3 Collected samples are stable for at least 6 weeks.

5. *Apparatus.*—5.1 Sampling. See figure F1.

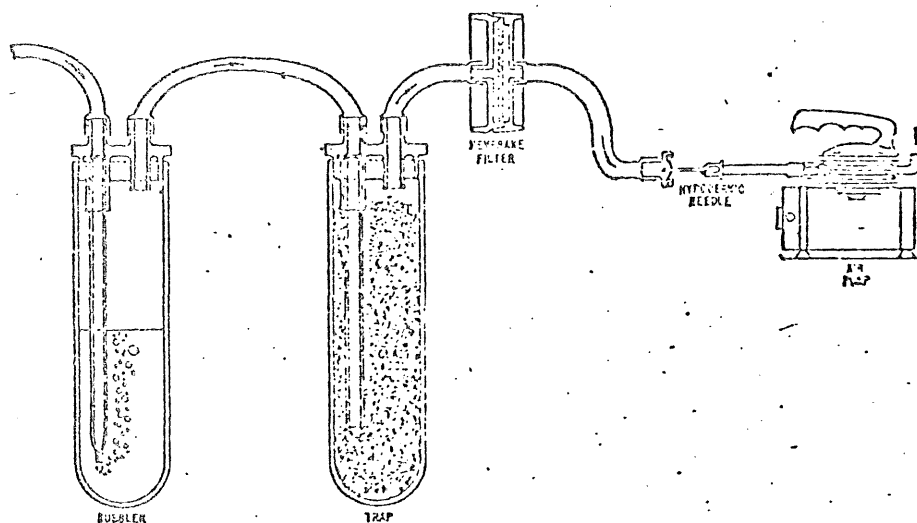


FIGURE F1.—Sampling train.

5.1.1 Absorber. Polypropylene tubes 164 by 32 mm, equipped with polypropylene two-port closures. Calibrate the absorber tube by adding exactly 50 ml of distilled water to the tube, then scribe a mark at the top of the liquid level. Rubber stoppers cause high and varying blank values and should not be used. The gas dispersion tube—a glass tube with the bubbler end drawn out to 0.6–0.2 mm i.d. and approximately 152 mm long—is used. The dispersion tube should be positioned so as to allow a clearance of 6 mm from the bottom of the absorber.

5.1.2 Probe. Teflon, polypropylene, or glass tube with a polypropylene or glass funnel at the end.

5.1.3 Flow control device. Calibrated 27-gauge hypodermic needle, three-eighths of an inch long to maintain a flow of approximately 200 cm^3/min . The needle should be protected by a membrane filter placed between the glass wool trap and the needle. Change the filter after collecting 10 samples.

5.1.4 Air pump. Capable of maintaining a pressure differential of at least 0.3 atm across the flow control device.

5.1.5 Calibration equipment. Flowmeter for measuring airflows up to ap-

¹ Christie, A. A., Midway, R. G., and Radford, D. W. F., *Analyst*, 75, 619 (1970).

² Jacobs, M. E., and Hochheiser, G., "Continuous Sampling and Ultraviolet Determination of Nitrogen Dioxide in Air," *Anal. Chem.* 30, 426 (1958).

³ Unpublished results, Environmental Protection Agency, Research Triangle Park, N.C.

proximately 275 cm³/min within ±2 percent, stopwatch, and precision wet test meter (1 liter/revolution).

5.2 Analysis.

5.2.1 Volumetric flasks. 50, 100, 200, 250, 500, 1,000 ml.

5.2.2 Graduated cylinder. 1,000 ml.

5.2.3 Pipets. 1, 2, 5, 10, 15 ml volumetric; 2 ml, graduated in 1/10 ml intervals.

5.2.4 Test tube.

5.2.5 Spectrophotometer or colorimeter. Capable of measuring absorbance at 540 nm. Bandwidth is not critical.

6. Reagents.—6.1 Sampling.

6.1.1 Absorbing reagent. Dissolve 4.0 g sodium hydroxide (ACS reagent grade) in distilled water, add 1 g of sodium arsenite (ACS reagent grade) and dilute to 1,000 ml with distilled water.

6.2 Analysis.

6.2.1 Sulfanilamide. Dissolve 20 g sulfanilamide in 700 ml distilled water. Add, with mixing, 50 ml concentrated phosphoric acid (85 percent ACS reagent grade) and dilute to 1,000 ml. This solution is stable for a month if refrigerated.

6.2.2 NEDA solution. Dissolve 0.5 g N-1-naphthylethylenediamine dihydrochloride (NEDA) in 500 ml of distilled water. This solution is stable for a month if refrigerated and protected from light.

6.2.3 Hydrogen peroxide. Dilute 0.2 ml of 30 percent hydrogen peroxide to 250 ml with distilled water. This solution may be used for a month if protected from light.

6.2.4 Standard nitrite solution. Dissolve sufficient desiccated sodium nitrite (NaNO₂, assay of 97 percent or greater) and dilute with distilled water to 1,000 ml so that a solution containing 1,000 µg NO₂/ml is obtained. The amount of NaNO₂ to use is calculated as follows:

$$G = \frac{1.500}{A} \times 100$$

G = Amount of NaNO₂, g.

1.500 = Gravimetric factor in converting NO₂ into NaNO₂.

A = Assay, percent.

7. Procedure.—7.1 Sampling. Assemble the sampling apparatus as shown in figure F1. Add exactly 50 ml of absorbing reagent to the calibrated absorber. Disconnect funnel, insert calibrated flowmeter, and measure flow before sampling denoted as F₁ in 9.1.1. If flow rate before sampling is less than 95 percent of needle calibration, check the system for leaks and change the filters if necessary. Remove flowmeter and replace funnel. Sample for 24 hours from midnight to midnight if possible and measure flow at end of sampling period denoted as F₂.

7.2 Analysis. Replace any water lost by evaporation during sampling by adding distilled water until level reaches calibration mark. Pipet 10 ml of the collection sample into a test tube. Add 1.0 ml hydrogen peroxide solution, 10.0 ml sulfanilamide solution, and 1.3 ml NEDA solution with thorough mixing after the addition of each reagent. Prepare a blank in the same manner with 10 ml absorbing reagent. After a 10-minute color-development interval, measure the absorbance at 540 nm against the blank. Read µg NO₂/ml from standard curve (§ 8.2).

Samples with an absorbance greater than that obtained with the 2.0 µg/ml standard should be diluted with the absorbing reagent until the absorbance of the sample is within the range of the calibration curve.

8. Calibration and efficiencies.—8.1 Sampling.

8.1.1 Calibration of flowmeter. With a wet test meter and a stopwatch, determine the rates of airflow (cm³/min) through the flowmeter at several ball positions. Plot ball positions versus flow rates.

8.1.2 Calibration of hypodermic needle. Connect the calibrated flowmeter, the needle to be calibrated, and the source of vacuum in such a way that the direction of airflow through the needle is the same as in the sampling train (fig. 1). Read the position of the ball and determine flow rate in cm³/min from the calibration chart prepared in 8.1.1. Reject all needles not having flow rates between 150 and 210 cm³/min before sampling.

8.2 Calibration curve. Dilute 5.0 ml of the 1,000 µg NO₂/ml solution to 200 ml with absorbing reagent. This solution contains 25 µg NO₂/ml. Pipet 1, 2, 5, and 15 ml of the 25 µg NO₂/ml solution into 50-, 50-, 100-, and 250-ml volumetric flasks and dilute to the mark with absorbing reagent. The solutions contain 0.50, 1.00, 1.25, and 1.50 µg NO₂/ml, respectively. Run standards as instructed in 7.2. Plot absorbance versus µg NO₂/ml. When samples are obtained with lower levels prepare additional standard in the range of 0.01 to 0.5 µg NO₂/ml and run as indicated above.

8.3 Efficiencies. The overall average efficiency of the method is 35 percent over the range of 50 to 750 µg/ml NO₂ concentration.

9. Calculation.—9.1 Sampling.

9.1.1 Calculate volume of air sampled.

$$V = \frac{F_1 + F_2}{2} \times T \times 10^{-6}$$

V = Volume of air sampled, m³.

F₁ = Measured flow rate before sampling, cm³/min.

F₂ = Measured flow rate after sampling, cm³/min.

T = Time of sampling, min.

10⁻⁶ = Conversion of cm³ to m³.

9.2 Calculate the concentration of nitrogen dioxide as µg NO₂/m³.

$$\mu\text{g NO}_2/\text{m}^3 = \frac{(\mu\text{g NO}_2/\text{ml}) \times 50}{V \times 0.85}$$

50 = Volume of absorbing reagent used in sampling, ml.

V = Volume of air sampled, m³.

0.85 = Collection efficiency.

9.2.1 If desired, concentration of nitrogen dioxide may be calculated as p/m NO₂.

$$p/m = (\mu\text{g NO}_2/\text{m}^3) \times 5.32 \times 10^{-4}$$

SULFUR DIOXIDE 24-HR. BUBBLER

and

SUSPENDED PARTICULATES HIGH-VOLUME METHOD

2. Range and Sensitivity. 2.1 Concentrations of sulfur dioxide in the range of 25 to 1,050 $\mu\text{g}/\text{m}^3$ (0.01 to 0.10 p.p.m.) can be measured under the conditions given. One can measure concentrations below 25 $\mu\text{g}/\text{m}^3$ by sampling larger volumes of air, but only if the absorption efficiency of the particulate system is first determined. Higher concentrations can be analyzed by using smaller gas samples, a larger collection volume, or a suitable aliquot of the collected sample. Beer's Law is followed through the working range from 0.03 to 1.0 absorbance units (9.8 to 27 μg of sulfite ion in 25 ml. final solution computed as SO_2).

2.2 The lower limit of detection of sulfur dioxide in 10 ml. TCM is 0.75 μg , (based on twice the standard deviation) representing a concentration of 25 $\mu\text{g}/\text{m}^3 \text{SO}_2$ (0.01 p.p.m.) in an air sample of 30 liters.

3. Interferences. 3.1 The effects of the principal known interferences have been minimized or eliminated. Interferences by oxides of nitrogen are eliminated by sulfamic acid (4, 5), ozone by time-delay (6), and heavy metals by EDTA (ethylenediaminetetraacetic acid, disodium salt) and phosphoric acid (4, 6.). At least 60 μg . Fe (III), 10 μg . Mn(II), and 10 μg . Cr(III) in 10 ml. absorbing reagent can be tolerated in the procedure. No significant interference was found with 10 μg . CU (II) and 22 μg . V(V).

4. Precision, Accuracy, and Stability. 4.1 Relative standard deviation at the 95 percent confidence level is 4.6 percent for the analytical procedure using standard samples. (5)

4.2 After sample collection the solutions are relatively stable. At 22° C. losses of sulfur dioxide occur at the rate of 1 percent per day. When samples are stored at 5° C. for 30 days, no detectable losses of sulfur dioxide occur. The presence of EDTA enhances the stability of SO_2 in solution, and the rate of decay is independent of the concentration of SO_2 . (7)

5. Apparatus.

5.1 Sampling.

5.1.1 Absorber. Absorbers normally used in air pollution sampling are acceptable for concentrations above 25 $\mu\text{g}/\text{m}^3$ (0.01 p.p.m.). An all-glass midjet impinger, as shown in Figure A1, is recommended for 30-minute and 1-hour samples.

For 24-hour sampling, assemble an absorber from the following parts:

Polypropylene 2-port tube closures, special manufacture (available from Bel-Art Products, Pequannock, N.J.).

Glass impingers, 6 mm. tubing, 6 inches long, one end drawn to small diameter such that No. 79 jewelers will pass through, but No. 78 jewelers will not. (Other end fire polished.)

Polypropylene tubes, 164 by 32 mm. Nalgene or equal).

5.1.2 Pump. Capable of maintaining an air pressure differential greater than 0.7 atmosphere at the desired flow rate.

5.1.3 Air Flowmeter or Critical Orifice. A calibrated rotameter or critical orifice capable of measuring air flow within ± 2 percent. For 30-minute sampling, a 22-gauge hypodermic needle 1 inch long may be used as a critical orifice to give a flow of about 1 liter/minute. For 1-hour sampling, a 23-gauge hypodermic needle five-eighths of an inch long may be used as a critical orifice to give a flow of about 0.5 liter/minute. For 24-hour sampling, a 21-gauge hypodermic needle three-eighths of an inch long may be used to give a flow of about 0.2 liter/minute. Use a membrane filter to protect the needle (Figure A1a).

6.2 Analysis.

5.2.1 Spectrophotometer. Suitable for measurement of absorbance at 643 nm, with an effective spectral band width of less than 15 nm. Reagent blank problems may occur with spectrophotometers having greater spectral band width. The wavelength calibration of the instrument should be verified. If transmittance is measured, this can be converted to absorbance:

$$A = \log_{10} (1/T)$$

6. Reagents.

6.1 Sampling.

6.1.1 Distilled water. Must be free from oxidants.

6.1.2 Absorbing Reagent [0.04 M Potassium Tetrachloromercurate (TCM)]. Dissolve 10.85 g. mercuric chloride, 0.053 g. EDTA (ethylenediaminetetraacetic acid, disodium salt), and 6.0 g. potassium chloride in water and bring to mark in a 1,000-ml. volumetric flask. (Caution: highly poisonous. If spilled on skin, flush off with water immediately). The pH of this reagent should be approximately 4.0, but it has been shown that there is no appreciable difference in collection efficiency over the range of pH 5 to pH 3. (7) The absorbing reagent is normally stable for 6 months. If a precipitate forms, discard the reagent.

5.2 Analysis.

6.2.1 Sulfamic Acid (0.6 percent). Dissolve 0.6 g. sulfamic acid in 100 ml. distilled water. Prepare fresh daily.

6.2.2 Formaldehyde (0.3 percent). Dilute 5 ml. formaldehyde solution (36-38 percent) to 1,000 ml. with distilled water. Prepare daily.

6.2.3 Stock Iodine Solution (0.1 N). Place 12.7 g. iodine in a 250-ml. beaker; add 40 g. potassium iodide and 25 ml. water. Stir until all is dissolved, then dilute to 1,000 ml. with distilled water.

6.2.4 Iodine Solution (0.01 N). Prepare approximately 0.01 N iodine solution by diluting 50 ml. of stock solution to 500 ml. with distilled water.

6.2.5 Starch Indicator Solution. Trillitate 0.4 g. soluble starch and 0.602 g. mercuric iodide (preservative) with a little water, and add the paste slowly to 200 ml. boiling water. Continue boiling until the solution is clear; cool, and transfer to a glass-stoppered bottle.

6.2.6 Stock Sodium Thiosulfate Solution (0.1 N). Prepare a stock solution by dissolving 25 g. sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$) in 1,000 ml. freshly boiled, cooled, distilled water and add 0.1 g. sodium carbonate to the solution. Allow the solution to stand 1 day before standardizing. To standardize, accurately weigh, to the nearest 0.1 mg., 1.5 g. primary standard potassium iodate dried at 190° C. and dilute to volume in a 500-ml. volumetric flask. To a 500-ml. iodine flask, pipet 50 ml. of iodate solution. Add 2 g. potassium iodide and 10 ml. of 1 N hydrochloric acid. Stopper the flask. After 5 minutes, titrate with stock thiosulfate solution to a pale yellow. Add 5 ml. starch indicator solution and continue the titration until the blue color disappears. Calculate the normality of the stock solution:

$$N = \frac{W}{M} \times 2.60$$

N = Normality of stock thiosulfate solution.

M = Volume of thiosulfate required, ml.

W = Weight of potassium iodate, grams.

APPENDIX A.—REFERENCE METHOD FOR THE DETERMINATION OF SULFUR DIOXIDE IN THE ATMOSPHERE (PARAROSANILINE METHOD)

1. Principle and Applicability. 1.1 Sulfur dioxide is absorbed from air in a solution of potassium tetrachloromercurate (TCM). A dichlorosulfonmercurate complex, which resists oxidation by the oxygen in the air, is formed (1, 2). Once formed, this complex is stable to strong oxidants (e.g., ozone, oxides of nitrogen). The complex is reacted with *o*-aniline and formaldehyde to form highly colored pararosaniline methyl sulfonate acid (3). The absorbance of the solution is measured spectrophotometrically.

1.2 The method is applicable to the measurement of sulfur dioxide in ambient air using sampling periods up to 24 hours.

$$2.80 = \frac{10(\text{conversion of g. to mg.}) \times 0.1 (\text{fraction iodate used})}{35.67 (\text{equivalent weight of potassium iodate})}$$

6.2.7 Sodium Thiosulfate Titrant (0.01 N). Dilute 100 ml. of the stock thiosulfate solution to 1,000 ml. with freshly boiled distilled water.

Normality = Normality of stock solution $\times 0.100$.

6.2.8 Standard Sulfite Solution for Preparation of Working Sulfite-TCM Solution. Dissolve 0.3 g. sodium metabisulfite ($\text{Na}_2\text{S}_2\text{O}_5$) or 0.40 g. sodium sulfite (Na_2SO_3) in 500 ml. of recently boiled, cooled, distilled water. (Sulfite solution is unstable; it is therefore important to use water of the highest purity to minimize this instability.) This solution contains the equivalent of 320 to 400 $\mu\text{g./ml.}$ of SO_2 . The actual concentration of the solution is determined by adding excess iodine and back-titrating with standard sodium thiosulfate solution. To back-titrate, pipet 50 ml. of the 0.01 N iodine into each of two 500-ml. iodine flasks (A and B). To flask A (blank) add 25 ml. distilled water, and to flask B (sample) pipet 25 ml. sulfite solution. Stopper the flasks and allow to react for 5 minutes. Prepare the working sulfite-TCM solution (6.2.9) at the same time iodine solution is added to the flasks. By means of a buret containing standardized 0.01 N thiosulfate, titrate each flask in turn to a pale yellow. Then add 5 ml. starch solution and continue the titration until the blue color disappears.

6.2.9 Working Sulfite-TCM Solution. Pipet accurately 2 ml. of the standard solution into a 100 ml. volumetric flask and bring to mark with 0.01 M TCM. Calculate the concentration of sulfur dioxide in the working solution:

$$\mu\text{g SO}_2/\text{ml.} = \frac{(A - B) (N) (32,000)}{25} \times 0.02$$

A = Volume thiosulfate for blank, ml.

B = Volume thiosulfate for sample, ml.

N = Normality of thiosulfate titrant.

32,000 = Milliequivalent wt. of SO_2 , $\mu\text{g.}$

25 = Volume standard sulfite solution, ml.

0.02 = Dilution factor

This solution is stable for 30 days if kept at 5° C. (refrigerator). If not kept at 5° C., prepare daily.

6.2.10 Purified Pararosaniline Stock Solution (0.2 percent nominal).

6.2.10.1 Dye Specifications. The pararosaniline dye must meet the following performance specifications: (1) the dye must have a wavelength of maximum absorbance at 540 nm. when assayed in a buffered solution of 0.1 M sodium acetate-acetic acid; (2) the absorbance of the reagent blank, which is temperature-sensitive (0.015 absorbance unit/°C), should not exceed 0.170 absorbance unit at 22° C. with a 1-cm. optical path length, when the blank is prepared according to the prescribed analytical procedure and to the specified concentration of the dye; (3) the calibration curve (Section 8.2.1) should have a slope of 0.030 ± 0.002 absorbance units/ $\mu\text{g. SO}_2$ at this path length when the dye is pure and the sulfite solution is properly standardized.

6.2.10.2 Preparation of Stock Solution. A specially purified (90-100 percent pure) solution of pararosaniline, which meets the above specifications, is commercially available in the required 0.20 percent concentration (Harteco*). Alternatively, the dye may be purified, a stock solution prepared and then assayed according to the procedure of Scaringelli, et al. (4).

6.2.11 Pararosaniline Reagent. To a 250-ml. volumetric flask, add 20 ml. stock pararosaniline solution. Add an additional 0.3 ml. stock solution for each percent the stock

assays below 100 percent. Then add 25 ml. 3 M phosphoric acid and dilute to volume with distilled water. This reagent is stable for at least 9 months.

7. Procedure.

7.1 Sampling. Procedures are described for short-term (30 minutes and 1 hour) and for long-term (24 hours) sampling. One can select different combinations of sampling rate and time to meet special needs. Sample volumes should be adjusted, so that linearity is maintained between absorbance and concentration over the dynamic range.

7.1.1 30-Minute and 1-Hour Samplings. Insert a midrest impinger into the sampling system, Figure A1. Add 10 ml. TCM solution to the impinger. Collect sample at 1 liter/minute for 30 minutes, or at 0.5 liter/minute for 1 hour, using either a rotameter, as shown in Figure A1, or a critical orifice, as shown in Figure A1a, to control flow. Shield the absorbing reagent from direct sunlight during and after sampling by covering the impinger with aluminum foil, to prevent deterioration. Determine the volume of air sampled by multiplying the flow rate by the time in minutes and record the atmospheric pressure and temperature. Remove and stopper the impinger. If the sample must be stored for more than a day before analysis, keep it at 5° C. in a refrigerator (see 4.2).

7.1.2 24-Hour Sampling. Place 50 ml. TCM solution in a large absorber and collect the sample at 0.2 liter/minute for 24 hours from midnight to midnight. Make sure no entrainment of solution results with the impinger. During collection and storage protect from direct sunlight. Determine the total air volume by multiplying the air flow rate by the time in minutes. The correction of 24-hour measurements for temperature and pressure is extremely difficult and is not ordinarily done. However, the accuracy of the measurement will be improved if meaningful corrections can be applied. If storage is necessary, refrigerate at 5° C. (see 4.2).

7.2 Analysis.

7.2.1 Sample Preparation. After collection, if a precipitate is observed in the sample, remove it by centrifugation.

7.2.1.1 30-Minute and 1-Hour Samples. Transfer the sample quantitatively to a 25-ml. volumetric flask; use about 5 ml. distilled water for rinsing. Delay analyses for 20 minutes to allow any ozone to decompose.

7.2.1.2 24-Hour Sample. Dilute the entire sample to 50 ml. with absorbing solution. Pipet 5 ml. of the sample into a 25-ml. volumetric flask for chemical analyses. Bring volume to 10 ml. with absorbing reagent. Delay analyses for 20 minutes to allow any ozone to decompose.

7.2.2 Determination. For each set of determinations prepare a reagent blank by adding 10 ml. unexposed TCM solution to a 25-ml. volumetric flask. Prepare a control solution by adding 2 ml. of working sulfite-TCM solution and 8 ml. TCM solution to a 25-ml. volumetric flask. To each flask containing either sample, control solution, or reagent blank, add 1 ml. 0.6 percent sulfamic acid and allow to react 10 minutes to destroy the nitrite from oxides of nitrogen. Accurately pipet in 2 ml. 0.2 percent formaldehyde solution, then 6 ml. pararosaniline solution. Start a laboratory timer that has been set for 30 minutes. Bring all flasks to volume with freshly boiled and cooled distilled water and mix thoroughly. After 30 minutes and before 60 minutes, determine the absorbances of the sample (denote as A), reagent blank (denote as A₀) and the control solution at 540 nm. using 1-cm. optical path length cells. Use distilled water, not the reagent blank, as the reference. (Note! This is important because of the color sensitivity of the reagent blank to temperature changes which can be induced in the

cell compartment of a spectrophotometer.) Do not allow the colored solution to stand in the absorbance cells, because a film of dye may be deposited. Clean cells with alcohol after use. If the temperature of the determinations does not differ by more than 2° C. from the calibration temperature (8.2), the reagent blank should be within 0.03 absorbance unit of the y-intercept of the calibration curve (8.2). If the reagent blank differs by more than 0.03 absorbance unit from that found in the calibration curve, prepare a new curve.

7.2.3 Absorbance Range. If the absorbance of the sample solution ranges between 1.0 and 2.0, the sample can be diluted 1:1 with a portion of the reagent blank and read within a few minutes. Solutions with higher absorbance can be diluted up to sixfold with the reagent blank in order to obtain on-scale readings within 10 percent of the true absorbance value.

8. Calibration and Efficiencies.

8.1 Flowmeters and Hypodermic Needle. Calibrate flowmeters and hypodermic needle (8) against a calibrated wet test meter.

8.2 Calibration Curves.

8.2.1 Procedure with Sulfite Solution. Accurately pipet graduated amounts of the working sulfite-TCM solution (5.2.9) (such as 0, 0.5, 1, 2, 3, and 4 ml.) into a series of 25-ml. volumetric flasks. Add sufficient TCM solution to each flask to bring the volume to approximately 10 ml. Then add the remaining reagents as described in 7.2.2. For maximum precision use a constant-temperature bath. The temperature of calibration must be maintained within $\pm 1^\circ\text{C.}$ and in the range of 20° to 30° C. The temperature of calibration and the temperature of analysis must be within 2 degrees. Plot the absorbance against the total concentration in $\mu\text{g. SO}_2$ for the corresponding solution. The total $\mu\text{g. SO}_2$ in solution equals the concentration of the standard (Section 6.2.9) in $\mu\text{g. SO}_2/\text{ml.}$ times the ml. sulfite solution added ($\mu\text{g. SO}_2 = \mu\text{g./ml. SO}_2 \times \text{ml. added}$). A linear relationship should be obtained, and the y-intercept should be within 0.03 absorbance unit of the zero standard absorbance. For maximum precision determine the line of best fit using regression analysis by the method of least squares. Determine the slope of the line of best fit, calculate its reciprocal and denote as B. B is the calibration factor. (See Section 6.2.10.1 for specifications on the slope of the calibration curve). This calibration factor can be used for calculating results provided there are no radical changes in temperature or pH. At least one control sample containing a known concentration of SO_2 for each series of determinations, is recommended to insure the reliability of this factor.

8.2.2 Procedure with SO_2 Permeation Tubes.

8.2.2.1 General Considerations. Atmospheres containing accurately known amounts of sulfur dioxide at levels of interest can be prepared using permeation tubes. In the systems for generating these atmospheres, the permeation tube emits SO_2 gas at a known, low, constant rate, provided the temperature of the tube is held constant ($\pm 0.1^\circ\text{C.}$) and provided the tube has been accurately calibrated at the temperature of use. The SO_2 gas permeating from the tube is carried by a low flow of inert gas to a mixing chamber where it is accurately diluted with SO_2 -free air to the level of interest and the sample taken. These systems are shown schematically in Figures A2 and A3 and have been described in detail by O'Keefe and Ortmann (9), Scaringelli, Frey, and Hartman (10), and Scaringelli, O'Keefe, Rosenberg, and Bell (11).

8.2.2.2 Preparation of Standard Atmospheres. Permeation tubes may be prepared

*Hartman-Leddon, 20th and Woodland Avenue, Philadelphia, PA 19143.

achieved. Searlingelli, O'Keefe, Rosen- and Bell (11) give detailed, explicit instructions for permeation tube calibration. With a certified permeation rate are able from the National Bureau of Standards permeation rates from 0.2 to 0.4 minute inert gas flows of about 50 ml./e and dilution air flow rates from 1.1 liters/minutes conveniently give standard atmospheres containing desired levels (25 to 300 $\mu\text{g./m.}^3$; 0.01 to 0.15 p.p.m.). The concentration of SO_2 in any standard atmosphere can be calculated as follows:

$$C = \frac{P \times 10^3}{R_d + R_i}$$

Concentration of SO_2 , $\mu\text{g./m.}^3$ at reference conditions.

Tube permeation rate, $\mu\text{g./minute}$.

Flow rate of dilution air, liter/minute at reference conditions.

Flow rate of inert gas, liter/minute at reference conditions.

2.3 Sampling and Preparation of Calibration Curve. Prepare a series (usually six) standard atmospheres containing SO_2 from 25 to 300 $\mu\text{g./m.}^3$. Sample each sphere using similar apparatus and take exactly the same air volume as will be in atmospheric sampling. Determine balances as directed in 7.2. Plot the concentration of SO_2 in $\mu\text{g./m.}^3$ (x-axis) against values (y-axis), draw the straight line of best fit and determine the slope. Alternatively, regression analysis by the method of least squares may be used to calculate the slope. Calculate the reciprocal of the slope and denote as B_s .

Sampling Efficiency. Collection efficiency is above 93 percent; efficiency may be lower, however, at concentrations below 25 $\mu\text{g./m.}^3$ (12, 13).

Calculations.

Conversion of Volume. Convert the volume of air sampled to the volume at reference conditions of 25° C. and 760 mm. Hg. 24-hour samples, this may not be applicable.

$$V_R = V \times \frac{P}{760} \times \frac{298}{t + 273}$$

= Volume of air at 25° C. and 760 mm. Hg, liters.

= Volume of air sampled, liters.

= Barometric pressure, mm. Hg.

= Temperature of air sample, °C.

Sulfur Dioxide Concentration.

1. When sulfite solutions are used to prepare calibration curves, compute the concentration of sulfur dioxide in the sample:

$$\text{SO}_2/\text{m.}^3 = \frac{(A - A_0) (10^3) (B_s)}{V_R} \times D$$

= Sample absorbance.

= Reagent blank absorbance.

= Conversion of liters to cubic meters.

= The sample corrected to 25° C. and 760 mm. Hg, liters.

= Calibration factor, $\mu\text{g./absorbance unit}$.

= Dilution factor.

For 30-minute and 1-hour samples, $D = 1$.

For 24-hour samples, $D = 10$.

2. When SO_2 gas standard atmospheres are used to prepare calibration curves, compute the sulfur dioxide in the sample by the following formula:

$$\text{SO}_2, \mu\text{g./m.}^3 = (A - A_0) \times B_s$$

= Sample absorbance.

= Reagent blank absorbance.

(See 8.2.2.3).

3. Conversion of $\mu\text{g./m.}^3$ to p.p.m. = If C is the concentration of sulfur dioxide

may be calculated as p.p.m. SO_2 at reference conditions as follows:

$$\text{p.p.m. SO}_2 = \mu\text{g. SO}_2/\text{m.}^3 \times 3.32 \times 10^{-4}$$

10. References.

- (1) West, P. W., and Gacke, G. C., "Fixation of Sulfur Dioxide as Sulfotomercurate III and Subsequent Colorimetric Determination", *Anal. Chem.* 23, 1816 (1951).
- (2) Ephraïm, F., "Inorganic Chemistry," p. 562, Edited by P.C.L. Thorne and E. R. Roberts, 5th Edition, Interscience, (1948).
- (3) Lyles, G. N., Dowling, F. B., and Blanchard, V. J., "Quantitative Determination of Formaldehyde in Parts Per Hundred Million Concentration Level", *J. Air Poll. Cont. Assoc.* 15, 195 (1965).
- (4) Searlingelli, F. P., Saltzman, B. E., and Frey, S. A., "Spectrophotometric Determination of Atmospheric Sulfur Dioxide", *Anal. Chem.* 39, 1709 (1967).
- (5) Pate, J. B., Ammons, B. E., Swanson, G. A., Lodge, J. P., Jr., "Nitrite Interference in Spectrophotometric Determination of Atmospheric Sulfur Dioxide", *Anal. Chem.* 37, 912 (1965).
- (6) Zurlo, N. and Graffini, A. M., "Measurement of the SO_2 Content of Air in the Presence of Oxides of Nitrogen and Heavy Metals", *Med. Lavoro*, 53, 330 (1962).
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- (9) O'Keefe, A. E., and Ortman, G. C., "Primary Standards for Trace Gas Analysis", *Anal. Chem.* 38, 750 (1965).
- (10) Searlingelli, F. P., Frey, S. A., and Saltzman, B. E., "Evaluation of Teflon Permeation Tubes for Use with Sulfur Dioxide", *Amer. Ind. Hygiene Assoc. J.* 28, 260 (1967).
- (11) Searlingelli, F. P., O'Keefe, A. E., Rosenberg, E., and Bell, J. P., "Preparation of Known Concentrations of Gases and Vapors with Permeation Devices Calibrated Gravimetrically", *Anal. Chem.* 42, 871 (1970).
- (12) Urone, P., Evans, J. B., and Noyes, C. M., "Tracer Techniques in Sulfur Dioxide Colorimetric and Conductometric Methods", *Anal. Chem.* 37, 1104 (1965).
- (13) Bostrom, C. E., "The Absorption of Sulfur Dioxide at Low Concentrations (p.p.m.) Studied by an Isotopic Tracer Method", *Intern. J. Air Water Poll.* 9, 33 (1965).

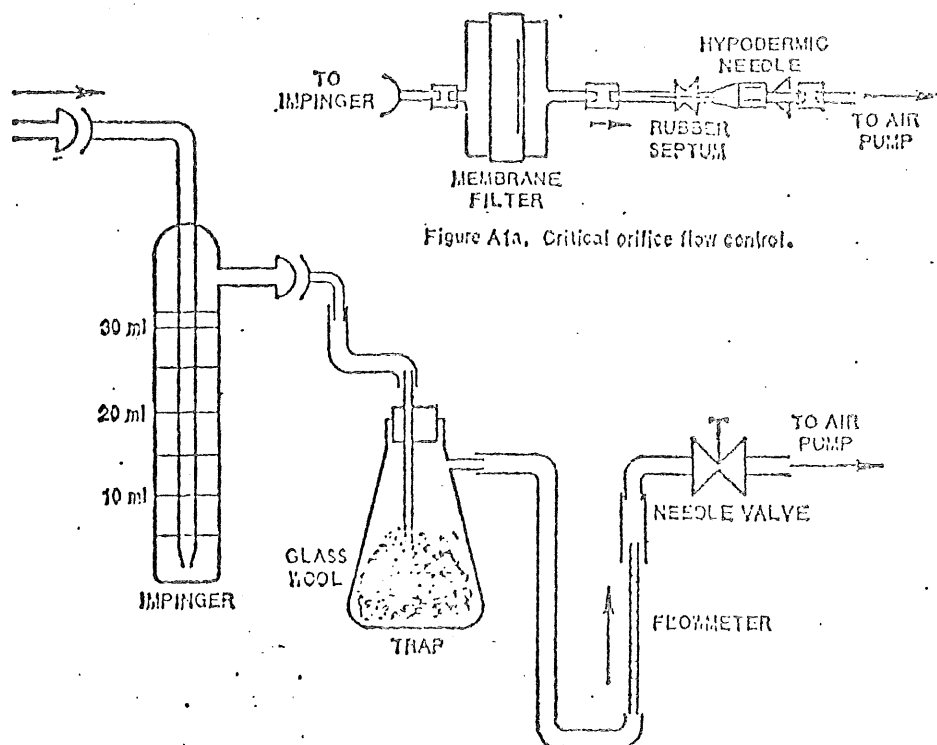


Figure A1a. Critical orifice flow control.

Figure A1. Sampling train.

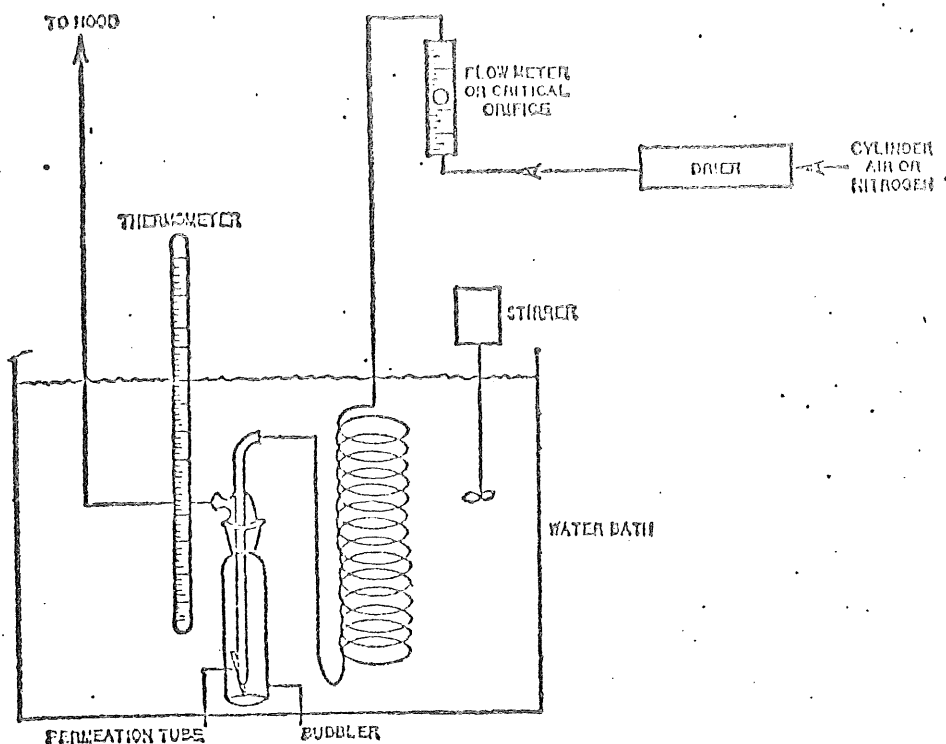


Figure A2. Apparatus for gravimetric calibration and field use.

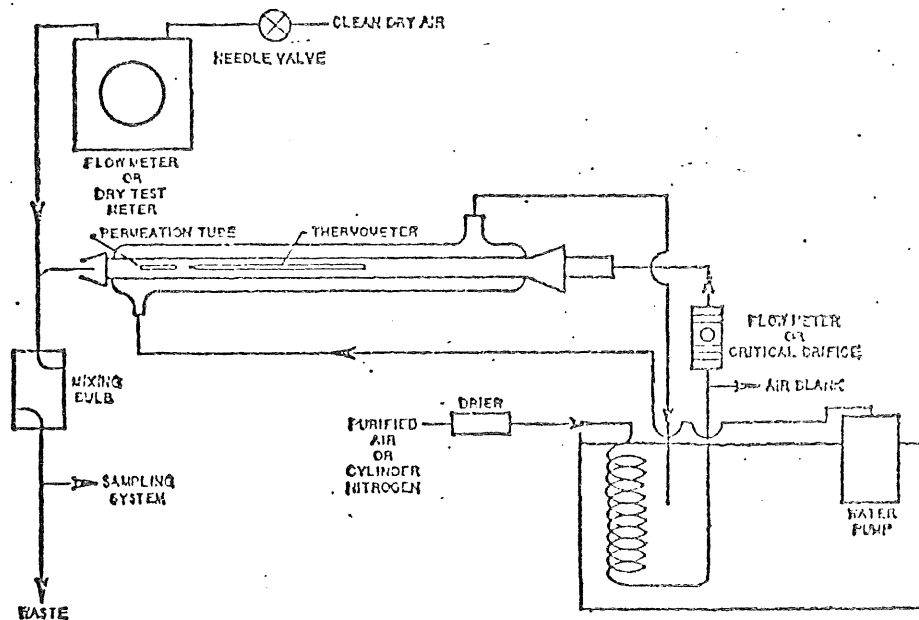


Figure A3. Permeation tube schematic for laboratory use.

APPENDIX B—REFERENCE METHOD FOR THE DETERMINATION OF SUSPENDED PARTICULATES IN THE ATMOSPHERE (HIGH VOLUME METHOD)

1. Principle and Applicability.

1.1 Air is drawn into a covered housing and through a filter by means of a high-flow-rate blower at a flow rate (1.13 to 1.70 m³/min.; 40 to 60 ft³/min.) that allows suspended particles having diameters of less than 100 μ m. (Stokes equivalent diameter) to pass to the filter surface. (1) Particles within the size range of 100 to 0.1 μ m. diameter are ordinarily collected on glass fiber filters. The mass concentration of suspended particulates in the ambient air (μ g./m³) is computed by measuring the mass of collected particulates and the volume of air sampled.

1.2 This method is applicable to measurement of the mass concentration of suspended particulates in ambient air. The size of the sample collected is usually adequate for other analyses.

2. Range and Sensitivity.

2.1 When the sampler is operated at an average flow rate of 1.70 m³/min. (60 ft³/min.) for 24 hours, an adequate sample will be obtained even in an atmosphere having concentrations of suspended particulates as low as 1 μ g./m³. If particulate levels are unusually high, a satisfactory sample may be obtained in 6 to 8 hours or less. For determination of average concentrations of suspended particulates in ambient air, a standard sampling period of 24 hours is recommended.

2.2 Weights are determined to the nearest milligram, airflow rates are determined to the nearest 0.03 m³/min. (1.0 ft³/min.), times are determined to the nearest 2 minutes, and mass concentrations are reported to the nearest microgram per cubic meter.

3. Interferences.

3.1 Particulate matter that is oily, such as photochemical smog or wood smoke, may block the filter and cause a rapid drop in airflow at a nonuniform rate. Dense fog or high humidity can cause the filter to become too wet and severely reduce the airflow through the filter.

3.2 Glass-fiber filters are comparatively insensitive to changes in relative humidity, but collected particulates can be hygroscopic. (2)

4. Precision, Accuracy, and Stability.

4.1 Based upon collaborative testing, the relative standard deviation (coefficient of variation) for single analyst variation (repeatability of the method) is 3.0 percent. The corresponding value for multilaboratory variation (reproducibility of the method) is 8.7 percent. (3)

4.2 The accuracy with which the sampler measures the true average concentration depends upon the constancy of the airflow rate through the sampler. The airflow rate is affected by the concentration and the nature of the dust in the atmosphere. Under these conditions the error in the measured average concentration may be in excess of ± 50 percent of the true average concentration, depending on the amount of reduction of airflow rate and on the variation of the mass concentration of dust with time during the 24-hour sampling period. (4)

5. Apparatus.

5.1 Sampler.

5.1.1 *Sampler.* The sampler consists of three units: (1) the cassette and gasket (2) the filter adapter assembly, and (3) the motor unit. Figure B1 shows an exploded view of these parts, their relationship to each other, and how they are assembled. The sampler must be capable of passing environmental air through a 498.5 cm² (63 in.²) portion of a clean 20.3 by 25.4 cm (8 by 10-in.) glass-fiber filter at a rate of at least 1.70 m³/min. (60 ft³/min.). The motor must be capable of continuous operation for 24-hour periods with input voltages ranging from 110 to 120 volts, 60-60 cycles alternating current and must have third-wire safety ground. The housing for the motor unit may be of any convenient construction so long as the unit remains airtight and leak-free. The life of the sampler motor can be extended by lowering the voltage by about 10 percent with a small "buck or boost" transformer between the sampler and power outlet.

5.1.2 *Sampler Shelter.* It is important that the sampler be properly installed in a suitable shelter. The shelter is subjected to extremes of temperature, humidity, and all types of air pollutants. For these reasons the materials of the shelter must be chosen carefully. Properly painted exterior plywood or heavy gauge aluminum serve well. The sampler must be mounted vertically in the shelter so that the glass-fiber filter is parallel with the ground. The shelter must be provided with a roof so that the filter is protected from precipitation and debris. The internal arrangement and configuration of a suitable shelter with a cable roof are shown in Figure B2. The clearance area between the main housing and the roof at its closest point should be 509.5 \pm 102.5 cm² (60 \pm 10 in.²). The main housing should be rectangular, with dimensions of about 20 by 26 cm. (11 $\frac{1}{2}$ by 14 in.).

5.1.3 *Rotameter.* Marked in arbitrary units, frequently 0 to 70, and capable of being calibrated. Other devices of at least comparable accuracy may be used.

- (5) Fete, J. B., and Taber, R. C., "Analytical Aspects of the Use of Glass-Fiber Filters for the Collection and Analysis of Atmospheric Particulate Matter", *Am. Ind. Hyg. Assoc. J.* 23, 141-150 (1962).

APPENDIX

A. Alternative Equipment.

A modification of the high-volume sampler incorporating a method for recording the actual airflow over the entire sampling period has been described, and is acceptable for measuring the concentration of suspended particulates (Henderson, J. S., Eighth Conference on Methods in Air Pollution and Industrial Hygiene Studies, 1967, Oakland, Calif.). This modification consists of an exhaust orifice meter assembly connected through a transducer to a system for continuously recording airflow on a circular chart. The volume of air sampled is calculated by the following equation:

$$V = Q \times T$$

Q = Average sampling rate, $m^3/min.$

T = Sampling time, minutes.

The average sampling rate, Q , is determined from the recorder chart by estimation if the flow rate does not vary more than 0.11 $m^3/min.$ (4 $ft^3/min.$) during the sampling period. If the flow rate does vary more than 0.11 m^3 (4 $ft^3/min.$) during the sampling period, read the flow rate from the chart at 2-hour intervals and take the average.

B. Pressure and Temperature Corrections.

If the pressure or temperature during high-volume sampler calibration is substantially different from the pressure or temperature during orifice calibration, a correction of the flow rate, Q , may be required. If the pressures differ by no more than 15 percent and the temperatures differ by no more than 100 percent ($^{\circ}C$), the error in the uncorrected flow rate will be no more than 15 percent. If necessary, obtain the corrected flow rate as directed below. This correction applies only to orifice meters having a constant orifice coefficient. The coefficient for the calibrating orifice described in 5.1.4 has been shown experimentally to be constant over the normal operating range of the high-volume sampler (0.6 to 2.2 $m^3/min.$; 20 to 78 $ft^3/min.$). Calculate corrected flow rate:

$$Q_2 = Q_1 \left[\frac{T_2 P_1}{T_1 P_2} \right]^{1/4}$$

Q_2 = Corrected flow rate, $m^3/min.$

Q_1 = Flow rate during high-volume sampler calibration (Section 3.1.2), $m^3/min.$

T_1 = Absolute temperature during orifice unit calibration (Section 8.1.1), $^{\circ}K$ or $^{\circ}R$.

P_1 = Barometric pressure during orifice unit calibration (Section 8.1.1), mm. Hg.

T_2 = Absolute temperature during high-volume sampler calibration (Section 8.1.2), $^{\circ}K$ or $^{\circ}R$.

P_2 = Barometric pressure during high-volume sampler calibration (Section 8.1.2), mm. Hg.

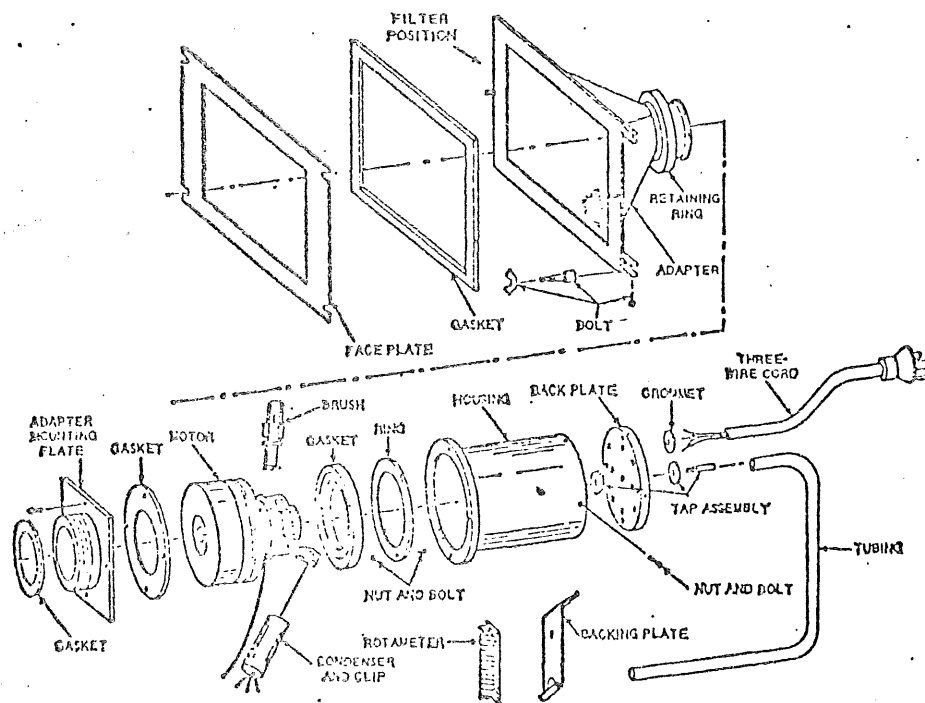


Figure B1. Exploded view of typical high-volume air sampler parts.

5.1.4 Orifice Calibration Unit. Consisting of a metal tube 7.6 cm. (3 in.) ID and 15.9 cm. (6¼ in.) long with a static pressure tap 5.1 cm. (2 in.) from one end. See Figure B3. The tube end nearest the pressure tap is flanged to about 10.8 cm. (4¼ in.) OD with a male thread of the same size as the inlet end of the high-volume air sampler. A single metal plate 9.2 cm. (3½ in.) in diameter and 0.24 cm. (¾ in.) thick with a central orifice 2.9 cm. (1½ in.) in diameter is held in place at the air inlet end with a female threaded ring. The other end of the tube is flanged to hold a loose female threaded coupling, which screws onto the inlet of the sampler. An 18-hole metal plate, an integral part of the unit, is positioned between the orifice and sampler to simulate the resistance of a clean glass-fiber filter. An orifice calibration unit is shown in Figure B3.

5.1.5 Differential Manometer. Capable of measuring to at least 40 cm. (16 in.) of water.

5.1.6 Positive Displacement Meter. Calibrated in cubic meters or cubic feet, to be used as a primary standard.

5.1.7 Barometer. Capable of measuring atmospheric pressure to the nearest mm.

5.2 Analysis.

5.2.1 Filter Conditioning Environment. Balance room or desiccator maintained at 15° to 35°C. and less than 50 percent relative humidity.

5.2.2 Analytical Balance. Equipped with a weighing chamber designed to handle unfolded 20.3 by 25.4 cm. (8- by 10-in.) filters and having a sensitivity of 0.1 mg.

5.2.3 Light Source. Frequently a table of the type used to view X-ray films.

5.2.4 Numbering Device. Capable of printing identification numbers on the filters.

6. Reagents.

6.1 Filter Media. Glass-fiber filters having a collection efficiency of at least 99 percent for particles of 0.3 µm. diameter, as measured by the DOP test, are suitable for the quantitative measurement of concentrations of suspended particulates, (5) although some other medium, such as paper, may be desirable for some analyses. If a more detailed analysis is contemplated, care must be exercised to use filters that contain low background concentrations of the pollutant being investigated. Careful quality control is required to determine background values of these pollutants.

7. Procedure.

7.1 Sampling.

7.1.1 Filter Preparation. Expose each filter to the light source and inspect for pinholes, particles, or other imperfections. Filters with visible imperfections should not be used. A small brush is useful for removing particles. Equilibrate the filters in the filter conditioning environment for 24 hours. Weigh the filters to the nearest milligram; record tare weight and filter identification number. Do not bend or fold the filter before collection of the sample.

7.1.2 Sample Collection. Open the shelter, loosen the wing nuts, and remove the faceplate from the filter holder. Install a numbered, preweighed, glass-fiber filter in position (rough side up), replace the faceplate without disturbing the filter, and fasten securely. Undertightening will allow air leakage, overtightening will damage the sponge-rubber faceplate gasket. A very light application of talcum powder may be used on the sponge-rubber faceplate gasket to prevent the filter from sticking. During inclement weather the sampler may be removed to a protected area for filter change. Close the roof of the shelter, run the sampler for about 5 minutes, connect the rotameter to the nipple on the back of the sampler, and read the rotameter ball with rotameter in a vertical position. Estimate to the nearest whole number. If the ball is fluctuating rapidly, tip the rotameter and slowly straighten it

until the ball gives a constant reading. Disconnect the rotameter from the nipple; record the initial rotameter reading and the starting time and date on the filter folder. (The rotameter should never be connected to the sampler except when the flow is being measured.) Sample for 24 hours from midnight to midnight and take a final rotameter reading. Record the final rotameter reading and ending time and date on the filter folder. Remove the faceplate as described above and carefully remove the filter from the holder, touching only the outer edges. Fold the filter lengthwise so that only surfaces with collected particulates are in contact, and place in a manila folder. Record on the folder the filter number, location, and any other factors, such as meteorological conditions or razing of nearby buildings, that might affect the results. If the sample is defective, void it at this time. In order to obtain a valid sample, the high-volume sampler must be operated with the same rotameter and tubing that were used during its calibration.

7.2 Analysis. Equilibrate the exposed filters for 24 hours in the filter conditioning environment, then reweigh. After they are weighed, the filters may be saved for detailed chemical analysis.

7.3 Maintenance.

7.3.1 Sampler Motor. Replace brushes before they are worn to the point where motor damage can occur.

7.3.2 Faceplate Gasket. Replace when the margins of samples are no longer sharp. The gasket may be sealed to the faceplate with rubber cement or double-sided adhesive tape.

7.3.3 Rotameter. Clean as required, using alcohol.

8. Calibration.

8.1 Purpose. Since only a small portion of the total air sampled passes through the rotameter during measurement, the rotameter must be calibrated against actual airflow with the orifice calibration unit. Before the orifice calibration unit can be used to calibrate the rotameter, the orifice calibration unit itself must be calibrated against the positive displacement primary standard.

8.1.1 Orifice Calibration Unit. Attach the orifice calibration unit to the intake end of the positive displacement primary standard and attach a high-volume motor blower unit to the exhaust end of the primary standard. Connect one end of a differential manometer to the differential pressure tap of the orifice calibration unit and leave the other end open to the atmosphere. Operate the high-volume motor blower unit so that a series of different, but constant, airflows (usually six) are obtained for definite time periods. Record the reading on the differential manometer at each airflow. The different constant airflows are obtained by placing a series of leadplates, one at a time, between the calibration unit and the primary standard. Placing the orifice before the inlet reduces the pressure at the inlet of the primary standard below atmospheric; therefore, a correction must be made for the increase in volume caused by this decreased inlet pressure. Attach one end of a second differential manometer to an inlet pressure tap of the primary standard and leave the other open to the atmosphere. During each of the constant airflow measurements made above, measure the true inlet pressure of the primary standard with this second differential manometer. Measure atmospheric pressure and temperature. Correct the measured air volume to true air volume as directed in 9.1.1, then obtain true airflow rate, Q , as directed in 9.1.3. Plot the differential manometer readings of the orifice unit versus Q .

8.1.2 High-Volume Sampler. Assemble a high-volume sampler with a clean filter in place and run for at least 5 minutes. Attach a rotameter, read the ball, adjust so that the ball reads 65, and seal the adjusting mech-

anism so that it cannot be changed easily. Shut off motor, remove the filter, and attach the orifice calibration unit in its place. Operate the high-volume sampler at a series of different, but constant, airflows (usually six). Record the reading of the differential manometer on the orifice calibration unit, and record the readings of the rotameter at each flow. Measure atmospheric pressure and temperature. Convert the differential manometer reading to m^3/mm , Q , then plot rotameter reading versus Q .

8.1.3 Correction for Differences in Pressure or Temperature. See Addendum B.

9. Calculations.

9.1 Calibration of Orifice.

9.1.1 True Air Volume. Calculate the air volume measured by the positive displacement primary standard.

$$V_s = \frac{(P_s - P_m)}{P_a} (V_m)$$

V_s = True air volume at atmospheric pressure, m^3

P_s = Barometric pressure, mm. Hg.

P_m = Pressure drop at inlet of primary standard, mm. Hg.

V_m = Volume measured by primary standard, m^3

9.1.2 Conversion Factors.

Inches Hg. $\times 25.4$ = mm. Hg.

Inches water $\times 73.43 \times 10^{-2}$ = inches Hg.

Cubic feet air $\times 0.0283$ = cubic meters air.

9.1.3 True Airflow Rate.

$$Q = \frac{V_s}{T}$$

Q = Flow rate, m^3/min .

T = Time of flow, min.

9.2 Sample Volume.

9.2.1 Volume Conversion. Convert the initial and final rotameter readings to true airflow rate, Q , using calibration curve of 8.1.2.

9.2.2 Calculate volume of air sampled

$$V = \frac{Q_i Q_f}{2} \times T$$

V = Air volume sampled, m^3

Q_i = Initial airflow rate, m^3/min .

Q_f = Final airflow rate, m^3/min .

T = Sampling time, min.

9.3 Calculate mass concentration of suspended particulates

$$S.P. = \frac{(W_i - W_f) \times 10^3}{V}$$

$S.P.$ = Mass concentration of suspended particulates, $\mu g/m^3$

W_i = Initial weight of filter, g.

W_f = Final weight of filter, g.

V = Air volume sampled, m^3

10^3 = Conversion of g. to μg .

10. References.

- (1) Robson, C. D., and Foster, K. E., "Evaluation of Air Particulate Sampling Equipment", *Am. Ind. Hyg. Assoc. J.* 24, 491 (1963).
- (2) Tierney, G. P., and Conner, W. D., "Hygroscopic Effects on Weight Determinations of Particulates Collected on Glass-Fiber Filters", *Am. Ind. Hyg. Assoc. J.* 28, 223 (1967).
- (3) Unpublished data based on a collaborative test involving 12 participating laboratories conducted under the direction of the Methods Standardization Service, Section of the National Air Pollution Control Administration, October, 1967.
- (4) Harrison, W. H., Nader, J. S., and P. S., "Constant Flow Rotameter for High-Volume Air Sampling", *Am. Ind. Hyg. Assoc. J.* 21, 114-120 (1960).

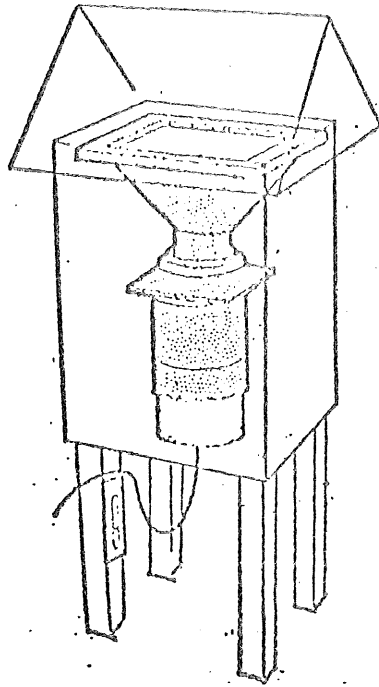
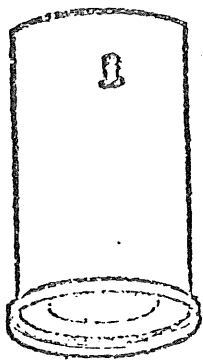
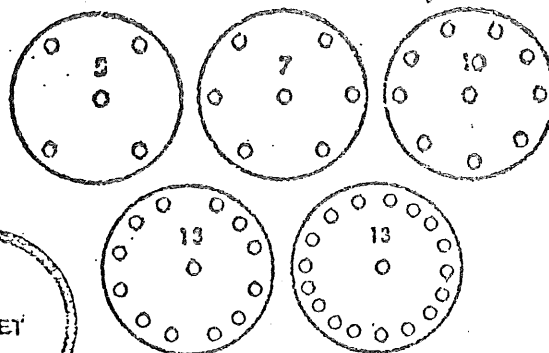


Figure B2. Assembled sampler and shelter.



ORIFICE



RESISTANCE PLATES



GASKET

Figure B3. Orifice calibration unit.

APPENDIX A-11

AUDIT PROCEDURES TO BE PERFORMED BY
QUALITY ASSURANCE UNIT OF
MINNESOTA POLLUTION CONTROL AGENCY, AIR QUALITY DIVISION

Philips SO₂ Audit Procedure

Bubbler Audit Procedure

High-Volume Procedure

Membrane Procedure

Cascade Impactor Procedure

Fluoride Procedure

AUDIT PROCEDURE 1

Philips SO₂ Audit Procedure

A. General

The audit procedure is designed as a spot check on the operation, maintenance and calibration of the monitors. Strip charts are audited by randomly selecting six days of charts, reading them and comparing them to reported data.

B. Equipment

- a) Calibration device and appropriate curve (usually ML calibrator)
- b) Checklists
 - 1. Previous service and calibration checklist
 - 2. Audit checklist (Audit Forms A-1, A-2, A-3)
- c) Tools (including a volt meter)

C. Procedure

- a) At scheduled site complete Audit Forms A-1, A-2 and A-3
- b) Return completed forms to the Supervisor

| | YES | NO | COMMENTS |
|---|-----|----|----------|
| A. Operator: | | | |
| 1. Has the operator recorded the daily zero readings in the log book and on the strip chart? | | | |
| 2. Did the operator date and initial daily functions (zero adjustment, H ₂ O level)? | | | |
| 3. Has the flow value been recorded in the log book? | | | |
| 4. Is the general appearance of the monitor acceptable? | | | |
| 5. Has the operator verbally called in daily information to the data section? | | | |
| B. Calibration: | | | |
| 1. Is there a calibration curve located at the site and within the quarterly limit? | | | |
| 2. Have log entries been made documenting the calibration? | | | |
| 3. Are appropriate stickers (dated, initialed) on the monitor? | | | |
| 4. Using a calibration device, check at least three points. Were the values in reasonable agreement (+5%) with the calibration curve? | | | |
| 5. Have previous calibration data compared to audit data been recorded on Form A-3? | | | |
| C. Maintenance: | | | |
| 1. Have entries for the last maintenance been recorded in the log book? | | | |
| 2. Is there a sticker (dated and initialed) on the monitor? | | | |
| 3. By comparing the maintenance checklist with the monitor, is there reasonable agreement? | | | |
| 4. Has the maintenance been performed within the quarterly/yearly time limit? | | | |
| D. Auditor: | | | |
| 1. Has the auditor recorded entries in the log book documenting the audit? | | | |
| 2. Have the strip charts for six days been read and recorded on the strip chart form? | | | |
| 3. Has the calibration data compared to the audit data been recorded in the log book? | | | |

By: _____

Date: _____

Site and Operator _____

SO₂ Strip Chart Readings
Site and Operator _____

| Date/ Hr. | Scale zero | PPM chart | PPM tele | PPM SAROAD sheet | $\frac{(1)-(2) \text{ or } (3)}{(1)} \times 100\%$ | Date Hr. | Scale zero | PPM chart | PPM tele | PPM SAROAD sheet | $\frac{(1)-(2) \text{ or } (3)}{(1)} \times 100\%$ |
|--------------|---------------|--------------|-------------|------------------------|--|-------------|---------------|--------------|-------------|------------------------|--|
| 0100 | | | | | | | | | | | |
| 0200 | | | | | | | | | | | |
| 0300 | | | | | | | | | | | |
| 0400 | | | | | | | | | | | |
| 0500 | | | | | | | | | | | |
| 0600 | | | | | | | | | | | |
| 0700 | | | | | | | | | | | |
| 0800 | | | | | | | | | | | |
| 0900 | | | | | | | | | | | |
| 1000 | | | | | | | | | | | |
| 1100 | | | | | | | | | | | |
| 1200 | | | | | | | | | | | |
| 1300 | | | | | | | | | | | |
| 1400 | | | | | | | | | | | |
| 1500 | | | | | | | | | | | |
| 1600 | | | | | | | | | | | |
| 1700 | | | | | | | | | | | |
| 1800 | | | | | | | | | | | |
| 1900 | | | | | | | | | | | |
| 2000 | | | | | | | | | | | |
| 2100 | | | | | | | | | | | |
| 2200 | | | | | | | | | | | |
| 2300 | | | | | | | | | | | |
| 2400 | | | | | | | | | | | |
| 0100 | | | | | | | | | | | |
| 0200 | | | | | | | | | | | |
| 0300 | | | | | | | | | | | |
| 0400 | | | | | | | | | | | |
| 0500 | | | | | | | | | | | |
| 0600 | | | | | | | | | | | |
| 0700 | | | | | | | | | | | |
| 0800 | | | | | | | | | | | |
| 0900 | | | | | | | | | | | |
| 1000 | | | | | | | | | | | |
| 1100 | | | | | | | | | | | |
| 1200 | | | | | | | | | | | |
| 1300 | | | | | | | | | | | |
| 1400 | | | | | | | | | | | |
| 1500 | | | | | | | | | | | |
| 1600 | | | | | | | | | | | |
| 1700 | | | | | | | | | | | |
| 1800 | | | | | | | | | | | |
| 1900 | | | | | | | | | | | |
| 2000 | | | | | | | | | | | |
| 2100 | | | | | | | | | | | |
| 2200 | | | | | | | | | | | |
| 2300 | | | | | | | | | | | |
| 2400 | | | | | | | | | | | |

By: _____

Date: _____

AUDIT - CALIBRATION COMPARISON

| CALIBRATION CURVE READINGS | | | | | AUDIT RECORDINGS | | | | | |
|----------------------------|-----------|---------|---------------|-------|------------------|-----------|---------|---------------|-------|--|
| Point | PPM input | % Scale | "O" corrected | C PPM | Point | PPM input | % Scale | "O" corrected | A PPM | Difference $\frac{A_{ppm} - C_{ppm}}{(A_{ppm})} \times 100\%$ |
| 1 | | | | | 1 | | | | | |
| 2 | | | | | 2 | | | | | |
| 3 | | | | | 3 | | | | | |
| 4 | | | | | 4 | | | | | |
| 5 | | | | | 5 | | | | | |

By: _____

Date: _____

Site and Operator: _____

AUDIT PROCEDURE 2

RAC and MISCO Bubbler Audit Procedure

A. General

The audit procedure is designed as a spot check on the operation, maintenance and calibration of the monitor. The audit should be performed with the operator as he prepares for a sampling period.

B. Equipment

- a) Calibrated flowmeter and curve
- b) Data Card #628 (completed prior to audit)
- c) Audit Form A-4, A-5
- d) Bubbler Maintenance Form M-1

C. Procedure

- a) For each scheduled site complete Audit Forms A-4, A-5
- b) Return the audit forms to the Supervisor

RWC and SCO Bubbler Audit Form

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11/1
Page 1 of 3

YES NO

COMMENTS

| | | | |
|--|--|--|--|
| <p>A. Operator:</p> <p>1. Prior to the audit. Randomly choose 4 sampling days at the site from the previous or existing quarter and examine the data cards for these days. Has the operator recorded location, date, pollutant, time flow and operator initials on data card #628?</p> | | | |
| <p>2. Has the operator maintained the sampling schedule? (Schedule may be obtained from Data Analysis Section)</p> | | | |
| <p>3. During the audit. Does the operator employ proper laboratory techniques in pipetting solutions and calibrating critical orifices?</p> | | | |
| <p>4. Does the operator follow proper operation procedures as outlined in Operation Procedure 1? Is light exposure of samples kept to a min.?</p> | | | |
| <p>5. Are the samples refrigerated immediately after the sampling period (within 24 hrs.)?</p> | | | |
| <p>B. Calibration:</p> <p>1. With a calibrated flowmeter calibrate the critical orifices immediately after the operator; is there reasonable agreement (± 5)?</p> | | | |
| <p>2. Has the calibration data been recorded on the back of this form?</p> | | | |
| <p>C. Maintenance:</p> <p>1. Has the bubbler from the site received a complete maintenance as scheduled once per quarter? (See Bubbler Maintenance Form M-1).</p> <p>2. Is the Bubbler Maintenance Form M-1 complete?</p> <p>3. Are the filters on the field unit reasonably clean?</p> | | | |
| <p>D. Auditor:</p> <p>1. Have the audit forms A-4, A-5 been completed?</p> | | | |

By: _____

Date: _____

Site and Operator: _____

Audit - Critical Orifice Calibration Comparison

| Orifice | Operator Readings cc/min (O) | Auditor Readings cc/min (A) | % Difference $\frac{A-O}{A} \times 100$ |
|---------|------------------------------------|-----------------------------------|--|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

COMMENTS:

Site and Operator _____

By: _____

Date: _____

AUDIT PROCEDURE 3
Hi-Vol Audit Procedure

A. General

The audit procedure is designed as a spot check on the operation, maintenance and calibration of the monitor. The audit is an independent check and should be performed with the operator. The checks made include flow-rate, calibration and time.

B. Equipment

- a) field calibration kit, orifice calibration curve
- b) thermometer
- c) Audit Forms A-6, A-7
- d) hi-vol calibration curve for motor being audited
- e) volt meter

C. Procedure

- a) At scheduled site complete Audit Forms A-6, A-7.
- b) Return completed forms to the Supervisor.

| | YES | NO | COMMENTS |
|--|-----|----|----------|
| A. Operator: | | | |
| 1. Prior to the field audit. Randomly chose 10 sampling days from the previous or existing quarter and examine the data from these days. Has the operator recorded the pertinent information on the filter envelopes? | | | |
| 2. Has the operator maintained the sampling schedule? | | | |
| 3. Have the times and flows been within the criteria? (22-26 hrs., 32-72 cfm)? | | | |
| 4. Complete Form A-7 with the information requested. | | | |
| 5. Field flow rate check. Allow the operator to service the sampler and measure the final flow rate and the initial flow rate. Make an independent check of each within 15 minutes after the operator and record the flows on Form A-7. Has the operator employed proper technique in reading flows? | | | |
| 6. Does the operator perform filter installment and removal using acceptable technique and care? | | | |
| 7. Does the operator allow the motor to warm-up before reading flows? | | | |
| 8. If the sampling schedule from Part A, Form A-7 was off, check the operator's time setting. Is the operator setting the time properly? | | | |
| B. Calibration: | | | |
| 1. Field Calibration. After the operator has removed the loaded filter, perform a one point calibration check using the #18 hole plate. Other points may be checked. | | | |
| 2. Are the flows from Part A lower than 50 cfm? If yes, perform a field line voltage check. | | | |
| C. Maintenance: | | | |
| 1. Prior to audit. Was the last scheduled maintenance performed to within + 1 week? | | | |
| 2. Inspect wiring, tubing, gaskets, etc., do they appear in good shape? | | | |
| D. Auditor: | | | |
| 1. Has the auditor completed forms A-6 and A-7? | | | |

Hi-Vol Audit Data

A. Prior to field audit.

| Scheduled Sampling Day | Actual Sampling Day | Flow 32-72cfm | Time 22-26hrs. | Date filter analyzed | Comments |
|------------------------------|---------------------------|------------------|-------------------|-------------------------|----------|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| | | | | | |

Total days off sampling schedule: _____

Total days flow out of range: _____

Total days time out of range: _____

Date filter analyzed - date filter ran - 1: _____

B. Field Flow Check

| | Auditor (A) cc/min | Operator (O) cc/min | A-O | $\frac{A - O}{A} \times 100$ |
|---------|-----------------------|------------------------|-----|------------------------------|
| initial | | | | |
| final | | | | |
| initial | | | | |
| final | | | | |

C. HiVol Field Calibration Check

Site & Operator: _____

Orifice No: _____

Temp. (°C): _____

Bar press (mmHg): _____

Sample No: _____

Indicator No: _____
(rotometer.transducer)

By: _____

Date: _____

| Plate No. | Manometer reading of H ₂ O | Actual flow rate (Q _a) | rotometer reading | Flow rate (Q _r) | Corrected flow rate (Q) ¹ | % diff. $\frac{Q_r - Q_a}{Q_a} \times 100$ | % diff. $\frac{Q_r - Q_a}{Q_a} \times 100$ |
|-----------|---------------------------------------|------------------------------------|-------------------|-----------------------------|--------------------------------------|--|--|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

¹ Calculate corrected flow rate:

$$Q = Q_r \left\{ \frac{T_2 P_1}{T_1 P_2} \right\}^{\frac{1}{2}}$$

Q = corrected flow rate, m³/min.

Q_r = uncorrected flow rate read from the orifice unit calibration curve for a given pressure in inches of water

T₁ = Absolute temp when orifice was calibrated °K.

P₁ = Barometric pressure when orifice unit was calibrated, mmHg.

T₂ = Absolute temperature while calibrating the sampler, °K.

P₂ = Barometric pressure while calibrating the sampler. mmHg.