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Air Pollution Effects Field Research Facility: 1. Ozone Flow Control and Monitoring System

Jim A. McEvers
Terry L. Bowers
Nelson Edwards

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
NTIS price codes—Printed Copy: A05 Microfiche A01

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Instrumentation and Controls Division

AIR POLLUTION EFFECTS FIELD RESEARCH FACILITY: 1. OZONE FLOW CONTROL AND MONITORING SYSTEM

Jim A. McEvers
Terry L. Bowers*
Nelson Edwards†

Manuscript Completed: February 11, 1987
Date Published: January 1989

*Westinghouse Corporation.
†Environmental Sciences Division.

Research sponsored by the Electric Power Research Institute under Interagency Agreement No. TVA 1610-1610-A1 with the U.S. Department of Energy under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under Contract No. DE-AC05-84OR21400

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ACKNOWLEDGMENTS

The authors wish to acknowledge the help afforded by the following persons and organizations:

Dr. George Taylor and Dr. Sandy McLaughlin of the ORNL Environmental Sciences Division for giving us the opportunity to perform this study.

Mr. William Selvidge of the ORNL Environmental Sciences Division for his assistance in system checkout and operations; Mr. A. J. Beal, Mr. Ken Weaver, and Mr. Robert Hopson of the Instrumentation and Controls Division for their assistance in system fabrication and checkout; and Mr. Jeff Riggs of the Instrumentation and Controls division for system maintenance support.

ABSTRACT

The Ozone Flow Control and Monitoring System was developed in 1986 for the controlled exposure of diverse plant species to various concentrations of ozone gas. Design, operation, and performance are described for the automated system for generation, distribution, sampling, analysis, and control of ozone gas for plant exposure. The system has proved to be reliable, easy to maintain, and flexible in adapting to exposure programs. System software is reliable, and the user interface (CRT keyboard) is easy to use, providing quick-glance viewing of overall exposure conditions. The capability to expose plants to ozone concentrations in multiples of the ambient ozone level has been added, and software improvements in the areas of system response and user input are planned.

1. SCOPE

The Ozone Flow Control and Monitoring System has been developed to provide growth chambers for the controlled exposure of diverse plant species to various concentrations of ozone gas.

The system also provides for the inclusion of ambient exposure, that is, exposure of control groups to ambient levels of ozone, and "zero" exposure, that is, exposure of control groups to ambient air from which the majority of the ozone has been removed by means of charcoal filters.

This report describes the overall design, operation, and level of performance of the system. It does not discuss results of particular plant groups that have been exposed in the system. Detailed papers on specific experiments will be published later.

2. SYSTEM OVERVIEW

The Ozone Flow Control and Monitoring System consists of four major components, or subsystems: (1) one subsystem is for the generation and controlled distribution of ozone; (2) one is for the exposure of test specimens; (3) one is for sampling and analyzing gas concentrations within the exposure area; and finally (4) one subsystem is for acquisition, processing, and storage of exposure data and for overall system control.

A photograph of the entire exposure facility is shown in Fig. 1.

Organization of the exposure system is shown diagrammatically in Fig. 2. As indicated by this figure, each subsystem is very closely linked to the preceding and succeeding subsystems. Each specific subsystem is discussed in detail in succeeding sections.

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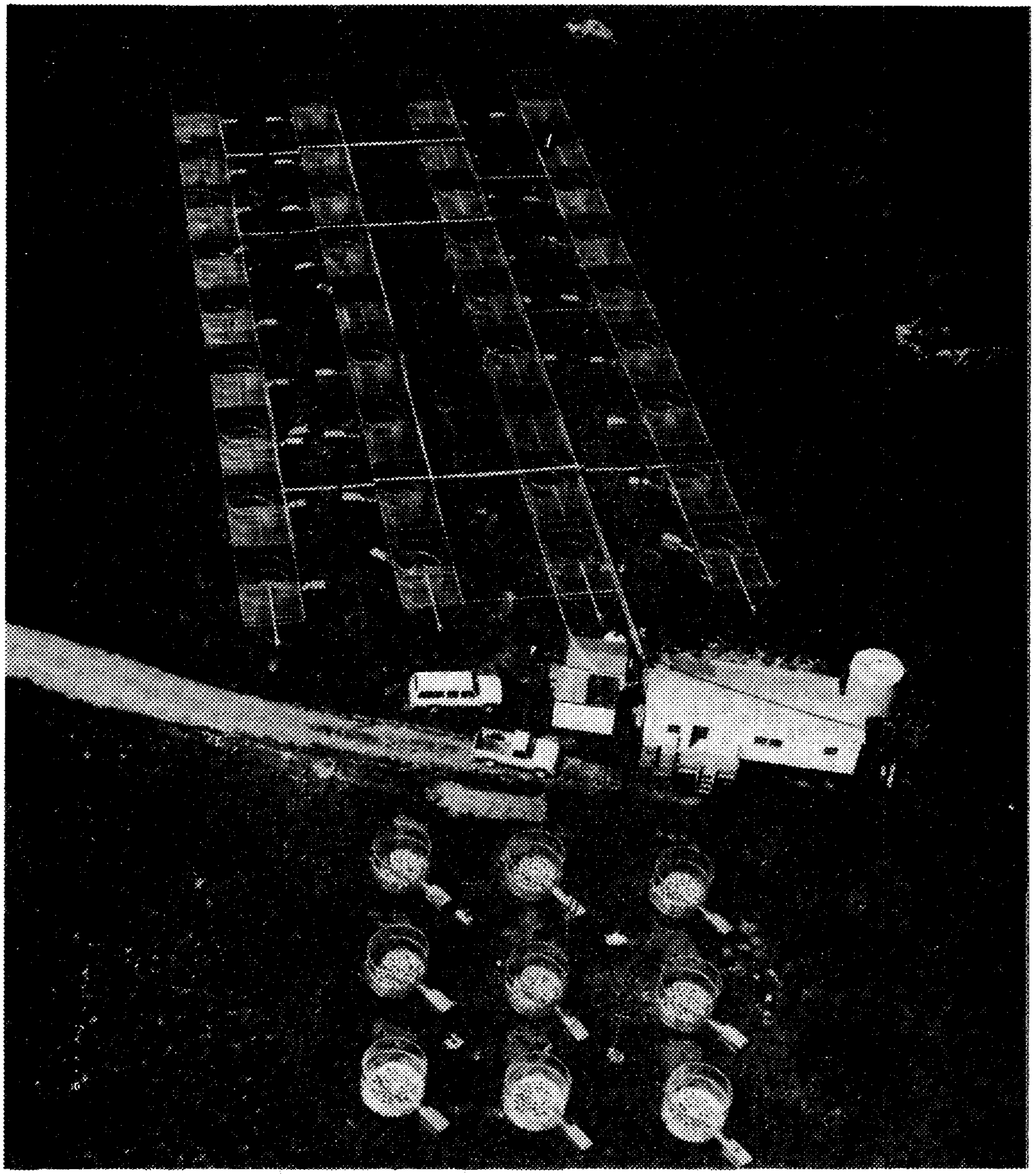


Fig. 1. Photograph of the Air Pollution Effects Field Exposure facility.

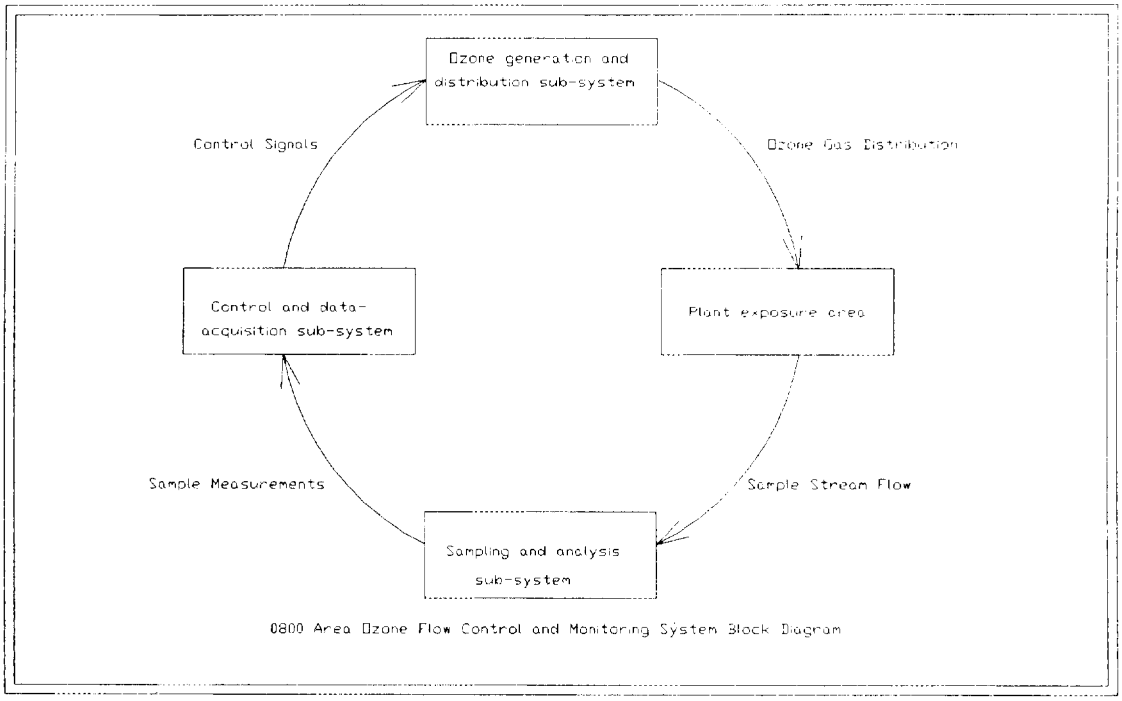


Fig. 2. Ozone system block diagram.

3. HAZARDS AND PRECAUTIONS

Ozone is a toxic gas whose presence can cause extreme difficulty in breathing. It can also cause choking, nausea, vomiting, and even death. Therefore, because of the concentration and volume of ozone gas produced by 0800 Area system, extreme caution must be exercised while working on or around the gas generation and distribution components.

In addition to being toxic, ozone is also a strong oxidizing agent and has been known to initiate spontaneous combustion when allowed to come in contact with combustible materials at concentrations produced by 0800 facility equipment. Therefore, system operators do not allow combustible materials to become exposed to the concentrated ozone gas stream.

In addition, ozone generators use high voltage in the production of ozone gas. This voltage may be as high as 15,000 V with a current capacity sufficient to produce a lethal shock.

As a result of these hazards, it is mandatory that personnel take appropriate precautions.

4. OZONE GENERATION AND DISTRIBUTION SUBSYSTEM

4.1 OZONE GENERATOR

This subsystem consists of an Ozone Research and Equipment Corporation Model 03SP38-A.2 ozone generator and associated equipment, as shown in Fig. 3. The generator itself is a self-contained unit with an internal compressor and drying system which permit the use of ambient air for the source gas supply. An integral cooling water distribution network permits the use of ordinary tap water (at ~25°C) as the coolant.

Ozone gas is produced within the generator by exposing a stream of dried ambient air supplied by the compressor and driers to a high potential (~15-kV) electric field. Because of the extreme oxidizing action of ozone, all components of the ozone distribution subsystem that are normally exposed to the highly concentrated (11,000-ppm) gas stream are fabricated of 316 stainless steel and/or Teflon.

4.2 OZONE DISTRIBUTION

The ozone gas generated by the unit is routed through Teflon tubing to a set of four electrically operated stainless steel control valves. These valves serve as control elements for regulating the rate of flow of ozone gas for each major level of concentration. The trim for each of the valves was selected to permit a reasonable range of adjustment about the desired value for the particular gas stream, based on the number of chambers that require the given concentration. The actual determination of the valve trim is explained in Sect. 4.2.1, Control Valve Sizing.

A control signal is provided for each actuator from a separate analog output channel of the control and data acquisition subsystem. The magnitudes of these signals, determined by the control program running within the computer, range from 0 to 100% of valve position.

The gas stream is routed from the respective control valve to a distribution manifold. The manifold has as many outlets as chambers to be exposed to the particular concentrations. Each outlet is connected to a variable area flowmeter (rotameter), which is equipped with a manually operated metering valve.

The gas stream that passes from the flowmeter is mixed with a stream of ambient air, referred to as the "carrier gas," that serves to minimize the transport delay of the ozone gas. The mixed stream is then sent to an exposure chamber.

The use of individual manual trim valves with the flowmeters rather than a computer-controlled valve for each chamber is due to the large number of exposure chambers and the relatively high cost of control valve actuators.

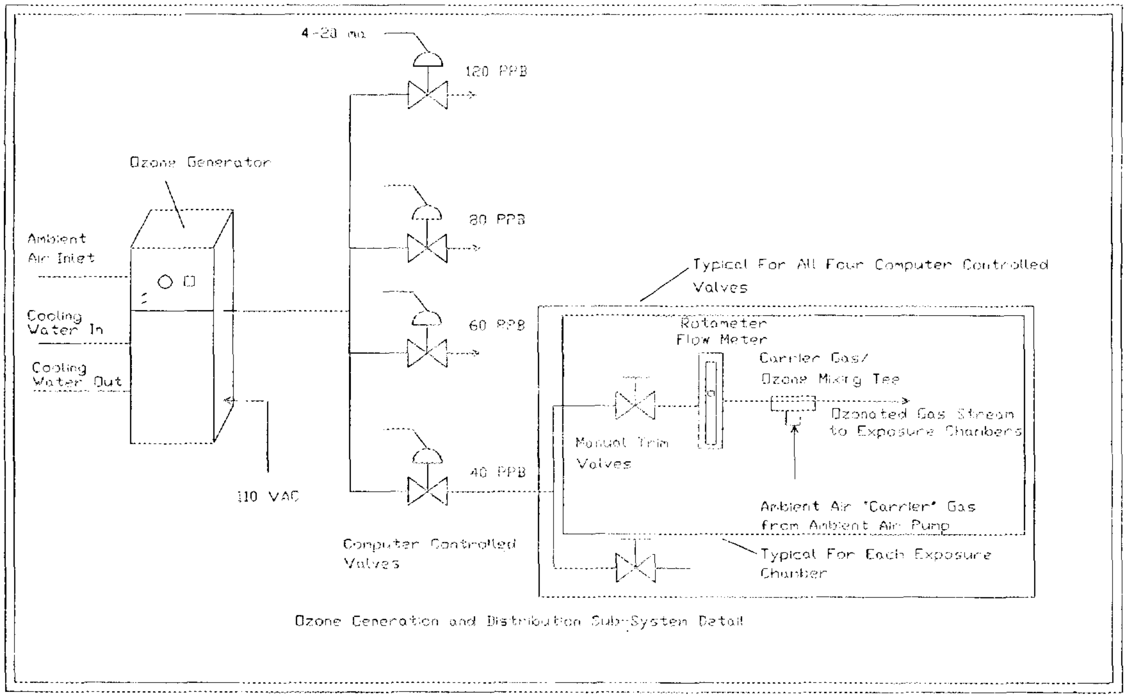


Fig. 3. Ozone generation and distribution subsystem.

Since all chambers being exposed to a particular concentration are fed from a single control valve, and the setting of the control valve is based on measurements of ozone concentration in each of the corresponding chambers, it is very important that chambers fed from the stream be adjusted as closely as possible to each other. This has the effect of making a group of chambers appear as a single chamber to the control computer.

The generation and distribution subsystem terminates at the point where the distribution line enters the blower at the exposure chamber site, and the gas is injected into the blower for dispersion into the chamber.

4.2.1 Control Valve Sizing

Control valve trim size may be determined by using the flow equation

$$Q_C\sigma_C = Q_{O_3}\sigma_{O_3} + Q_A\sigma_A \quad , \tag{1}$$

where

Q_C = total flow to the chamber,
Q_A = flow of ambient air,
Q_{O_3} = flow of ozone-enriched air from ozone generator,
σ_C = concentration of ozone to chamber,

σ_A = concentration of ozone in ambient air,
σ_{O_3} = concentration of ozone from ozone generator.

Since $Q_A >> Q_{O_3}$, $Q_c \simeq Q_A$ and Eq. (1) can be rewritten as

$$Q_c\sigma_c = Q_{O_3}\sigma_{O_3} + Q_c\sigma_A \quad .$$

Solving for the flow of ozone-enriched air yields

$$Q_{O^3} = \frac{Qc(\sigma_c - \sigma_A)}{\sigma_{O_3}} \quad . \qquad (2)$$

The blower for the chamber produces an air flow of 72,000 L/min, and the ozone generator produces a concentration of 11,000 ppm of ozone. Thus, the flow of ozone-enriched air from the ozone generator follows the relationship

$$Q_{O_3} = 6.55(\sigma_c - \sigma_A) \quad , \qquad (3)$$

where σ is in parts per million and Q_{O_3} is in liters per minute.

Equation (3) is then used to determine the flow necessary to produce the desired concentration of ozone within a chamber.

For example, if it is desired to produce a concentration of 100 ppb of ozone above ambient, then $\sigma_c - \sigma_A$ = 100 ppb, or 0.1 ppm. Then the ozone flow required is

$$Q_{O_3} = 6.55(0.1) = 0.655 L/min \quad .$$

Similarly, if 60 ppb above ambient is the desired concentration within a chamber, then

$$Q_{O_3} = 6.55(0.060) = 0.39\ L/min \quad .$$

If the desired concentration of ozone is a function of the ambient concentration such as $\sigma_c = 2\sigma_A$, then the highest ambient concentration of ozone expected must be estimated for factoring into Eq. (3). (Note that this estimate was not necessary in the "offset" example used above).

A good estimate of the highest ozone concentration anticipated might be 150 ppb; this estimate may include some buffer. Then,

$$Q_{O_3} = 6.55(2\sigma_A - \sigma_A) = 6.55(0.15)$$
$$= 0.98\ L/min \quad .$$

Following through on this example, ~1 L/min of ozone-enriched gas is required to be fed by the control valve per chamber. If the control valve is to feed five chambers, the total flow needed through the valve is

$$\text{Total } Q_{O_3} = (\text{number of chambers}) \times Q_{O_3}$$
$$= 5 \times 1 \text{ L/min} = 5 \text{ L/min} \quad .$$

This equation assumes equal distribution.

It is now necessary to convert liters per minute to standard cubic feet per hour (SCFH):

$$Q_{O_3} = 5 \text{ L/min} \times (0.035315 \text{ ft}^3\text{/L}) \times 60 \text{ min/h}$$
$$= 10.6 \text{ SCFH} \quad .$$

If it is assumed that there is a 5-psi pressure drop across the valve and the supply pressure is 15 psig, then

$$C_V = \frac{Q_{O_3} \sqrt{520}}{1360\sqrt{15 \times 5}} = 2 \times 10^{-3} \, Q_{O_3} \quad ,$$

and

$$C_V = (2 \times 10^{-3})(10.6 \text{ SCFH})$$
$$= 0.0212 \quad ,$$

which, from Table 1, requires an L trim on the control valve.

Table 1. Valve trim sizing for research control valves (Badger Meter, Inc.)

Control valve	Trim size designation
0.32	F
0.2	G
0.12	H
0.08	I
0.05	J
0.03	K
0.02	L
0.01	M
0.006	N
0.003	O

4.2.2 Flow Balancing

Once the control valve trim is selected and installed, it is necessary to balance ozone flow to the individual chambers by adjusting the rotameters with the system software running (see Sect. 7, Control and Data Acquisition Subsystem). This can be done by selecting the F6 key to access the controller configuration options and setting the output of the desired controller to manual mode at a value of 100%. Following instructions on the display returns the screen to overall display and continued chamber sampling. The float in the rotameters is then adjusted to provide a full-scale reading for each chamber being supplied.

Because distribution of the ozone to the chambers through the header is not quite uniform, it is necessary to make trim adjustments to equalize the flow to each chamber. Again, the F6 key is used to set the output of the corresponding controller to 50%. Monitoring the concentration of ozone in each chamber and adjusting the corresponding rotameter attains the desired concentration. After each cycle, rotameters are adjusted until the concentrations are as nearly equal as possible. When all chambers for a particular concentration are equalized, the F6 key is used to access the control display and return the corresponding controller to the automatic mode.

5. EXPOSURE AREA SUBSYSTEM

5.1 CHAMBERS

As mentioned in the previous section, the ozone distribution tubing terminates in the blower located at each of the ozone exposure chambers. These chambers, together with the ambient and "zero" chambers, make up the exposure area. Top and side diagrammatic views of the equipment arrangement are shown in Figs. 4 and 5.

The only difference between those chambers that receive ozone and those that do not is the absence of an ozone distribution line in the blower housing of the chambers that do not receive ozone.

5.2 AIR CIRCULATION/OZONE INJECTION

Ambient air is moved through the blower at a rate of ~72,000 L/min. Both the zero exposure chambers and the ambient exposure chambers are equipped with ordinary blowers; that is, there is no ozone injection line. Chambers that are to have a reduced level of ozone (zero chambers) are equipped with a series of activated charcoal filters on the inlet. These filters reduce the ambient ozone concentration to values ranging from 10 to 15 ppb. Chambers that are to receive an elevated level of ozone are equipped with ozone distribution lines that terminate in the side of the blower housing behind the blower motor.

In all cases, the outlet of the blower is connected to the chamber by a plastic duct ~2 ft long by 2 ft^2. The air from the blower enters the chamber through a series of holes in a diffusing baffle located around the lower half of the chamber, providing an even diffusion of the inlet air and preventing exposure of plant samples to direct high-velocity air currents.

The chamber exhausts through the open top into the atmosphere. The ratio of input flow rate to chamber volume provides an exchange of air at ~6-s intervals.

5.3 CHAMBER SAMPLING LINES

Although only ozone exposure chambers are fitted with a distribution line, all chambers are equipped with a 6-mm-diam Teflon sample line. The sample line originates at a filter in the center of each chamber as near as possible to the vertical center of the plant being exposed/sampled. The lines then proceed to the sampling and analysis subsystem where they terminate in a corresponding sample line selection solenoid valve.

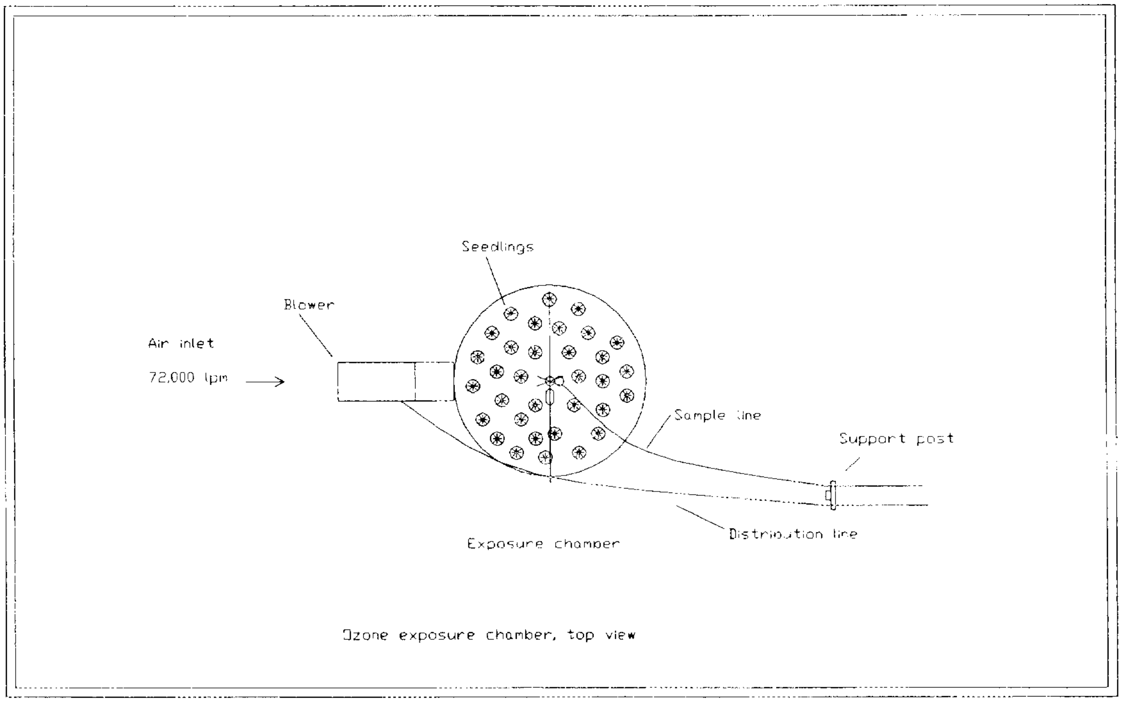


Fig. 4. Diagram of ozone exposure chamber, top view.

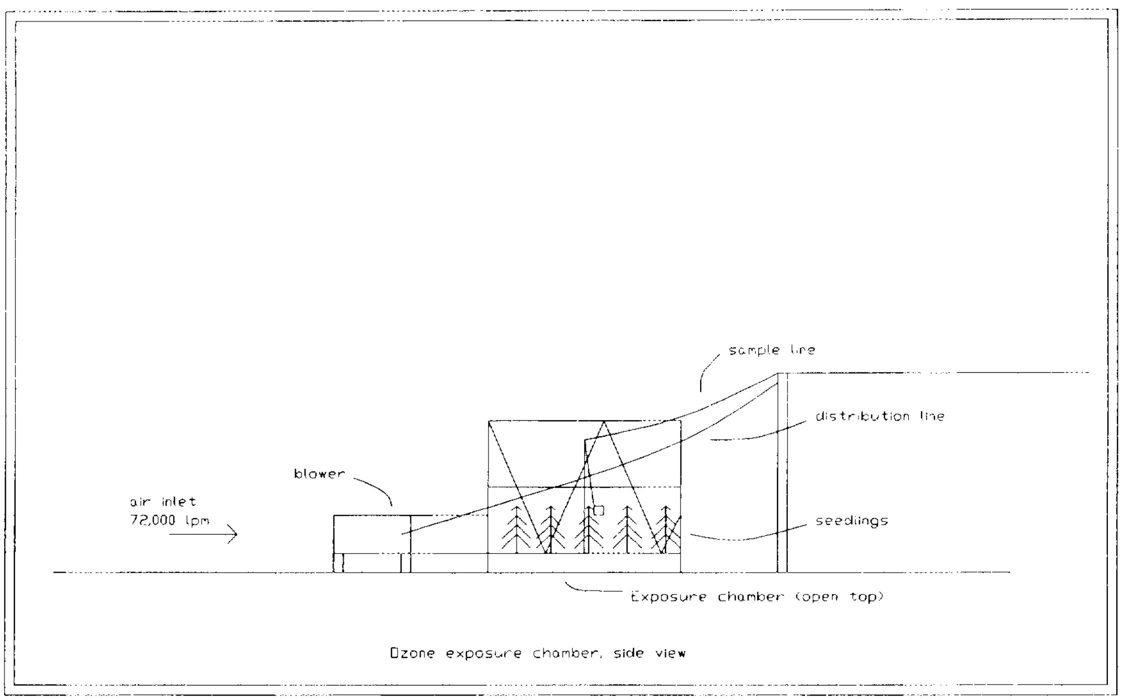


Fig. 5. Diagram of ozone exposure chamber, side view.

It is important to note that all sample lines are of the same type of 6-mm-diam Teflon tubing and of the same length to within a foot. They are ~60 m in length with the excess loosely coiled at the chamber site.

Compliance with these requirements ensures that all sample lines have reasonably equal absorbtion of gas samples and equal flow rates.

5.4 UNIFORMITY OF EXPOSURE

A major concern in the exposure of plants is the uniformity of ozone concentration within the chamber. To assess the uniformity, a profile of one chamber was taken.

Horizontal ozone concentration variability within chambers was determined by comparing O_3 concentrations drawn from 13 locations within a single chamber. The filtered ends of 13 sample lines were systematically positioned in the chamber at seedling canopy height. The control valves were set to deliver a fixed concentration of O_3. Ozone in the air drawn through these sample lines was sequentially analyzed at 6-min intervals, and the results are depicted in Fig. 6. The coefficient of variation was 7%.

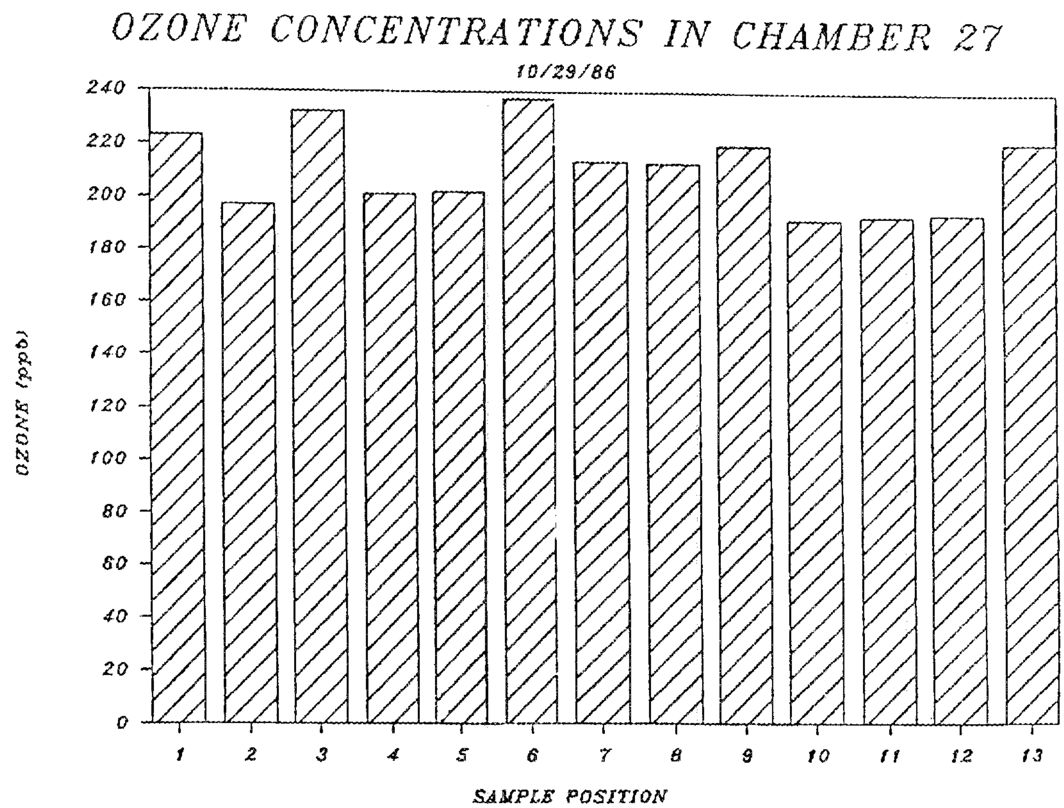


Fig. 6. Distribution of O_3 across chamber.

6. SAMPLING AND ANALYSIS SUBSYSTEM

6.1 SAMPLE LINES

Each chamber is fitted with a 6-mm-diam Teflon sampling line to facilitate measurement of the actual levels of ozone in the chambers for both control and monitoring purposes. A detail of the sampling and analysis subsystem is shown in Fig. 7.

The inlet of the sampling line is fitted with a filter element to prevent the induction of dirt, insects, and any other solid particulate material, and it is positioned at a level equal to that of the main portion of the plants to be exposed.

6.2 SAMPLE MULTIPLEXING

A pneumatic multiplexing system constantly draws a sample stream from each chamber: ambient, zero, and exposed. Streams are selected in a cyclic manner at fixed intervals for routing to an ozone analyzer.

Sample line selection is controlled by the control and data acquisition computer.

The three-way solenoid valve connected to each sample line is normally in the off position to permit the sample stream from a chamber to be continually drawn by the common sample stream vacuum pump. When a sample stream is to be analyzed, the corresponding three-way valve is switched on, thereby directing the sample stream into the glass manifold and into the ozone analyzer. The selected sample stream is drawn into the analyzer by the analyzer's internal sample pump. Sample gas is analyzed for ~60 to 70 s following selection by the control computer. At the end of this period, the control computer accesses the corresponding ozone analyzer and obtains an electrical signal proportional to the ozone concentration value. After the value is read, the control computer performs a sweep cycle to minimize residual gas effects on the next sample to be taken. This sweep cycle is ~20 s in duration. The reading obtained from the analyzer is processed by the control and data acquisition program and stored on magnetic disk. Following each analysis cycle, the sweep cycle is initiated and the sequence repeated for the next chamber.

Three analyzers are used and switched concurrently to decrease the overall sampling time and thereby provide better exposure control. Each analyzer services 15 chambers.

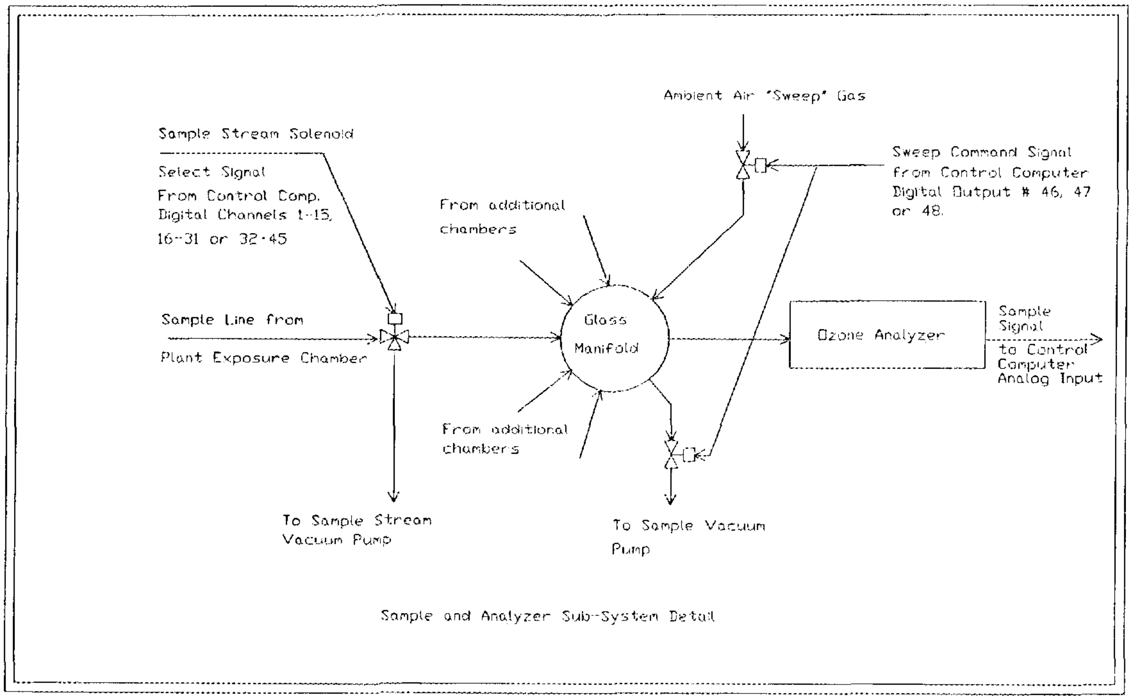


Fig. 7. Detailed diagram of sampling and analysis subsystem.

6.3 ANALYSIS OF OZONE CONCENTRATION

A Dasibi Model 1003PC ozone analyzer, calibrated by the EPA Designate Equivalent Method, EQOA-0577-019 (reference standard traceable to NBS), is used to calibrate a Protocal CSI 3000 ozone generator, which in turn is used to calibrate the three Dasibi (Model 1008-AH) ozone analyzers used to monitor the O_3 concentration in the chamber. The results of this calibration are presented in Table 2.

6.4 SAMPLE LINE OZONE ABSORPTION

Since the ozone concentration is being determined from a gas sample that has passed through a considerable length of tubing, one of the concerns is the error in the concentration values as a result of absorption by the tubing.

Ozone loss rates on sample lines (Teflon tubing, 6 mm diam and 60 m long and fitted with Teflon dust filters) were determined by measuring O_3 generated in known concentrations by a Protocal CSI 3000 generator and introduced into the ends of the sample lines located in each chamber. Loss rates averaged 14.4% with a 36% coefficient of variation. The values obtained are shown in Table 3.

Table 2. Calibrations of ozone analyzers 1986

Date	Protocal settings (ppb)	Dasibi analyzer readings (ppb)	Analyzer ID No.
Oct. 9, 1986	1	9	58005
	0	8	58006
	0	7	58007
	200	201	58005
	201	207	58006
	196	198	58007
Oct. 17, 1986	0	4	58005
	0	9	58006
	0	6	58007
	199	198	58005
	203	204	58006
	205	204	58007
Oct. 24, 1986	0	7	58005
	0	6	58006
	0	7	58007
	199	203	58005
	201	209	58006
	200	206	58007

NOTE: Analyzers are offset by about +8 ppb at zero.

Table 3. Ozone sample line calibrations
October 13, 1986

Chamber	Protocal output (ppb)	Analyzer reading (ppb)	Line delivery efficiency (%)	Loss on line (%)
10	100	88	88.00	12.00
11	99	83	83.84	16.16
12	99	82	82.83	17.17
14	100	84	84.00	16.00
15	99	80	80.81	19.19
17	101	95	94.06	5.94
21	102	95	93.14	6.86
22	99	85	85.86	14.14
24	101	83	82.18	17.82
27	101	97	96.04	3.96
30	101	91	90.10	9.90
31	100	82	82.00	18.00
32	100	81	81.00	19.00
33	101	84	83.17	16.83
36	101	83	82.18	17.82
37	101	87	86.14	13.86
39	99	73	73.74	26.26
40	100	85	85.00	15.00
41	102	93	91.18	8.82
42	99	81	81.82	18.18
43	100	90	90.00	10.00
Means	100.24	85.81	85.57	14.43
Standard deviation	0.97	5.78	5.21	5.21

Note: Ozone from the Protocal was introduced into the ends of the sample lines in the individual chambers at the concentrations indicated in this table.

7. SYSTEM DYNAMICS

This section defines the dynamic response characteristics of the ozone distribution, exposure, and sampling subsystems.

As discussed earlier, the distribution of the ozone is accomplished by mixing the concentrated ozone gas (nominal 11×10^6 ppb) stream with the atmospheric air carrier gas (nominal 60 ppb) stream.

This mixing operation is required because the volumetric rate of the concentrated gas stream is so low that the transport delay would be unacceptable.

The resultant ozone concentration of the mixed stream is given by

$$\sigma_m = \frac{\sigma_{O_3} Q_{O_3} + \sigma_{air} Q_{air}}{Q_m} ,$$

where

- σ_m = volumetric concentration of ozone in mixed stream, parts per billion,
- Q_m = volumetric flow rate of mixed stream, liters per second,
- σ_{O_3} = volumetric concentration of ozone in concentrated stream, parts per billion,
- Q_{O_3} = volumetric flow rate of concentrated ozone stream, liters per second,
- σ_{air} = volumetric ozone concentration of atmospheric air (nominal), parts per billion,
- Q_{air} = volumetric flow rate of atmospheric air stream, liters per second.

The transport delay for a step change in ozone concentration within the distribution lines is given by

$$t_{dd} = \frac{V_{dl}}{Q_m} ,$$

where

- t_{dd} = distribution line transport delay time in seconds,
- Q_m = volumetric flow rate of mixed gas stream, liters per second,
- V_{dl} = total volume of the distribution line, liters.

A typical value for t_{dd} for this system would be

$$t_{dd} = \frac{V_{dl}}{Q_m} = \frac{0.1 \text{ L}}{0.0167 \text{ L/s}} = 5.98 \text{ s} .$$

The carrier gas/ozone mixed stream is mixed with ambient air in the chamber blower unit. This is where the majority of dilution occurs to produce the desired concentration. The concentration of ozone as a result of this mixing is given by

$$\sigma_i = \frac{\sigma_m Q_m + \sigma_{air} Q_{blower}}{Q_i} ,$$

where

σ_i = concentration of ozone in chamber inlet stream, parts per billion,
Q_i = chamber inlet flow rate ($Q_m + Q_{blower}$), liters per second,
σ_m = ozone concentration in mixed stream (carrier gas/ozone), parts per billion,
Q_m = volumetric flow rate of mixed stream, liters per second,
σ_{air} = volumetric ozone concentration of atmospheric air (nominal), parts per billion,
Q_{blower} = volume flow rate of ambient air from blower, liters per second.

The dynamic response of the ozone concentration within the chamber is determined by the following:

Performing a mass balance on the chamber:

$$m_{O_{3\,s}} = m_{O_{3\,i}} - m_{O_{3\,o}},$$

where

$m_{O_{3\,s}}$ = rate of mass storage of ozone within chamber,
$m_{O_{3\,i}}$ = mass flow rate of ozone into the chamber,
$m_{O_{3\,o}}$ = mass flow rate of ozone out of the chamber.

The inlet mass flow rate (moles per second) is given by

$$m_{O_{3\,i}} = \rho_{O_3} Q_i \sigma_i ,$$

where

ρ_{O_3} = nominal density of ozone, moles per liter,
Q_i = volume flow rate into the chamber, liters per second,

σ_i = concentration of ozone in the inlet stream, parts per billion.

The outlet mass flow rate is given by

$$m_{O_{3\,o}} = \rho_{O_3} Q_o \sigma_o \quad ,$$

where

Q_o = volume flow rate out of the chamber, liters per second,
σ_o = concentration of ozone in the outlet stream (chamber exhaust), parts per billion.

The rate of ozone mass storage in the chamber is given by

$$m_{O_{3\,s}} = \rho_{O_3} V_c \frac{d\sigma_c}{dt} \quad ,$$

where

V_c = chamber volume, liters,
σ_c = ozone concentration within the chamber, parts per billion.

The mass balance becomes:

$$V_c \frac{d\sigma_c}{dt} + Q_o\sigma_c = Q_i\sigma_i \quad .$$

This gives the time constant for the chamber concentration as:

$$\tau_c = \frac{V_c}{Q_o} \quad .$$

The response of the chamber to a step change in input concentration is therefore

$$\sigma_c(t) = \sigma_{init} + \sigma_i\left[1 - e^{-t(Q_o/V_c)}\right] \quad ,$$

where

σ_{init} = chamber ozone concentration prior to step change.

A typical value of τ_c for this system is

$$\tau_c = \frac{V_c}{Q_o} = \frac{125.5 \times 10^3 L}{1.2 \times 10^3 L/s} = 104.6 \text{ s} \quad .$$

Therefore, the time for the chamber to come to 99.3% of the new concentration is $5\tau_c$ or

$$(5)(104.6 \text{ s}) = 523 \text{ s or } 8 \text{ min} \quad .$$

The transport delay for samples being drawn from the chamber is a function of sample flow rate and sample line volume. This delay is given by

$$t_{sd} = \frac{V_{sl}}{Q_s} \quad ,$$

where

Q_s = sample flow rate, liters per second,
V_{sl} = volume of sample line, liters.

A typical sample line delay time is

$$t_{sd} = \frac{V_{sl}}{Q_s} = \frac{0.1\ \text{L}}{0.033\ \text{L/s}} = 3\ \text{s} \quad .$$

8.0 CONTROL AND DATA ACQUISITION SUBSYSTEM

The control and data acquisition subsystem is responsible for all control commands, digital output for actuation of the sample selection solenoids, and analog output for control valve positioning. The subsystem is also responsible for all data acquisition and storage operations. Figure 8 is a photograph of the subsystem, and Fig. 9 is a diagram of major subsystem components.

8.1 COMPUTER CONFIGURATION

The subsystem is based on an International Business Machines, Inc., Model 7234 industrial, rack mount PC AT. This particular unit was selected for its relatively low cost, general functionalism, and capability to be mounted in a standard 19-in. industrial rack cabinet. An IBM Model 7534 industrial, rack mount color graphics monitor permits display of real-time status information and can display data in graphic form.

8.2 ANALOG INPUT

All process information required by the system is acquired through a MetraByte Model DASH-8 eight-channel multiplexed, 12-bit, bipolar analog-to-digital converter (ADC), which plugs directly into one of the backplane expansion slots in the IBM PC AT.

The ozone analyzer output signal is intended essentially as input to a stripchart recorder and is therefore ranged for 0 to 1 V dc. The DASH-8 analog input module accepts a signal in the range 0 to 5 V dc. The signal is converted by a 12-bit resolution, bipolar ADC on the DASH-8 module. The equivalent resolution of ozone concentration values is therefore as follows:

$$-5\ \text{V} - 0\ \text{counts},$$
$$0\ \text{V} - 2048\ \text{counts},$$
$$5\ \text{V} - 4095\ \text{counts};$$

obtaining equivalent mV/count,

$$\frac{5\ \text{V}}{2048\ \text{counts}} = 2.44\ \text{mV/count};$$

and, obtaining the equivalent analyzer output sensitivity,

$$\frac{1000\ \text{ppb}}{1\ \text{V}} = \frac{1\ \text{ppb}}{\text{mV}}$$

ORNL-PHOTO 6830-86

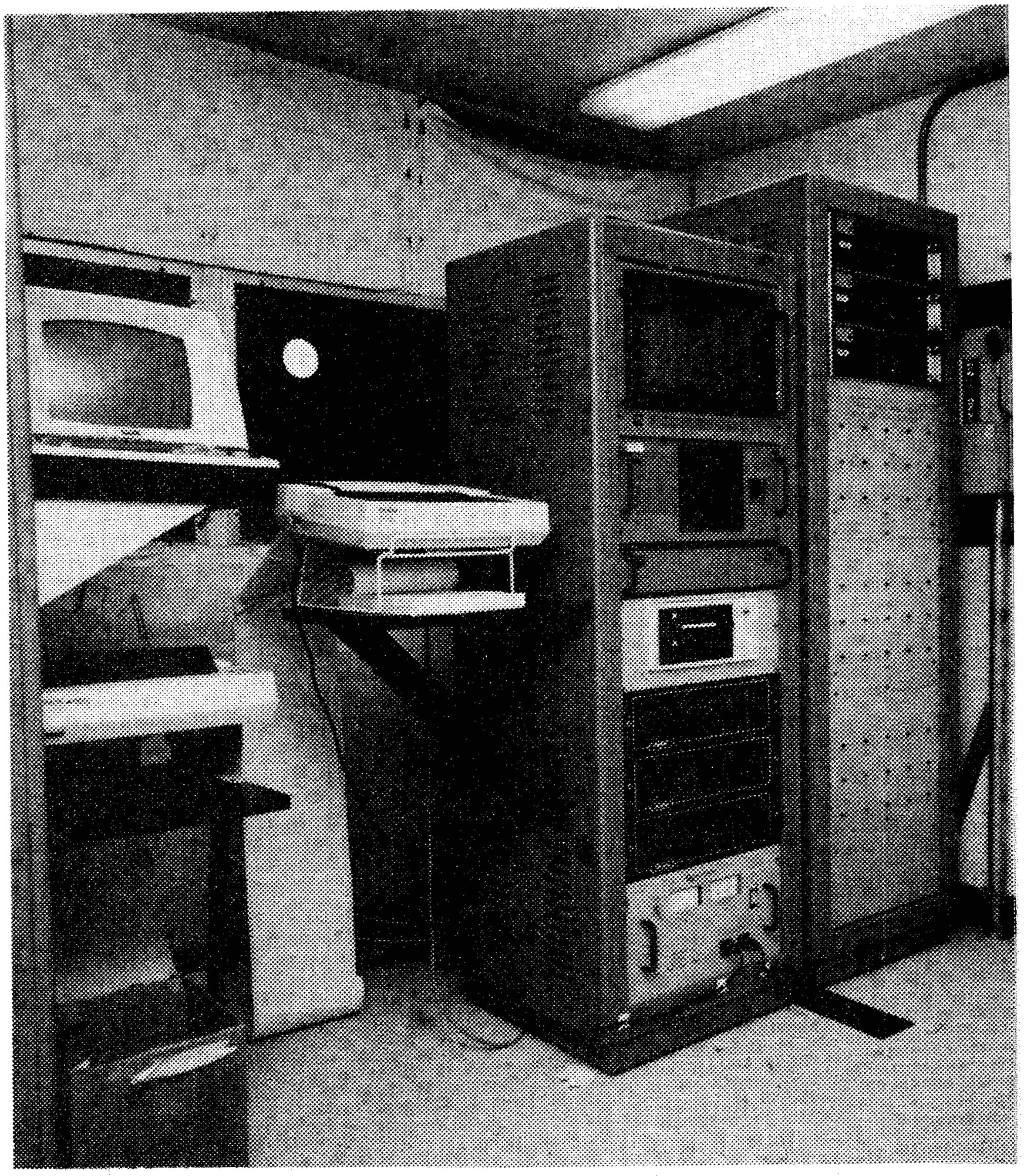


Fig. 8. Photograph of control and data acquisition subsystem.

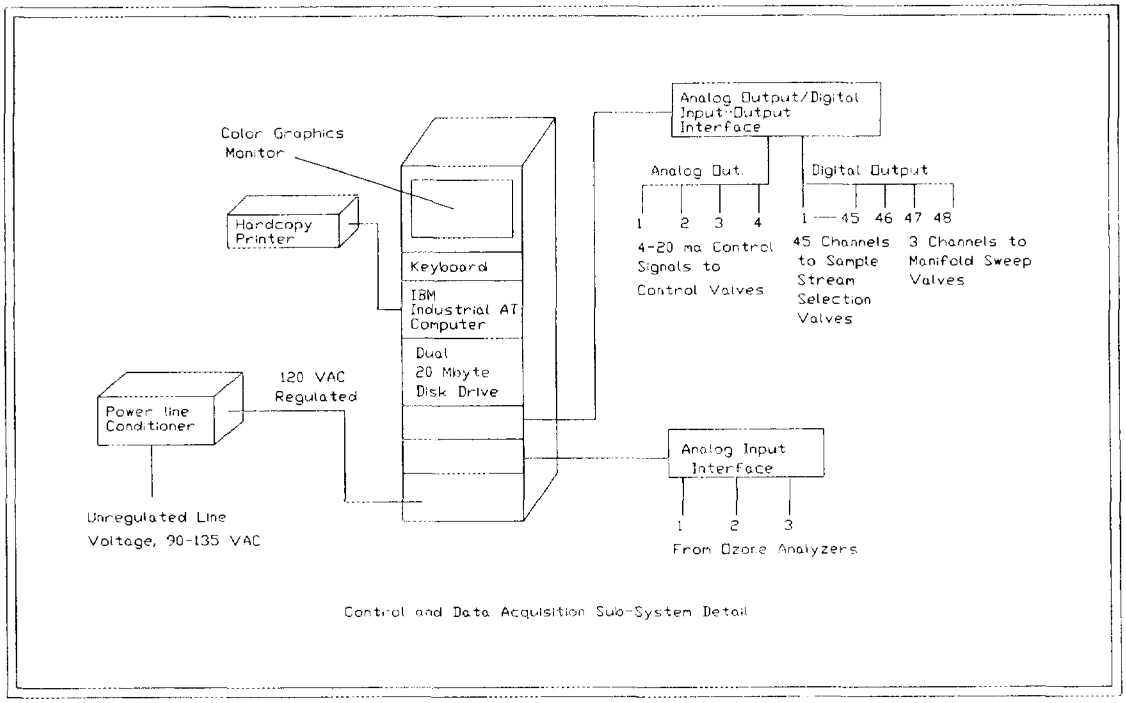


Fig. 9. Diagram of control and data acquisition subsystem.

Converting to obtain sensitivity in terms of parts per billion per count:

$$\frac{2.44 \text{ mV}}{\text{count}} \times \frac{1 \text{ ppb}}{\text{mV}} = \frac{2.44 \text{ ppb}}{\text{count}}$$

Therefore, the full-scale analog input range of 0 to 1 V from the analyzer is equivalent to 0 to 409.6 counts, or,

$$409.6 \text{ counts} \times \frac{2.44 \text{ ppb}}{\text{count}} = 999.4 \text{ ppb}$$

Therefore, the system is capable of resolving 2.44 ppb over the range of ~0 to 1000 ppb. While this range does not utilize the full capabilities of the conversion equipment (it uses only the 0- to +5-V portion of A/D range), we feel that the resolution is adequate.

8.3 ANALOG OUTPUT

Control valve output signals are provided by a MetraByte Model DDA-06 six-channel analog output module, which also plugs directly into the backplane of the IBM PC AT. The analog output signals are derived from 12-bit ADCs, one per channel. The converters' outputs are switch-selectable for 0 to 10 V dc or 4 to 20 mA output. The 4- to 20-mA selection is used because of its compatibility with the control valve input and the generally superior noise immunity provided by current-loop operation.

8.4 DIGITAL OUTPUT

The on-off (open-close) signals needed to control the sample stream-to-analyzer selection are also provided by the DDA-06 module since it also supports 24 channels of digital input/output. Additional digital channels are provided by a MetraByte Model PIO-12 digital I/O module, which also plugs directly into the IBM PC AT backplane.

Although the DDA-06 and PIO-12 module's digital outputs can be configured for a mix of input-output, all input, or all output, they were configured for all output to provide sufficient channels for solenoid valve control.

Two MetraByte ERB-24 form C relay boards are driven by the DDA-06 and PIO-12 modules to actually switch the solenoid valves.

Experience has shown that some noise is present in measurements from the analyzers. It is not certain where the noise originates, but it can be eliminated. The 0800 Area system currently uses a technique of multiple sampling, discarding the highest and the lowest values and averaging the remaining values. This technique has been found to be effective and is accepted because the measurement sample interval is much, much less than system response time.

The subsystem is provided with a time-of-day clock, which permits accurate sampling intervals and proper time-stamping of the values as they are stored to disk and/or printed on hard copy.

8.5 DATA STORAGE

Data storage for the system is provided by a dual drive IOMEGA 20-Mbyte (40 Mbytes total) removable disk unit. This type of unit was selected for its low initial cost, low media cost, and ruggedness. The removable media permit data to be accumulated in the field and removed for analysis in the laboratory or office.

8.6 SYSTEM POWER CONDITIONING

Power for the control and data acquisition subsystem is provided by a power line conditioner/regulator. The inclusion of the conditioner/ regulator was necessary because of the remoteness of the site and the corresponding fluctuations in supply voltage.

9. SYSTEM SOFTWARE

The system software is responsible for all data acquisition and control operations for the system. The software is written entirely in the BASIC programming language and is organized as a series of specific sections, each designed to perform a particular function. Examination of the program listing provided in the appendix will yield a more complete understanding of system operation.

The interface between the system software and the user is a series of screens accessed through function keys on the IBM PC AT keyboard.

The most commonly used screen is the overall system display.

9.1 OVERALL SYSTEM DISPLAY

A copy of the overall system data display is shown in Fig. 10. The data are presented on the system color display and updated in real time.

Components of the display are as follows:

Upper left corner: Current date
Upper right corner: Present time of day
Top Line: Display title ("OZONE CONCENTRATION IN PPB VS CANOPY NUMBER")

2nd Line (left side): "CANOPIES JUST UPDATED: 13 28 43"

These are the canopies (chambers) which have just been sampled and updated.

2nd Line (right side): "AMBIENT OZONE LEVEL (PPB): 66.0"

This is the current ambient ozone level as measured by a separate ozone analyzer.

3rd Line: "Canopy #: 1 2 ... 8 9"

This line identifies the number for which the corresponding data on line 4 apply.

4th Line: "Minimum: 58.7 ... 39.1"

This line shows the minimum level of ozone measured in the corresponding chamber since midnight.

```
10-09-1987          OZONE CONCENTRATION IN PPB VS CANOPY NUMBER          16:06:36
CANOPIES JUST UPDATED:   13 28 43               AMBIENT OZONE LEVEL (PPB):   66.0
CANOPY#:          1     2     3     4     5     6     7     8     9
MINIMUM:       58.7 119.8  31.8  26.9  58.7  61.1  61.1  95.4  39.1 CNTL: 1 MODE:M
PRESENT:       70.9 158.9  31.8  36.7  70.9  75.8  68.5 166.3  53.8 SP:     0.0
MAXIMUM:       70.9 158.9  41.6  39.1  70.9  75.8  68.5 166.3  53.8 PV:
CANOPY#:         10    11    12    13    14    15    16    17    18 OUT:      0
MINIMUM:       66.0  51.3  19.6  58.7  61.1 107.6  56.2  22.0  17.1
PRESENT:      124.7  53.8  24.4  70.9  66.0 119.8  66.0  29.3  19.6 CNTL: 2 MODE:A
MAXIMUM:      124.7  53.8  24.4  70.9  66.0 119.8  66.0  29.3  19.6 SP:   130.1
CANOPY#:         19    20    21    22    23    24    25    26    27 PV:   166.3
MINIMUM:       58.7  14.7 102.7 129.6  17.1  66.0  56.2  19.6  58.7 OUT:     87
PRESENT:       66.0  19.6 129.6 163.8  19.6 132.0  68.5  22.0  66.0
MAXIMUM:       66.0  22.0 129.6 168.7  19.6 132.0  68.5  22.0  66.0 CNTL: 3 MODE:A
CANOPY#:         28    29    30    31    32    33    34    35    36 SP:   120.2
MINIMUM:       58.7  17.1  58.7  46.5  14.7  36.7   9.8  41.6 107.6 PV:   124.7
PRESENT:       66.0  31.8  66.0  48.9  22.0  41.6   9.8  44.0 110.0 OUT:     59
MAXIMUM:       66.0  31.8  66.0  51.3  22.0  41.6  12.2  44.0 112.5
CANOPY#:         37    38    39    40    41    42    43    44    45 CNTL: 4 MODE:A
MINIMUM:       26.9   9.8  31.8  31.8  36.7  26.9  36.7  12.2  14.7 SP:   119.3
PRESENT:       48.9  12.2  85.6  51.3  51.3  51.3  51.3  12.2  24.4 PV:    51.3
MAXIMUM:       48.9  12.2  85.6  51.3  51.3  51.3  51.3  12.2  24.4 OUT:     65
STATUS:

1STOP   2RESET  3FACE   4LOG    5NOSTOR 6CONTRL 7DRIVE  8ASSIGN 9HELP   0STATS
```

Fig. 10. Overall system data display.

5th Line: "Present: 70.9 ... 53.8"

This line shows the present level of ozone as measured in the corresponding chamber.

6th Line: "Maximum: 70.9 ... 53.8"

This line shows the maximum level of ozone as measured in the corresponding chambers since midnight.

Lines 7 through 10, 11 through 14, 15 through 18, and 19 through 22 show similar information for the remaining chambers.

The line with the word "Status:" is reserved for system status information such as "printer not ready", "diskfull", and so forth.

The label "CNTL:" refers to one of four control loops. The controller number is located just to the right of the label.

The label "MODE:" refers to either automatic (A) or manual (M) mode. In the automatic mode, the control system makes the necessary adjustments to the control valves to accomplish proper control. In manual mode, the user is responsible for adjusting the valves to their proper positions.

The label "SP:" indicates the present value of the setpoint for the corresponding controller. The units read parts per billion.

Immediately under the setpoint label and values are the "PV:", or process variable, label and value. This readout is the current ozone concentration value corresponding to the controller.

The "Out:" label refers to the current controller output signal as a percentage from 0% (closed) to 100% (open).

The line across the bottom lists the function keys (F1 through F10) and the corresponding program function.

9.2 SYSTEM CHANNEL ASSIGNMENT

The assignment of chambers (to controllers, analyzers, etc.) is performed through the "SYSTEM CHANNEL ASSIGNMENT INFORMATION" screen, a copy of which is shown in Fig. 11. The format for each of the three sets of information is shown at the top of the display. For each of the three groupings, the information is as follows:

1st Column: Canopy or chamber number

These numbers, which run from 1 through 15, 16 through 30, and 31 through 45, correspond to the actual exposure chambers.

2nd Column:

This column indicates the status of the corresponding chamber, either active (ACT) or inactive (INA). If a chamber is active, it will be scanned and the value used in control or setpoint calculations, if necessary.

3rd Column:

This column shows to which controller the chamber is assigned. Legal values for this column are controllers 1 through 4 (Ctl #1, 2, 3, or 4) or a name indicating that the chamber is either a zero or ambient chamber.

4th Column:

This column indicates to which of the three ozone analyzers the chamber is connected.

5th Column:

This column shows to which sampler multiplex line the chamber is assigned.

SYSTEM CHANNEL ASSIGNMENT INFORMATION

FORMAT: CANOPY#, STATUS, CONTROLLER #, ANALYZER #, SAMPLER CHANNEL., CONTROLLED

1	ACT	NONE	1	1	N	16	ACT	NONE	2	16	N	31	ACT	CTL #4	3	31	Y
2	ACT	CTL #2	1	2	Y	17	ACT	NONE	2	17	N	32	ACT	NONE	3	32	N
3	ACT	NONE	1	3	N	18	ACT	NONE	2	18	N	33	ACT	CTL #4	3	33	Y
4	ACT	NONE	1	4	N	19	ACT	NONE	2	19	N	34	ACT	NONE	3	34	N
5	ACT	NONE	1	5	N	20	ACT	NONE	2	20	N	35	ACT	NONE	3	35	N
6	ACT	CTL #2	1	6	Y	21	ACT	CTL #3	2	21	Y	36	ACT	CTL #3	3	36	Y
7	ACT	NONE	1	7	N	22	ACT	CTL #3	2	22	Y	37	ACT	NONE	3	37	N
8	ACT	CTL #2	1	8	Y	23	ACT	NONE	2	23	N	38	ACT	NONE	3	38	N
9	ACT	NONE	1	9	N	24	ACT	CTL #3	2	24	Y	39	ACT	CTL #3	3	38	Y
10	ACT	CTL #3	1	10	Y	25	ACT	NONE	2	25	N	40	ACT	NONE	3	38	N
11	ACT	CTL #4	1	11	Y	26	ACT	NONE	2	26	N	41	ACT	CTL #4	3	41	Y
12	ACT	NONE	1	12	N	27	ACT	NONE	2	27	N	42	ACT	NONE	3	42	N
13	ACT	NONE	1	13	N	28	ACT	NONE	2	28	N	43	ACT	CTL #4	3	43	Y
14	ACT	NONE	1	14	N	29	ACT	NONE	2	29	N	44	ACT	NONE	3	44	N
15	ACT	CTL #3	1	15	Y	30	ACT	NONE	2	30	N	45	ACT	NONE	3	45	N

ARE ANY CHANGES TO BE MADE TO TABLE [Y/N]?:

1STOP 2RESET 3FACE 4LOG 5NOSTOR 6CONTRL 7DRIVE 8ASSIGN 9HELP 0STATS

Fig. 11. System channel assignment display.

6th Column:

This column indicates whether the chamber is being controlled.

Changes may be made in the assignments on this screen by answering "Y" to the query ARE ANY CHANGES TO BE MADE TO TABLE [Y/N]? The user is then guided through steps to make necessary changes.

9.3 DISK DATA STORAGE DRIVE ASSIGNMENT

Data acquired by the system are stored on disk for later analysis or plotting. Selection of the disk drive on which data are to be stored is made through the screen shown in Fig. 12.

The disk-logging interval determines the frequency with which data will be written to disk. This interval may be examined and altered by responding "Y" to the query DO YOU WANT TO CHANGE DISK LOGGING INTERVAL [Y/N]?:

```
CURRENT DATA DRIVE IS:      C:
ALTERNATE DATA DRIVE IS:    D:
DO YOU WANT TO CHANGE DRIVE ASSIGNMENTS? [Y/N]: N

DO YOU WANT TO CHANGE DISK LOGGING INTERVAL [Y/N]?:N









1STOP   2RESET  3FACE   4LOG    5NOSTOR 6CONTRL 7DRIVE  8ASSIGN 9HELP   0STATS
```

Fig. 12. Disk data storage drive assignment.

9.4 HELP DISPLAY

A brief "HELP" display has been provided to aid the user in accessing various system functions. The screen is shown in Fig. 13.

9.5 CONTROLLER PARAMETER DISPLAY

A display showing each of the controllers and the key parameters associated with each has been provided and is shown in Fig. 14.

The column headed "Controller #" indicates which controller is being referenced.

The "Setpoint (PPB)" column shows the present setpoint for each controller. These setpoints must be interpreted along with the column labeled "MODE" as follows:

- If the "MODE" indicates "OFFSET", then the setpoint is considered as a constant offset above the ambient level (addition).

- If the "MODE" indicates "Proportional", then the setpoint is considered a multiplier for the ambient level. For example, if the setpoint is 2, the actual controller setpoint will be two times the average ambient atmospheric ozone concentration.

The other field in the "MODE" column is the "MAN"/"AUTO" column. This shows whether the controller is active in the automatic mode (auto) or is depending upon the user to set the control valve (man).

```
10-09-1987          OZONE FLOW CONTROL SYSTEM HELP SCREEN                    14:48:25
KEY#  DISPLAY   FUNCTION
 1    START     INITIATE ALL DATA ACQUISITION/CONTROL ACTIONS.
 1    STOP      SUSPEND DATA ACQUISITION AND CONTROL.
 2    RESET     RESET DAILY MINIMUMS AND MAXIMUMS.
 3    FACE      DISPLAY ALL VALUES IN FACEPLATE FORMAT.
 4    LOG       LOG ALL VALUES TO PRINTER AT REGULAR INTERVAL.
 4    NOLOG     DISCONTINUE LOGGING VALUES TO PRINTER.
 5    STORE     STORE ALL VALUES TO DISK AT REGULAR INTERVAL.
 5    NOSTORE   DISCONTINUE STORING VALUES TO DISK.
 6    CONTRL    SET CONTROLLER SETPOINTS AND AUTO/MANUAL MODES.
 7    DRIVE     CHANGE DATA STORAGE DRIVE ASSIGNMENT.
 8    ASSIGN    ASSIGN CANOPIES,INPUT CHANNELS,ANALYZERS,ETC.
 9    HELP      DISPLAY THIS SCREEN.
 0    STATS     DAILY AND HISTORICAL STATISTICS PRINT OPTIONS


STATUS:

1STOP   2RESET   3FACE   4LOG    5NOSTOR 6CONTRL 7DRIVE  8ASSIGN 9HELP   0STATS
```

Fig. 13. System help display.

```
                    CONTROLLER PARAMETERS

CONTROLLER#   SETPOINT(PPB)          MODE               OUTPUT(%)

     1               0        MAN    OFFSET                0
     2              60        AUTO   OFFSET               29
     3               2        AUTO   PROPORTIONAL          5
     4               2        AUTO   PROPORTIONAL         27
ENTER CONTROLLER [1,2,3,4 OR <CR> FOR NO CHANGE]:



1STOP   2RESET   3FACE   4LOG    5NOSTOR 6CONTRL 7DRIVE  8ASSIGN 9HELP   0STATS
```

Fig. 14. Controller configuration display.

The column headed "OUTPUT %" contains the present valve position value being presented to the ozone flow control valves. The values range from 0% (valve closed) to 100% (valve fully open).

Changes may be made to each of the controls by entering the corresponding controller number in response to the prompt. If no changes are to be made, the "Enter" or "carriage return" key is pressed without specifying a controller.

10. DATA ANALYSIS AND CONTROL EVALUATION

System performance and exposure conditions were evaluated from data logged automatically by the control system over the course of the growing season.

Since the details of data storage are discussed in Sect. 7, this section will focus on retrieval and analysis of the data.

The data analysis serves two very important purposes. First, it permits correlation of changes in plant behavior with ozone concentration (this, of course is the main reason the system exists). Second, it permits the control performance of the system to be measured and evaluated.

Examples of data acquired from the system are shown in Figs. 15, 16, and 17. Figure 15 shows the variations in ambient ozone level over a 24-h period as measured in a typical chamber. Figure 16 shows the variations in ozone level in a typical ozone exposure chamber with a setpoint of ambient +60 ppb. Figure 17 shows typical data for a zero chamber.

Figure 18 is a composite graph of all three of the chambers to permit comparison between chambers. All values were taken on the same day.

Analysis of control system performance can be done simply by comparing the desired conditions with the actual conditions experienced.

As stated previously, the operating mode for the system during the first growing season was to maintain the ozone level in the exposure chambers at a constant level above the ambient value.

As can be seen from the composite plot, the zero chamber remains at a level below 20 ppb while the ambient level rises to between 40 and 45 ppb.

The ozone exposure chamber tracks at or near the setpoint at a level ~60 ppb above the ambient.

Figure 19 shows the frequency distribution of the difference between the ozone exposure concentration and the ambient ozone level. The mean and standard deviations are also included to provide a measure of control performance.

20 Sept. 1986

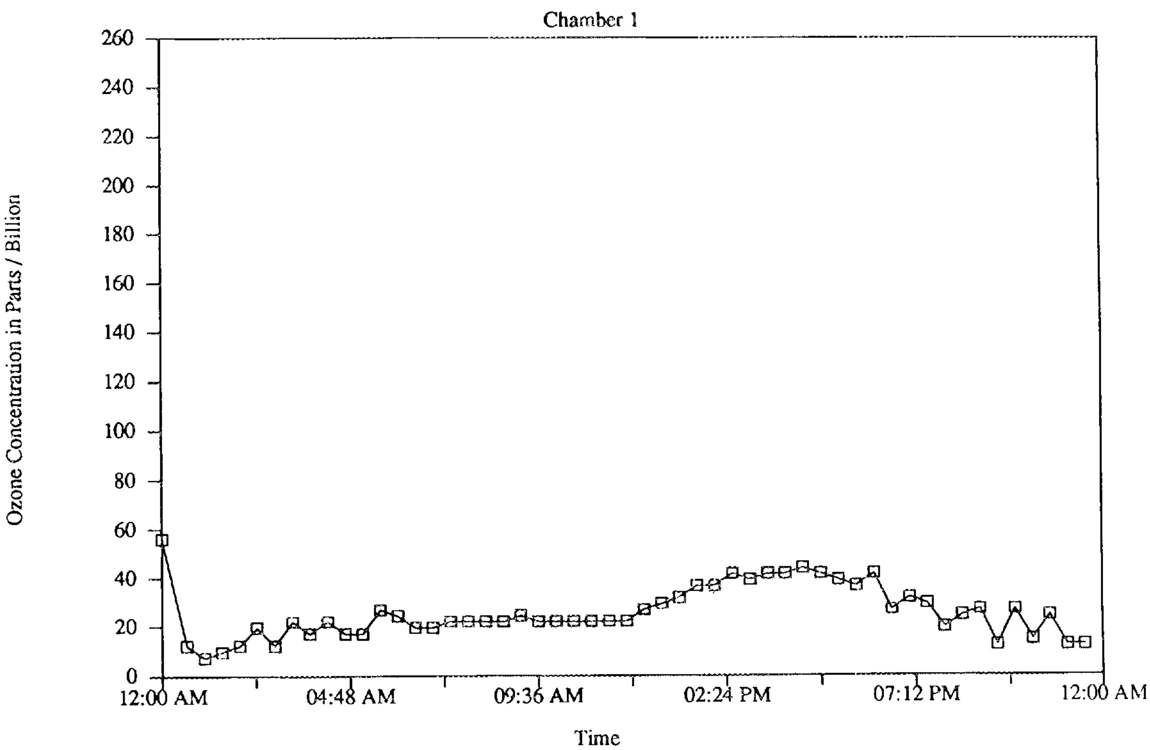


Fig. 15. Variations in ambient ozone exposure.

20 Sept. 1986

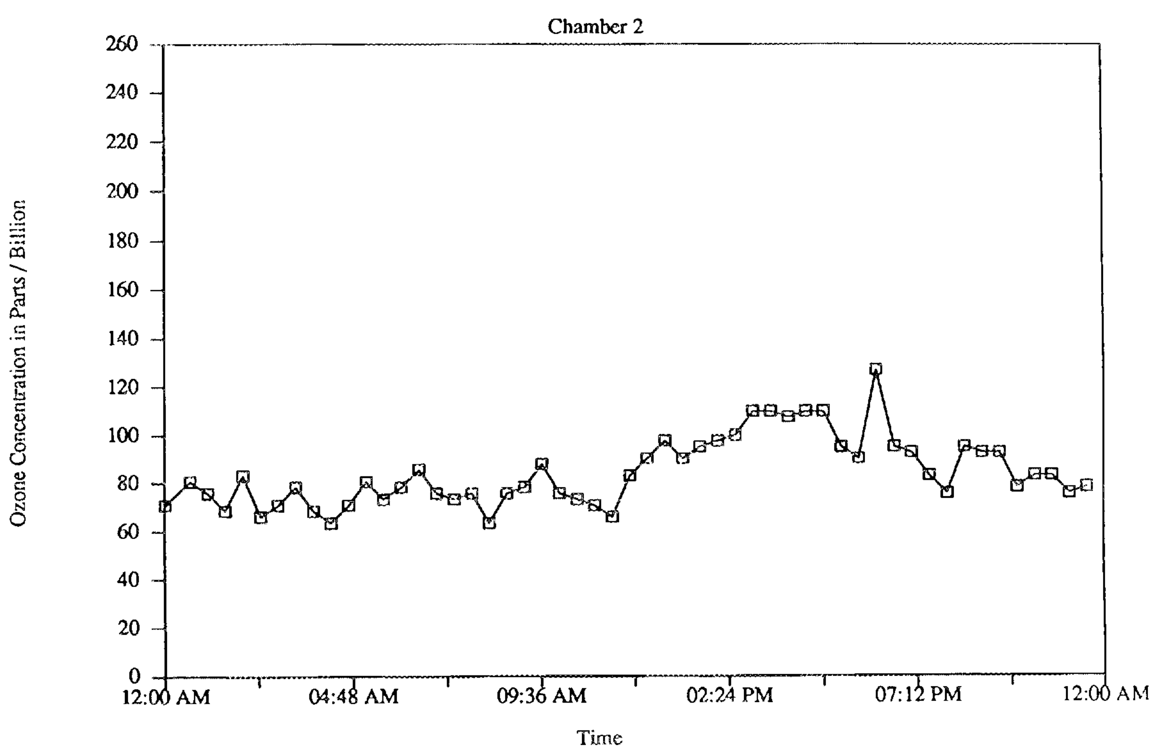


Fig. 16. Variations in controlled ozone exposure.

20 Sept. 1986

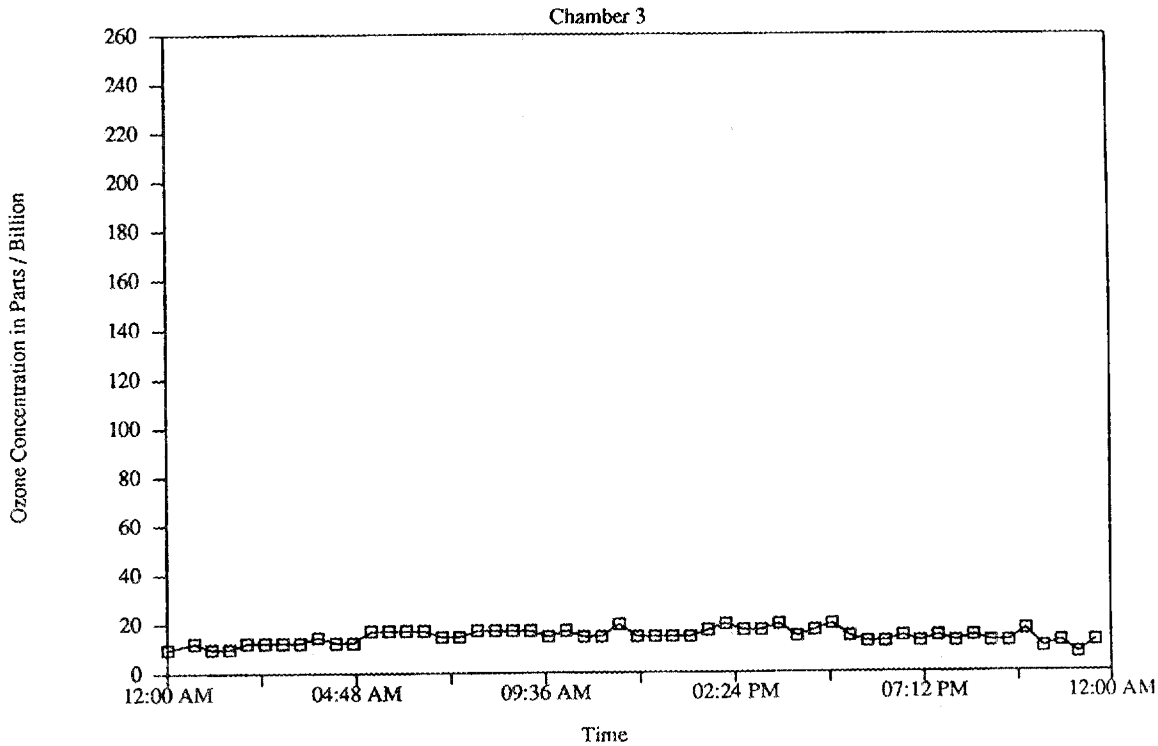


Fig. 17. Zero chamber exposure.

20 Sept. 1986

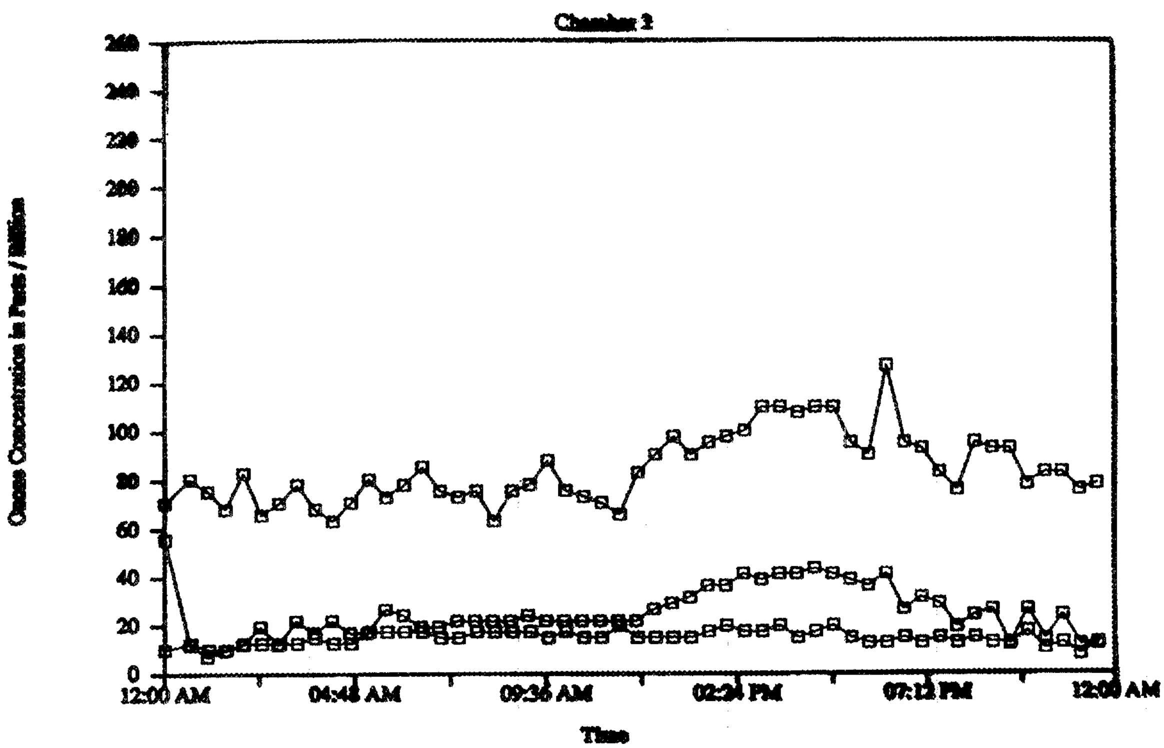
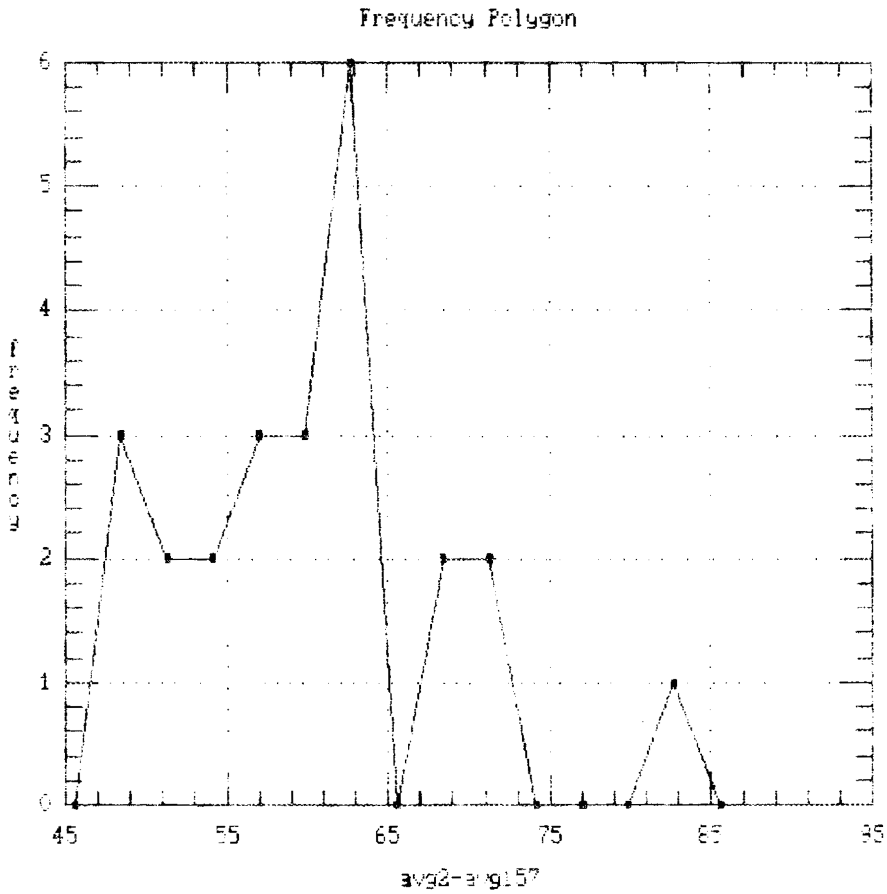


Fig. 18. Composite of exposures.



Average: 60.2437
Standard deviation: 8.29023

Fig. 19. Frequency distribution of ozone exposure.

11. SUMMARY

A flexible, automated system for the generation, distribution, sampling, analysis, and control of ozone gas for plant exposure has been developed and is operational.

The equivalent of two seasons of exposure has been accomplished with the system, and plans are being made for additional exposure.

The system has proven to be reliable, easy to maintain, and flexible in adapting to new exposure programs.

12. CONCLUSIONS AND RECOMMENDATIONS

The system has performed well over the first and second seasons and has provided a large quantity of consistent, accurate data. In addition, it has maintained proper control of exposure conditions.

The software has proven to be flexible and reliable and has provided excellent interaction with the system. The user interface (CRT keyboard) has proved to be easy to use and provides a complete overview of exposure conditions. The "faceplate" or overall data display screen has been particularly useful because it provides the user with quick-glance capability for viewing overall exposure conditions.

One of the recommendations for system improvement was the addition of a capability to expose plants to an ozone concentration which is a multiple of the ambient ozone level. This addition to the software has been made and is now operational.

Other improvements to the software will be added in the areas of system response and user input.

APPENDIX

PROGRAM LISTING

```
10 'WRITTEN 3-24-86 BY JIM A. MCEVERS
15 'MODIFIED 4-27-87 BY TERRY L. BOWERS
30 OPTION BASE 1
40 COLOR 2,9,12
50 SYSDRIVE$="B:"
70 DATADRIVE$="C:"
90 ALTRDRIVE$="D:"
110 'DEFINE ALL HARDWARE I/O ADDRESSES AND OFFSETS:
130 DDA06BASE%=&H300
150 DASH8BASE%=&H330
170 PIO12BASE%=&H340
180 EXP.GAIN%=10
190 AMBIENT%=128                'AMBIENT OZONE CHANNEL (CHNL 8 * 16 (SHIFT))=128
210 WNDUPLMT=100!
230 DLINTRVL=420!           'DEFINE DISK LOGGING INTERVAL IN SECONDS.
250 PLINTRVL=1800!              'DEFINE PRINTER LOGGING INTERVAL IN SECONDS.
270 CDRV$="C:"
290 DDRV$="D:"
310 EDRV$="E:"
330 FDRV$="F:"
350 BLANK$=""
370 'DEFINE INPUT CHANNEL ON DASH-8 USED TO MONITOR LINE VOLTAGE.
390 PWRCHNL%=7
410 'ESTABLISH POWER FAIL LEVEL.
430 POWERFAIL=4.75
450 'ESTABLISH COMMON OUTPUT WORDS FOR DIGITAL I/O.
470 DIM OUTWORD%(2,3)
490 'DEFINE LOGICAL TRUE AND FALSE FLAGS.
510 TRUE%=1
530 FALSE%=0
540 BIAS%=1           'FLAG FOR ADDITIVE CONTROL
545 RATIO%=2          'FLAG FOR PROPORTIONAL CONTROL
550 'DEFINE SOME COMMON BIT PATTERNS
570 BIT0%=1
590 BIT1%=2
610 BIT2%=4
630 BIT3%=8
670 BIT5%=32
690 BIT6%=64
710 BIT7%=128
730 BIT8%=256
750 BIT9%=512
770 BIT10%=1024
790 BIT11%=2048
810 BIT12%=4096
830 BIT13%=8192
850 BIT14%=16384
870 BIT15%=-32768!
890 NBIT1112%=NOT(BIT11% OR BIT12%)
910 BIT010%=&H7FF
930 NBIT010%=NOT(BIT010%)
950 'DEFINE ALL DDA06 DIGITAL CHANNELS AS OUTPUT.
970 DDA06ABC%=&H80
990 'DEFINE ALL PIO12 DIGITAL CHANNELS AS OUTPUT.
1010 PIO12ABC%=&H80
1030 'DEFINE MASKS USED TO DECODE SAMPLE TABLE.
1050 DEVICEMASK%=&H400
1070 PORTMASK%=&H300
1090 CHNLMASK%=&HFF
1110 ANLMASK%=&H1800
1111 'ESTABLISH MAXIMUM ALLOWABLE SETPOINT.
1112 MAXSETPNT=250!
1113 'ESTABLISH SYSTEM SHUTDOWN LIMIT.
1114 SHTDWNLMT=400!
1130 'ESTABLISH CONTROLLED POINT AND SETPOINT TABLES.
1150 DIM CONTROLLED%(45)
1170 DIM SETPOINTS(4)
1190 DIM AMBCAN%(4,10)
1210 CPPCT=40.95                'OUTPUT GAIN IN COUNTS PER PERCENT.
1230 SPMASK%=&H7
1250 KP(1)=.3
1270 KP(2)=.3
1290 KP(3)=.3
1310 KP(4)=.3
1330 KI(1)=.05
1350 KI(2)=.05
```

```
1370 KI(3)=.05
1390 KI(4)=.05
1410 KD(1)=0!
1430 KD(2)=0!
1450 KD(3)=0!
1470 KD(4)=0!
1490 SPAN(1)=500!
1510 SPAN(2)=500!
1530 SPAN(3)=500!
1550 SPAN(4)=500!
1570 DIM ERRDIF(4),SPMPV(4),OLDERR(4)
1590 DIM MIN(4),MAX(4),MEDIAN(4)
1610 DIM ACTIVE%(4)
1630 DIM MODE%(4)
1640 DIM SETPNTTYPE(4)
1650 AUTOMODE%=TRUE%
1670 MANUALMODE%=FALSE%
1680 FIRST=TRUE%
1685 SINGLE%=TRUE%    'CONTROLS TO INDIVIDUAL TREATED CHAMBERS.
1690 DIM STRTTIME(4)
1710 DIM STOPTIME(4)
1720 ' Define day of year for end of each month.
1722 DIM EOPM(12)
1724 EOPM(1)=0 : EOPM(2)=31 : EOPM(3)=59 : EOPM(4)=90 : EOPM(5)=120
1725 EOPM(6)=151 : EOPM(7)=181 : EOPM(8)=212 : EOPM(9)=243 : EOPM(10)=273
1726 EOPM(11)=304 : EOPM(12)=334
1730 'DEFINE WATCHDOG UPDATING PARAMETERS.
1750 WDTMRCNTL%=&H30
1770 WDLB%=&H8           'DEFINE RESET INTERVAL AS 30 SECONDS,
1790 WDHB%=&H7           '60PPS*30SEC=1800 (BASE 10) = 708 (BASE 16).
1810 'DEFINE THE DIMENSIONS OF A FACEPLATE CELL.
1830 CELLWIDTH%=6
1850 CELLHEIGHT%=4
1870 CONCMASK%=&H6000
1890 'DEFINE INPUT SENSITIVITY : PPB/COUNT (0 - 1000 PPB RANGE/409 COUNTS).
1910 PPBPCOUNT=1000!/409!
1930 'ESTABLISH THE ANALYZER SAMPLE TABLES.
1950 DIM ANLTBL%(3,45),ANLCNT%(3),ANLPTR%(3)
1970 'ESTABLISH THE CONCENTRATION VALUE TABLE.
1990 DIM VALUE(45),MINVAL(45),MAXVAL(45),DPCNT(45),O3VAR(45),O3AVG(45)
1995 SREAD%=FALSE%
2010 DIM DEVICE%(3),PORT%(3),CHANNEL%(3)
2020 DIM CNTRLO3(4)     'ARRAY FOR AVERAGEDOZONE IN TREATED CHAMBERS BY CONTRLLR
2030 DIM UPDATE%(3)
2035 DIM CNTS%(5)              ' Array for analyzer spike removal
2040 DIM NEWVALU(45)           'New analyzer reading for disk storage.
2050 DIM FACECOORD%(2,45)                'FACEPLATE DISPLAY COORDINATE PAIRS.
2070 'DEFINE THE CHAMBER SAMPLE TABLE.
2090 DIM SAMPLE%(45)
2110 DDAT$=".DAT"
2130 DRIVE$="C:"
2135 DIM TIMSTMP#(45)
2150 'DEFINE FLAG USED TO INITIATE A 12 BIT A/D CONVERSION.
2170 START12BIT%=0
2190 'DEFINE PERIOD OF TIME TO WAIT (IN SECONDS) FOR OZONE MEASUREMENT.
2210 SAMPLEDELAY=95
2230 ' DEFINE TIME TO WAIT FOR SWEEPING "SPUTNIK".
2250 SWPDELAY=10
2260 DIM SWEEPING(3) ', SWPSTRT
2270 'SET DIGITAL I/O DEVICES PORT DIRECTION.
2290 OUT DDA06BASE% + &HF, DDA06ABC%
2310 OUT PIO12BASE% + &H3, PIO12ABC%
2330 'ANALYZERS.
2350 'ESTABLISH THE CHAMBER SAMPLE TABLE.
2370 'DATA &H8801,&H8802,&H8804,&H8808,&H8810,&H8820,&H8840,&H8880
2390 'DATA &H9901,&H9902,&H9904,&H9908,&H9910,&H9920,&H9940,&H9980
2410 'DATA &H9A01,&H9A02,&H9A04,&H9A08,&H9A10,&H9A20,&H9A40,&H9A80
2430 'DATA &H9C01,&H9C02,&H9C04,&H9C08,&H9C10,&H9C20,&H9C40,&H9C80
2450 'DATA &H9D01,&H9D02,&H9D04,&H9D08,&H9D10,&H9D20,&H9D40,&H9D80
2470 'DATA &H9E01,&H9E02,&H9E04,&H9E08,&H9E10
2490 'CONTROL WORD FOR CHANNEL SAMPLES IS AS FOLLOWS:
2510 '******************SAMPLE TABLE ENTRY BIT ASSIGNMENTS***************
2530 'BIT 15 - ACTIVE CHANNEL FLAG, 1=ACTIVE, 0=OMIT.
2550 'BIT 13-14 UNUSED
2570 'BIT 11-12 OZONE SAMPLE INPUT CHANNEL, I.E.; ANALYZER #(RANGE 0 THRU 3).
2590 'BIT 10 - DIGITAL OUTPUT DEVICE: 0=DDA06, 1=PIO24
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2610 'BIT 09-08 - PORT: 00=PORT A, 01=PORT B, 10=PORT C.
2630 'BIT 07-00 - CHANNEL WITHIN THE PORT.
2650 '***********END OF SAMPLE TABLE ENTRY BIT ASSIGNMENTS*****************
2670 'DEFINE CONTROLLED POINT TABLE
2690 DATA &H8000,&H8000,&H8000,&H8000,&H8000,&H8000,&H8000,&H8000
2710 DATA &H8000,&H8000,&H8000,&H8000,&H8000,&H8000,&H8000,&H8000
2730 DATA &H8000,&H8000,&H8000,&H8000,&H8000,&H8000,&H8000,&H8000
2750 DATA &H8000,&H8000,&H8000,&H8000,&H8000,&H8000,&H8000,&H8000
2770 DATA &H8000,&H8000,&H8000,&H8000,&H8000,&H8000,&H8000,&H8000
2790 DATA &H8000,&H8000,&H8000,&H8000,&H8000
2810 '******************** PROGRAM SET-UP SECTION *********************
2830 CLS
2850 KEY OFF
2870 'REDEFINE KEYS, DISPLAY THEM AND THE FLAG PAGE.
2890 KEY 1,"START"
2910 KEY 2,"RESET"
2930 KEY 3,"FACE"
2950 KEY 4,"LOG"
2970 KEY 5,"STORE"
2990 KEY 6,"CONTRL"
3010 KEY 7,"DRIVE"
3030 KEY 8,"ASSIGN"
3050 KEY 9,"HELP"
3070 KEY 10,"STATS"
3090 KEY (1) ON
3110 KEY (2) ON
3130 KEY (3) ON
3150 KEY (4) ON
3170 KEY (5) ON
3190 KEY (6) ON
3210 KEY (7) ON
3230 KEY (8) ON
3250 KEY (9) ON
3270 KEY (10) ON
3290 'DEFINE ROUTING FOR FUNCTION KEYS AS PRESENTLY DEFINED.
3310 ON KEY (1) GOSUB 20670
3330 ON KEY (2) GOSUB 20730
3350 ON KEY (3) GOSUB 20850
3370 ON KEY (4) GOSUB 21250
3390 ON KEY (5) GOSUB 21310
3410 ON KEY (6) GOSUB 20990
3430 ON KEY (7) GOSUB 21550
3450 ON KEY (8) GOSUB 21130
3470 ON KEY (9) GOSUB 21730
3490 ON KEY (10) GOSUB 21670
3510 LOCATE 7,1
3530 PRINT;TAB(10);CHR$(201);STRING$(59,205);CHR$(187)
3550 FOR LOOP%=1 TO 10
3570 PRINT;TAB(10);CHR$(186);TAB(70);CHR$(186)
3590 NEXT LOOP%
3610 PRINT;TAB(10);CHR$(200);STRING$(59,205);CHR$(188)
3630 KEY ON
3650 LOCATE 9,20
3670 PRINT "Ozone Field Studies Data Acquisition"
3690 LOCATE 11,38
3710 PRINT "and"
3730 LOCATE 13,25
3750 PRINT "Control System"
3770 LOCATE 15,25
3790 PRINT "Version: 2.1"
3810 LOCATE 16,25
3830 PRINT "Written: April 27,1987"
3850 'DISPLAY THE FLAG PAGE FOR A REASONABLE PERIOD OF TIME, THEN PROCEED.
3870 TOD0=TIMER
3890 TOD1=TIMER
3910 IF TOD0 > TOD1 GOTO 3870
3930 IF (TOD1 - TOD0) < 3! GOTO 3890
3950 CLS
3970 'DEFINE "CELLS-LOCATIONS" FOR THE DATA ON THE FACEPLATE DISPLAY SCREEN
3990 ENTRY%=0
4010 FOR ROW%=1 TO 5
4030 FOR COLM%=1 TO 9
4050 ENTRY%=ENTRY%+1
4070 FACECOORD%(1,ENTRY%)=1 + (ROW% - 1) * CELLHEIGHT%
4090 FACECOORD%(2,ENTRY%)=1 + (COLM% - 1) * CELLWIDTH%
4110 NEXT COLM%
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4130 NEXT ROW%
4150 'CONSTRUCT SCAN TABLES ORGANIZED BY ANALYZER.
4170 GOSUB 5270
4190 'CHECK FOR AUTO-RESTART FROM POWERFAIL.
4210 GOSUB 7150
4230 '******************END OF PROGRAM SET-UP SECTION******************
4250 '******************OVERALL PROGRAM "IDLE-LOOP" SECTION*****************
4270 'PROGRAM IDLE LOOP, ALWAYS COME BACK TO HERE TO SEE WHAT TO DO NEXT.
4290 'DISPLAY TIME OF DAY IN THE UPPER RIGHT HAND CORNER OF SCREEN.
4310 LOCATE 1,73
4330 PRINT TIME$
4350 LOCATE 1,1
4370 PRINT DATE$
4380 ' Go to Julian Calendar routine.
4385 GOSUB 21910
4390 'GO TO POWER FAIL CHECKING ROUTINE, MAY NOT COME BACK.
4410 'GOSUB 6630
4430 'UPDATE THE WATCHDOG TO KEEP IT FROM TIMING OUT.
4450 IF RUNNING% THEN GOSUB 19390
4470 'CHECK FOR NEW FUNCTIONS AS A RESULT OF FUNCTION KEY BEING PRESSED.
4490 'DETERMINE IF DATA ACQUISITION AND CONTROL IS TO BE STARTED.
4510 IF START% = TRUE% THEN GOSUB 9550
4530 'IF ENABLED, GO SELECT THE NEXT CHANNEL(S) TO BE PROCESSED.
4550 IF SELECT% = TRUE%  THEN GOSUB 5970
4570 'IF ENABLED, GO SEE IF THE SELECTED INPUTS ARE READY TO BE READ YET.
4590 IF ACQUIRE% = TRUE% THEN GOSUB 7430
4610 'IF ENABLED, GO SEE IF THE CONTROL OUTPUTS NEED TO BE UPDATED.
4630 IF CONTROL% = TRUE% THEN GOSUB 8710
4650 'DETERMINE IF THE FACEPLATE DISPLAY IS ACTIVE.
4670 IF FACEPLATE% = TRUE% THEN GOSUB 12990 ELSE GOSUB 14590
4690 'DETERMINE IF THE CLEAR SCREEN/RESET MIN,MAX IS ACTIVE.
4710 IF CLRSCRN% = TRUE% THEN GOSUB 14710
4730 'DETERMINE IF PRINTER LOGGING IS ACTIVE.
4750 IF PLOG% = TRUE% THEN GOSUB 10590 ELSE GOSUB 11030
4770 'DETERMINE IF DISK STORAGE IS ACTIVE.
4790 IF STORE% = TRUE% THEN GOSUB 11390 ELSE GOSUB 11190
4810 'SEE IF CHANNEL ASSIGNMENT OPTION IS ACTIVE.
4830 IF ASSIGN% = TRUE% THEN GOSUB 15050
4850 'SEE IF UPDATE OF SCAN TABLES IS REQUIRED.
4870 IF UPDATETBL% = TRUE% THEN GOSUB 5250
4890 'SEE IF SETPOINTS ARE TO BE MODIFIED.
4910 IF SETPOINT% = TRUE% THEN GOSUB 17950
4930 'SEE IF PROGRAM IS TO STOP EXECUTION.
4950 IF STOPPROG% = TRUE% THEN GOSUB 10190
4970 'SEE IF DISK DRIVE ASSIGNMENTS ARE TO BE CHANGED.
4990 IF DRVSEL% THEN GOSUB 12150
5010 'SEE IF STATISTICS ARE SUPPOSED TO BE PRINTED.
5030 IF STATS% = TRUE% THEN GOSUB 22100
5050 'SEE IF HELP IS BEING REQUESTED.
5070 IF HELP% THEN GOSUB 19950
5090 'UPDATE THE STATUS LINE.
5110 GOSUB 19850
5130 'CHECK FOR MIDNIGHT ROLLOVER PARAMETER RESET.
5150 GOSUB 19530
5170 GOTO 4270                  'GO BACK TO THE BEGINNING OF THE IDLE LOOP.
5190 '***************END OF OVERALL PROGRAM "IDLE-LOOP" SECTION**************
5210 '*********CONSTRUCT SCANNING TABLES ORGANIZED BY ANALYZER # ************
5230 'CONSTRUCT TABLES FOR CONCURRENT SAMPLING FROM ANALYZERS.
5250 'ENTRY POINT
5270 FOR ANLYZR%=1 TO 3
5290 ANLCNT%(ANLYZR%)=0
5310 NEXT ANLYZR%
5330 ON ERROR GOTO 0
5350 OPEN SYSDRIVE$+"SAMPLE.TBL" FOR INPUT AS #1
5370 OPEN SYSDRIVE$+"CONTROLD.TBL" FOR INPUT AS #2
5390 FOR ENTRY% = 1 TO 45
5410 INPUT #1,SAMPLE%(ENTRY%)
5430 INPUT #2,CONTROLLED%(ENTRY%)
5450 NEXT ENTRY%
5470 CLOSE #1
5490 CLOSE #2
5510 OPEN SYSDRIVE$+"SETPOINT.TBL" FOR INPUT AS #1
5530 FOR CNTL%= 1 TO 4
5550 INPUT #1,SETPOINTS(CNTL%),MODE%(CNTL%),CNTLOUT(CNTL%),AMBCAN%(CNTL%,1)
     ,AMBCAN%(CNTL%,2),AMBCAN%(CNTL%,3),AMBCAN%(CNTL%,4),
     AMBCAN%(CNTL%,5),AMBCAN%(CNTL%,6),AMBCAN%(CNTL%,7),AMBCAN%(CNTL%,8)
     ,AMBCAN%(CNTL%,9),AMBCAN%(CNTL%,10),SETPNTTYPE(CNTL%)
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5570 ACTIVE%(CNTL%)=FALSE%
5590 NEXT CNTL%
5610 CLOSE #1
5630 FOR ENTRY%=1 TO 45
5650 IF SAMPLE%(ENTRY%) > 0 GOTO 5870
5670 ANLYZR%=(SAMPLE%(ENTRY%) AND  ANLMASK%)/2048
5690 IF (ANLYZR% < 1) OR (ANLYZR% > 3) GOTO 5830
5710 ANLCNT%(ANLYZR%)=ANLCNT%(ANLYZR%)+1
5730 ANLTBL%(ANLYZR%,ANLCNT%(ANLYZR%))=ENTRY%
5750 IF ANLCNT%(1) > ANLMAX% THEN ANLMAX% = ANLCNT%(1)
5770 IF ANLCNT%(2) > ANLMAX% THEN ANLMAX% = ANLCNT%(2)
5790 IF ANLCNT%(3) > ANLMAX% THEN ANLMAX% = ANLCNT%(3)
5810 GOTO 5870
5830 PRINT "INVALID ANALYZER VALUE = ",ANLYZR%,"ENTRY #",ENTRY%
5850 PRINT "PROGRAM TERMINATED":END
5870 NEXT ENTRY%
5890 UPDATETBL%=FALSE%
5910 RETURN
5930 '*************END OF SCANING TABLE CONSTRUCTION SECTION*****************
5950 '********************SAMPLE LINE SELECTION SECTION**********************
5970 'ENTRY POINT
5975 IF FIRST=TRUE% GOTO 5986
5980 FOR SWPCK=1 TO 3
5982 IF SWEEPING(SWPCK)=TRUE% GOTO 6390
5984 NEXT SWPCK
5986 FIRST=FALSE%
5990 CPOINT%=CPOINT%+1
6010 IF CPOINT% <= ANLMAX% THEN GOTO 6030
6020 FOR ANLYZR%=1 TO 3
6022 ANLPTR%(ANLYZR%)=0
6024 NEXT ANLYZR%
6026 CPOINT%=1
6030 FOR ANLYZR%=1 TO 3
6050 ANLRUNG%(ANLYZR%)=FALSE%
6070 IF ANLPTR%(ANLYZR%) => ANLCNT%(ANLYZR%) THEN GOTO 6370
6090 ANLPTR%(ANLYZR%)=ANLPTR%(ANLYZR%) +1
6110 POINTER%=ANLPTR%(ANLYZR%)
6130 DEVICE%(ANLYZR%)=(SAMPLE%(ANLTBL%(ANLYZR%,POINTER%)) AND DEVICEMASK%)/1024
6150 PORT%(ANLYZR%)=(SAMPLE%(ANLTBL%(ANLYZR%,POINTER%)) AND PORTMASK%)/256
6170 CHANNEL%(ANLYZR%)=SAMPLE%(ANLTBL%(ANLYZR%,POINTER%)) AND CHNLMASK%
6190 'LOCATE 2+ANLYZR%,1:PRINT CHANNEL%(ANLYZR%),CPOINT%,ANLYZR%         'DEBUG
6210 '"OR" THE NEW CHANNEL INTO THE COMMON OUTPUT WORD FOR DEVICE/PORT.
6230 OUTWORD%(DEVICE%(ANLYZR%)+1,PORT%(ANLYZR%)+1)=(OUTWORD%(DEVICE%(ANLYZR%)+1,
     PORT%(ANLYZR%)+1) OR CHANNEL%(ANLYZR%))
6250 IF DEVICE%(ANLYZR%) = 0 THEN OUTBASE%=DDA06BASE%+&HC
6270 IF DEVICE%(ANLYZR%) = 1 THEN OUTBASE%=PIO12BASE%
6290 OUT OUTBASE%+PORT%(ANLYZR%), OUTWORD%(DEVICE%(ANLYZR%)+1,PORT%(ANLYZR%)+1)
6330 ANLSTRT(ANLYZR%)=TIMER
6350 ANLRUNG%(ANLYZR%)=TRUE%
6370 NEXT ANLYZR%
6390 ACQUIRE%=TRUE%
6410 SELECT%=FALSE%
6430 GOTO 6570
6450 'SELECT%=TRUE%
6470 'ACQUIRE%=FALSE%
6490 'FOR ANLYZR%=1 TO 3
6510 'ANLPTR%(ANLYZR%)=0
6530 'NEXT ANLYZR%
6550 'CPOINT%=0
6570 RETURN
6590 '*****************END OF SAMPLE LINE SELECTION SECTION******************
6610 '********************POWER FAIL DETECTION SECTION*********************
6630 'CHECK LINE VOLTAGE TO SEE IF POWER FAIL HAS OCCURED.
6650 OUT DASH8BASE%+2, PWRCHNL%
6670 OUT DASH8BASE%+1, START12BIT%
6690 EOC%=INP(DASH8BASE%+2) AND &H80
6710 IF EOC% = 1 GOTO 6690
6730 LO%=INP(DASH8BASE%)
6750 HI%=INP(DASH8BASE%+1)
6770 COUNTS%=HI% * 16 + LO% /16
6790 PWRLVL=(COUNTS%*10/4096)-5!
6810 'PRINT "POWERLEVEL=",PWRLVL,COUNTS%        'DEBUG
6830 IF PWRLVL > POWERFAIL GOTO 7090
6850 'INDICATIONS ARE THAT LINE POWER HAS FAILED ,CLOSE UP SHOP.
6870 PRINT "POWER FAIL DETECTED, FILES BEING CLOSED."
6890 'PLACE ANY POWER FAIL CODE HERE!!!!!!
6910 IF DATAFILE% = FALSE% THEN GOTO 6950
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6930 CLOSE #2
6950 DATAFILE% = FALSE%
6970 'SAVE KEY INDICATORS TO RESTORE SYSTEMS ON POWER UP.
6990 OPEN SYSDRIVE$+"PWRFAIL.FIL" FOR OUTPUT AS #2
7010 WRITE #2,START%,PROFILE%,FACEPLATE%,ASSIGN%,PLOG%,STORE%
7030 CLOSE #2
7050 SYSTEM
7070 END
7090 RETURN
7110 '*****************END OF POWER FAIL DETECTION SECTION*******************
7130 '**************AUTO-RESTART (AFTER POWERFAIL) SECTION*******************
7150 'ENTRY POINT
7170 ON ERROR GOTO 7290
7190 OPEN SYSDRIVE$+"PWRFAIL.FIL" FOR INPUT AS #2
7210 INPUT #2,START%,PROFILE%,FACEPLATE%,ASSIGN%,PLOG%,STORE%
7230 CLOSE #2
7250 KILL SYSDRIVE$+"PWRFAIL.FIL"
7270 GOTO 7350
7290 IF ERR = 53 THEN GOTO 7330
7310 LPRINT "AUTO-RESTART FILE ERROR:",ERR,"TIME=",TIME$
7330 RESUME 7350
7350 ON ERROR GOTO 0
7370 RETURN
7390 '********************END OF AUTO-RESTART SECTION************************
7410 '*********************ANALYZER INPUT SECTION*****************************
7430 'ENTRY POINT
7450 FOR ANLYZR%=1 TO 3
7460 IF SWEEPING(ANLYZR%)=TRUE% GOTO 8230
7470 IF ANLRUNG%(ANLYZR%) = FALSE% THEN GOTO 8310
7490 TOD=TIMER
7510 'TEST FOR MIDNIGHT ROLL-OVER.
7530 IF ANLSTRT(ANLYZR%) > TOD THEN TOD=TOD+86400!
7550 ELAPSED=TOD-ANLSTRT(ANLYZR%)
7570 IF ELAPSED < SAMPLEDELAY GOTO 8310
7590 'READ THE OZONE CONCENTRATION VALUE.
7610 ANLCHNL%=(ANLYZR%+4)*16
7630 OUT DASH8BASE% + 2, ANLCHNL%
7635 'READ CHAMBER 5 TIMES , DISCARD HI & LO READINGS , AVERAGE 3 REMAINING
     (i.e. MIDDLE 3).
7640 FOR READING= 1 TO 5
7650 OUT DASH8BASE%+1, START12BIT%
7670 'WAIT FOR THE CONVERSION TO COMPLETE.
7690 EOC%=INP(DASH8BASE%+2) AND &H80
7710 IF EOC% GOTO 7690
7730 'READ THE ACTUAL VALUE AND CONVERT TO PPM O3.
7750 LO%=INP(DASH8BASE%)
7770 HI%=INP(DASH8BASE%+1)
7780 XTHEN=TIMER
7782 NOW=TIMER
7784 IF (NOW-XTHEN) < 0! GOTO 7780
7786 IF (NOW-XTHEN) < .05 GOTO 7782
7790 COUNTS%=HI% * 16 + LO% / 16
7792 CNTS%(READING)=COUNTS%
7794 NEXT READING
7796 FOR SORT= 1 TO 5
7798 FOR ORDER=1 TO 5
7800 IF CNTS%(ORDER) < CNTS%(SORT) GOTO 7804
7802 TEMP=CNTS%(SORT) : CNTS%(SORT)=CNTS%(ORDER) : CNTS%(ORDER)=TEMP
7804 NEXT ORDER
7806 NEXT SORT
7808 COUNTS%=(CNTS%(2) + CNTS%(3) + CNTS%(4))/3
7810 PPBO3=PPBPCOUNT*(COUNTS%-2048)/EXP.GAIN%
7830 'DEPOSIT VALUE IN DATA ARRAY.
7850 POINTER%=ANLTBL%(ANLYZR%,ANLPTR%(ANLYZR%))
7855 IF PPBO3 < SHTDWNLMT GOTO 7870
7856 IF SREAD%=TRUE% THEN LOCATE 23,10:PRINT "SHUTDOWN DUE TO #",POINTER%,
     "O3=";PPBO3 ; "AT " ; TIME$ : STOPPROG%=TRUE%
7857 SREAD%=TRUE%
7858 XTHEN=TIMER
7860 NOW=TIMER
7862 IF (NOW - XTHEN) < O! GOTO 7858
7864 IF (NOW - XTHEN) < 45! GOTO 7860
7866 GOTO 7640
7870 IF PPBO3 > 0! THEN VALUE(POINTER%)=PPBO3
7872 TMCK=TIMER
```

```
7873 IF DATECK > TIMER  THEN TIMSTMP#(POINTER%)=(JULDATE + 1) ,
     ELSE TIMSTMP#(POINTER%)=JULDATE
7875 IF PPBO3 > 0! THEN TIMSTMP#(POINTER%)=TIMSTMP#(POINTER%) + TIMER/(60*60*24)
7876 IF TMCK > TIMER THEN GOTO 7872
7877 IF PPBO3 > 0! THEN NEWVALU(POINTER%)=TRUE%
7890 IF VALUE(POINTER%) > MAXVAL(POINTER%) THEN MAXVAL(POINTER%)=VALUE(POINTER%)
7910 IF VALUE(POINTER%) < MINVAL(POINTER%) THEN MINVAL(POINTER%)=VALUE(POINTER%)
7920 DPCNT(POINTER%)=DPCNT(POINTER%)+1
7922 O3VAR(POINTER%)=(DPCNT(POINTER%)-1) * O3VAR(POINTER%)/DPCNT(POINTER%)
       + (O3AVG(POINTER%)-VALUE(POINTER%))^2 * (DPCNT(POINTER%)-1)/DPCNT(POINTER%)^2
7924 O3AVG(POINTER%)=(DPCNT(POINTER%)-1) * O3AVG(POINTER%)/DPCNT(POINTER%)
       + VALUE(POINTER%)/DPCNT(POINTER%)
7928 SREAD%=FALSE%
7930 UPDATE%(ANLYZR%)=POINTER%
7950 'IF POINT IS A CONTROLLED POINT, SET THE CONTROLLER ACTIVE.
7970 IF CONTROLLED%(POINTER%)=> 0 GOTO 8030
7990 CONTROLLER%=CONTROLLED%(POINTER%) AND SPMASK%
8010 ACTIVE%(CONTROLLER%)=TRUE%
8011 CONTRLPNT%(CONTROLLER%)=POINTER%
8030 'CLEAR THE CHANNEL AND PROCEED TO THE NEXT ONE.
8050 OUTWORD%(DEVICE%(ANLYZR%)+1,PORT%(ANLYZR%)+1)=OUTWORD%(DEVICE%(ANLYZR%)+1,
     PORT%(ANLYZR%)+1) AND (NOT(CHANNEL%(ANLYZR%)))
8070 IF DEVICE%(ANLYZR%) = 0 THEN OUTBASE%=DDA06BASE%+&HC
8090 IF DEVICE%(ANLYZR%) = 1 THEN OUTBASE%=PIO12BASE%
8110 'OUT OUTBASE%+PORT%(ANLYZR%), OUTWORD%(DEVICE%(ANLYZR%)+1,PORT%(ANLYZR%)+1)
8130 ANLRUNG%(ANLYZR%)=FALSE%
8150 'SWEEP THE "SPUTNIK" BETWEEN CHANNELS.
8160 SWEEPING(ANLYZR%)=TRUE%
8170 OUTWORD%(2,2)=OUTWORD%(2,2) AND (NOT (2^(4+ANLYZR%)))
8190 OUT PIO12BASE%+1, OUTWORD%(2,2)
8200 OUT OUTBASE%+PORT%(ANLYZR%), OUTWORD%(DEVICE%(ANLYZR%)+1,PORT%(ANLYZR%)+1)
8210 SWPSTRT=TIMER
8220 FIRST=TRUE%
8230 TOD=TIMER
8250 IF (TOD-SWPSTRT) < 0! THEN GOTO 8210
8270 IF (TOD-SWPSTRT) < SWPDELAY THEN GOTO 8310
8280 OUTWORD%(2,2)=OUTWORD%(2,2) OR (2^(4+ANLYZR%))
8290 OUT PIO12BASE%+1, OUTWORD%(2,2)
8300 SWEEPING(ANLYZR%)=FALSE%
8310 NEXT ANLYZR%
8330 'read the ambient ozone level.
8350 OUT DASH8BASE%+2, AMBIENT%
8370 OUT DASH8BASE%+1, START12BIT%
8390 EOC%=INP(DASH8BASE%+2) AND &H80
8410 IF EOC% GOTO 8390
8430 LO%=INP(DASH8BASE%)
8450 HI%=INP(DASH8BASE%+1)
8470 COUNTS%=HI%*16+LO%/16
8490 NEWAMBO3=PPBPCOUNT*(COUNTS%-2048)/EXP.GAIN%
8510 IF NEWAMBO3 > 0! THEN AMBIENTO3=NEWAMBO3
8530 FOR ANLYZR%=1 TO 3          'SEE IF THERE ARE ANY ANALYZERS RUNNING.
8550 IF ANLRUNG%(ANLYZR%) = TRUE% THEN GOTO 8650
8570 NEXT ANLYZR%
8590 SELECT%=TRUE%
8610 ACQUIRE%=FALSE%
8630 CONTROL%=TRUE%
8650 RETURN
8670 '********************END OF ANALYZER INPUT SECTION**********************
8690 '*******************CONTROL & OUTPUT SECTION**************************
8710 'ENTRY POINT
8730 FOR CONTROLLER%=1 TO 4
8750 IF ACTIVE%(CONTROLLER%)=FALSE% GOTO 8790
8770 MAX(CONTROLLER%)=-10000!
8780 MIN(CONTROLLER%)=10000!
8790 NEXT CONTROLLER%
8810 FOR POINTER%=1 TO 45
8830 IF SAMPLE%(POINTER%) > 0 GOTO 8970
8850 IF CONTROLLED%(POINTER%) => 0 GOTO 8970
8870 CONTROLLER%=CONTROLLED%(POINTER%) AND SPMASK%
8890 IF VALUE(POINTER%) = 0! GOTO 8970
8910 IF MAX(CONTROLLER%) < VALUE(POINTER%) THEN MAX(CONTROLLER%)=VALUE(POINTER%)
8930 IF MIN(CONTROLLER%) > VALUE(POINTER%) THEN MIN(CONTROLLER%)=VALUE(POINTER%)
8950 MEDIAN(CONTROLLER%)=MIN(CONTROLLER%)+(MAX(CONTROLLER%)-MIN(CONTROLLER%))/2!
8970 NEXT POINTER%
8990 FOR CONTROLLER%=1 TO 4
```

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9010 IF MODE%(CONTROLLER%) = MANUALMODE% THEN GOTO 9350
9030 IF ACTIVE%(CONTROLLER%) = FALSE% THEN GOTO 9450
9032 CNTRLSUM=0!
9034 CNTRLCNT%=0
9036 FOR LOOP%=1 TO 45
9038 IF CONTROLLED%(LOOP%)=>0 GOTO 9046
9039 IF (CONTROLLER%<>(CONTROLLED%(LOOP%) AND SPMASK%)) GOTO 9046
9040 IF VALUE(LOOP%)<=0! GOTO 9046
9042 CNTRLSUM=CNTRLSUM + VALUE(LOOP%)
9044 CNTRLCNT%=CNTRLCNT%+1
9046 NEXT LOOP%
9047 'LPRINT "COUNT=" , CNTRLCNT%
9048 IF CNTRLCNT%<>0 THEN CNTRLO3(CONTROLLER%)=CNTRLSUM/CNTRLCNT% ELSE GOTO 9450
9049 'LPRINT "OZONE AVG=" , CNTRLO3(CONTROLLER%) , "CONTROLLER #" , CONTROLLER%
9050 TEMPAMB=0!
9070 AMBCOUNT%=0
9090 FOR LOOP%=1 TO 10
9110 IF AMBCAN%(CONTROLLER%,LOOP%) = 0 THEN GOTO 9190
9115 IF VALUE(AMBCAN%(CONTROLLER%,LOOP%)) = 0 GOTO 9170
9130 TEMPAMB=TEMPAMB+VALUE(AMBCAN%(CONTROLLER%,LOOP%))
9150 AMBCOUNT%=AMBCOUNT%+1
9170 NEXT LOOP%
9190 IF AMBCOUNT% <> 0 THEN AMBOZONE(CONTROLLER%)=TEMPAMB/AMBCOUNT% ELSE AMBOZONE
     (CONTROLLER%)=AMBIENTO3
9192 IF VALUE(CONTRLPNT%(CONTROLLER%)) <= 0! GOTO 9435
9194 IF SETPNTTYPE(CONTROLLER%)=BIAS% GOTO 9200
9198 SETPNT(CONTROLLER%)=SETPOINTS(CONTROLLER%)*AMBOZONE(CONTROLLER%)
9199 GOTO 9201
9200 SETPNT(CONTROLLER%)=SETPOINTS(CONTROLLER%)+AMBOZONE(CONTROLLER%)
9201 IF SETPNT(CONTROLLER%) > MAXSETPNT THEN SETPNT(CONTROLLER%)=MAXSETPNT
9203 GOSUB 22500  ' Control Evaluation
9205 IF SINGLE%=TRUE% GOTO 9211
9207 SPMPV(CONTROLLER%)=SETPNT(CONTROLLER%)-CNTRLO3(CONTROLLER%)  'CONTOLS TO AVERAGE OF
     TREATED CHAMBERS
9209 GOTO 9230
9211 SPMPV(CONTROLLER%)=SETPNT(CONTROLLER%)-VALUE(CONTRLPNT%(CONTROLLER%))
     'CONTROLS TO INDIVIDUAL TREATED CHAMBERS
9230 IF KI(CONTROLLER%) =< 0! THEN GOTO 9250
9231 ERRSUM(CONTROLLER%)=ERRSUM(CONTROLLER%)+SPMPV(CONTROLLER%)
9232 IF ABS(ERRSUM(CONTROLLER%)) > WNDUPLMT THEN ERRSUM(CONTROLLER%)=WNDUPLMT*SGN
     (ERRSUM(CONTROLLER%))
9250 ERRDIF(CONTROLLER%)=SPMPV(CONTROLLER%)-OLDERR(CONTROLLER%)
9270 OLDERR(CONTROLLER%)=SPMPV(CONTROLLER%)
9290 CNTLOUT(CONTROLLER%)=CNTLOUT(CONTROLLER%)+(KP(CONTROLLER%)*SPMPV(CONTROLLER%)+
     (KI(CONTROLLER%)*ERRSUM(CONTROLLER%)))
9292 IF CONTROLLER%=1 GOTO 9310
9294 IF CONTROLLER%=2 THEN CNT$="02"
9296 IF CONTROLLER%=3 THEN CNT$="03"
9298 IF CONTROLLER%=4 THEN CNT$="04"
9300 OPEN DATADRIVE$ + "CNTRLR." + CNT$ FOR APPEND AS #1
9302 PRINT #1, USING " ####.#####, ###, ##, ###.#"; TIMSTMP#(CONTRLPNT%(CONTROLLER%)),
     CNTLOUT(CONTROLLER%),CONTRLPNT%(CONTROLLER%), CNTRLCK(CONTROLLER%)
9304 CLOSE #1
9310 IF CNTLOUT(CONTROLLER%) < 5! THEN CNTLOUT(CONTROLLER%)=5!
9330 IF CNTLOUT(CONTROLLER%) > 95! THEN CNTLOUT(CONTROLLER%)=95!
9350 DAOUT%(CONTROLLER%)=CNTLOUT(CONTROLLER%)*CPPCT
9370 DAH%=INT(DAOUT%(CONTROLLER%)/256)
9390 DAL%=DAOUT%(CONTROLLER%)-DAH%*256
9410 OUT DDA06BASE%+2*(CONTROLLER%-1), DAL%
9430 OUT DDA06BASE%+1+2*(CONTROLLER%-1), DAH%
9435 ACTIVE%(CONTROLLER%)=FALSE%
9450 NEXT CONTROLLER%
9470 CONTROL%=FALSE%
9490 RETURN
9510 '*******************END OF CONTROL & OUTPUT SECTION********************
9530 '*************INITIATE DATA ACQUISITION AND CONTROL******************
9550 START%=FALSE%
9570 SELECT%=TRUE%
9590 ACQUIRE%=FALSE%
9610 CONTROL%=TRUE%
9630 RUNNING%=TRUE%
9640 STORE%=TRUE%
9650 CPOINT%=0
9670 SDATE$=DATE$
9690 STIME$=TIME$
```

```
9710 FOR LOOP%=1 TO 45
9730 MINVAL(LOOP%)=10000!
9750 MAXVAL(LOOP%)=-10000!
9770 NEXT LOOP%
9790 FOR ANLYZR%=1 TO 3
9810 ANLPTR%(ANLYZR%)=0
9830 NEXT ANLYZR%
9850 OPEN SYSDRIVE$+"SETPOINT.TBL" FOR INPUT AS #1
9870 FOR CNTL%= 1 TO 4
9890 INPUT #1,SETPOINTS(CNTL%),MODE%(CNTL%),CNTLOUT(CNTL%),AMBCAN%(CNTL%,1),AMBCAN%
     (CNTL%,2),AMBCAN%(CNTL%,3), AMBCAN%(CNTL%,4),AMBCAN%(CNTL%,5),AMBCAN%(CNTL%,6),
     AMBCAN%(CNTL%,7),AMBCAN%(CNTL%,8),AMBCAN%(CNTL%,9),AMBCAN%(CNTL%,10),SETPNTTYPE(CNTL%)
9910 MIN(CNTL%)=10000!
9930 MAX(CNTL%)=-10000!
9940 CKMAX(CNTL%)=-1000
9945 CKMIN(CNTL%)=1000
9950 ERRSUM(CNTL%)=0!
9970 NEXT CNTL%
9990 CLOSE #1
10010 FOR LOOP%=0 TO 2:OUT PIO12BASE%+LOOP%, 0:NEXT LOOP%
10030 FOR LOOP%=1 TO 3:OUT DDA06BASE%+&HB+LOOP%, 0:NEXT LOOP%
10050 OUT PIO12BASE%+1, &HE0
10070 OUTWORD%(2,2)=OUTWORD%(2,2) OR &HE0
10090 KEY 1,"STOP"
10109 IF TEMP% > 45 THEN GOTO 19070
10110 ON KEY (1) GOSUB 21490
10130 RETURN
10150 '********END OF DATA ACQUISITION AND CONTROL INITIATION SECTION*********
10170 '**********************STOP PROGRAM EXECUTION SECTION******************
10190 'ENTRY POINT
10210 KEY 1,"START"
10230 STOPPROG%=FALSE%
10250 RUNNING%=FALSE%
10270 SELECT%=FALSE%
10290 ACQUIRE%=FALSE%
10310 CONTROL%=FALSE%
10330 FACEPLATE%=FALSE%
10350 CLRSCRN%=FALSE%
10370 FLOG%=FALSE%
10372 'INITIALIZE THE OUTWORD% ARRAY TO RESTART PROPERLY
10374 FOR LOOPA%=1 TO 2
10376 FOR LOOPB%=1 TO 3
10378 OUTWORD%(LOOPA%,LOOPB%)=0
10380 OUT OUTBASE% + LOOPB% , OUTWORD%(LOOPA%,LOOPB%)
10382 NEXT LOOPB%
10384 NEXT LOOPA%
10390 KEY 4,"LOG"
10410 ON KEY (4) GOSUB 21250
10430 STORE%=FALSE%
10450 KEY 5,"STORE"
10470 ON KEY (5) GOSUB 21310
10490 ON KEY (1) GOSUB 20670
10510 CLOSE
10530 RETURN
10550 '***********************END OF PROGRAM STOP SECTION********************
10570 '*********************PRINTER LOGGING SECTION*************************
10590 'ENTRY POINT
10610 PPLTIME=TIMER
10630 ON ERROR GOTO 10950
10650 KEY 4,"NOLOG"
10670 ON KEY (4) GOSUB 21370
10690 IF PPLTIME < PLTIME THEN GOTO 10930
10700 IF ((PPLTIME > 79200!) AND (PLTIME < 7200)) GOTO 10930
10710 PLTIME=PPLTIME+PLINTRVL
10730 IF PLTIME > 86400! THEN PLTIME=PLTIME-86400!
10750 LPRINT DATE$,TIME$
10770 FOR LPOINT%=1 TO 45 STEP 9
10790 LP%=LPOINT%
10810 LPRINT USING "###.#,";VALUE(LP%),VALUE(LP%+1),VALUE(LP%+2),VALUE(LP%+3),VALUE(LP%+4),
      VALUE(LP%+5), VALUE(LP%+6),VALUE(LP%+7),VALUE(LP%+8)
10830 NEXT LPOINT%
10850 LPRINT "CONTROL#","SETPOINT","AMBIENT","MINIMUM","MEDIAN","MAXIMUM"
10870 FOR CONTROLLER%=1 TO 4
10890 LPRINT CONTROLLER%,SETPOINTS(CONTROLLER%),AMBOZONE(CONTROLLER%),MIN(CONTROLLER%),
      MEDIAN(CONTROLLER%),MAX(CONTROLLER%)
```

```
10910 NEXT CONTROLLER%
10930 RETURN
10950 IF (ERR=27) OR (ERR=24) OR (ERR=25) THEN LOCATE 23,9:PRINT "PRINTER FAULT:",ERR
10970 PLOG%=FALSE%
10990 RESUME 10930
11010 '******************DISABLE PRINTER LOGGING SECTION***********************
11030 'ENTRY POINT
11050 KEY 4,"LOG"
11070 ON KEY (4) GOSUB 21250
11090 PLTIME=0!
11110 RETURN
11130 '**************END OF DISABLE PRINTER LOGGING SECTION*******************
11150 '******************NORMAL DATAFILE CLOSING SECTION**********************
11170 'DISK DATA STORAGE FILE CLOSING.
11190 'entry point
11210 DLTIME=0!
11230 'IF DATAFILE% = FALSE% THEN GOTO 11330
11250 'CLOSE #2
11270 'DATAFILE%=FALSE%
11290 KEY 5,"STORE"
11310 ON KEY (5) GOSUB 21310
11330 RETURN
11350 '***************END OF NORMAL DATAFILE CLOSING SECTION******************
11370 '*******************DISK DATA STORAGE SECTION****************************
11390 'ENTRY POINT
11410 PDLTIME=TIMER
11450 ON ERROR GOTO 11830
11550 KEY 5,"NOSTORE"
11570 ON KEY (5) GOSUB 21430
11630 IF PDLTIME < DLTIME THEN GOTO 11790
11640 IF ((PDLTIME > 85200!) AND (DLTIME < 1200)) GOTO 11790
11650 DLTIME = PDLTIME+DLINTRVL
11670 IF DLTIME > 86400! THEN DLTIME=DLTIME-86400!
11675 'DISK DATA STORAGE BY CHAMBER NUMBER FILES
11680 FOR CHAMBER= 1 TO 45
11690 IF NEWVALU(CHAMBER)=FALSE% GOTO 11770
11700 TENS = FIX(CHAMBER/10) + 48
11710 UNITS = (CHAMBER - (FIX(CHAMBER/10)*10)) + 48
11720 PNT$ = CHR$(TENS) + CHR$(UNITS)
11730 OPEN DATADRIVE$ + "CHAMBER." + PNT$ FOR APPEND AS #2
11740 PRINT #2, USING "####.#####, ###.##";TIMSTMP#(CHAMBER),VALUE(CHAMBER)
11750 NEWVALU(CHAMBER)= FALSE%
11760 CLOSE #2
11770 NEXT CHAMBER
11790 ON ERROR GOTO 0
11810 RETURN
11830 IF ERR <> 61 AND ERR <> 67 THEN GOTO 11950
11850 TEMPDRIVE$=DATADRIVE$
11870 DATADRIVE$=ALTRDRIVE$
11890 ALTRDRIVE$=TEMPDRIVE$
11910 'DATAFILE%=FALSE%
11930 RESUME 11790
11950 IF ERR <> 58 THEN GOTO 12010
11970 'DATAFILE%=FALSE%
11990 RESUME 11790
12010 IF ERR <> 68 THEN GOTO 12050
12030 STORE%=FALSE%
12050 PRINT "DISK ERROR,ERROR=",ERR
12070 PRINT "DATA FILE=",DATAFILE$
12090 RESUME 11790
12110 '******************END OF DISK DATA STORAGE SECTION *********************
12130 '******************DISK DRIVE ASSIGNMENT SECTION.**********************
12150 'ENTRY POINT
12170 CLS
12190 LOCATE 3,1
12210 PRINT "CURRENT DATA DRIVE IS: ",DATADRIVE$
12230 LOCATE 4,1
12250 PRINT "ALTERNATE DATA DRIVE IS: ",ALTRDRIVE$
12270 LOCATE 5,1
12290 PRINT SPACE$(80):LOCATE 5,1
12310 INPUT "DO YOU WANT TO CHANGE DRIVE ASSIGNMENTS? [Y/N]: ",YNRES$
12330 IF YNRES$="N" OR YNRES$="n" OR YNRES$="" THEN GOTO 12690
12350 IF YNRES$<>"Y" AND YNRES$<>"y" THEN GOTO 12290
12370 LOCATE 6,1:PRINT SPACE$(80):LOCATE 6,1
12390 INPUT "ENTER NEW DATA DRIVE I.D. [C:,D:,E:,F: OR <CR> FOR NO CHANGE]:",NEWDRV$
12410 IF NEWDRV$=BLANK$ THEN GOTO 12550
```

```
12430 IF NEWDRV$<>CDRV$ AND NEWDRV$<>DDRV$ AND NEWDRV$<>EDRV$ AND NEWDRV$<>
      FDRV$ THEN GOTO 12370
12450 IF NEWDRV$=DATADRIVE$ THEN GOTO 12550
12470 'SAVESTAT%=DATAFILE%
12490 DATADRIVE$=NEWDRV$
12510 'IF DATAFILE% THEN GOSUB 11190
12530 'IF SAVESTAT% THEN STORE%=TRUE%
12550 LOCATE 7,1:PRINT SPACE$(80):LOCATE 7,1
12570 INPUT "ENTER NEW ALTERNATE DRIVE I.D. [C:,D:,E:,F: OR <CR> FOR NO CHANGE]:",NEWDRV$
12590 IF NEWDRV$=BLANK$ THEN GOTO 12690
12610 IF NEWDRV$ = DATADRIVE$ THEN GOTO 12550
12630 IF NEWDRV$<>CDRV$ AND NEWDRV$<>DDRV$ AND NEWDRV$<>EDRV$ AND NEWDRV$<>
      FDRV$ THEN GOTO 12550
12650 IF NEWDRV$=ALTRDRIVE$ THEN GOTO 12690
12670 ALTRDRIVE$=NEWDRV$
12690 LOCATE 8,1:PRINT SPACE$(80):LOCATE 8,1
12710 INPUT "DO YOU WANT TO CHANGE DISK LOGGING INTERVAL [Y/N]?:",YNRES$
12730 IF YNRES$ = "N" OR YNRES$ = "n" OR YNRES$ = "" THEN GOTO 12890
12750 IF YNRES$ <> "Y" AND YNRES$ <> "y" THEN GOTO 12690
12770 LOCATE 8,1:PRINT SPACE$(80):LOCATE 8,1
12790 PRINT "CURRENT INTERVAL IS"DLINTRVL/60!"MINUTES."
12810 LOCATE 9,1:PRINT SPACE$(80):LOCATE 9,1
12830 INPUT "ENTER NEW INTERVAL [1 <= VALUE <= 1440] IN MINUTES: ",NEWINT
12850 IF NEWINT <1 OR NEWINT > 1440 THEN GOTO 12810
12870 DLINTRVL=NEWINT*60
12890 DRVSEL%=FALSE%
12910 CLS
12930 RETURN
12950 '*********************END OF DRIVE SELECT SECTION.***********************
12970 '********FACEPLATE DISPLAY CREATION AND UPDATING SECTION***********
12990 'ENTRY POINT
13010 'DETERMINE IF FACEPLATE TEMPLATE HAS BEEN DRAWN YET.
13030 IF FPTEMPLATE%  THEN GOTO 14030
13050 CLS
13070 LOCATE 1,20
13090 PRINT "OZONE CONCENTRATION IN PPB VS CANOPY NUMBER"
13110 LOCATE 2,1
13130 PRINT "CANOPIES JUST UPDATED:"
13150 LOCATE 2,47
13170 PRINT "AMBIENT OZONE LEVEL (PPB):"
13190 FOR LOOP%=1 TO 45 STEP 9
13210 LOCATE FACECOORD%(1,LOOP%)+2,1
13230 PRINT "CANOPY#:"
13250 LOCATE FACECOORD%(1,LOOP%)+3,1
13270 PRINT "MINIMUM:"
13290 LOCATE FACECOORD%(1,LOOP%)+4,1
13310 PRINT "PRESENT:"
13330 LOCATE FACECOORD%(1,LOOP%)+5,1
13350 PRINT "MAXIMUM:"
13370 NEXT LOOP%
13390 FOR DPOINT%=1 TO 45                    'DRAW THE TEMPLATE.
13410 LOCATE FACECOORD%(1,DPOINT%)+2,FACECOORD%(2,DPOINT%)+12
13430 PRINT USING "    ##";DPOINT%
13450 IF SAMPLE%(DPOINT%) > 0 GOTO 13650
13470 IF VALUE(DPOINT%) = 0! GOTO 13530
13490 LOCATE FACECOORD%(1,DPOINT%)+4,FACECOORD%(2,DPOINT%)+12
13510 PRINT USING "###.#"; VALUE(DPOINT%)
13530 IF MINVAL(DPOINT%) = 10000! GOTO 13590
13550 LOCATE FACECOORD%(1,DPOINT%)+3,FACECOORD%(2,DPOINT%)+12
13570 PRINT USING "###.#";MINVAL(DPOINT%)
13590 IF MAXVAL(DPOINT%) = -10000! GOTO 13650
13610 LOCATE FACECOORD%(1,DPOINT%)+5,FACECOORD%(2,DPOINT%)+12
13630 PRINT USING "###.#";MAXVAL(DPOINT%)
13650 NEXT DPOINT%
13670 FOR LOOP%=1 TO 4
13690 ROW%=4+(LOOP%-1)*5
13710 COLUMN%=67
13730 LOCATE ROW%,COLUMN%
13750 PRINT "CNTL:   MODE: "
13770 LOCATE ROW%,COLUMN%+6
13790 PRINT USING "#";LOOP%
13810 IF MODE%(LOOP%) THEN MODE$="A" ELSE MODE$="M"
13830 LOCATE ROW%,COLUMN%+13
13850 PRINT USING "!";MODE$
13870 LOCATE ROW%+1,COLUMN%
13890 PRINT "SP:"
```

```
13910 LOCATE ROW%+2,COLUMN%
13930 PRINT "PV:"
13950 LOCATE ROW%+3,COLUMN%
13970 PRINT "OUT:"
13990 NEXT LOOP%
14010 FPTEMPLATE%=TRUE%                    'THE TEMPLATE IS NOW ON SCREEN.
14030 FOR ANLYZR%=1 TO 3
14050 DPOINT%=UPDATE%(ANLYZR%)
14070 UPDATE%(ANLYZR%)=0
14090 IF DPOINT% = 0 GOTO 14270
14110 LOCATE 2,24+(ANLYZR%-1)*3
14130 PRINT USING " ##";DPOINT%
14150 LOCATE FACECOORD%(1,DPOINT%)+4,FACECOORD%(2,DPOINT%)+12
14170 PRINT USING "###.#"; VALUE(DPOINT%)
14190 LOCATE FACECOORD%(1,DPOINT%)+3,FACECOORD%(2,DPOINT%)+12
14210 PRINT USING "###.#";MINVAL(DPOINT%)
14230 LOCATE FACECOORD%(1,DPOINT%)+5,FACECOORD%(2,DPOINT%)+12
14250 PRINT USING "###.#";MAXVAL(DPOINT%)
14270 NEXT ANLYZR%
14290 LOCATE 2,74
14310 PRINT USING "###.#";AMBIENTO3
14330 FOR LOOP%=1 TO 4
14350 ROW%=4+(LOOP%-1)*5
14370 COLUMN%=67
14390 LOCATE ROW%+1,COLUMN%+4
14410 PRINT USING " ###.#";SETPNT(LOOP%)
14430 LOCATE ROW%+2,COLUMN%+4
14435 IF CONTRLPNT%(LOOP%) = 0 GOTO 14470
14440 IF SINGLE%=TRUE% GOTO 14451
14445 PRINT USING " ###.#";CNTRLO3(LOOP%)    'AVERAGE OF TREATED CHAMBERS
14450 GOTO 14470
14451 PRINT USING " ###.#";VALUE (CONTRLPNT%(LOOP%)) 'INDIVIDUAL CHAMBER
14470 LOCATE ROW%+3,COLUMN%+6
14490 PRINT USING " ###";CNTLOUT(LOOP%)
14510 NEXT LOOP%
14530 RETURN
14550 '***************END OF FACEPLATE DISPLAY SECTION*******************
14570 '*********************FACEPLATE RESET SECTION*************************
14590 'ENTRY POINT
14610 FPTEMPLATE%=FALSE%
14630 RETURN
14650 '*******************END OF FACEPLATE RESET SECTION*********************
14670 '*******************CLEAR SCREEN AND RESET MIN/MAX SECTION**************
14690 'CLEAR DISPLAY/RESET MIN,MAX SECTION.
14710 'ENTRY POINT
14730 CLS
14750 LOCATE 4,1:PRINT SPACE$(80):LOCATE 4,1
14770 INPUT "RESET DAILY MINIMUMS AND MAXIMUMS ? [Y/N]:",YNRES$
14790 IF YNRES$ <> "Y" AND YNRES$ <> "y" THEN GOTO 14910
14810 FOR LOOP%=1 TO 45
14830 MINVAL(LOOP%)=10000!
14850 MAXVAL(LOOP%)=-10000!
14870 NEXT LOOP%
14890 GOTO 14930
14910 IF YNRES$ <> "n" AND YNRES$ <> "N" AND YNRES$ <> "" THEN GOTO 14750
14930 CLRSCRN%=FALSE%
14950 CLS
14970 RETURN
14990 '****************END OF PROFILE DISPLAY SECTION************************
15010 '*************SYSTEM CHANNEL ASSIGNMENT LISTING SECTION*****************
15030 'DISPLAY THE CHANNEL ASSIGNMENT INFORMATION AND ACCEPT CHANGES.
15050 'ENTRY POINT
15070 CLS
15090 ON ERROR GOTO 0
15110 LOCATE 1,30
15130 PRINT "SYSTEM CHANNEL ASSIGNMENT INFORMATION"
15150 LOCATE 3,1
15170 PRINT "FORMAT: CANOPY#, STATUS, CONTROLLER #, ANALYZER #, SAMPLER CHANNEL., CONTROLLED"
15190 FOR ENTRY% = 1 TO 45
15191 IF ENTRY%=1 OR ENTRY%=16 OR ENTRY%=31 THEN ROW%=0
15192 ROW%=ROW%+1
15193 IF ENTRY%=1 THEN COLUMN%=1
15194 IF ENTRY%=16 THEN COLUMN%=29
15195 IF ENTRY%=31 THEN COLUMN%=57
15210 LOCATE 4+ROW%,COLUMN%
15230 IF SAMPLE%(ENTRY%) < 0 THEN STATUS$="ACT" ELSE STATUS$="INA"
```

```
15250 SPNUM%=CONTROLLED%(ENTRY%) AND SPMASK%
15270 IF SPNUM% = 0 THEN SPNUM$="NONE"
15290 IF SPNUM% = 1 THEN SPNUM$="CTL #1"
15310 IF SPNUM% = 2 THEN SPNUM$="CTL #2"
15330 IF SPNUM% = 3 THEN SPNUM$="CTL #3"
15350 IF SPNUM% = 4 THEN SPNUM$="CTL #4"
15370 ANLYZR%=(SAMPLE%(ENTRY%) AND ANLMASK%)/2048
15390 TEMP%=SAMPLE%(ENTRY%) AND BIT010%
15410 IF TEMP% > 255 THEN GOTO 15530
15430 FOR N=0 TO 7
15450 IF 2^N = TEMP% THEN GOTO 15490
15470 NEXT N
15490 CHNL%=N+1
15510 GOTO 16190
15530 IF TEMP% > 511 THEN GOTO 15670
15550 TEMP%=TEMP%-256
15570 FOR N = 0 TO 7
15590 IF 2^N = TEMP% THEN GOTO 15630
15610 NEXT N
15630 CHNL%=N+17
15650 GOTO 16190
15670 IF TEMP% > 767 THEN GOTO 15810
15690 TEMP%=TEMP%-512
15710 FOR N = 0 TO 7
15730 IF 2^N = TEMP% THEN GOTO 15770
15750 NEXT N
15770 CHNL%=N+9
15790 GOTO 16190
15810 IF TEMP% > 1279 THEN GOTO 15950
15830 TEMP%=TEMP%-1024
15850 FOR N= 0 TO 7
15870 IF 2^N = TEMP% THEN GOTO 15910
15890 NEXT N
15910 CHNL%=N+25
15930 GOTO 16190
15950 IF TEMP% > 1535 THEN GOTO 16090
15970 TEMP%=TEMP%-1280
15990 FOR N=0 TO 7
16010 IF 2^N = TEMP% THEN GOTO 16050
16030 NEXT N
16050 CHNL%=N+41
16070 GOTO 16190
16090 TEMP%=TEMP%-1536
16110 FOR N=0 TO 4
16130 IF 2^N = TEMP% THEN GOTO 16170
16150 NEXT N
16170 CHNL%=N+33
16190 CNTL$="N"
16210 IF CONTROLLED%(ENTRY%) < 0 THEN CNTL$="Y"
16230 PRINT USING " ## \  \\      \ #  ## \ \";ENTRY%,STATUS$,SPNUM$,ANLYZR%,CHNL%,CNTL$
16250 NEXT ENTRY%
16270 'REQUEST ANY CHANGES TO THE CHANNEL ASSIGNMENT TABLE.
16290 LOCATE 22,1:PRINT SPACE$(80):LOCATE 22,1
16310 INPUT "ARE ANY CHANGES TO BE MADE TO TABLE [Y/N]?: ",YNRES$
16330 IF YNRES$ = "N" OR YNRES$="n" OR YNRES$="" THEN GOTO 17610
16350 IF YNRES$ <> "Y" THEN GOTO 16290
16370 LOCATE 22,1
16390 PRINT SPACE$(80):LOCATE 22,1
16410 INPUT "ENTER CANOPY TO BE MODIFIED [RANGE:1-45,<cr> FOR NO CHANGE]:",CANPY%
16430 IF CANPY% <= 0 THEN GOTO 17610
16450 IF CANPY% > 45 THEN GOTO 16370
16470 LOCATE 22,1
16490 PRINT SPACE$(80):LOCATE 22,1
16510 LOCATE 22,1
16530 INPUT "ENTER ITEM TO BE MODIFIED [STRING:1-10]:",ITEM$
16550 IF ITEM$ = "" THEN GOTO 16410
16570 IF ITEM$ <> "STATUS" THEN GOTO 16710
16590 LOCATE 22,1
16610 PRINT SPACE$(80):LOCATE 22,1
16630 INPUT "ENTER NEW STATUS [ACTIVE/INACTIVE]:",STATUS$
16650 IF STATUS$ = "ACTIVE" THEN SAMPLE%(CANPY%)=SAMPLE%(CANPY%) OR BIT15%
16656 TENS=FIX(LOOP%/10) + 48
16670 IF STATUS$ = "INACTIVE" THEN SAMPLE%(CANPY%)=(SAMPLE%(CANPY%) AND (NOT BIT15%))
16690 GOTO 17530
16710 IF ITEM$ <> "CONTROLLER" THEN GOTO 16910
16730 LOCATE 22,1
16750 PRINT SPACE$(80):LOCATE 22,1
```

```
16770 INPUT "ENTER CONTROLLER NUMBER [NONE,#1,#2,#3, OR #4]:",CTLNUM$
16790 IF CTLNUM$ = "NONE" THEN CONTROLLED%(CANPY%)=0
16810 IF CTLNUM$ = "#1" THEN CONTROLLED%(CANPY%)=&H8001
16830 IF CTLNUM$ = "#2" THEN CONTROLLED%(CANPY%)=&H8002
16850 IF CTLNUM$ = "#3" THEN CONTROLLED%(CANPY%)=&H8003
16870 IF CTLNUM$ = "#4" THEN CONTROLLED%(CANPY%)=&H8004
16890 GOTO 17530
16910 IF ITEM$ <> "ANALYZER" THEN GOTO 17070
16930 LOCATE 22,1
16950 PRINT SPACE$(80):LOCATE 22,1
16970 INPUT "ENTER ANALYZER NUMBER [1,2 OR 3]:",ANL%
16990 IF ANL% = 0 THEN GOTO 16470
17010 IF (ANL% < 0) OR (ANL% > 3) THEN GOTO 16930
17030 SAMPLE%(CANPY%) = ((SAMPLE%(CANPY%) AND NBIT1112%) OR (ANL% * 2048))
17050 GOTO 17530
17070 IF ITEM$ <> "CHANNEL" THEN GOTO 16470
17090 LOCATE 22,1
17110 INPUT "ENTER NEW CHANNEL NUMBER [RANGE: 1-45, <cr> FOR NO CHANGE]:",CHNL%
17130 IF CHNL% = 0 THEN GOTO 16370
17150 IF CHNL% > 8 THEN GOTO 17210
17170 SAMPLE%(CANPY%)=(SAMPLE%(CANPY%) AND NBIT010%) OR 2^(CHNL%-1)
17190 GOTO 17530
17210 IF CHNL% > 16 THEN GOTO 17290
17230 SAMPLE%(CANPY%)=(((SAMPLE%(CANPY%) AND NBIT010%) OR BIT9%) OR 2^(CHNL%-9))
17250 PRINT HEX$(SAMPLE%(CANPY%))
17270 GOTO 17530
17290 IF CHNL% > 24 THEN GOTO 17350
17310 SAMPLE%(CANPY%)=(((SAMPLE%(CANPY%)AND NBIT010%) OR BIT8%) OR 2^(CHNL%-17))
17330 GOTO 17530
17350 IF CHNL% > 32 THEN GOTO 17410
17370 SAMPLE%(CANPY%)=(((SAMPLE%(CANPY%) AND NBIT010%) OR BIT10%) OR 2^(CHNL%-25))
17390 GOTO 17530
17410 IF CHNL% > 40 THEN GOTO 17470
17430 SAMPLE%(CANPY%)=((((SAMPLE%(CANPY%) AND NBIT010%) OR BIT10%) OR BIT9%) OR 2^(CHNL%-33))
17450 GOTO 17530
17470 IF CHNL% > 45 THEN GOTO 17570
17490 SAMPLE%(CANPY%)=((((SAMPLE%(CANPY%) AND NBIT010%) OR BIT10%) OR BIT8%) OR 2^(CHNL%-41))
17510 GOTO 17530
17530 UPDATETBL%=TRUE%
17550 GOTO 15070
17570 PRINT "INVALID CHANNEL NUMBER."
17590 GOTO 17090
17610 ASSIGN%=FALSE%
17630 IF UPDATETBL% = FALSE% THEN GOTO 17870
17650 ON ERROR GOTO 0
17670 OPEN SYSDRIVE$+"SAMPLE.TBL" FOR OUTPUT AS #1
17690 FOR ENTRY%=1 TO 45
17710 WRITE #1,SAMPLE%(ENTRY%)
17730 NEXT ENTRY%
17750 CLOSE #1
17770 OPEN SYSDRIVE$+"CONTROLD.TBL" FOR OUTPUT AS #1
17790 FOR ENTRY%=1 TO 45
17810 WRITE #1, CONTROLLED%(ENTRY%)
17830 NEXT ENTRY%
17850 CLOSE #1
17870 CLS
17890 RETURN
17910 '**********END OF SYSTEM CHANNEL ASSIGNMENT LISTING SECTION*************
17930 '******************CONTROLLER MODIFICATION SECTION*********************
17950 'ENTRY POINT
17970 CLS
17990 LOCATE 1,20
18010 PRINT "CONTROLLER PARAMETERS"
18030 LOCATE 3,1:PRINT "CONTROLLER#"SPC(2)"SETPOINT(PPB)"SPC(9)"MODE"SPC(13)"OUTPUT(%)"
18050 FOR CONTROLLER% = 1 TO 4
18070 LOCATE 4+CONTROLLER%,1
18075 IF SETPNTTYPE(CONTROLLER%)=BIAS% THEN CNTRLMODE$="OFFSET      "
18080 IF SETPNTTYPE(CONTROLLER%)=RATIO% THEN CNTRLMODE$="PROPORTIONAL"
18090 IF MODE%(CONTROLLER%) THEN MODE$="AUTO" ELSE MODE$="MAN"
18110 PRINT USING "     #           ###       \    \ \          \     ###   ";
        CONTROLLER%,SETPOINTS(CONTROLLER%),MODE$,CNTRLMODE$,CNTLOUT(CONTROLLER%)
18130 NEXT CONTROLLER%
18150 FOR CLRW=1 TO 14:LOCATE CLRW + 8,1:PRINT SPACE$(80):NEXT CLRW:LOCATE 9,1
18170 INPUT "ENTER CONTROLLER [1,2,3,4 OR <CR> FOR NO CHANGE]:",CONTROLLER%
18190 IF CONTROLLER% = 0 THEN GOTO 19210
18210 IF CONTROLLER% < 1 OR CONTROLLER% > 4 THEN GOTO 18150
```

```
18230 FOR CLRW=1 TO 14:LOCATE CLRW + 8,1:PRINT SPACE$(80):NEXT CLRW:LOCATE 9,1
18250 INPUT "ENTER ITEM TO BE MODIFIED [SETPNT,MODE,OUTPUT,AMBIENT, OR <CR>]:",ITEM$
18270 IF ITEM$ = "" THEN GOTO 18150
18280 FOR CLRW=1 TO 14:LOCATE CLRW + 8,1:PRINT SPACE$(80):NEXT CLRW:LOCATE 9,1
18290 IF ITEM$ <> "SETPNT" THEN GOTO 18390
18310 LOCATE 9,1:PRINT SPACE$(160):LOCATE 9,1
18315 INPUT "ENTER SETPOINT TYPE [PROPORTIONAL,OFFSET] :" , SPTYPE$
18317 IF SPTYPE$ = "O" GOTO 18329
18318 IF SPTYPE$ <> "P" GOTO 18315
18320 SETPNTTYPE(CONTROLLER%)=RATIO%
18322 INPUT "ENTER NEW PROPORTIONAL SETPOINT [1.00-4.00] :", NEWSETPNT
18324 IF NEWSETPNT => 1! AND NEWSETPNT <= 4! THEN SETPOINTS(CONTROLLER%)
      =NEWSETPNT ELSE GOTO 18322
18326 GOTO 17990
18329 SETPNTTYPE(CONTROLLER%)=BIAS%
18330 INPUT "ENTER NEW SETPOINT [ IN PPB ]:",NEWSETPNT
18350 IF NEWSETPNT => 0! AND NEWSETPNT <= 500! THEN SETPOINTS(CONTROLLER%)
      =NEWSETPNT ELSE GOTO 18330
18370 GOTO 17990
18390 IF ITEM$ <> "MODE" THEN GOTO 18590
18410 LOCATE 9,1:PRINT SPACE$(160):LOCATE 9,1
18430 INPUT "ENTER CONTROLLER MODE [AUTO,MANUAL, OR <CR>]:",ITEM$
18450 IF ITEM$ <> "AUTO" THEN GOTO 18510
18470 MODE%(CONTROLLER%)=AUTOMODE%
18475 '###########INPUT " ENTER CONTROLLER MODE [IND or AVG] ;", ITEM$
18480 '########IF ITEM$ = "AVG" THEN SINGLE%=FALSE% ELSE SINGLE%=TRUE%
18490 GOTO 17990
18510 IF ITEM$ <> "MANUAL" THEN  GOTO 18410
18530 MODE%(CONTROLLER%)=MANUALMODE%
18550 GOTO 17990
18570 'GOTO 18250
18590 IF ITEM$ <> "OUTPUT" THEN GOTO 18730
18610 LOCATE 9,1:PRINT SPACE$(160):LOCATE 9,1
18630 INPUT "ENTER OUTPUT VALUE [0.0 <= VALUE <= 100.0] IN %:",OUTPCT
18650 IF OUTPCT < 0 THEN OUTPCT = 0!
18670 IF OUTPCT >100 THEN OUTPCT = 100!
18690 CNTLOUT(CONTROLLER%)=OUTPCT
18710 GOTO 17990
18730 IF ITEM$ <> "AMBIENT" GOTO 18230
18750 AMBFLG%=FALSE%
18770 FOR LOOP%=1 TO 10
18790 IF AMBCAN%(CONTROLLER%,LOOP%) <>0 THEN AMBFLG%=TRUE%
18810 NEXT LOOP%
18830 IF AMBFLG% = TRUE% GOTO 18910
18850 LOCATE 9,1:PRINT SPACE$(160):LOCATE 9,1
18870 PRINT "NO AMBIENT CHANNELS DEFINED FOR THIS CONTROLLER."
18890 GOTO 19050
18910 LOCATE 9,1:PRINT SPACE$(160):LOCATE 9,1
18930 PRINT "AMBIENT CANOPIES: "
18950 FOR LOOP%=1 TO 10
18970 IF AMBCAN%(CONTROLLER%,LOOP%) = 0 GOTO 19030
18990 LOCATE 9,19+(LOOP%-1)*3
19010 PRINT USING "## ";AMBCAN%(CONTROLLER%,LOOP%)
19030 NEXT LOOP%
19050 FOR LOOP%=1 TO 10
19070 LOCATE 10,1:PRINT SPACE$(80):LOCATE 10,1
19090 INPUT "ENTER AMBIENT CANOPY NUMBER [NN<CR>, -1 TO CLEAR OR <CR> TO END]:",TEMP%
19091 IF TEMP% <> -1 GOTO 19096
19092 FOR LOOP1%=1 TO 10
19093 AMBCAN%(CONTROLLER%,LOOP1%)=0
19094 NEXT LOOP1%
19095 GOTO 19170
19096 IF TEMP% = 0 THEN GOTO 19170
19109 IF TEMP% > 45 THEN GOTO 19070
19110 AMBCAN%(CONTROLLER%,LOOP%)=TEMP%
19150 NEXT LOOP%
19170 LOCATE 10,1:PRINT SPACE$(80):LOCATE 10,1
19190 GOTO 17990
19210 SETPOINT%=FALSE%
19230 OPEN SYSDRIVE$+"SETPOINT.TBL" FOR OUTPUT AS #1
19250 FOR CNTL%=1 TO 4
19270 WRITE #1,SETPOINTS(CNTL%),MODE%(CNTL%),CNTLOUT(CNTL%),AMBCAN%(CNTL%,1),AMBCAN%(CNTL%,2),
      AMBCAN%(CNTL%,3),AMBCAN%(CNTL%,4),AMBCAN%(CNTL%,5),AMBCAN%(CNTL%,6),AMBCAN%(CNTL%,7),
      AMBCAN%(CNTL%,8),AMBCAN%(CNTL%,9),AMBCAN%(CNTL%,10),SETPNTTYPE(CNTL%)
19290 NEXT CNTL%
19310 CLOSE #1
```

```
19330 CLS
19350 RETURN
19370 '***************END OF CONTROLLER MODIFICATION SECTION.*****************
19390 '*****************WATCHDOG UPDATING SECTION**********************
19410 OUT DASH8BASE%+7, WDTMRCNTL%
19430 OUT DASH8BASE%+4, WDLB%
19450 OUT DASH8BASE%+4, WDHB%
19470 RETURN
19490 '**************END OF WATCHDOG UPDATING SECTION******************
19510 '*****************MIDNIGHT ROLLOVER RESET SECTION*********************
19530 'ENTRY POINT
19550 TOD=TIMER
19570 IF TOD > 60! THEN GOTO 19790
19590 IF ROLLOVER% THEN GOTO 19810
19610 'SAVESTAT%=DATAFILE%
19630 'IF DATAFILE% THEN GOSUB 11190
19650 'IF SAVESTAT% THEN STORE%=TRUE%
19651 'IF (JULDATE-STATDATE)=1 GOTO 19670
19652 IF DATECK > TOD THEN STATDATE=JULDATE ELSE STATDATE=JULDATE - 1
19654 FOR LOOP%=1 TO 45
19656 TENS=FIX(LOOP%/10) + 48
19658 UNITS=(LOOP% - (FIX(LOOP%/10)*10)) + 48
19660 PNT$= CHR$(TENS) + CHR$(UNITS)
19662 OPEN DATADRIVE$ + "\O3STATS\MMMSD." +PNT$ FOR APPEND AS #2
19664 PRINT #2, USING " ####, ###.#, ##.#, ###.#, ##.#" ; STATDATE, O3AVG(LOOP%),
      SQR(O3VAR(LOOP%)),MAXVAL(LOOP%),MINVAL(LOOP%)
19666 CLOSE #2
19668 NEXT LOOP%
19670 FOR LOOP%=1 TO 45
19680 DPCNT(LOOP%)=0
19690 MINVAL(LOOP%)=10000!
19695 O3VAR(LOOP%)=0
19710 MAXVAL(LOOP%)=-10000!
19715 O3AVG(LOOP%)=0
19730 NEXT LOOP%
19732 FOR LOOP%=2 TO 4
19733 UNITS=(LOOP% - (FIX(LOOP%/10)*10)) + 48
19734 PNT$= CHR$(UNITS)
19735 OPEN DATADRIVE$ + "\O3STATS\MMMSD.C" +PNT$ FOR APPEND AS #2
19736 PRINT #2, USING " ####, ###.#, ##.#, ###.#, ##.#" ; STATDATE,
      CKAVG(LOOP%),SQR(CKVAR(LOOP%)),CKMAX(LOOP%),CKMIN(LOOP%)
19737 CLOSE #2
19738 NEXT LOOP%
19739 FOR LOOP%=2 TO 4
19740 CKCNT(LOOP%)=0
19741 CKMIN(LOOP%)=10000!
19742 CKVAR(LOOP%)=0
19743 CKMAX(LOOP%)=-10000!
19744 CKAVG(LOOP%)=0
19745 NEXT LOOP%
19750 ROLLOVER%=TRUE%
19770 GOTO 19810
19790 ROLLOVER%=FALSE%
19810 RETURN
19830 '*********************STATUS LINE UPDATE SECTION*********************
19850 'ENTRY POINT
19870 LOCATE 23,1:PRINT "STATUS:"
19890 RETURN
19910 '******************END OF STATUS LINE UPDATE SECTION*****************
19930 '********************HELP SCREEN SECTION*******************************
19950 'ENTRY POINT
19970 CLS
19990 LOCATE 1,23
20010 PRINT "OZONE FLOW CONTROL SYSTEM HELP SCREEN"
20030 LOCATE 2,1
20050 PRINT "KEY#  DISPLAY   FUNCTION"
20070 LOCATE 3,1
20090 PRINT " 1    START     INITIATE ALL DATA ACQUISITION/CONTROL ACTIONS."
20110 LOCATE 4,1
20130 PRINT " 1    STOP      SUSPEND DATA ACQUISITION AND CONTROL."
20150 LOCATE 5,1
20170 PRINT " 2    RESET     RESET DAILY MINIMUMS AND MAXIMUMS."
20190 LOCATE 6,1
20210 PRINT " 3    FACE      DISPLAY ALL VALUES IN FACEPLATE FORMAT."
20230 LOCATE 7,1
```

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20250 PRINT " 4     LOG        LOG ALL VALUES TO PRINTER AT REGULAR INTERVAL."
20270 LOCATE 8,1
20290 PRINT " 4     NOLOG      DISCONTINUE LOGGING VALUES TO PRINTER."
20310 LOCATE 9,1
20330 PRINT " 5     STORE      STORE ALL VALUES TO DISK AT REGULAR INTERVAL."
20350 LOCATE 10,1
20370 PRINT " 5     NOSTORE    DISCONTINUE STORING VALUES TO DISK."
20390 LOCATE 11,1
20410 PRINT " 6     CONTRL     SET CONTROLLER SETPOINTS AND AUTO/MANUAL MODES."
20430 LOCATE 12,1
20450 PRINT " 7     DRIVE      CHANGE DATA STORAGE DRIVE ASSIGNMENT."
20470 LOCATE 13,1
20490 PRINT " 8     ASSIGN     ASSIGN CANOPIES,INPUT CHANNELS,ANALYZERS,ETC."
20510 LOCATE 14,1
20530 PRINT " 9     HELP       DISPLAY THIS SCREEN."
20550 LOCATE 15,1
20570 PRINT " 0     STATS      DAILY AND HISTORICAL STATISTICS PRINT OPTIONS"
20590 HELP%=FALSE%
20610 HELP%=FALSE%
20630 RETURN
20650 '*****************FUNCTION KEY RESPONSE SECTION************************
20670 'START FUNCTION RESPONSE.
20690 START%=TRUE%
20710 RETURN
20730 'RESET FUNCTION RESPONSE.
20750 CLRSCRN%=TRUE%
20770 'DISABLE ALL OTHER DISPLAY TYPES.
20790 FACEPLATE%=FALSE%
20810 ASSIGN%=FALSE%
20830 RETURN
20850 'FACEPLATE FUNCTION RESPONSE.
20870 FACEPLATE%=TRUE%
20890 'DISABLE ALL OTHER DISPLAY TYPES.
20910 CLRSCRN%=FALSE%
20930 ASSIGN%=FALSE%
20950 RETURN
20970 'SETPOINT MODIFICATION RESPONSE.
20990 SETPOINT%=TRUE%
21010 'DISABLE ALL OTHER DISPLAY TYPES.
21030 CLRSCRN%=FALSE%
21050 FACEPLATE%=FALSE%
21070 ASSIGN%=FALSE%
21090 RETURN
21110 'ENABLE ASSIGNMENT FUNCTION.
21130 ASSIGN%=TRUE%
21150 'DISABLE ALL OTHER TYPES OF DISPLAYS.
21170 CLRSCRN%=FALSE%
21190 FACEPLATE%=FALSE%
21210 RETURN
21230 'ENABLE LOGGING OF DATA TO PRINTER.
21250 PLOG%=TRUE%
21270 RETURN
21290 'ENABLE STORAGE OF DATA TO DISK.
21310 STORE%=TRUE%
21330 RETURN
21350 'DISABLE LOGGING OF DATA TO PRINTER.
21370 PLOG%=FALSE%
21390 RETURN
21410 'DISABLE STORAGE OF DATA TO DISK.
21430 STORE%=FALSE%
21450 RETURN
21470 'STOP KEY RESPONSE.
21490 'ENTRY POINT
21510 STOPPROG%=TRUE%
21530 RETURN
21550 'SET DRIVES KEY FUNCTION RESPONSE.
21570 DRVSEL%=TRUE%
21590 'DISABLE OTHER DISPLAYS.
21610 CLRSCRN%=FALSE%
21630 FACEPLATE%=FALSE%
21650 RETURN
21670 'STATS FUNCTION RESPONSE.
21690 STATS%=TRUE%
21710 RETURN
21730 'HELP KEY FUNCTION RESPONSE.
21750 HELP%=TRUE%
```

```
21770 'DISABLE OTHER DISPLAYS.
21790 ASSIGN%=FALSE%
21810 CLRSCRN%=FALSE%
21830 FACEPLATE%=FALSE%
21850 RETURN
21870 '***************END OF FUNCTION KEY RESPONSE SECTION*******************
21900 '***************JULIAN CALENDAR SUBROUTINE******************************
21910 'Entry point
21920 LYF=VAL(MID$(DATE$,9,2)) MOD 4
21930 IF LYF > 0 GOTO 21965
21940 FOR LOOP = 3 TO 12
21950 EOPM(LOOP)=EOPM(LOOP) + 1
21960 NEXT LOOP
21965 DATECK=TIMER
21970 MTH = VAL(MID$(DATE$,1,2))
21980 DAY = VAL(MID$(DATE$,4,2))
21985 IF DATECK >TIMER GOTO 21965
21990 JULDATE = EOPM(MTH) + DAY
22000 RETURN   ' back to idle loop
22100 '****************** STATISTICS SUBROUTINE *****************************
22110 CLS
22120 INPUT "TODAY'S STATS ONLY [Y orN]" ; RPLY$
22130 IF RPLY$ = "N" GOTO 22330
22140 LPRINT CHR$(12)
22150 LPRINT USING "OZONE STATISTICS FOR DAY ###"  ; JULDATE
22160 FOR LOOP% = 1 TO 45
22170 LPRINT CHR$(10)
22180 LPRINT "CHAMBER" ; LOOP%
22185 LPRINT "MEAN" ; O3AVG(LOOP%)
22190 LPRINT "SIGMA" ; SQR(O3VAR(LOOP%))
22210 LPRINT "MAX" ; MAXVAL(LOOP%)
22220 LPRINT "MIN" ; MINVAL(LOOP%)
22230 NEXT LOOP%
22231 FOR CNTRLR%=2 TO 4
22232 LPRINT CHR$(10)
22233 LPRINT "CONTROLLER"; CNTRLR%
22234 LPRINT "MEAN";CKAVG(CNTRLR%)
22235 LPRINT "SIGMA";SQR(CKVAR(CNTRLR%))
22236 LPRINT "MAX";CKMAX(CNTRLR%)
22237 LPRINT "MIN";CKMIN(CNTRLR%)
22238 NEXT CNTRLR%
22240 GOTO 22498
22330 INPUT "ENTER STARTING JULIAN DAY -- " , SJD
22340 LPRINT CHR$(12)
22360 FOR LOOP% = 1 TO 45
22363 LPRINT CHR$(10)
22365 LPRINT "HISTORICAL OZONE STATISTICS"
22366 LPRINT "          CHAMBER"; LOOP%
22367 LPRINT "  DAY  MEAN  SIGMA  MAX MIN"
22370 TENS= FIX(LOOP%/10) + 48
22380 UNITS= (LOOP% - (FIX(LOOP%/10)*10)) + 48
22390 PNT$ = CHR$(TENS) + CHR$(UNITS)
22400 OPEN DATADRIVE$ + "\O3STATS\MMMSD." + PNT$ FOR INPUT AS #2
22410 INPUT #2, JDAY,O3MEAN,SIGMA,O3MAX,O3MIN
22420 IF JDAY<SJD GOTO 22410
22430 LPRINT USING " ###, ###.#,  ##.#,###, ##" ; JDAY,O3MEAN,SIGMA,O3MAX,O3MIN
22432 IF EOF(2)=-1 THEN GOTO 22437
22435 GOTO 22410
22437 CLOSE #2
22440 NEXT LOOP%
22450 FOR CLP%=2 TO 4
22452 LPRINT CHR$(10)
22454 LPRINT "HISTORICAL CONTROLLER STATISTICS"
22456 LPRINT "        CONTROLLER"; CLP%
22458 LPRINT "  DAY  MEAN  SIGMA  MAX MIN"
22460 UNITS = (CLP% - (FIX(CLP%/10)*10)) + 48
22462 PNT$ = CHR$(UNITS)
22464 OPEN DATADRIVE$ + "\O3STATS\MMMSD.C" + PNT$ FOR INPUT AS #2
22466 INPUT #2, JDAY,CKMEAN,CKSIG,MAXCK,MINCK
22468 IF JDAY < SJD GOTO 22466
22470 LPRINT USING " ###, ###.#,  ##.#,###, ##" ; JDAY,CKMEAN,CKSIG,MAXCK,MINCK
22472 IF EOF(2)=-1 GOTO 22476
22474 GOTO 22466
22476 CLOSE #2
```

```
22478 NEXT CLP%
22498 STATS%=FALSE%
22499 RETURN
22500 '********************CONTROL EVALUATION**********************************
22510 IF SETPNTTYPE(CONTROLLER%)=BIAS% GOTO 22530
22520 CNTRLCK(CONTROLLER%)=VALUE(CONTRLPNT%(CONTROLLER%))/AMBOZONE(CONTROLLER%)
22525 GOTO 22540
22530 CNTRLCK(CONTROLLER%)=VALUE(CONTRLPNT%(CONTROLLER%))-AMBOZONE(CONTROLLER%)
22540 IF CNTRLCK(CONTROLLER%) > CKMAX(CONTROLLER%) THEN CKMAX(CONTROLLER%) =
      CNTRLCK(CONTROLLER%)
22550 IF CNTRLCK(CONTROLLER%) < CKMIN(CONTROLLER%) THEN CKMIN(CONTROLLER%) =
      CNTRLCK(CONTROLLER%)
22560 CKCNT(CONTROLLER%) = CKCNT(CONTROLLER%) + 1
22570 CKVAR(CONTROLLER%) = (CKCNT(CONTROLLER%)-1) * CKVAR(CONTROLLER%) / CKCNT(CONTROLLER%)
       + (CKAVG(CONTROLLER%)-CNTRLCK(CONTROLLER%))^2 * (CKCNT(CONTROLLER%) - 1)
       /CKCNT(CONTROLLER%)^2
22580 CKAVG(CONTROLLER%) = (CKCNT(CONTROLLER%)-1)*CKAVG(CONTROLLER%)/CKCNT(CONTROLLER%)
       + CNTRLCK(CONTROLLER%)/CKCNT(CONTROLLER%)
22590 RETURN ' to Control & Output Section
22600 '********************END OF PROGRAM**************************************
```

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