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MODEL 200 AC/DC AIR SAMPLER

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MODEL 200 AC/DC AIR SAMPLER

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ABSTRACT

The Model 200 AC/DC air sampler is a completely portable, compact instrument for the qualitative detection of radioactive gases in the atmosphere. It is used in this Laboratory primarily for the detection of tritium in the air in concentrations greater than $50 \mu\text{Ci}/\text{m}^3$. The operation, maintenance, and performance in the field of the air sampler are described.

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INTRODUCTION

The purpose of this paper is to present a reasonably comprehensive discussion of the use and care of the Model 200 AC/DC air sampler. This instrument is intended to replace the Model 101 tritium sniffer which has been in use at this Laboratory for many years.¹ Many improvements have been built into this new air sampler although the instruments are essentially the same electronically. The new instrument can be operated as a portable unit (DC) or it can be used as an in-place monitor (AC). The rechargeable batteries provide a big advantage in lower cost and lighter weight. The replacement of a selector sensitivity switch with a 4-decade logarithmic response circuit eliminates range changing. In the field where laborious monitoring is required, the Model 101 was heavy and had a history of "knee gouging" by sharp corners. The Model 200 AC/DC reduces the weight of the instrument by half and has a case with rounded corners.

The operator of this instrument should recognize that its primary purpose is the qualitative detection of radioactive gases in the atmosphere. Low-level concentrations of less than 50 $\mu\text{Ci}/\text{m}^3$ of tritium water vapor are not detectable with this air sampler.

GENERAL DESCRIPTION

The Model 200 AC/DC air sampler (Fig. 1) is completely portable and compact, allowing ease of handling. It can be run constantly for 4 hours as a DC unit without a significant

¹Eutsler et al., Instruments for the Monitoring of Tritium in the Atmosphere, LA-1909, 1955.

Figure 1. Model 200 AC/DC Air Sampler.

change in blower battery power or it can be used as an in-place monitor by plugging it into a 110-volt outlet.

The detector system is contained internally and consists of a 300-cc ion chamber that is sensitive both to ions produced inside the chamber and to ions produced outside and drawn into it.

A. No ion trap was built into this sampler because this reduces the immediate response of the detector, and for practical purposes instant alarm is highly desirable. More sophisticated instruments are available for low-level continuous monitoring. The air is circulated through the chamber at the rate of 3 cubic feet per minute. When the sampler is operated from 110 volts AC, line voltage variation from 90 to 130 volts produces air flow of from 2.8 to 3.6 cubic feet per minute. When the sampler is used as a DC unit, the blower is powered by rechargeable nickel-cadmium batteries.

B. Eighteen Model 200 AC/DC instruments were calibrated to known concentrations of tritium water vapor and the results summarized in Fig. 2. The response to tritium gas was essentially the same. The logarithmic 4-decade meter presents a reading of $54 \mu\text{Ci}/\text{m}^3$ to $2.8 \times 10^6 \mu\text{Ci}/\text{m}^3$ for tritium concentrations. Since tritium HTO is the most hazardous form, Chart I was prepared to serve as a guide to the user of the instrument.

OPERATION

As a portable DC unit, the Model 200 AC/DC air sampler is completely battery operated. To use as an AC instrument, plug it into a 110-volt line. Operation in either mode is as follows.

1. Turn meter function switch in right-hand corner to WARM--allow 2 minutes.
2. Turn meter function switch to ZERO and adjust lower left "zero" switch so that meter pointer is at 0.
3. Turn meter function switch to RUN.

Figure 2. Instrument Sensitivity to Tritium Water Vapor.

CHART I

HTO Conversion

<u>Meter Reading</u>	<u>$\mu\text{Ci}/\text{m}^3$</u>
0.02	54
0.05	135
0.1	280
0.2	560
0.5	1,400
1	2,800
2	5,800
5	14,500
10	28,800
20	58,000
50	150,000
100	280,000

STAY TIME

$$\frac{200}{\mu\text{Ci}/\text{m}^3} = \text{hr per 40-hr week}$$

4. Turn blower on.
5. The meter covers 4 decades; use conversion chart for concentration of HTO when monitoring for tritium.
6. The alarm can be set to the desired level by turning the black knob on the face of the meter, which moves the red hand on the meter face.
7. Check the alarm by moving the red hand down scale until it meets the black hand. This trips the alarm mechanism (buzzer) which continues to sound until the reset button is pushed. This is a latching device, and if the alarm fails entirely or if the red and black hands fail to latch together, the 90-volt battery is probably bad.

The person using this instrument should become familiar with the meter reading when the meter function switch is set to RUN. This reading varies slightly between instruments.

Establish a meter reading for a check source such as zirconium-tritium. Once set, this should not vary appreciably if the instrument is operating correctly.

CIRCUIT DESCRIPTION

The circuit used to measure the currents from the ion chamber is an adaptation of the Neher-White "floating grid" detector. The heart of the circuit is the type-5886 electrometer tube which is essentially a logarithmic current amplifier. In this application, the input currents from the ion chamber range from about 5×10^{-13} to 10^{-9} amperes.

Proper design of the electrometer stage requires:

1. Conventional Ep-Ip curves for the tube used,
2. Ep-Ip characteristics with a high-megohm resistor in the grid and no external bias applied, and

3. E_g - I_g characteristics, determined by drawing known grid currents and finding E_g from the curves of step 1.

From step 2 above, one can bias the electrometer for a zero-grid-current operating point as a "zero" from which to start. From this point, for about 7 decades, the E_g - I_g characteristic is logarithmic by virtue of the log diode effect resulting from grid current drawn. In the present application, essentially all of the ion chamber current is drawn through the grid and the resulting grid voltage change is sensed by measuring the plate current.

Unfortunately, electrometer tube characteristics are not uniform, and the circuit configuration must be flexible to allow "fitting" of a random tube to the specific input-output requirements of the complete instrument. Potentiometer R-106 (see Fig. 3) provides the zero-grid-current operating point. The "zero" pot adjusts a bucking current into the metering circuit for cancellation of quiescent plate current. The "slope" pot shunts the meter and controls the overall sensitivity of the metering circuit. Since there is interaction among all three controls (especially between R-106 and the "zero" pot), the initial setup is quite tedious and the calibration procedure is detailed under Maintenance. Only one of the controls, the "zero" pot, is intended for operation adjustment. This allows for correction of instrument drifts between routine service inspections.

The polarizing voltage for the ion chamber is furnished by the 90-volt battery (BT 101). Since it is practical to ground the outer wall of the chamber, the entire electrometer circuit is "floated" 90 volts below ground. For this reason the service instructions dictate that the 90-volt battery be disconnected first and reconnected last.

The blower capacity (flow rate) is compatible with chamber voltage and chamber dimensions to allow complete sweep-out of ions formed in the chamber as the air passes through. The filtering network for the blower motor is required to minimize motor brush sparking and the resulting effect on the electrometer circuit.

Figure 3. Schematic Diagram of Model 200 AC/DC Air Sampler.

The plate-current meter relay has a continuously adjustable contact set point for activation of the alarm buzzer. The contact has a low current rating from 5 to 25 milliamperes, so a separate relay (K-101) must be used to operate the buzzer. The chamber polarizing battery (90-volt) is used to operate this relay; if it were not for the relatively high current needed to operate this relay, a much smaller 90-volt battery could have been used.

The rechargeable Nicad batteries furnish blower motor and alarm power when the instrument is DC operated. When the instrument is AC operated, these batteries automatically begin recharging, and relay K-102 connects the blower and alarm circuits to the simple line-operated supply.

The "Battery Indicator" shows the condition of tube filament batteries. Life of these batteries is about 1400 hours. The circuit is designed so that these batteries discharge before any of the other nonrechargeable batteries (unless an alarm period of 50 hours or more drains the 90-volt battery). Therefore, a significant show of white on this indicator signals need for replacement of BT 101-105, inclusive.

MAINTENANCE

A. Current Calibration

1. Place instrument on its feet.
2. Remove air inlet snout. Blower should be turned off.
3. Screw current calibrator (Figs. 4 and 5) into air intake.
4. Set meter function switch to ZERO and set zero with "zero" adjust pot. Calibrator switch position has no effect when meter function switch is on ZERO.
5. Set meter function switch to RUN.
6. Set current calibrator to 10^{11} and adjust "slope" pot so that meter reads full scale.

Figure 4. Current Calibrator.

Figure 5. Schematic Diagram of Current Calibrator.

7. Recheck zero set (step 4).
8. Set current calibrator to 10^{13} . Let it settle down about 2 minutes. Adjust bias pot (R-106) for a meter reading of 0.9. Readings should be made with the case closed as electrometer tubes are light sensitive.
9. Recheck zero set (step 4) and adjust.
10. Recheck full-scale reading (step 6) and adjust if necessary.
11. Recheck 0.9 meter reading (step 8) and adjust. Let it settle down about 2 minutes.
12. Repeat above steps until satisfactory readings are obtained.
13. Check meter reading with calibrator set to 10^{12} . Reading should be approximately 9.5.
14. Check meter reading with calibrator set to zero. Reading should not exceed 0.04. Let it settle down about 2 minutes.
15. Remove current calibrator. Replace air inlet snout.
16. Check meter reading with meter function switch set to RUN, with no source. Reading should not exceed 0.03. If reading exceeds 0.03, a thorough cleaning is necessary.

As a further check, a properly operating instrument (with the blower off) will give a meter reading of 1 when exposed to 750 ± 75 mR/hr gammas from a Co^{60} source. Check that meter reacts when brought close to gamma source.

If the above procedure cannot be followed, the instrument needs repair such as cleaning or replacement of parts. For a list of replacement parts see Fig. 6.

<u>Part No.</u>	<u>No. Req'd.</u>	<u>Name</u>	<u>Description</u>
R-101	1	Resistor	2.7 Ohms 1 watt A.B. 5%
R-102	1	"	100K " $\frac{1}{4}$ " " "
R-103	1	"	200K " " " " "
R-104	1	"	10 ¹² " Victoreen Type RX-1
R-105,114	2	"	100 " $\frac{1}{4}$ watt A.B. 5%
R-107	1	"	2K " " " " "
R-108	1	"	15K " " " " "
R-110	1	"	470 " " " " "
R-112	1	"	10K " " " " "
R-113	1	"	5.1K " " " " "
R-115,116	2	"	2.2 " $\frac{1}{2}$ " Speer 10%
R-106	1	Potentiometer	50 " Allen Bradley Type L
R-109	1	"	50K " " " "
R-111	1	"	2.5K " " " "
C-101	1	Capacitor	.02 μ F 500V. Cer. Disc.
C-102,105	2	"	.47 " 25V. " "
C-103	1	"	2000 " 15V. Electrolytic
C-104	1	"	6.8 " 35V. Tantalum
C-106,107	2	"	100 " 25V. "
J-101	1	Connector	Minia Jack Sealelectro #Skt 8
P-101	1	"	" " " #PR 300
P-103	1	"	3 Wire Male Plug #160-5 Amphenol
I-101	1	Indicator	EMI Mod. 801
I*102	1	"	Buzzer Edwards #15 Size 2
E*101	1	Meter-Relay	Assembly Products Mod. #261-C 0-20 UA.
S-101	1	Switch	SPST Toggle LASL Stock No. EE4996
S-102	1	"	4 Pole 4 Pos. Centralab #PA-300 Assemble with 2 #PA-2 Sections
S-103	1	"	SPST Push Button Acro # 4DC5-5P
T-101	1	Transformer	Stancor P-6134
V-101	1	Tube	5886
BT-101	1	Battery	90V. #N60 Burgess
BT-102,103	2	"	1.34V. RM42R Mallory
BT-104	1	"	1.34V. RMLR "
BT-105	1	"	4V. TR133R "
BT-106,107,108	3	"	2.75V. Gould Nicad Type FC-23
B*101	1	Blower	Special Globe Type C19A544
K-101	1	Relay	22 JNCC 5000G Sigma
K-102	1	"	22 JNCC 500G Sigma
CR-101-104	4	Rectifier	1N1342
D-101	1	Diode	1N2484

Figure 6. Parts List for Model 200 AC/DC Air Sampler.

NOTE: 1. Instability can be caused by an erratic electrometer tube. These tubes must be aged for several hours to assure stable operation.

2. Occasionally the ion chamber becomes tritium contaminated and calibration is impossible. In this case remove the ion chamber (see below), place it in a large beaker of distilled water, and evaporate to dryness. This must be done in a hood. This effectively decontaminates the ion chamber.

B. Chamber Removal and Cleaning Procedure (Refer to Figs. 7 and 8)

1. Disconnect 90-volt battery.
2. Remove air inlet snout.
3. Remove exhaust screen.
4. Disconnect motor cover by removing knurled nut and disconnecting motor wires. Pull jack (white) from resistor panel mounted on the back of meter. Pull metal cover free, being careful not to pull the wires. Do not pull the wires through the grommet in the motor cover.
5. Release fastener of chamber-holding strap. Completely disengage ends of strap.
6. The chamber is fastened to its base by friction fit. Remove the chamber by gently working it toward the motor end.
7. Clean the parts with trichloroethylene or any good solvent. Follow this with alcohol to remove the solvent residues. Be sure to thoroughly clean and dry the Teflon chamber base to eliminate leakage paths.

Figure 7. Disassembly for Cleaning. A. 90-volt battery (BT 101); B. air inlet snout; C. exhaust screen; D. motor cover; E. motor; F. resistor panel; G. chamber; H. Teflon chamber base.

Figure 8. Model 200 AC/DC Block Diagram. (a) Inside cover half (b) Inside lower half.

8. Replace in the reverse order of removal.

NOTE: Align air inlet holes in instrument case and chamber wall. The long slot allows the chamber to be removed and replaced without bending the collection rod.

C. Battery Replacement

1. The three rechargeable Gould Nicad batteries should not have to be replaced unless they fail to take a charge. To remove these batteries, first remove the two screws (under the case) holding the battery assembly. Any battery can then be removed from the assembly by removal of the molded end caps.
2. All five nonrechargeable batteries should be replaced at the same time. Do not overlook the mercury battery located in the lid of the instrument. The "Battery Indicator" on the front of the instrument shows white when the batteries need replacing. The red coding on the battery clips indicates the positive end of batteries. Always remove the 90-volt battery first, and replace it last.