

Handout

Visible Emission Enforcement Workshop

Smoke Generator Trouble Shooting Guide

by

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INTRODUCTION

Today's smoke generator is a technical, state-of-the-art, combination mechanical and electronic instrument, and certain precautions must be followed in its handling and storage. The electronic console must be stored **in** a heated warehouse or laboratory environment when not in actual operation. The electrical interconnect cables should be stored either in the generator storage **compartments or with** the console. The smoke generator **trailer** can be stored outdoors but it is preferable to store it in a warehouse or garage. If the trailer is stored outdoors, the stack **transmissometer. section must** have a waterproof cover. A tarpaulin covering the entire generator may be used, but care must be taken to avoid putting stress on the stack fans **or** the transmissometer **electrical** connections.

The generator is durably designed for field use and portability. However, like all things mechanical, the generator sometimes will break down. In this event, a supply of spare parts is the best solution. If no spare parts are available, some of the field procedures in this guide may enable the class to proceed.

The operation of the generator should be entrusted only to individuals who will treat it with the proper respect. Improper operation or handling is the cause of most problems encountered with a smoke generator. **Attempting** to "force" the generator and overheating the combustion chamber **or** the vaporizer can cause **permanent**

internal distortion, and result in unstable smoke production and/or reduced opacity capability. Once severely damaged, a major overhaul is usually required to correct the problem. Even the simple act of placing a waterproof cover over the console if it rains during a certification run can save hours of frustration and "down time" and should not be overlooked.

The electrical lines and fuel lines should all be handled **with** care. Damaged lines or improper connections can result in unstable performance and cause considerable frustration to operator and participants alike. The valves on the control console are metering valves not shut-off valves and should never be closed extremely tight.

Last, but by no means least, each of the systems discussed in this guide require a reasonable warm-up time prior to routine operation. Overlooking this fact can cause unnecessary problems with the generator and delays in conducting a smoke school.

TROUBLE SHOOTING

The modern smoke generator has several "component systems" combined into a single unit. Together they provide the capability of producing black and white **smoke** plumes in opacities from zero to one hundred percent. They also have the ability to reliably measure and record the opacities of these plumes as produced. It is impractical to attempt discussing all the systems at the same time. The most logical approach as used below is to deal with each system individually. The systems to be discussed and the order in which they will be presented are as follows:

Electrical power supply
Fans and **Blower**
Electronics - Transmissometer, Recorder, etc.
Fuel Delivery system
Black Smoke system
White Smoke system.

ELECTRICAL POWER SUPPLY

<u>Problem</u>	<u>Possible Cause & Remedy</u>
No electricity to console.	<ol style="list-style-type: none">1. Check to see if console is plugged in.2. Check electric cord connections to see that they are firmly made.3. Check ground fault interruptors and/or circuit breakers.4. Check connectors on extension cords to see that they are in good condition.

Problem (Continued)

Possible Cause & Remedy (continued)

Electricity reaches console
but not other **components**.

5. Check for cuts or breaks in extension cord and power supply cord.
6. Use VOM meter to measure each section at its junction with the next to isolate problem.
1. Check switches to see that they are turned on.
2. Check the fuses in **the** console.
3. Check the electrical interconnect cords for proper and tight hook up.
4. Check the electrical interconnect **cords** for damaged or broken spots.
5. Check systematically through the system with a VOM meter to see if problem can be isolated.

Electricity reaches console
and components but voltage
is low.

1. Check electrical supply for adequacy at source - if inadequate find another source.
2. If source is **adequate but voltage** drops before reaching console 'use a larger guage wire or a shorter extension cord or both.

FANS AND BLOWER

Stack fans not running.

1. Is main power switch on console' turned on?
2. Is fan switch, if present, turned on?
3. Have **electrical** interconnect cords been properly hooked up and tightened?

Problem (continued)

Possible Cause & Remedy (continued)

- | | |
|--|---|
| Stack fan running but not up to speed. | <ol style="list-style-type: none">4. Check for broken or damaged wires where exposed.5. Check for physical damage or obstructions - bent housing, lodged sticks or twigs, wasp nests, etc.6. Check to see if fans can be rotated by hand without dragging on housing.7. If fan turns freely by hand, and sufficient power is reaching fan motor and fan will not run a burned out motor is indicated. Replace fan. |
| Main blower or induced draft fan blower not running. | <ol style="list-style-type: none">1. Check to see if it is dragging on housing or is otherwise obstructed.2. Check electrical connections.3. Check to see if fan rotates freely by hand - if not and fan is not dragging bad bearings are indicated replace fan.4. Use VOM meter to see if voltage is adequate. If not see low voltage procedures under electrical supply section.
<ol style="list-style-type: none">i. Check console to see that main power switch and main blower switch are both turned on.2. Check electrical interconnect lines for tightness and for possible damage.3. Use VOM meter to check for adequate electrical supply to motor.4. Check supply connections at motor to verify good contacts. |

Problem (continued)

Possible Cause & Remedy (continued)

- Blower running but not up to speed.
5. If adequate electrical supply is reaching motor some type of internal short is indicated * have motor repaired or replace.
 1. Check for external damage or shaking loose which might cause misalignment of motor and blower.
 2. Use VOM meter to see if voltage is adequate. **If** not see low voltage procedures under electrical supply section.

ELECTRONICS - TRANSMISSOMETER & RECORDER

The transmissometer is composed of a light source and a photocell with interconnect lines to transmit power to the light source and the signal **from** the photocell. The signal from the photocell goes to the ten-turn pots on the console and then to the recorder. The signal is then simply converted to the input to the drive mechanisms of the recorder. This produces the response of the recorder indicator. If there is a digital component in the readout system an inverter for the signal from the photocell will also be included.

If a problem exists and the operator has determined by checkout that the problem is internal to the recorder **DO NOT ATTEMPT REPAIRS**. Substitute an alternate recorder or readout device for a check or expediency or contact the generator **manufacturer** . Repairs to the recorder should be attempted only by the generator manufacturer or by an instrument service company.

Problem

NO readout from
transmissometer

Possible Cause & Remedy

1. Check electric power supply cord to verify that it is **properly** connected.
2. Check all appropriate switches to see that they are turned on - main power, transmissometer, recorder, etc.
3. Check for blown fuses on the console.
4. Check electrical interconnect lines to ensure proper and tight connections.
5. Check light source for a burned out bulb.
6. Check recorder to verify that it is set on 10 millivolts.
7. Check for possible physical obstructions between light source and photocell.
8. Check interconnect lines very carefully for a **possible** broken wire.
9. If generator has been **exposed** to rain or other wetness check junction boxes for moisture and possible shorts.
10. If light source is not burned out but appears dim: a) check voltage to light source with a VOM meter, b) replace light source with a stronger (brighter) bulb.
11. Using a sensitive digital VOM meter check the **output** of the photocell.
12. If photocell **output** is adequate check the output **from** the ten turn pot. This will check the **performance** of the pot.

Problem (continued)

Possible Cause & Remedy (continued)

Readout is jittery

13. If the output from the pot is adequate, a problem with the recorder is indicated.
 14. If the problem is in the recorder and cannot be corrected by external adjustments, contact the generator manufacturer. A digital volt meter may be substituted temporarily in an emergency situation.
-
1. Check all interconnect lines for tight connections.
 2. Check interconnect lines for possibly damaged wires.
 3. Check to see if equipment has had sufficient warm-up time.
 4. Check possibility **of** ambient light reaching photocell.
 5. Check power supply to light source for proper voltage and fluctuations with a VOM meter.
 6. Check power supply to readout device for proper **voltage** with a VOM meter.
 7. Check input connections at the recorder for a dampening capacitor. If there is not one present install one rated between **150** ME and 250 MF. Be sure to keep the positive and negative poles correctly aligned.
 - a. Check the junction boxes on **the** trailer for a possible loose **wire** or snort.
 9. **Check** recorder to verify that it is operating on 10 **MV** range.

Problem (continued)

Possible Cause & Remedy (continued)

Readout is stable but not adequate for a span.

1. Check the recorder to ensure it is operating at 10 millivolts.
2. Check the light source for proper voltage and light intensity. If voltage is correct but light appears dim, replace light source with a stronger (brighter) bulb.
3. Check the **photocell** for aging or deterioration. This is normally a gradual process rather than an abrupt change. This can best be accomplished by use of a sensitive digital VOM meter.

Unable to adjust readout.

1. Check the recorder to ensure it is operating at 10 millivolts.
2. Check the adjustment of both 10 turn pots to ensure that one is not over-riding the other.
3. Check connection at pots to ensure their integrity.
4. Check the pots for damage or wear and replace as necessary.

FUEL DELIVERY **SYSTEM**

The fuel delivery system of the modern smoke generator consists of two essentially parallel systems. One is for white smoke and the other is for black smoke. Generally both are subject to the same problems. Therefore, we will discuss them simultaneously. The components of the fuel delivery system are:

1. Fuel reservoir (usually a 5 or 6 gallon tank).
2. Fuel interconnect lines to "pick up" the fuel **from** the reservoir and transport it to the console containing the **pumps**.

3. Fuel pumps (one for each fuel) which operate on 12 volts DC current and are the heart of the fuel delivery system.
4. A 12 volt DC current supply which converts the 120 volt AC current to the 12 volt DC required by the pumps.
5. Fuel interconnect lines to transport **the** fuel from the pumps in the console and "deliver" it to the "convenience" connections on the rear of the generator trailer.
6. Trailer mounted delivery lines are copper tubing which transport the fuel from the convenience connections at the rear of the trailer to **the** combustion chamber for black smoke and the vaporizer for white smoke.
7. The combustion **chamber** and the vaporizer each contain their respective final section. These are metal delivery tubes several inches long. They are selectively sized, shaped and placed for their specific application. They deliver the fuel to the exact place for combustion and vaporization.

A major problem with any one of the fuel delivery system components can have the effect of disabling the entire system. Therefore, we will pose one problem and trace through the system to try and correct it. Each major component will be discussed in turn and appropriate corrective procedures given.

Problem: NO FUEL TO COMBUSTION **CHAMBER** OR VAPORIZER

1. Verify that main power and fuel pump switches are on.
2. Verify that the appropriate fuel pump is running - listen for sound or feel for vibration. If pump is running, proceed to step 3. If pump is not running, proceed to step 11.
3. Check fuel **reservoirs** for an adequate **supply** and insure that pick-up line is submerged far enough for good pick up.
4. Check for disconnected, broken or crimped supply lines.

5. Check for loose connections or leaks. See if fuel can be observed flowing through flexible lines. IF BUBBLES ARE VISIBLE PROCEED TO STEP 15.
6. Make sure that fuel reservoir container has its vent open to allow air to replace the fuel removed.
7. If the problem has not been found by this time, turn off the fuel pump. Very carefully disconnect the line in question at the rear of the trailer. Turn on pump briefly and check for fuel flow. If fuel flows smoothly at this point, proceed to step 8. If fuel does not flow, proceed to step 9. IF FUEL FLOW IS ERRATIC PROCEED TO STEP 16.
8. Reconnect fuel line at the rear of the trailer. Exercising extreme caution - especially if equipment is hot - disconnect fuel line at last coupling before it enters the combustion chamber or vaporizer. Check for fuel flow. If fuel flows at this point, the problem is most likely carbonized fuel in the final section of the delivery line. Carefully remove the appropriate section and clean it out or replace it. if fuel does not flow at this point but does flow at step 7, proceed to step 10.
9. If fuel cannot be pumped through the delivery line when disconnected at the rear of the trailer, the problem is before that point. Work backwards one step at a time to locate the problem. After checking the fuel lines to ensure their integrity and proper connections, check the pump to see if it is pumping fuel. See step 12.
10. The fuel delivery lines between the combustion chamber and the rear of the trailer and between the vaporizer and the rear of the trailer are copper tubing. On rare occasions these will get crimped or crushed and prevent fuel flow. If so, replacement of the entire section is the best procedure from a safety standpoint. However, one may replace only the crushed portion if desired. The appropriate swagelock or other sealing fittings should be used.
11. If the fuel pump is not running and the switches are on, check the console for a blown fuse. If the fuse is good, check the electric supply (12 volts DC) at the rear of the console with a VOM meter. If the electric supply for the pumps is adequate and the

pump is properly connected but still will not run, an internal short in the motor is indicated. Repair or replace the pump. If the electric supply is turned on but does not supply electricity see step 14. For emergency only see step 13.

12. If the fuel pump is running but not pumping fuel, a ruptured diaphragm is indicated. A repair kit for the fuel pump can be obtained and this part rebuilt. For emergency only, see step 13.
13. If a fuel pump goes down in the field and replacement or repair is not feasible, the one remaining fuel pump can be used for both the white smoke and black smoke systems. This will necessitate disconnecting the fuel lines for one system and connecting the lines for the other system alternating as needed.
14. On rare occasions the 12 volt DC electric supply which provides electricity to the fuel pumps may fail. If so, replacement is usually the best procedure. In an emergency, an auto battery or other similar 12 volt DC supply can be substituted for short periods of time.
15. (a) Bubbles in fuel lines may occur when the generator is first set ~~in~~ due to fuel draining out of the interconnect lines. Operate the generator at about 30% opacity for either black or white smoke for a period of time adequate to clear the lines.
(b) If the bubbles are very small and persist for more than a few minutes they may be forming at a loose connection by aspiration or at the fuel pump by cavitation. Tighten all fuel line connections. Vary the flow through the pump by opening and closing the fuel valve.
(c) If the small bubbles appear to be developing at the fuel pump, are almost constant and cannot be eliminated by tightening and adjustment a problem with the fuel pump diaphragm is indicated. This can be corrected by use of a fuel pump repair kit.
16. (a) If the fuel flow fluctuates without adjusting the control valve, check to see if the pump speed varies. If the speed varies, check the electrical supply and the fuel supply in the reservoir.
(b) Check the control valve on the console for trash in the valve. Carefully take the valve apart and clean with cotton tipped cleaners. Be careful to avoid damage to the valve. The valves should be checked periodically.
(c) If pump speed is fairly constant and valves are clean and fuel flow is erratic, a problem with the

fuel pump diaphragm is indicated. Purchase a repair kit and service the **pump**.

BLACK SMOKE SYSTEM

This discussion assumes that the induced draft fan is working properly and that there are no problems with fuel supply. Corrective measures for these **items** have been discussed in their respective sections.

Problems

Possible Cause & Remedy

Fire goes out in combustion **chamber** at low opacities.

1. Check propane ignition torch to verify that it is burning.
2. Check fuel pan to verify its integrity - is it severely bent, warped or burned out?
3. Check for a small piece of brick or small amount of rubble in fuel pan to act as a wick.
4. Check air directional vanes on combustion chamber grill to ensure they are adjusted for proper air flow.

Unable to stabilize smoke.

NOTE: Smoke will not be stable with erratic fuel **supply**. See procedures for this problem under Fuel Delivery System.

1. Check air directional vanes on combustion chamber grill to ensure **adjustment** for proper air flow.
2. Check damper in mixing chamber between combustion chamber and induced draft fan. It should be adjusted so there is not too **much** air passing through the combustion chamber - approximately at a **45°** angle.
3. Check position of trailer to ensure that a stiff breeze is not blowing directly into the combustion chamber grill or the open end of the mixing chamber.

Problems (continued)

Possible Cause & Remedy (continued)

4. Check the fuel reservoir for water or other contaminants. Impurities result in erratic burning rates.
5. Check the inside of the combustion chamber for severe heat distortion. If this is the cause an extensive rebuilding **or** replacement of the combustion **chamber** is indicated.

WHITE SMOKE SYSTEM

This discussion assumes that the induced draft fan is working properly and that there are no problems with fuel supply. Corrective measures for these items have been discussed in their respective sections.

Problems

Possible Cause & Remedy

Vaporizer floods.

1. Check the vapor delivery pipe for adequate heat where it exits the vaporizer. This is most **easily** done by applying a few drops of water **from** a laboratory squeeze bottle. The water **drops** should vaporize immediately and not boil on the surface of the pipe.
2. Check warm-up time. The vaporizer requires several minutes to **reach** proper temperature. It will require slightly longer in cold weather.

Problems (continued)

Possible Cause & Remedy (continued)

- | | |
|---|---|
| | <ol style="list-style-type: none">3. Check adjustment of flame from propane torch to ensure it is adequate for heating the vaporizer but not so high as to cause combustion in the far end of the vaporizer. A "mushrooming" or "drumming" flame is too high.4. Check the distance between the tip of the propane nozzle and the air intake port of the vaporizer. Correct spacing is required (approximately one-half inch) for proper performance.5. Check alignment of torch with intake port.6. Check for adequate air flow through the vapor delivery pipe inside the mixing chamber. A build-up of soot or other particulate matter will reduce the air flow through the vaporizer. If clogged, remove the vapor delivery pipe and clean it out with a device to remove the residue such as a 12 guage shotgun bore brush. |
| <p>Unable to adjust propane torch flame properly.</p> | <ol style="list-style-type: none">1. Check all connections for tightness.2. Check supply of propane fuel.3. Make certain main valve on propane cylinder is opened sufficiently.4. Check the adjustment valve by feeling of it. If it is extremely cold, it may be "freezing up" due to the expanding gas. Heat it up carefully - a small portable propane torch may be used if extreme caution is exercised. |

Problems (continued)

Possible Cause & Remedy (continued)

Insufficient draft through
vaporizer.

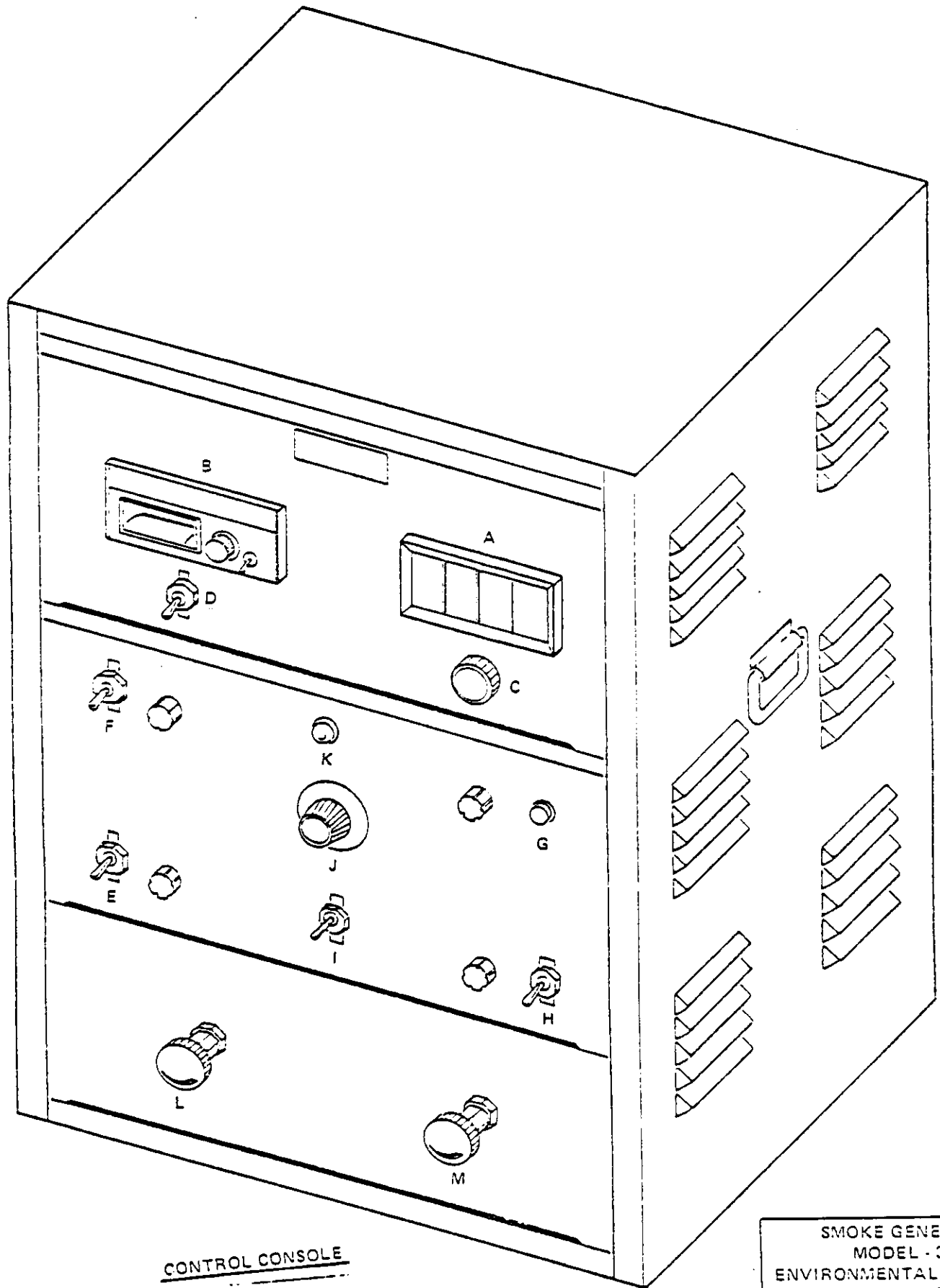
5. If the main valve on top of the propane tank is opened too fast after a period of storage, the internal safety mechanism may close and prevent the flow of propane. A **click** may be heard if **this** occurs. **Reclose** the **valve** and open it again very slowly
 6. Check the distance between the tip of the torch and the heat/air intake port **on** the **vaporizer**. This distance should be approximately one-half inch.
 7. Check alignment of torch with intake port.
1. **Check** position of damper in mixing chamber. It can be adjusted to pull more air through the vaporizer by closing off the air flow in the mixing chamber somewhat
 2. Check the delivery pipe from the vaporizer for build up of soot and other particulate matter. This will reduce the air passage through the vaporizer. If clogged, remove the vapor delivery pipe and clean it out.
 3. Check the vaporizer chamber itself for any type of physical obstruction.
 4. Check operation of the main blower **for** adequate air flow. Some older model smoke generators equipped with **a** 1/2 hp motor and paddle wheel type blower blades do **not**, develop, in **some** cases, sufficient air flow to accommodate a propane operated white smoke vaporizer.

problems (continued)

Flame up in vaporizer.

Possible Cause 6 Remedy (continued)

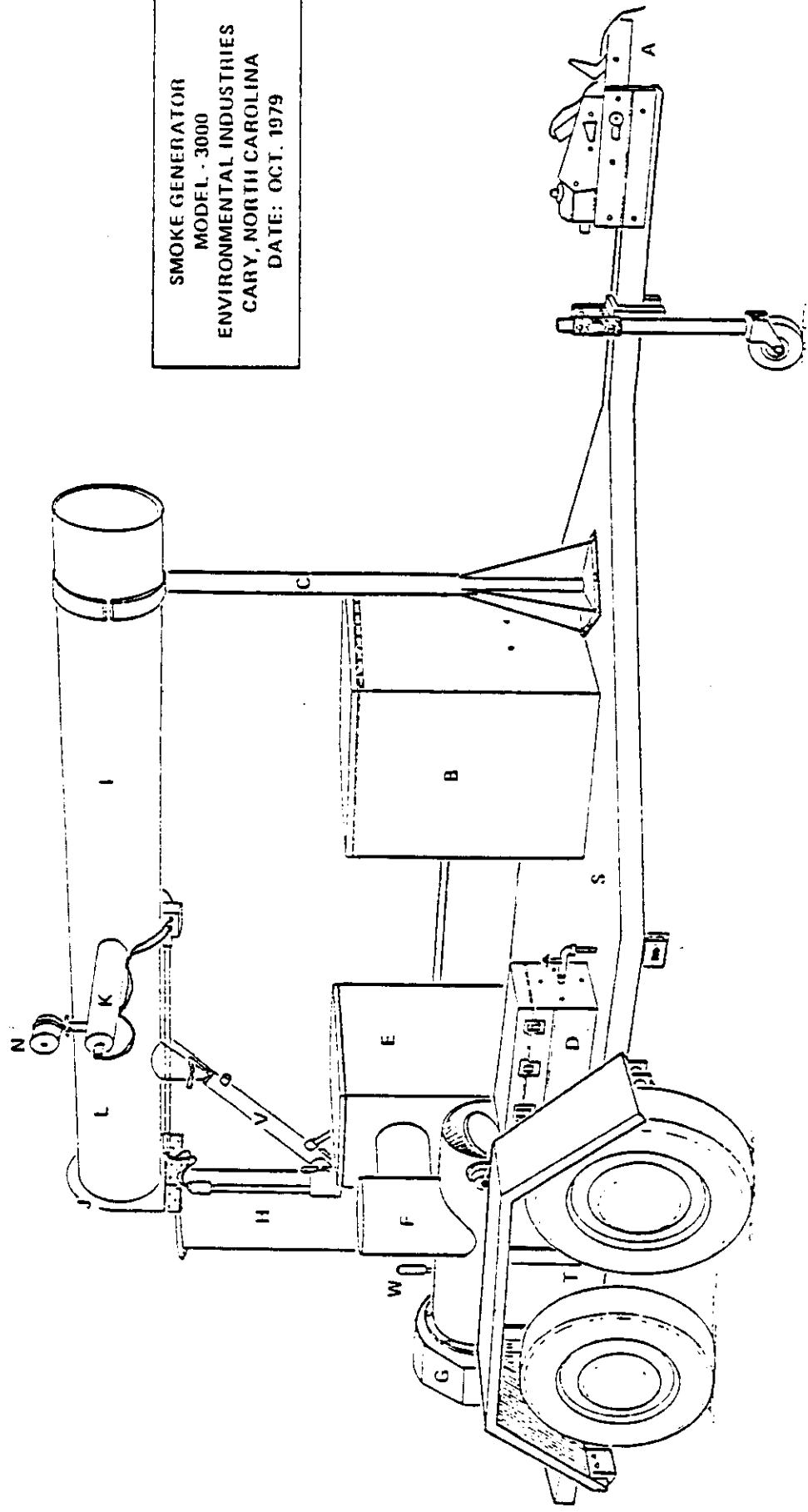
1. Check to verify that proper fuel (fuel oil not **toluene**) is being delivered to vaporizer.
2. Check fuel reservoir for contaminants.
3. Check the fuel delivery line fitting on the final section at the top of the vaporizer for proper fit and tightness of connection. A loose **connection** allowing fuel to drip outside of vaporization chamber can cause a flame up.
4. Check propane torch for proper flame adjustment and alignment with intake port of vaporizer.
5. Check for draft through vaporizer - see if smoke from a cigarette or a match is drawn into vaporizer when held near intake port.
6. If above four items are correct, it may be necessary to obtain fresh fuel oil from a **different** source to **correct** the **problem**.



CONTROL CONSOLE

SMOKE GENERATOR
MODEL - 3000
ENVIRONMENTAL INDUSTRIES
CARY, NORTH CAROLINA
DATE: OCT. 1979

SMOKE GENERATOR
MODEL - 3000
ENVIRONMENTAL INDUSTRIES
CARY, NORTH CAROLINA
DATE: OCT. 1979



ELECTRONIC CONTROL CONSOLE

- A. Digital opacity meter
- B. Digital opacity printer
- C. Span control
- D. Power on-off switch
- E. Main Power on-off switch
- F. Main blower control switch
- G. Stack fan control switch
- H. Fuel pump control switch
- I. Light source on-off switch
- J. Transmissometer span control
- K. Power indicator light
- L. Toluene fuel control valve
- M. Fuel oil fuel control valve

SMOKE GENERATOR TRAILER MOUNTED COMPONENTS

- A. Trailer hitch
- B. Storage compartments
- C. Stack support for transporting
- D. White smoke generator
- E. Black smoke combustion chamber
- F. Ambient air mixing section
- G. Main blower
- H. Lower stack section
- I. Upper stack section

- J. Hinged support flange
- K. Transmissometer
- L. Light source assembly
- M. Photocell assembly
- N. Stack fans
- O. Main electrical junction box
- P. Remote fuel line hook-up
- Q. Flexible fuel lines
- R. Electrical interconnect cables
- S. Solid sheet metal trailer bed
- T. Trailer axle and brake assembly
- U. Fuel storage tanks
- V. Hydraulic cylinder
- W. Hydraulic pump