OLD MODELS
UP TO ABOUT
JAN 1975

ALLEN

OLD STYLE CAL.
METHOD

C.O. METER 0-20
0-10

35

23-060
23-070

TAKE PARTS
PER MILLION
OF PROPANE
& MULTIPLY
BY UNITS
GAS CAL FACTOR
TO GET
HC

INFRA-RED ENGINE ANALYZER

23-060
23-070
23-080
18-010
18-150

SERVICE MANUAL

INTRODUCTION

This service manual covers the calibration troubleshooting and replacement of parts in the INFRARED ENGINE EXHAUST EMISSION ANALYZER, Model 23-060 and Model 23-070.

A thorough understanding of Section 1 - Theory of Operation is recommended before attempting to service the Models 23-060/070. A good knowledge of the principles of the analyzer is most essential to intelligent servicing.

Whenever ordering parts for your analyzer be sure to state the complete model number, date code and serial number. The plate containing this information is located on the lower right rear panel. Provide a complete description of the part desired together with the manufacturer's part number (if any). Refer to the Replacement Parts List appearing in the back of this manual.

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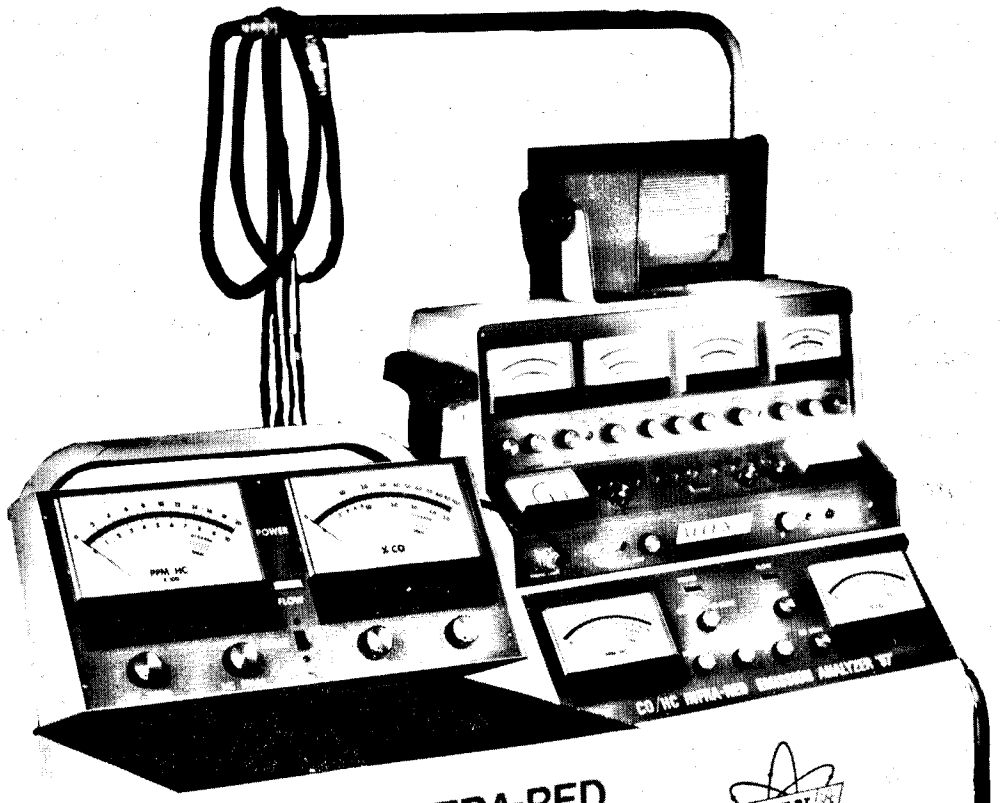
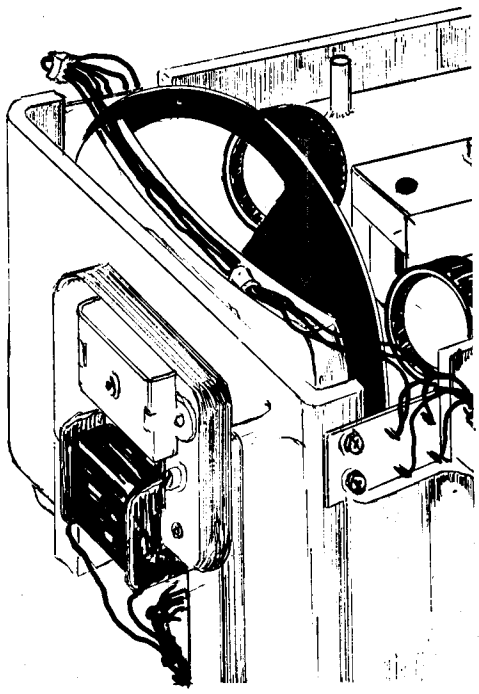
THEORY OF OPERATION



CO/HC INFRA-RED

EXHAUST EMISSION
ANALYZER



The Model 23-060/070 Analyzer is an NDIR analyzer (nondispersive infrared analyzer). It measures the concentration of two components of a multicomponent gas mixture from an automotive exhaust. The measurement is accomplished by measuring the infrared absorption of the desired components in the gas mixture.

Automobile engine performance can be characterized by the composition of its exhaust gas. Most forms of engine malfunction are reflected in this composition of the exhaust gases. Thus, fine tuning and other engine adjustments and engine diagnoses can be accomplished by emission analysis. Significant constituents such as carbon dioxide and nitric oxide make up the other remaining gas constituents.

Complete oxidation of hydrocarbon fuels yield only carbon dioxide and water as products of the combustion process. However in most combustion processes, by-products of carbon monoxide (CO) and nitric oxide (NO) are formed. In addition, some of the fuel is chemically changed to produce lighter fragments of the fuel molecule.

The absolute and relative concentration of the emission molecules are influenced by several operating parameters: air/fuel ratio, ignition timing, absolute charge density and such variable engine parameters as speed, load and engine temperature. Air/fuel ratio exerts the major influence in establishing the properties of the emission gas. For a given amount of fuel, a precise amoung of air is required (approximately 14-1/2 pounds of air per pound of fuel). Combustion of a rich mixture, produces CO and tends to result in residual fuel in the exhaust, either partially burned or unburned. Lean mixtures produce much less CO and lower concentrations of unburned hydrocarbons. With excessively lean mixtures engine misfires occur due to improper flame propagation. Emissions in this case of unburned hydrocarbon will rise quite high.

Infrared absorption in gas mixtures is a characteristic of the type and arrangement of the atoms comprising the gas molecules. The infrared radiant energy interacts with the molecules of the gas mixture as a function of the spectral regions or spectral bands for different gas components. There spectral bands are widely different for the two gas components of interest in the Model 23-060/070 for the analysis of automotive exhaust emission and therefore lend themselves to nondispersive infrared analysis (NDIR).

In general, all gas molecules (excluding the elemental gases) exhibit characteristic absorption spectra which are related to the number, configuration and type of atoms in the molecule. The more simple the molecular structure, the more simple the absorption spectrum. Conversely, the heavy complicated molecules exhibit quite complex spectra.

By examining the spectra of the gas components of interest, it is generally possible to locate an infrared absorption band which is unique to that gas. Similar components would be expected to have similar spectra and in fact the hydrocarbons, methane, ethane, propane, hexane and butane are quite similar although there are regions which differ in absorption. Fortunately, these differences are sufficiently small and provide overlapping absorption bands such that the analyzer can be sensitized to one of these components and yet responsive to some degree to all the others. NDIR analyzers therefore appear to inherently posess the ability to selectively correlate one gas in the presence of all other constituents and thereby to derive a near absolute total hydrocarbon concentration. Certain elemental gases, such as hydrogen, argon, oxygen and nitrogen do not absorb infrared energy and therefore have no effect on the analyzer readings.

Basically, the Model 23-060 and 23-070 analyzers consist of optical bench, signal processors and meters. The simplicity of construction of the overall analyzer makes these units one of the most advanced in the industry.

The optical bench assembly is the heart of the analyzer system. The bench contains the infrared energy source, a 50 hertz co-axial optical chopper, sample tube and reference tube, optical filters and detectors. These components are mounted to a self-supporting optical bench to rigidly support and accurately maintain alignment of these parts over the operating conditions.

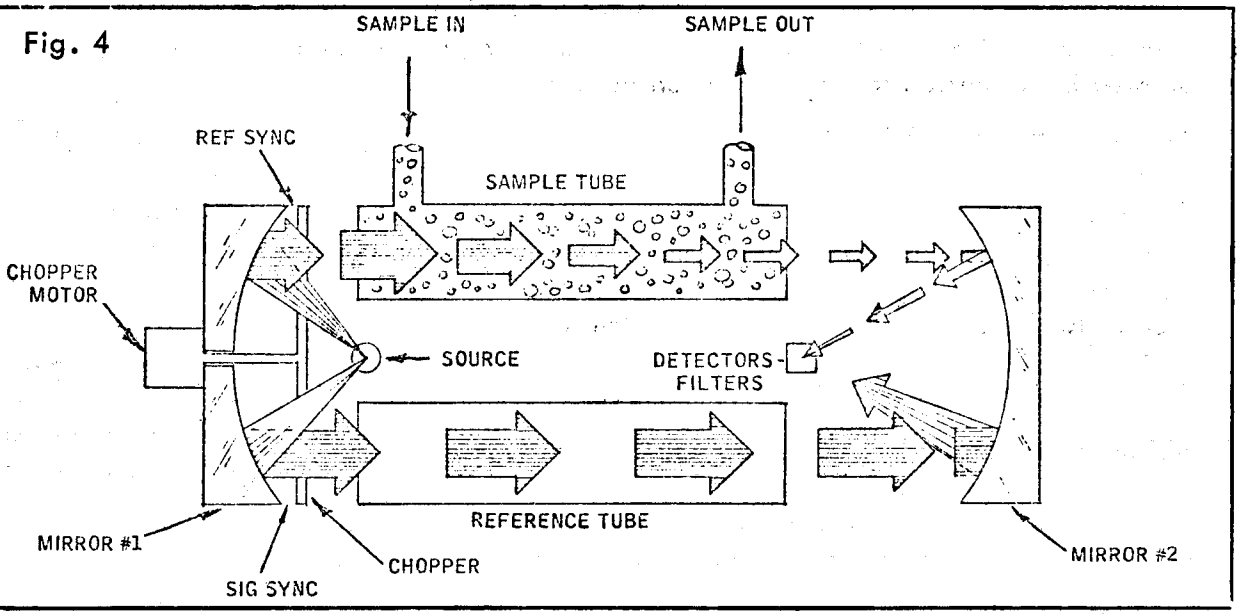
The signal processing assembly consists of two independent synchronous demodulating channels, one for each gas component, and self-contained power supply. These components making up the signal processor are all mounted onto a single printed circuit board for convenient servicing and signal tracing. Test points have been provided at major points required for test, adjustment and calibration.

BASIC OPERATING PRINCIPLE

In general the system compares the optical (infrared) transmittance of two identical optical paths. One optical path passes through the sample or unknown gas, the other optical path passes through the reference path. The difference in optical transmittance between these paths then is a measure of the optical absorption. These variations in transmittance are sensed by a photon detector. The signal from the detector is processed and used to drive the output meters as a direct measure of the concentration of the unknown gas.

The infrared source is a metal sheathed heater element operating at a temperature of about 1500° F (bright red color) where it emits infrared radiant energy optimized for the spectral bands of interest and long life. The emitted energy is directed to a concave front surface mirror. The infrared source surface being at the focal plane of the mirror, the reflected energy is effectively collimated where the rays leaving the mirror surface are essentially parallel.

Fig. 4



The reflected or collimated radiant energy forms two identical infrared beams. These beams of radiant energy are chopped by the co-axial chopper or beam interrupter to effect on alternate ON-OFF sequencing of each beam (Figure 4). The beams then pass through two paralell tubes which are rigidly mounted to the optical bench. One of these tubes contains the sample or unknown gas, the other tube, the reference tube, contains ambient air at ambient conditions. The length of the gas tube has been selected based on the intensity of the absorption bands and the calibration ranges of the instrument. The optical system

response over the range of calibration is in good agreement with the "Lambert-Beer" law of light absorption.

The radiant beams after passing through the two tubes are reflected and imaged by a second mirror onto two photon detectors after first passing through individual optical filters. The optical filters represent the precise "windows" of the absorption bands for the specific gases of interest, hydrocarbon (HC) and carbon monoxide (CO).

In effect, then, the system is tuned to see only energy in those two unique absorption bands, which represent those two gases. Energy outside these bands whether as part of the chopped energy or stray "light" from other sources are eliminated. This stray energy could result in adding an undesirable level of noise or unwanted signal to the system if that energy were permitted to strike the detectors. The filters in essence block out all the stray energy.

The detector converts the optical energy from the radiant beams into an electrical signal. The electrical signal is the analog of the optical beams and differences in amplitude are converted to a signal. This output signal is a direct measure of gas concentration and is used to drive an electrical output meter.

In operation then, with the system turned on and warmed up, sample gas (unknown) is introduced into the sample chamber, The alternating beam of radiant energy is directed first through the reference tube and then to the sample tube in a continual half cycle interruption at the rate of 50 cycles per second. As the beam passes through the reference chamber, the energy of the beam interruption at the rate of 50 cycles per second. As the beam passes through the reference chamber, the energy of the beam is unattended and provides a standard of measurement. On the second half cycle, as the beam passes through the sample tube, the beam will be selectively attentuated by the gas sample. In the case of the Model 23-060/070 only the two gases, HC and CO are of interest. If either or both gases are present in the sample tube, the beam energy will be attenuated proportional to the gas concentration within the two spectral bands and the HC and CO signals will be modulated in proportion to the gas concentrations.

In this way, the detector generates two electrical impulses per chopper revolution, one representing the reference level, the other the sample gas level. These signals are amplified demodulated and then read directly on the integral panel meters, one for CO in percent concentration, the other for HC in parts per million (ppm) concentration.

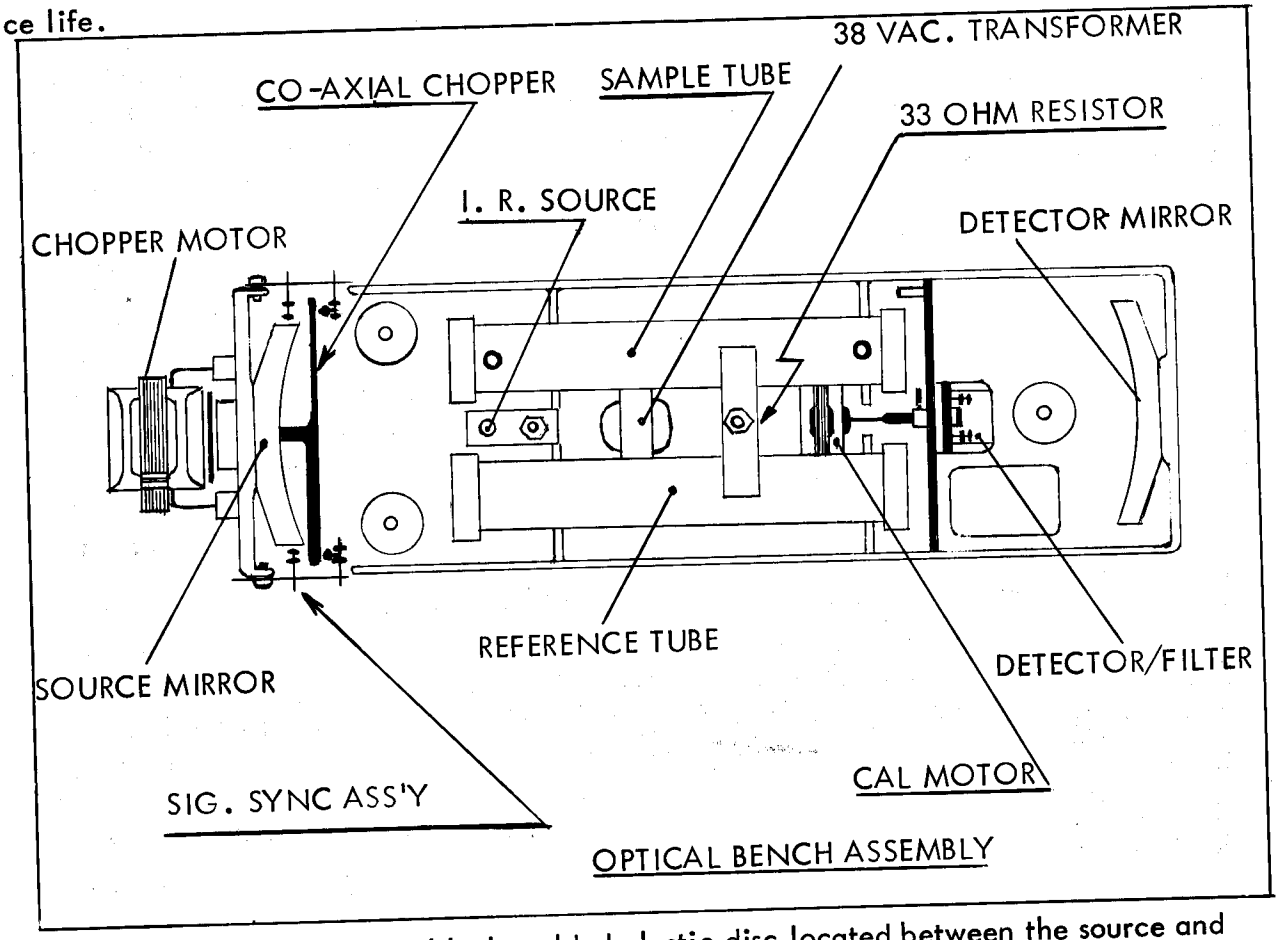
ELECTRICAL CIRCUITS

The purpose of the amplifier circuit is to convert the low level detector signal to a useable output voltage. The output of the pre-amplifier is fed to an automatic gain control (AGC) network. The AGC network maintains the output of the reference signal constant for any external influences on the signal amplitude such as line voltage variations, ambient temperature and source temperature variations.

The amplified signal following the AGC network is used to derive the AGC signal that controls the AGC network and to determine the amount of signal modulation. The resultant DC signal following the demodulator drives the meter circuits.

PARTS DESCRIPTION

1. INFRARED SOURCE. The infrared radiant source is located in a ceramic housing in front of the mirror and chopper. The source is a cartridge type heater that serves to provide the energy for both reference and sample beams. The source housing is a two-piece molded ceramic enclosure. The two sections are secured to the optical bench by means of a single bolt. This bolt permits a moderate degree of source positioning to effect optimum source alignment in the optical paths. The source is operated at a reduced temperature to extend its service life.



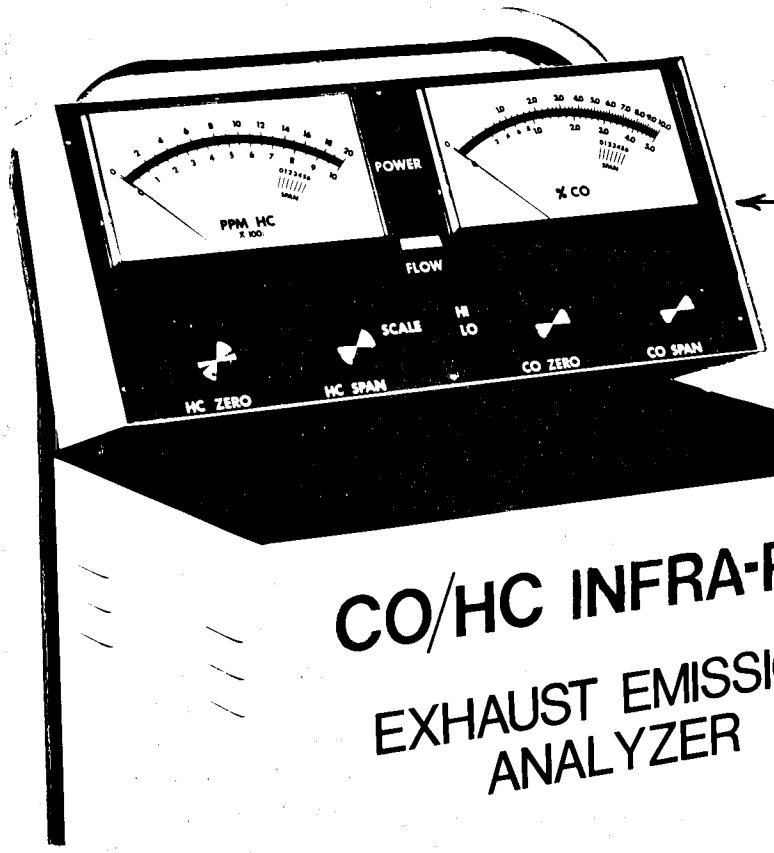
2. CHOPPER. The chopper is a black molded plastic disc located between the source and first mirror. It is attached to the shaded pole AC motor which is mounted at the source end of the optical bench. The motor rotates at about 3000 rpm (50 cycles). The chopper or beam interrupter has two openings. The larger or primary opening subtends an angle of 105° and provides the beam interruption to the gas tubes. The smaller cutout (45°) on the rim of the chopper provides the opening for the two synchronization signals, i.e., reference sync and signal sync, that are used to establish the meter signal in the signal processor.

3. MIRRORS. The two identical mirrors are located at either end of the optical bench. They serve to first collimate the rays from the infrared source to effect the two parallel beams and then to refocus the beams onto the two photo-conductive detectors. The mirrors are front surface parabolic type with a protective overcoating to resist scratching.

4. SAMPLE AND REFERENCE TUBES. The gas tubes are located in the center of the optical bench and are nested into V-grooves to secure their position. A single bolt and strap hold both tubes in place. It may be necessary to clean the sample chamber periodically since dust and condensate may collect in the sample cell. The cells are readily removed and cleaned with a cotton swab and isopropyl alcohol.

5. DETECTORS/FILTERS. The detector assembly, located in the mirror image position to the source, contains the two detector subassemblies which house the selector/filter combination. The filters and detectors are specifically designed for optimum operation within the two spectral bands selected for the HC and CO windows. These spectral bands minimize crosstalk from other absorption bands which might otherwise interfere with the output readings. The subassemblies are mounted to the detector assembly by means of a screw which permits adjusting the position of the individual detectors for optimum operating conditions.

6. ELECTRONICS. All amplifier components including the power supplies are mounted onto a self-contained plug-in printed circuit board, facilitating removal and replacement. This fully plug-in feature permits quick field replacement to minimize equipment downtime. There are three separate plug-in units, the detector assembly, the sync assembly and input power and output signal connection. The input power is 38V AC from a stepdown transformer mounted to the optical bench directly below the gas tubes. The output lines carry the meter circuits, span and zero lines to the meter panel, and other internal calibration lines.



7A. CONTROL PANEL.
MODEL 23-060
The control panel can be mounted to the analyzer cabinet or remotely mounted up to 15 feet away. The panel contains the indicating meters, ZERO and SPAN controls, Hi/Lo scale switch, POWER indicator and Flow indicator.

The CAL switch is located on the side of the cabinet. This switch is a quarter turn spring return type which activates the CAL motor.

7B. CONTROL PANEL 23-070 is identical in performance with the exception that all controls are located on the front panel.

8. METERS. The meter scales are direct reading for CO in percent concentration and HC in ppm concentration. When the "CAL" switch is activated, the CAL motor rotates to place a flag in the path of the sample gas optical beam which represents a meter deflection of approximately 70% of the low concentration scale.
The scale on the meter indicates the precise deflection required according to altitude (each division is 1000 feet).

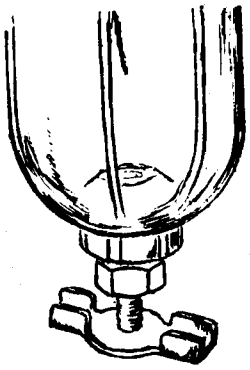
9. CABINET. The 23-070 is designed as a base cabinet for a scope analyzer while the 23-060 unit separates the meter and control panel.

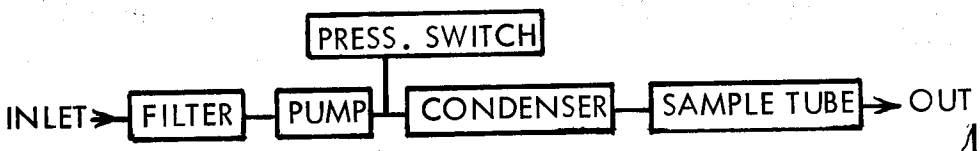
The lower cabinet assembly contains the gas handling system (pump, filter, flow switch and condenser) the optical bench and the input power panel.

10. GAS HANDLING SYSTEM.

The earlier models (series A) can be reorganized by the filter configuration as illustrated.

The pump draws auto exhaust gas into the inlet and pumps the gas and vapor into the particulate filter and primary water trap. The filter is designed with a petcock on the bottom of the bowl, to dump the condensed water. This must be performed occasionally by the operator. The flow switch is located on the pressure side of the pump which activates a flow indicator light when the pressure drops below recommended operation requirement. The flow light is normally "on".

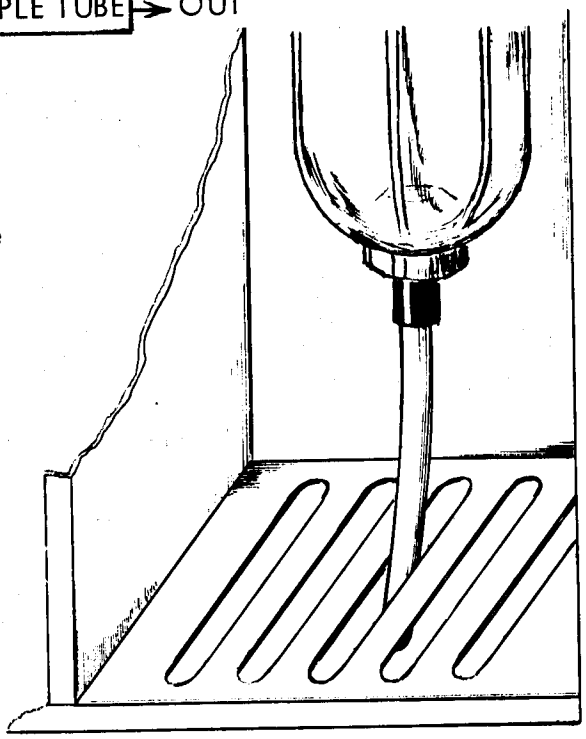


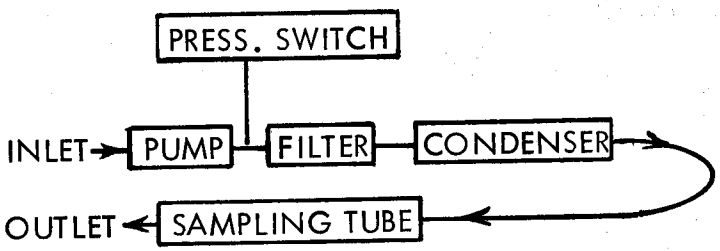


The B series differs only in the location and shape of the filter bowl. The filter is located on the pressure side of the pump and employs a small orifice in the bottom of the bowl which extends with a tube through the vent slot.

This feature makes the bowl self-draining.

Operation is otherwise identical to series A.





The condenser system is connected before the inlet to the sample tube. The position of the condenser has been selected to remove the remaining moisture from the system just prior to the exhaust gas entering the sample chamber to obviate condensate forming in the sample tube. Small holes are provided at the bottom of the condenser system to remove any water accumulation by action of the positive gas pressure in the condenser.

CALIBRATION PROCEDURES

MODELS
23-060/070

EQUIPMENT PREPARATION - DO NOT PLUG IN

A. Remove back panel.

B. Check meters for mechanical zero.

C. Remove sample hose.

D. Check filters and water trap.

VERIFY FUNCTIONAL ASPECT - UNIT PLUGGED IN

A. Turn unit on - back panel 23-060.
front panel 23-070.

B. Check power and flow lights (ON).

C. Block inlet to check flow light (should go off).

D. Check meter movement up to full scale with zero knob and note any binding positions.

E. Check span switch operation.

F. Check cables and external connectors for intermittency.

G. Check pump vacuum (should be 15-20").

ALLOW UNIT TO WARM UP FOR AT LEAST 15 MINUTES

Calibration can not be successfully accomplished unless the unit is mechanically as well as electronically functioning properly.
If any of the above check results are negative proceed to repair the unit before attempting to calibrate.

NOTE: ALL CALIBRATIONS MUST BE PERFORMED WITH THE UNIT IN UPRIGHT POSITION.

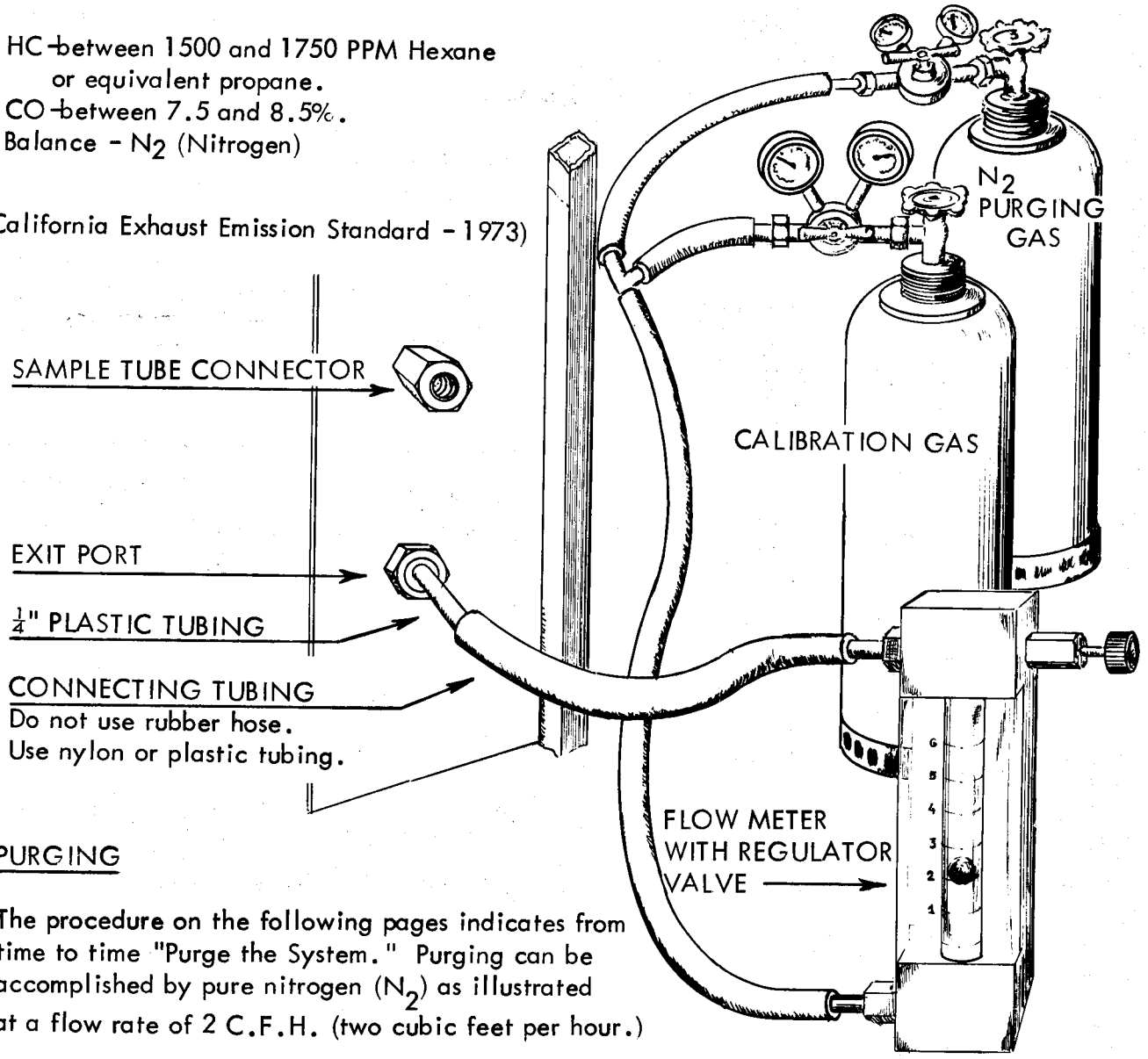
CALIBRATION GASSES

Span gas bottles of a certified concentration can be obtained from Scott Laboratories or Olson Laboratories.

Recommended concentration is:
80% of full scale ±5% (*) accuracy within 2%-certified.

HC-between 1500 and 1750 PPM Hexane
or equivalent propane.
CO-between 7.5 and 8.5%.
Balance - N_2 (Nitrogen)

* (California Exhaust Emission Standard - 1973)



PURGING

The procedure on the following pages indicates from time to time "Purge the System." Purging can be accomplished by pure nitrogen (N_2) as illustrated at a flow rate of 2 C.F.H. (two cubic feet per hour.)

or . . .

by reconnecting the pump with the sample gas tubing removed from the exit port. Check with your local or state requirements for your area, whether purging with "zero" gas (N_2) is required.

No disconnecting of the system is required when the calibrating gas is introduced through the exit port (in reverse to operating flow). Excess calibrating gas will escape through the drainholes in the condenser and filter drain tubing.

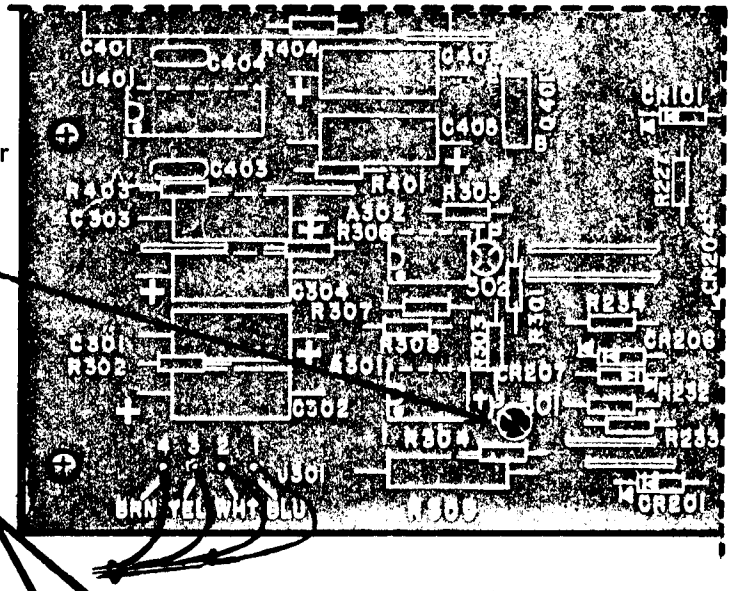
USE THE GAS SPARINGLY IN A WELL VENTILATED AREA.

ELECTRONIC ALIGNMENT PROCEDURE

It is essential that this procedure precedes any gas calibration, whenever any component has been changed, repaired or adjusted.

The upper part of the board contains the HC channel amplifier, designated with part numbers in the 100 series.

The lower part is identical in layout and component values and is used for the CO channel. These part numbers are in the 200 series.



USING FET METER

.4 VAC to .45 VAC

EQUIPMENT

Use a TEKTRONIC model 502 oscilloscope or equivalent.

Test point 301 may be used as sync for the sync probe.

PREAMPLIFIER

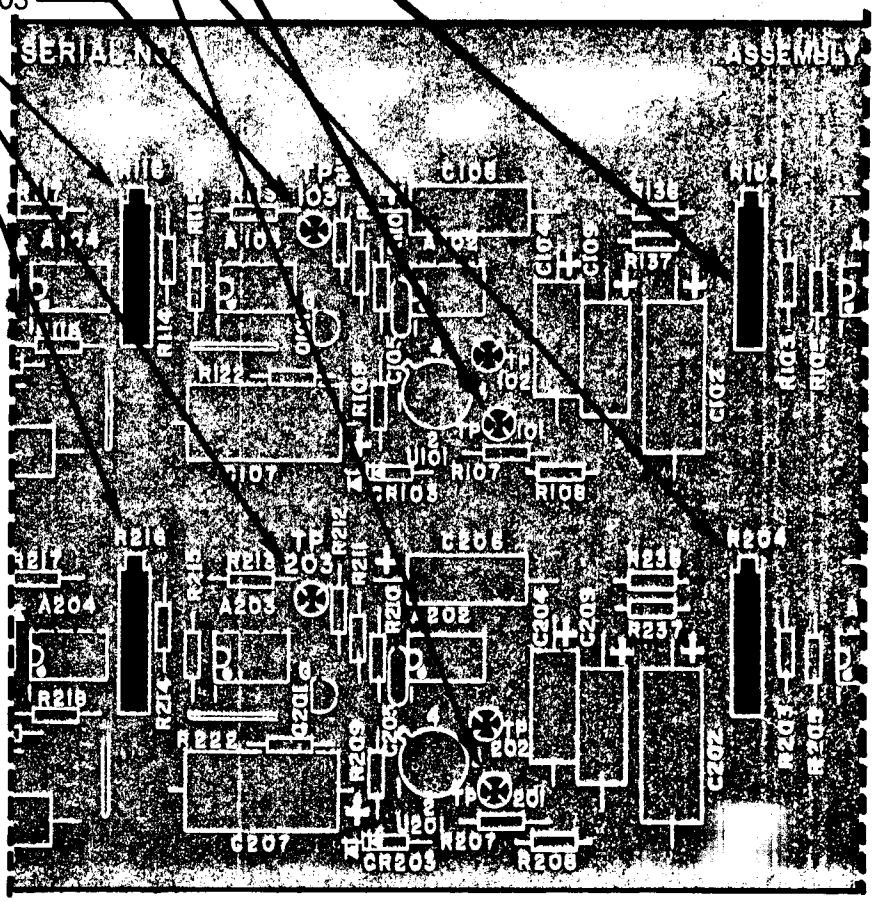
Attach test probe to test point TP-101.
Adjust output of preamplifier R-104 to 1 volt (±0.25 V.) peak to peak.
Repeat same test for CO channel TP-201 and adjust the preamplifier R-204 to 1 volt (±0.25 V.) peak to peak.

AGC LEVEL

Move test probe to test point TP-103 and adjust the AGC level R-116 to 1 volt (±0.1 V.) peak to peak.
Repeat the same test for TP-203 and adjust the CO-AGC R-216 to 1 volt (±0.1 V.) peak to peak

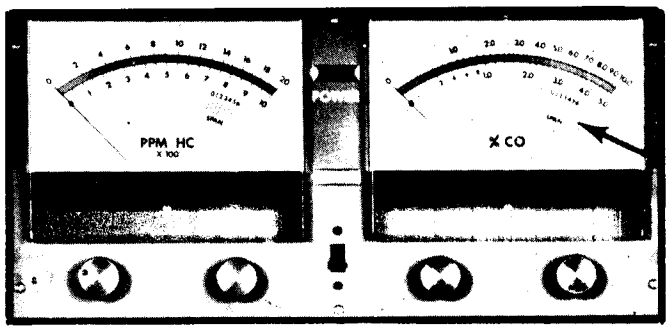
AMPLIFIER SYMMETRY

Set oscilloscope vertical gain to 100 millivolts per centimeter.
Verify that symmetry of the reference and sample signals is less than one division offset. If symmetry is greater than one division (100 millivolts) off, loosen source assembly - page 21.
Adjust the source angle facing the #1 mirror by pivoting around the mounting screw as necessary to obtain one division offset or less.
Retighten source mounring screw using a torque wrench set for 80 inch-ounces.



CENTERING ZERO CONTROLS

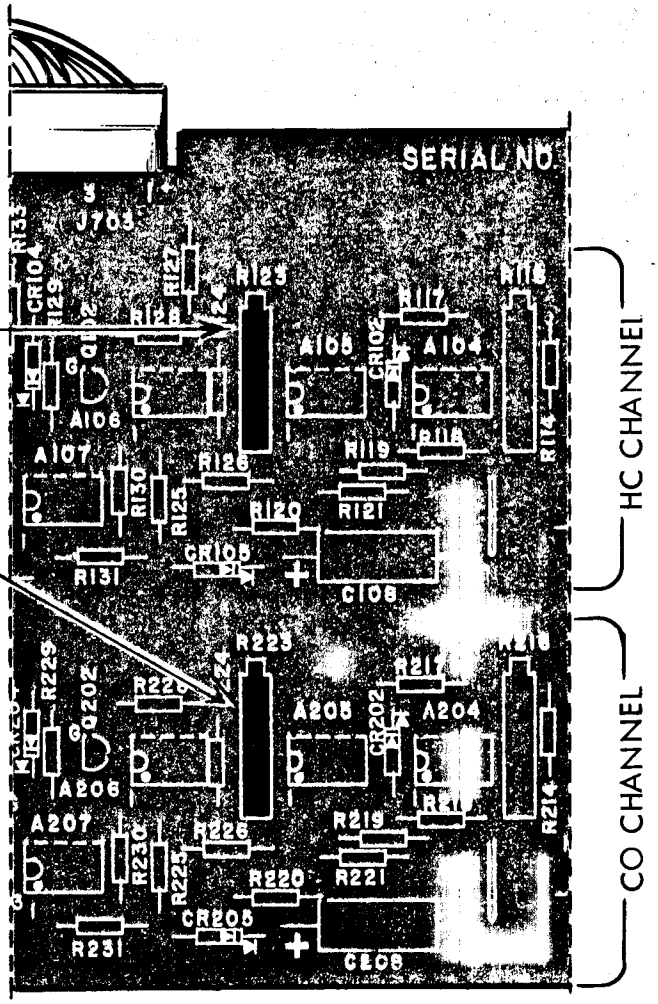
> **NOTE**
> If board replacement or circuitry repair has been made, proceed to "alignment procedure" before attempting the gas calibration below.



1. Turn HC and CO zero control several turns counter clockwise so that the potentiometers are in the maximum position. The controls are of multi turn, slip drive construction.

2. Using the black "dot" on the knob as an index, turn both controls $2\frac{1}{2}$ turns clockwise.

3. Purge the system. See purging methods page 9.



4. Adjust R-123 on the printed circuit board until the HC meter reads zero.

5. Adjust R-223 on the printed circuit board until the CO meter reads zero.

The above calibration sets the zero control knobs in mid range with maximum leeway for the operator to control his zero settings.

NOW TURN SPAN SWITCH AND SET SPAN POTS SO METER READ ELEVATION YOUR AT. (ABOUT 1,000 HERE). RECHECK ZERO AND GO TO NEXT STEP.

HI-LO SCALE CALIBRATION

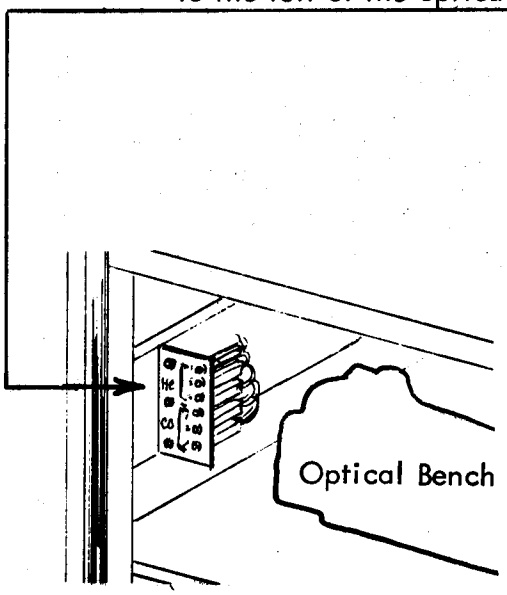
UNIT CONDITION - Purged with zero gas or in stable condition.
"HI/LO" switch in "HI" position.

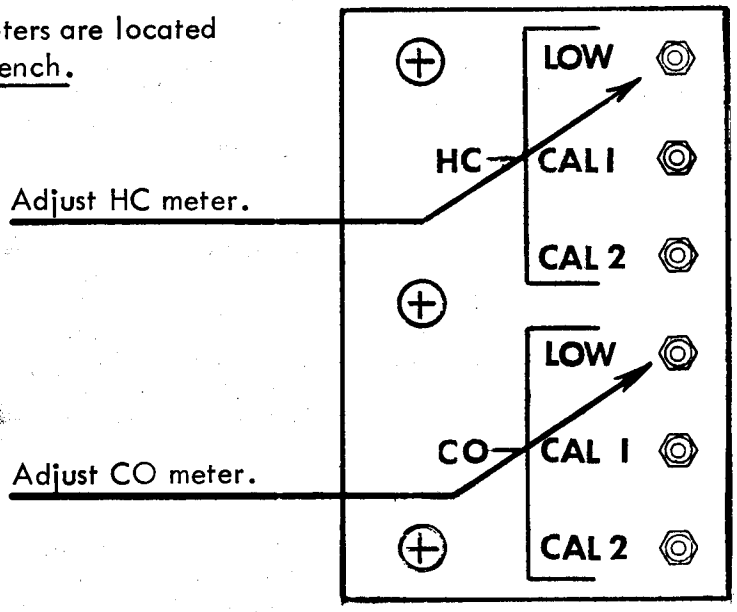
1. Turn the "zero" control knobs on the front panel until both meters read half scale (CO-5, HC-10).

2. Switch "HI/LO" switch to low scale and verify same reading on the low scale of the meter (full scale). Correct if required as outlined below.

LOW SCALE CORRECTION

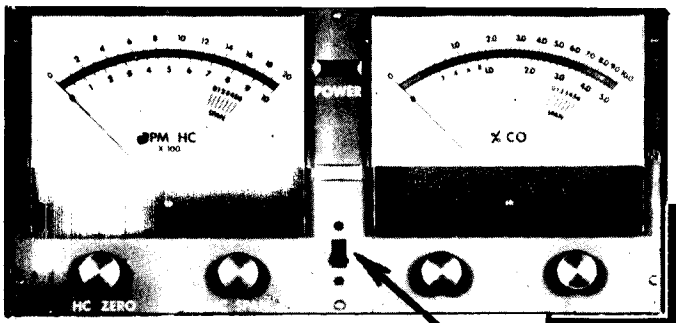
The calibration potentiometers are located to the left of the optical bench.





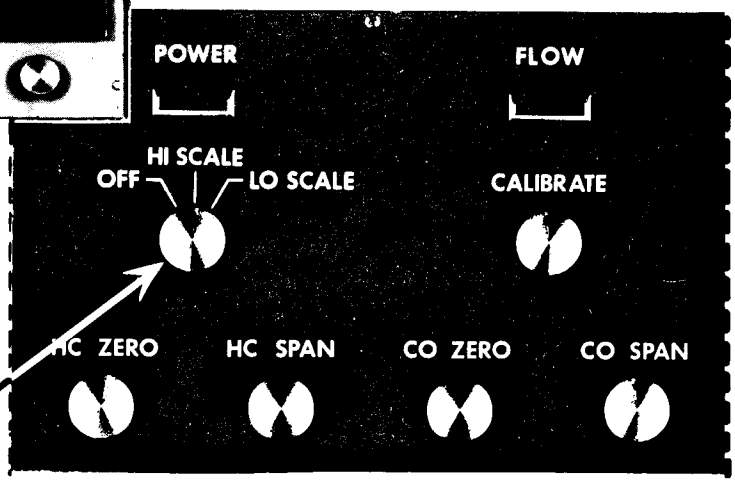
Adjust HC meter.

Adjust CO meter.



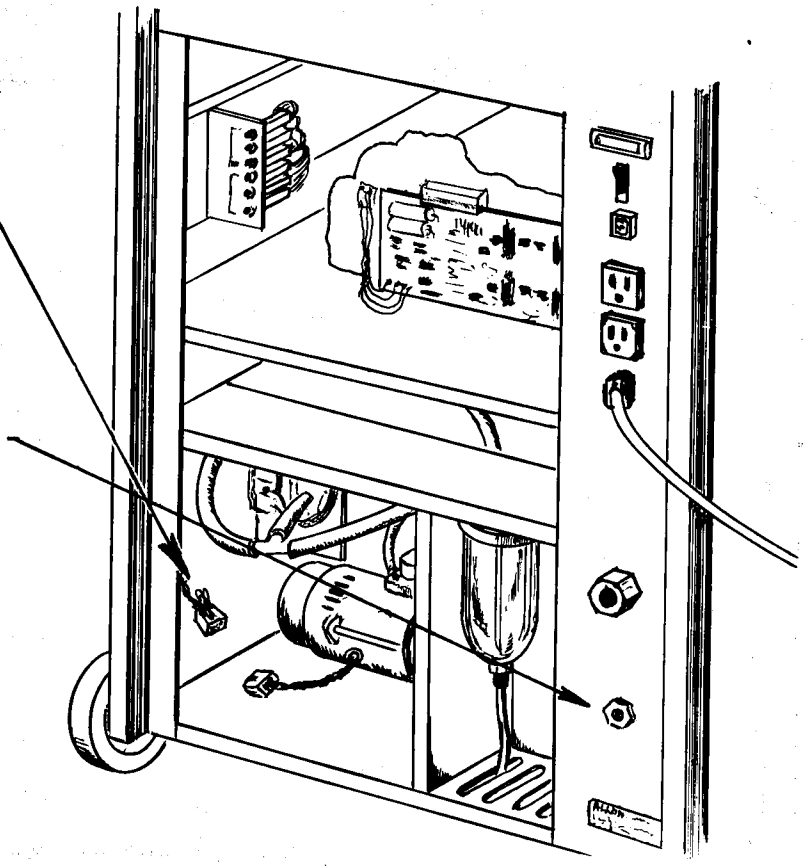
The 23-060 is a two position "HI-LO" toggle switch.

SWITCH LOCATION



The 23-070 switch is a combination "OFF-HI-LO" rotary switch.

CERTIFIED GAS CALIBRATION



1. Purge the system.

2. Disconnect the pump and zero the meters with the zero controls on the front panel.

3. Insert certified gas mixture into the "exhaust port" of that analyzer at a rate of 2 C.F.H. (See page 9).

NOTE: Since the calibration gas is heavier than air, it will concentrate and remain in the sample tube even when gas flow is turned off. It is recommended to reduce gas flow after the meter has stabilized to keep room contamination to a minimum.

4. Adjust the CO and HC span controls on the front panel until the meter readings coincide with the printed gas concentration on the certified gas cylinder.

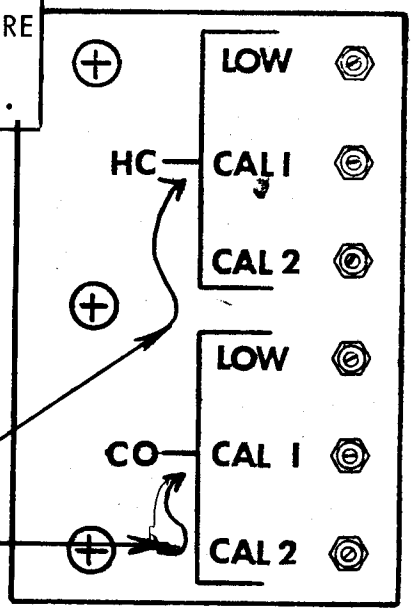
DO NOT MOVE SPAN KNOBS FROM NOW ON UNTIL THE ENTIRE CALIBRATION PROCEDURE IS COMPLETED.
If accidently moved, repeat procedure starting at step one this page.

5. Purge the system and reconnect the pump. If either meter is more than one half division from zero, reset zero and repeat steps three and four.

6. Recheck zero and adjust "dead on" if necessary.

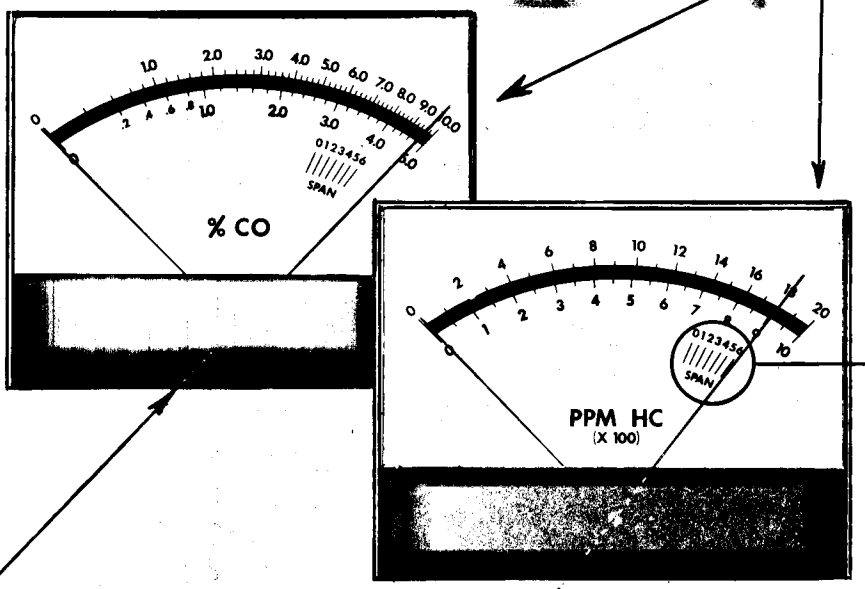
7. Turn and hold the spring loaded "span" switch in span position.

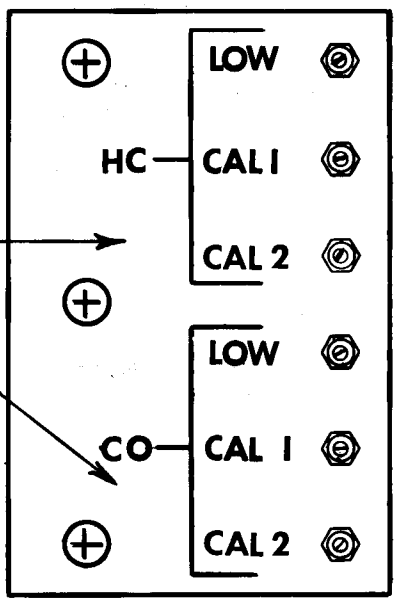
8. Adjust (CAL 1) for the altitude of your area. (Altitude-see next page.)



ALTITUDE - Compensation
If you are located at 500 feet above sea level calibrate between 0-1.
If your location is 4000 feet above sea level, calibrate on four, etc.

9. Disconnect pump and adjust zero knobs on front panel to read full scale.





10. Reconnect the pump and adjust CAL 2 for:
    9.82% on the CO meter
    1800 PPM on the HC meter

11. Reset "zero." Calibration completed.

NOTE: The above calibration is a routine method used to verify accuracy of a well functioning unit. If during any time, the readings can not be obtained or unstable meter response is noticed, check electronic alignment procedures or troubleshooting chart and repeat the calibration procedure after repairs are made and the unit is electronically and mechanically in good working condition.

MECHANICAL

DISASSEMBLY & ASSEMBLY

PROCEDURES

ELECTRONIC

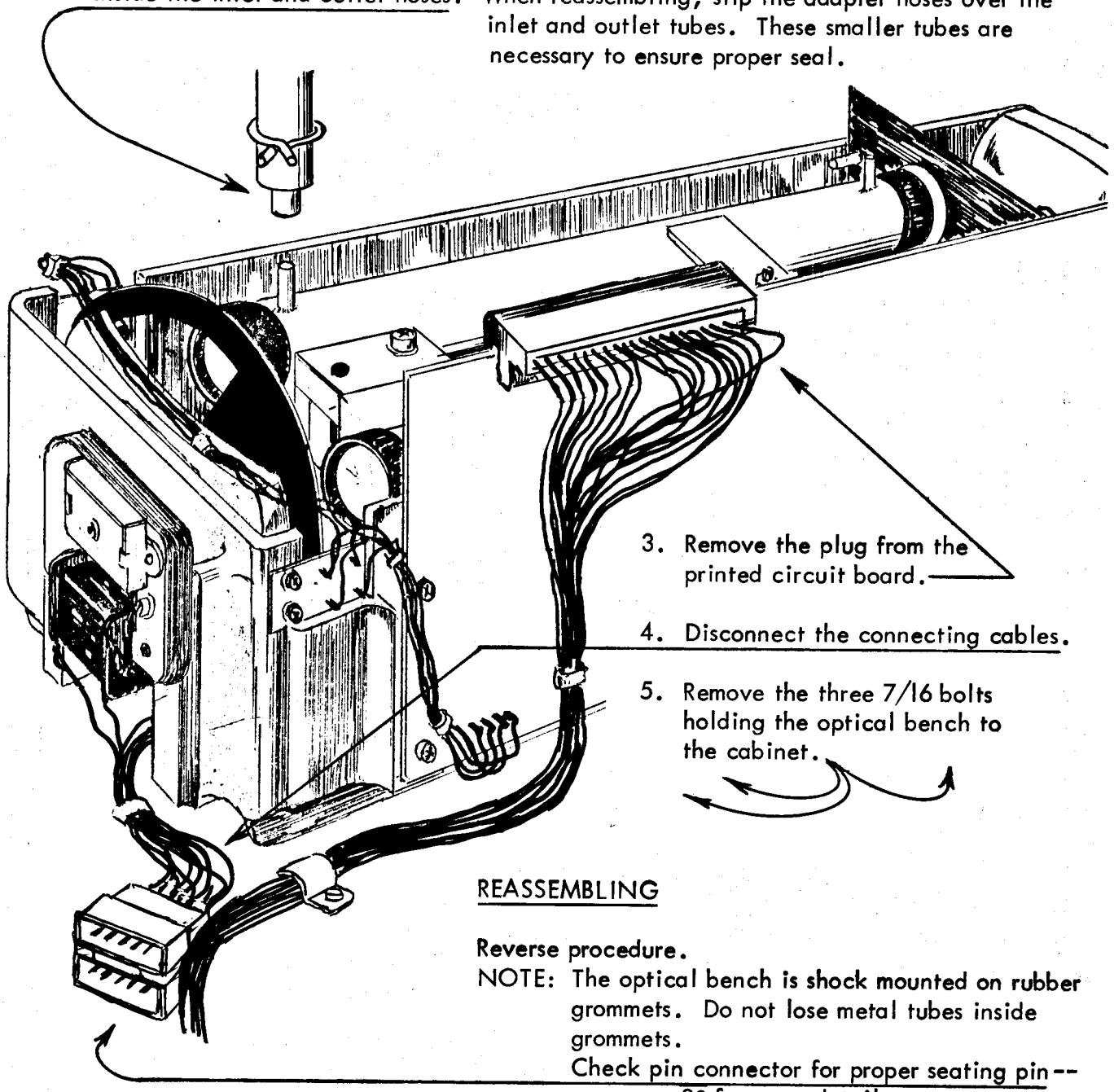
GAS HANDLING

OPTICAL BENCH

REMOVAL:

1. Disconnect AC power.

2. Remove hose clamps and hoses from sample tube. Two smaller adapter hoses are fitted inside the inlet and outlet hoses. When reassembling, slip the adapter hoses over the inlet and outlet tubes. These smaller tubes are necessary to ensure proper seal.



3. Remove the plug from the printed circuit board.

4. Disconnect the connecting cables.

5. Remove the three 7/16 bolts holding the optical bench to the cabinet.

REASSEMBLING

Reverse procedure.

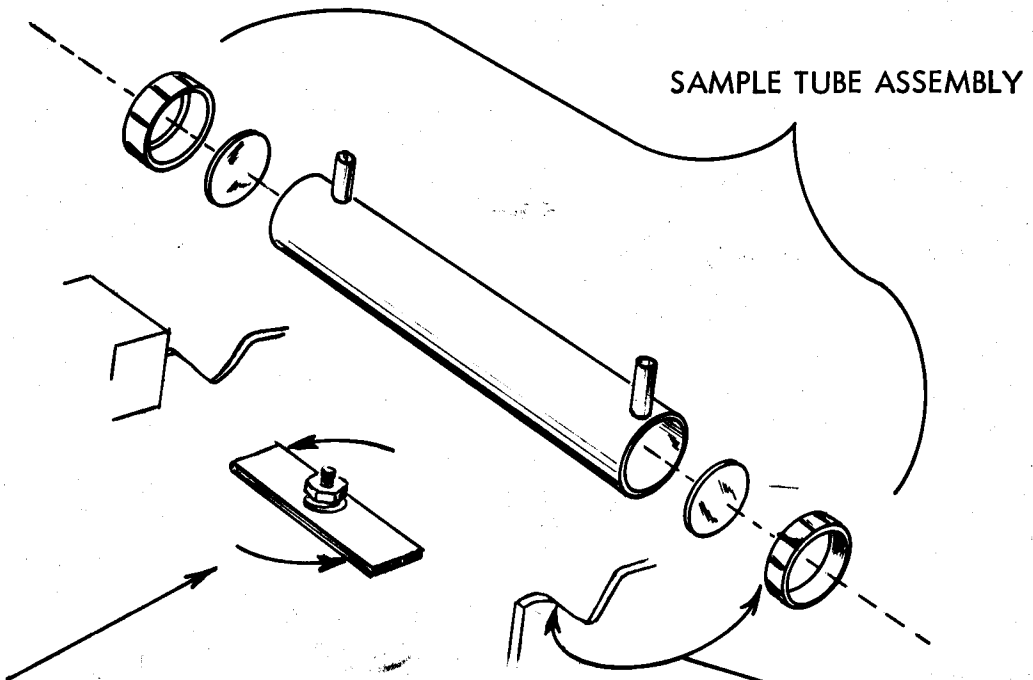
NOTE: The optical bench is shock mounted on rubber grommets. Do not lose metal tubes inside grommets.

Check pin connector for proper seating pin -- see page 23 for more detail.

SAMPLE TUBE

REMOVAL:

1. Remove optical bench as illustrated on page 17.



2. Loosen nut securing metal strap which holds sample and reference tube.
   Use 11/32" nutdriver wrench - Series A - screwdriver - Series B
3. Turn metal strap and remove sample tube.

CLEANING:

1. Carefully remove black nylon pressed on end caps. The two end windows are held in place by the end caps. These windows are thin silicon material and are very fragile. Do not drop. Handle with white cotton gloves.

2. Clean windows and sample tube with cotton swab and isopropyl alcohol. Handle windows with white cotton gloves to prevent body acids from coming in contact with the window surfaces. After cleaning, the tube should be heated to about 60°C (140°F) for about 30 minutes to remove traces of alcohol and other hydrocarbons before reassembly.

3. Reassemble in reverse order. The sample and reference tube should be spaced approximately $\frac{1}{4}$" from the detector baffle plate with the edge of the end cap touching the V-groove.

DETECTOR ASSEMBLY

REMOVAL

1. Remove optical bench, see page 17.

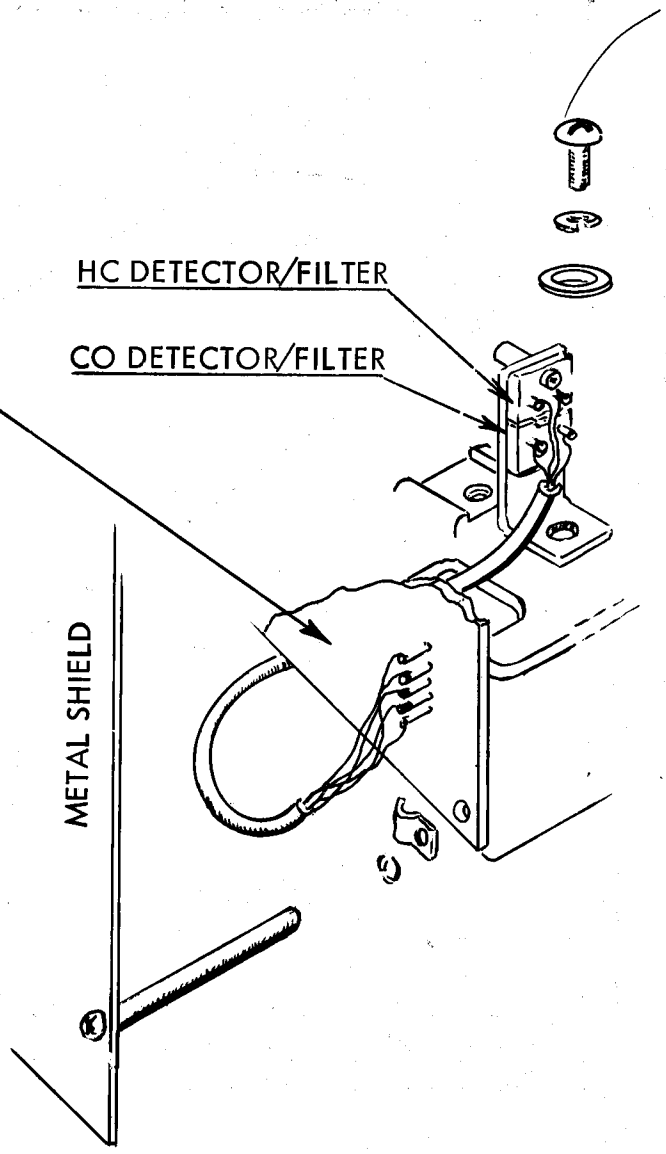
2. Remove shield covering part of the printed circuit board (B series only).

3. Unsolder the 5 leads off the printed circuit board (B series). (Unplug connector, A series.)

4. Remove screw holding the detector assembly.

5. The detector assembly is snugly held onto the mount for alignment purposes. Slide the detector assembly forward toward the mirror to clear the CAL flag stop which is attached to the detector assembly. Thread the cable and connector through the bottom access hole and lift detector out of optical bench.

6. Each detector and filter subassembly is held by a single Allen head screw. To remove a detector/filter assembly, unsolder leads and remove screw. A thin grey-tinted barrier is cemented to the interface between subassemblies to block out stray light when assembled and to hold the assembly together when disassembled. Do not attempt to remove barrier, filter or detector.

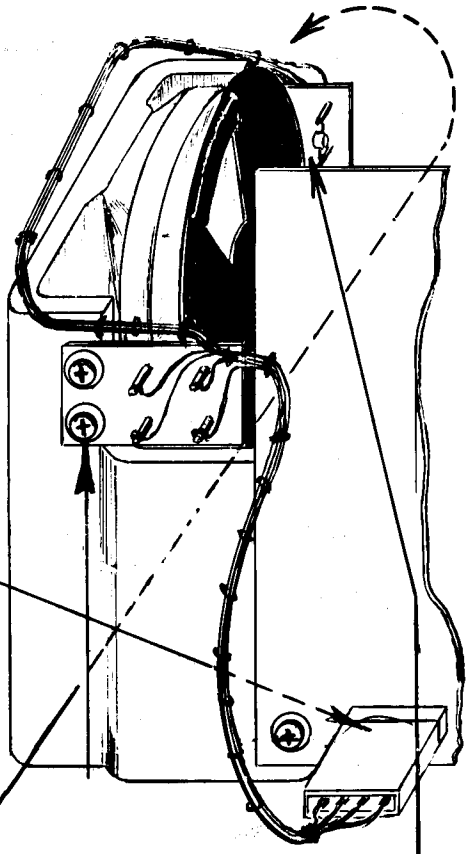


7. Replace detector and filter subassembly in reverse order. The upper subassembly is dedicated to the hydrocarbon channel and the lower assembly to the carbon monoxide channel. Recheck subassembly identification marking to insure correct placement as the unit will not function correctly if the assemblies are interchanged. Whenever replacing components either on the printed circuit board or detector assembly, it will be necessary to rerun a complete calibration procedure.

REASSEMBLY

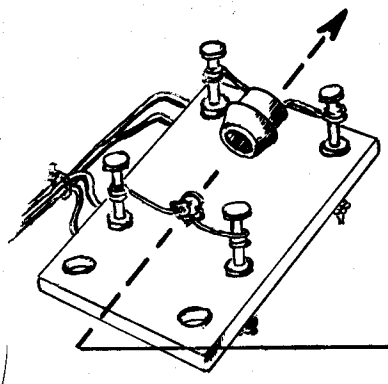
Reassemble the detector assembly in the reverse order. When mounting to alignment mount, manually rotate the CAL flag past its center position while sliding the detector assembly toward the detector baffle plate. The rubber CAL flag stop must pass through the clearance hole in the baffle plate before releasing the CAL flag. Secure assembly.

SYNC. ASSEMBLY



REMOVAL:

1. Remove optical bench, see page 17.
2. Disconnect the connector to the printed circuit board on the A-Series or unsolder the leads on the board on B-Series.
3. Remove the four mounting screws. Carefully slide the assemblies straight out from optical bench to prevent either the light emitting diode (LED) or phototransistor from snagging the chopper disc and thereby misaligning the assembly.

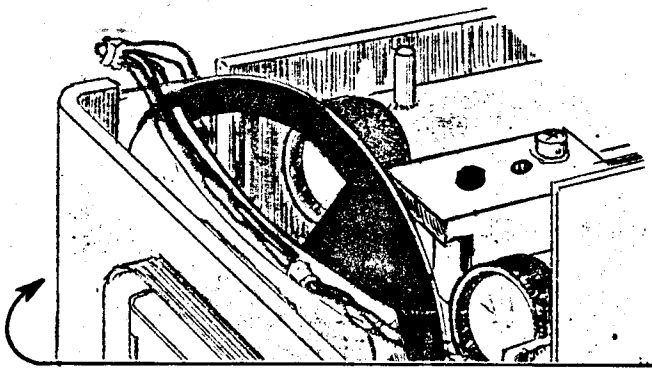


RE-ASSEMBLY

Before installation of the new assembly, align the photo diodes with the photo transistors (as shown). Emitted light from the diodes (not visible to the human eye) should enter the openings of the transistors. Install the new assembly making sure there is sufficient clearance between the wheel and photo diodes.

NOTE:
After assembly, rotate the disc by hand before turning the unit on to assure free rotation.

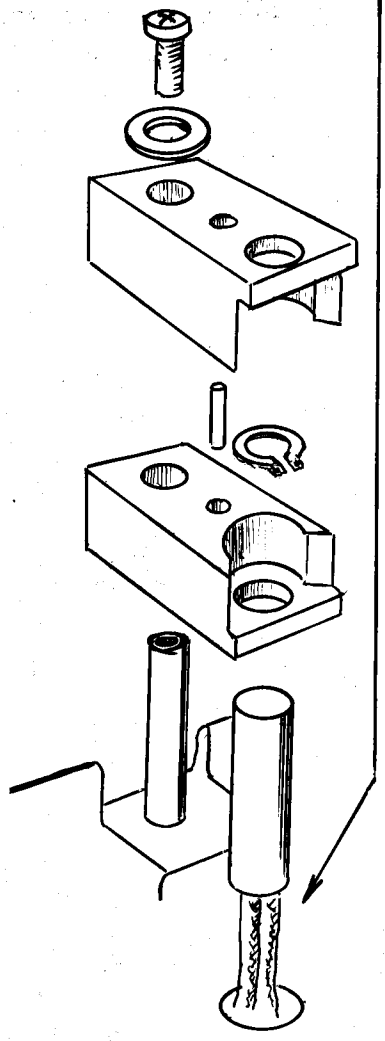
INFRA-RED SOURCE



REMOVAL

1. Remove optical bench, see page 17.
2. Check to make sure that source temperature is sufficiently cool to the touch before proceeding. Allow at least 15 minutes for cooldown.
3. Turn optical bench over and allow to rest on the side opposite the printed circuit board.
4. Locate the two leads coming from the source. Both leads are an olive drab color with dapple brown dots.

REPLACING SOURCE

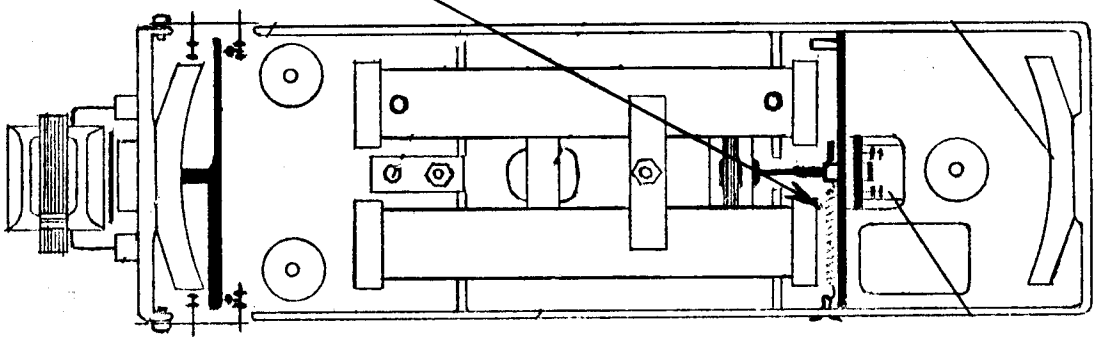


5. To replace infrared source, cut source leads near source assembly and pull leads out of harness.
6. Turn optical bench upright. Loosen nut securing source and remove source assembly. Replace source with truarc ring premounted to bottom of source body.
7. Thread leads from reassembled source through opening in base of optical bench and secure assembly to mount in reverse order. Tighten nut using torque wrench to 80 inch ounce torque.
8. Turn optical bench on side. Select one lead from the new source and one lead stripped from the wiring harness. Cut harness wire such that about one inch of wire extends beyond the nearest tie point on harness. Strip off about $\frac{1}{2}$" of insulation. Lay wire from source along side of harness wire and cut even with end. Strip source wire to expose about $\frac{1}{2}$" of insulation. First twist both wires together and secure with insulated wire nut (connector). Repeat same operation with second harness wire and second source wire.
9. Spot tie leads and wire nuts to main harness.

CAL FLAG ASSEMBLY

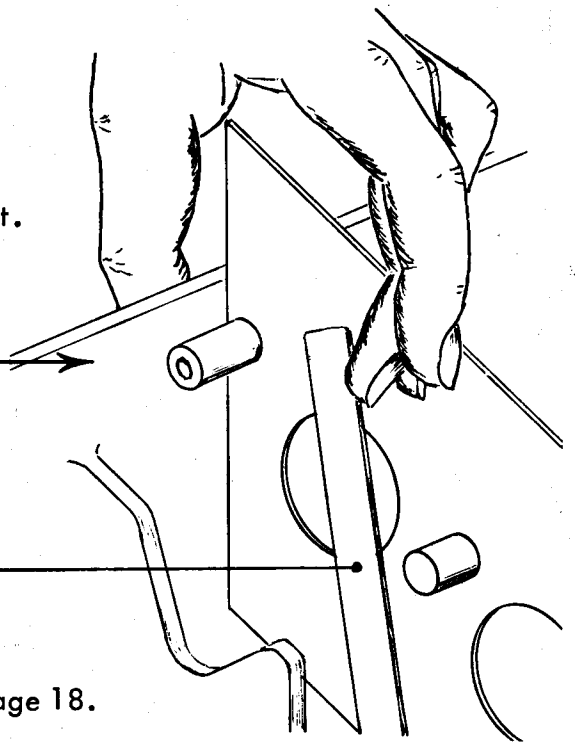
REMOVAL:

1. Remove optical bench, page 17.
2. Remove "sample" and "reference" tubes, page 18.
3. Turn the optical bench on the side (opposite side of printed circuit board).
4. Disconnect motor leads.
5. Locate and remove the two mounting screws holding assembly to the casting.
6. Disconnect the spring - remove assembly.

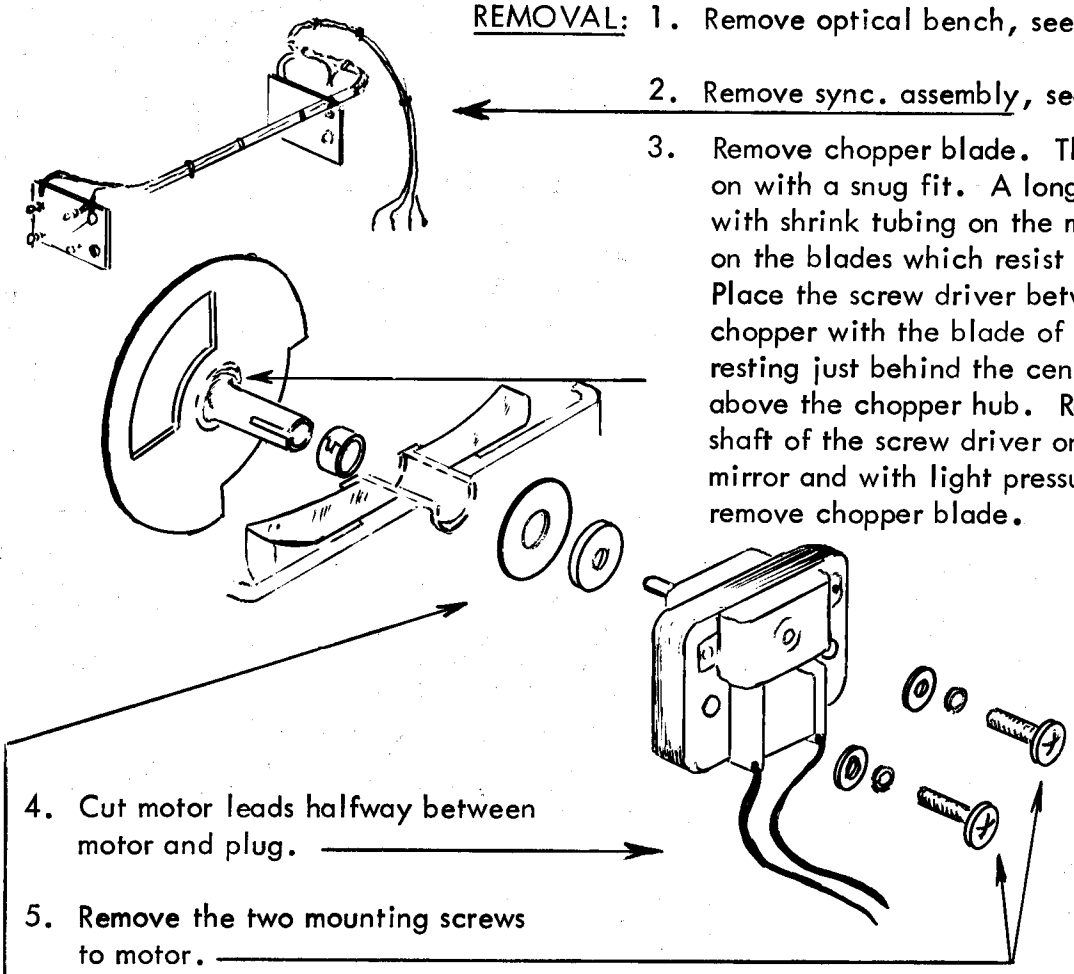


RE-ASSEMBLE

1. Locate the motor assembly in place but do not mount.
2. Connect spring and hold flag opposing the spring tension (in path of reference tube location) while installing and tightening the mounting screws.
3. Assure free travel of flag.
4. Reconnect motor leads.
5. Re-install sample and reference tubes as noted on page 18.



CHOPPER MOTOR ASSEMBLY



REMOVAL: 1. Remove optical bench, see page 17.

2. Remove sync. assembly, see page 20.

3. Remove chopper blade. The chopper is pressed on with a snug fit. A long narrow screw driver with shrink tubing on the metal shaft works best on the blades which resist normal hand removal. Place the screw driver between the mirror and chopper with the blade of the screw driver resting just behind the center of the chopper above the chopper hub. Rest the insulated shaft of the screw driver on the upper edge of mirror and with light pressure on the handle remove chopper blade.

4. Cut motor leads halfway between motor and plug.

5. Remove the two mounting screws to motor.

RE-ASSEMBLY

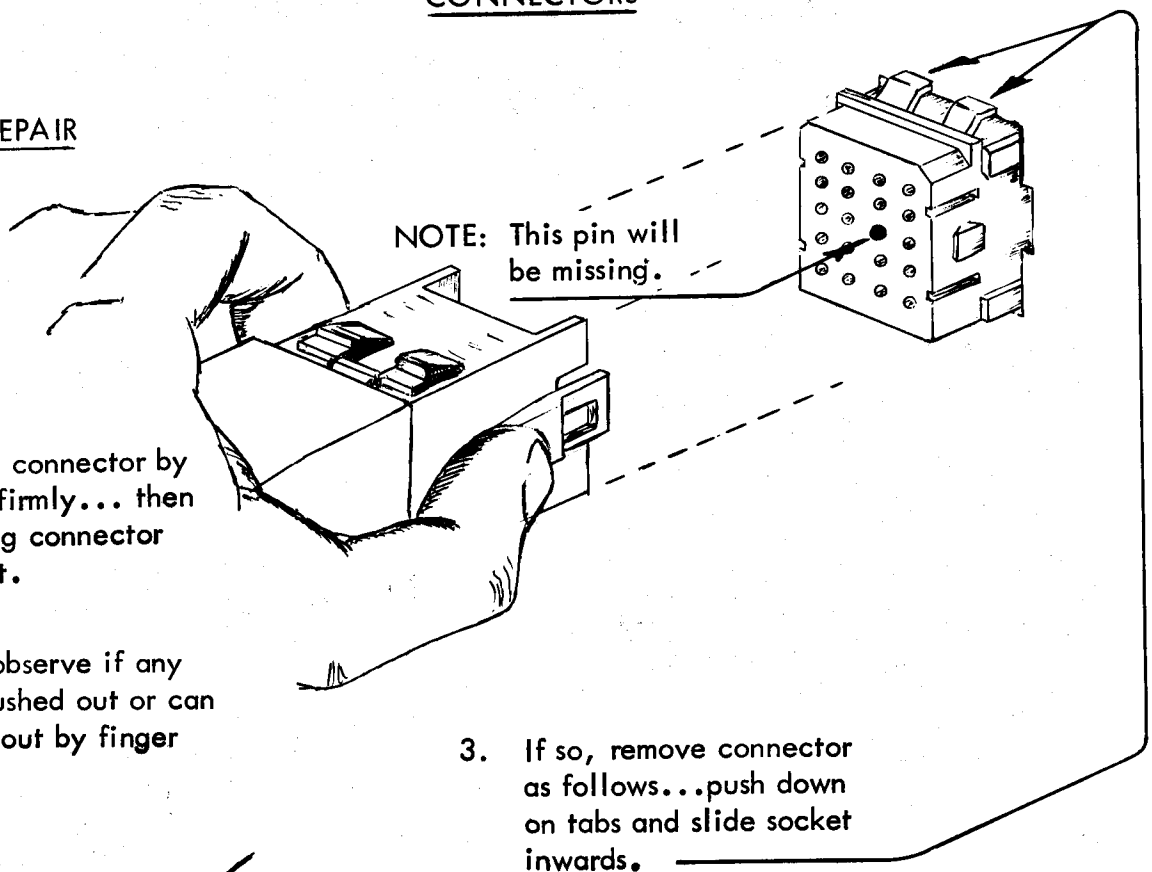
1. Note that two discs are mounted to the motor shaft, a felt disc (nearest the motor) and a plastic disc. The plastic disc should be snug onto the shaft (similar to the chopper blade). When reassembling motor, ensure that both discs are properly mounted and the plastic disc fits snugly. Replace plastic disc if loose on shaft.

   NOTE: The chopper motors are provided with factory lubricated sleeve-bearings and will not normally require lubrication during the life of the motor. The felt and plastic discs are required as protective barriers to the oil seals of these motors. The felt disc absorbs lubricating oils that may seep out of the oil cups during high ambient conditions. The plastic disc is a secondary protective barrier to prevent long term oil seepage from passing the felt disc. This latter disc removes the excessive oil.

2. Replace the motor. Resolder A.C. leads and wrap with electrical tape.

3. Reinstall the chopper disc and sync assembly. Align the disc halfway between photo diodes and photo transister. Carefully study the assembly instructions on page 20.

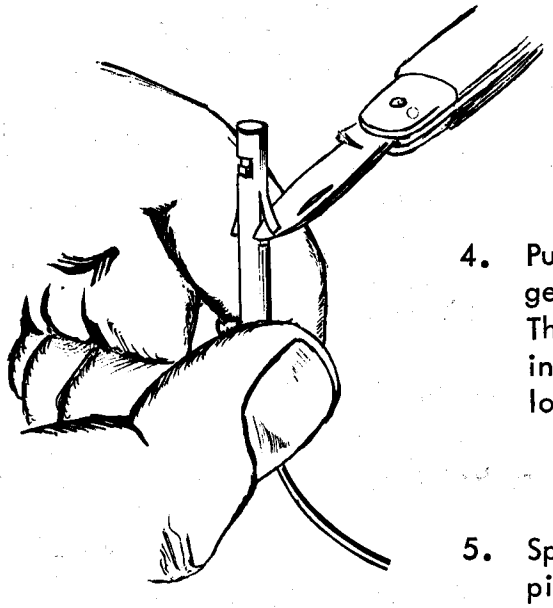
REMOVAL & REPAIR



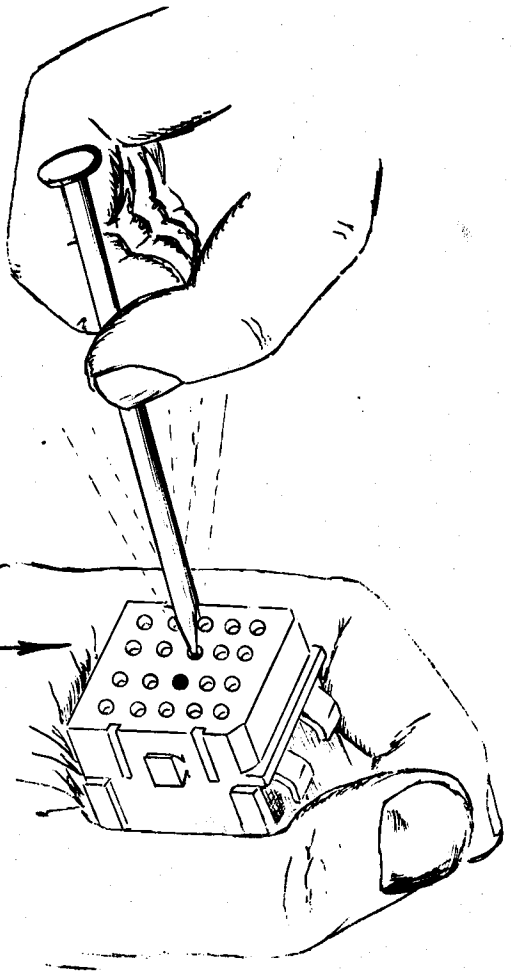
1. Disconnect connector by squeezing firmly... then withdrawing connector from socket.

2. Look and observe if any pins are pushed out or can be pushed out by finger pressure.

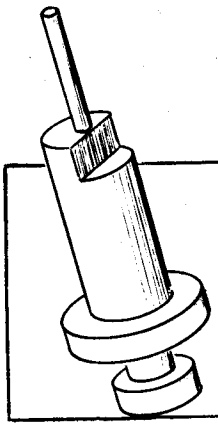
3. If so, remove connector as follows...push down on tabs and slide socket inwards.



4. Pull out loose pin and gently pry barbs out. Then slide pin back into socket until it locks into place.

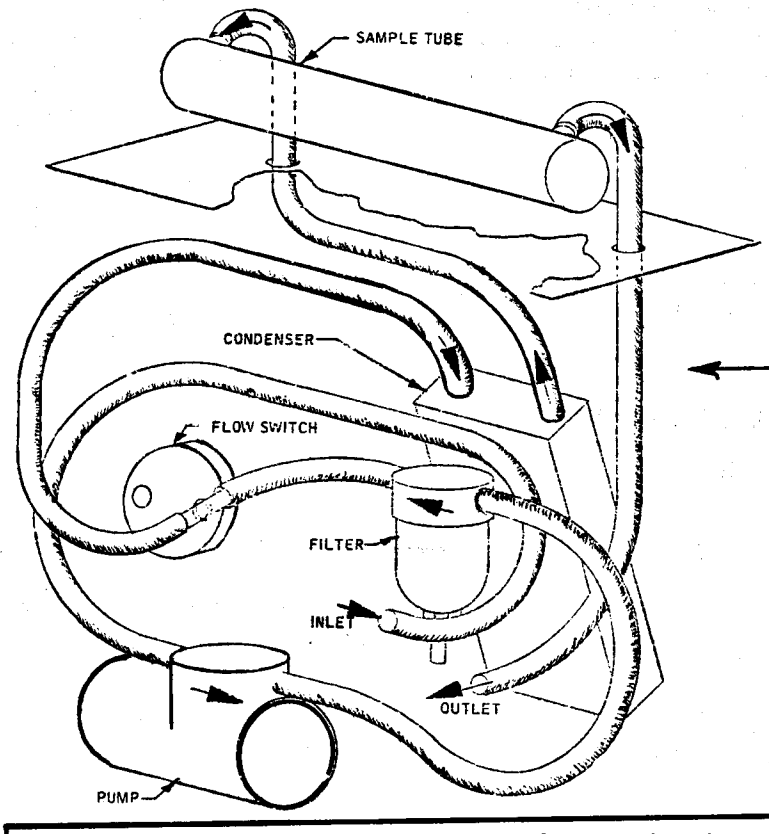


5. Spread all female socket pins with a beveled nail or center punch. Make a circular motion to flare the pin entrance only.



SPECIAL TOOL...
To service connectors is available from AMPHENOL under part No. 453468-2-A

GAS HANDLING SYSTEM



With the exception of the sample tube connections (see page 18), all tubing junctions are tightened by means of heat shrinking.

Series "B" illustrated.
For Series "A" refer to page 7.

Replacement tubing is only available in the 10 ft. length in 3 different dimensions. See parts list Z-108 through Z-110.

The automobile exhaust is not clean and emits many contanimants which could be harmful or effect the accuracy of the test. In order to protect the instrument, filters and traps are strategically located in easy access for maintenance purposes.

FILTERS

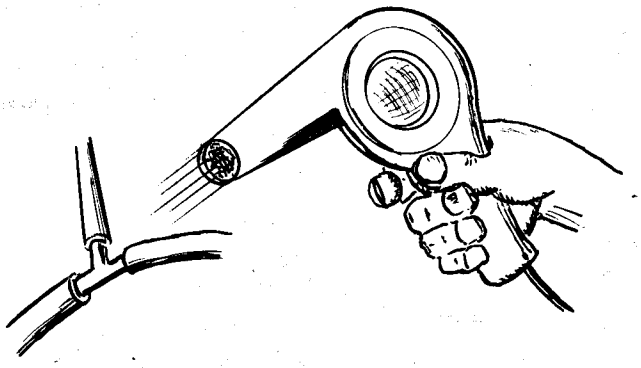
Like any fuel or oil filter in the automobile, periodic replacement is essential. In order to make replacement as convenient as possible, Allen has selected automotive filters which are readily available from local parts distributor. See page 32.

SYMPTOMS

Whenever the meter response is slower than normal, or when the flow indicator light flickers or turns off, a restricted flow is indicated. See page 30 for testing procedure.

HEAT SHRINKING THE TUBING

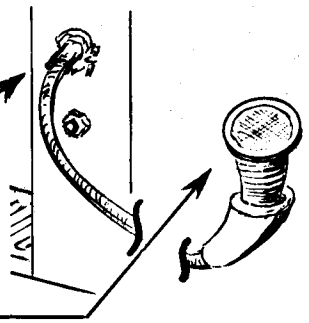
Once the nylon tubing has been removed from a connection, it is essential to heat-shrink the nylon for a tight fit. Apply just enough heat at the junction until the tube edges start to round out. Then allow it to cool without touching.
DO NOT OVERHEAT.



SAMPLING PROBE

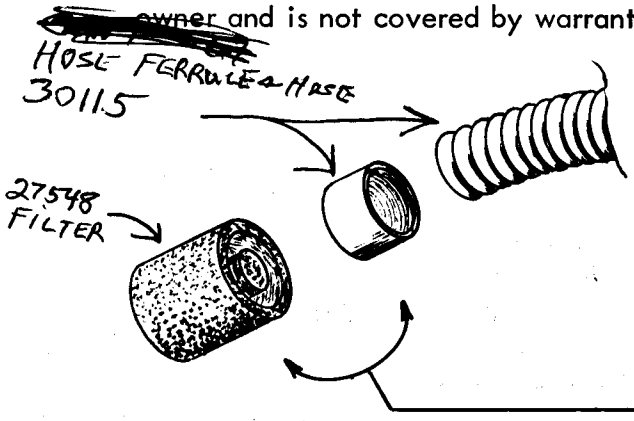
Type "A" Series

The early models used a stainless stell flexible tube with a clamp through the cabinet.
Extensive coiling and recoiling of the sample tube may loosen the nut and twist the flexhose inside to the point of restriction.
Check and secure clamp.
Check for tar accumulation on the fine screen mesh.
Clean if required.



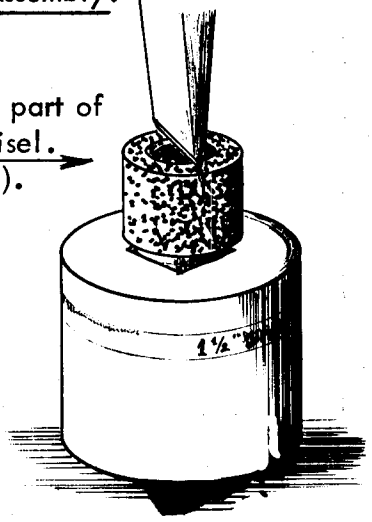
Type "B" Series

Since the filter/watertrap is located on the pressure side of the pump, see page 7. it is essential to filter particulate matter before the pump. Filter replacement is the responsibility of the owner and is not covered by warrantee.



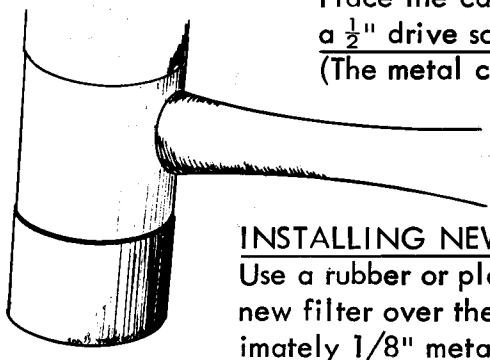
Filter replacement

The bronze fuel filter is press-fit on the end of the flexible tubing.
The large filtering area prevents rapid clogging and is able to withstand high temperature exhaust gases.
A counter clockwise twist will remove cap and filter assembly.



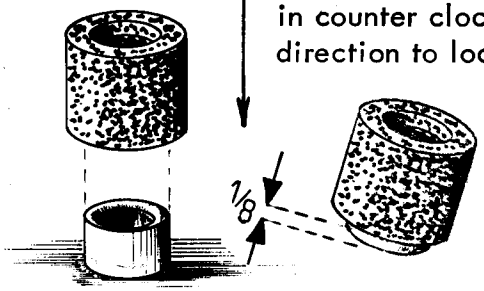
REMOVING OLD FILTER

Place the cap and filter assembly in the square part of a $\frac{1}{2}$" drive socket and split the filter with a chisel.
(The metal cap will fall out through the socket).



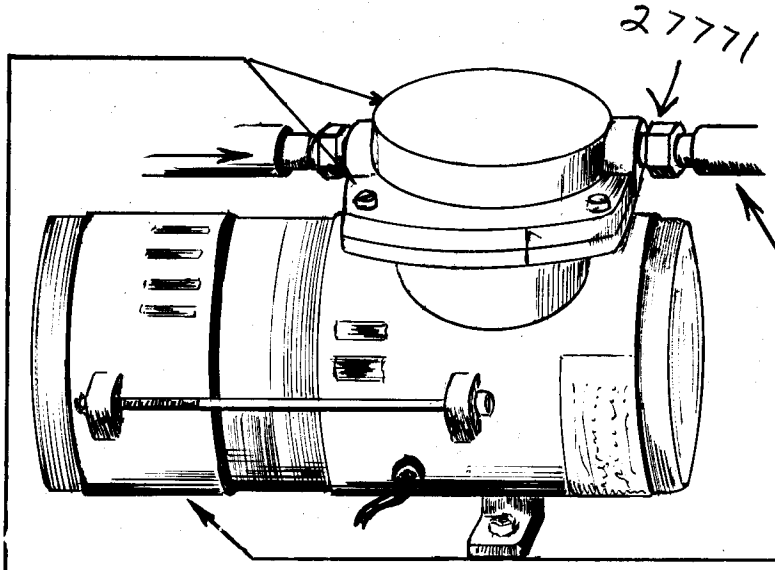
INSTALLING NEW FILTER

Use a rubber or plastic mallet to lightly tap the new filter over the metal cap, leaving approximately 1/8" metal part exposed.
Twist the new assembly on the flexible tubing in counter clockwise motion. Twist in clockwise direction to lock into position.



DO NOT OPERATE THE ANALYZER WITHOUT FILTER

MOTOR AND PUMP ASSEMBLY



REMOVAL:

1. Disconnect power source.
2. Remove 2 bolts from bottom of cabinet.
3. Disconnect nylon tubing.

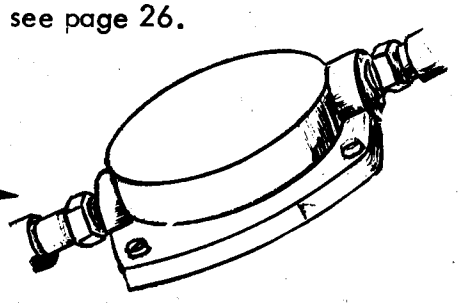
RE-ASSEMBLE:

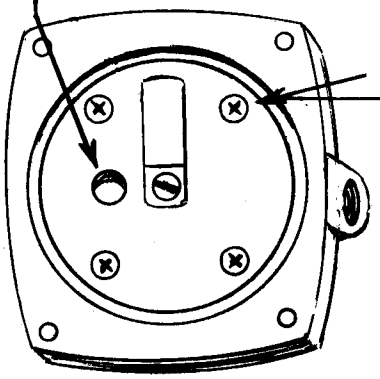
Reverse order.

NOTE: 1. Do not attempt to use a longer bolt on the fan side since this may jam the motor.
2. Heat shrink the nylon tubing on the nylon connectors-- see page 26.

CLEANING PUMP ASSEMBLY

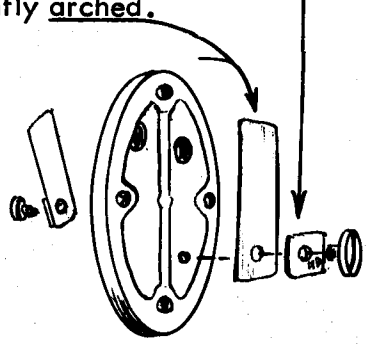
1. Remove the four screws of the pump valve chamber.
2. Operate pump and allow sand and debris to vibrate off the piston. Brush off excess.
3. Use 7/16 open end wrench to disconnect the nylon tubing. Check the flapper valves in the chamber for carbon deposits or dirt which may be lodged, preventing the valves from operating. Use air hose cautiously to clear foreign particles.





Remove the four (4) Phillips screws and shake the valve plate out on a flat surface. DO NOT PRY OR USE SHARP OBJECTS which may scratch the teflon coating.

Remove the stainless steel reeds, clean and check for warpage. Reverse sides if need be and reinstall. NOTE: The small plate under the screw is marked "up" which means towards the screw head.
Reeds should be slightly arched.



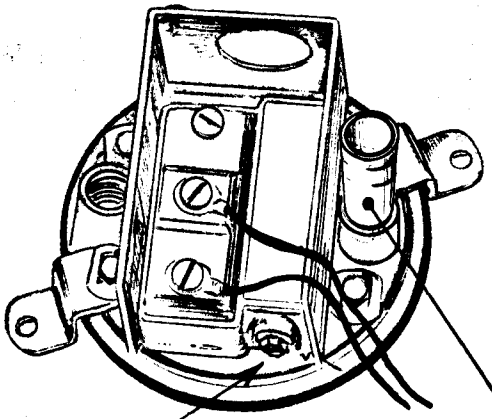
RE-ASSEMBLE

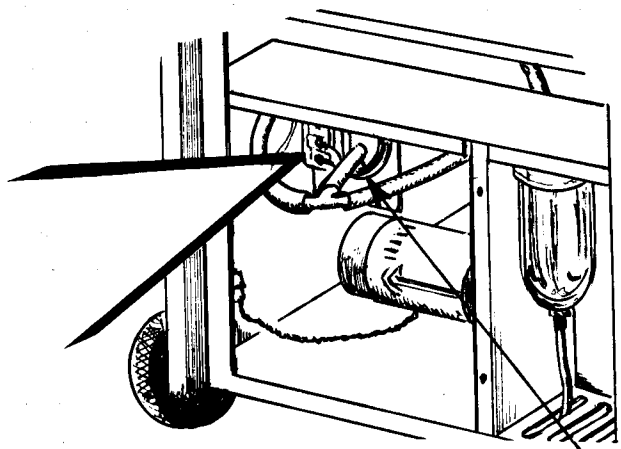
Before assembling, make sure that reeds are properly opposing the in and outlet ports. This can be determined by blowing in the ports and noting a one-way direction of flow.

FLOW SWITCH

REMOVAL:

1. Disconnect A.C. power.
2. Disconnect leads.
3. Remove the mounting screws.





4. Twist hose assembly off the pressure inlet and save the tube extension which is not supplied with the new switch.

REASSEMBLE in reverse.
Refer to page 26 for heatshrinking the nylon tubing.

ADJUSTING FLOW SWITCH

1. Use a 1/4" socket or flat blade screwdriver and turn the adjustment all the way counter-clockwise until stop. Flowlight should now be "on".

2. Turn adjustment (clockwise) three (3) turns. Light should now be off.

NOTE: Refer to trouble shooting section, page 32, for a more complete and accurate procedure, if flow light cannot be adjusted within these parameters.

DO NOT REPLACE SWITCH UNTIL PUMP-VACUUM OPERATION IS ESTABLISHED.

TROUBLE SHOOTING BY SYMPTOMS

THE FOLLOWING TROUBLE-SHOOTING PROCEDURES ARE COMPREHENSIVE AND ALTHOUGH NOT ALL INCLUSIVE, PROVIDE FOR THE MAJORITY OF MAJOR FAULTS THAT MIGHT BE EXPECTED.

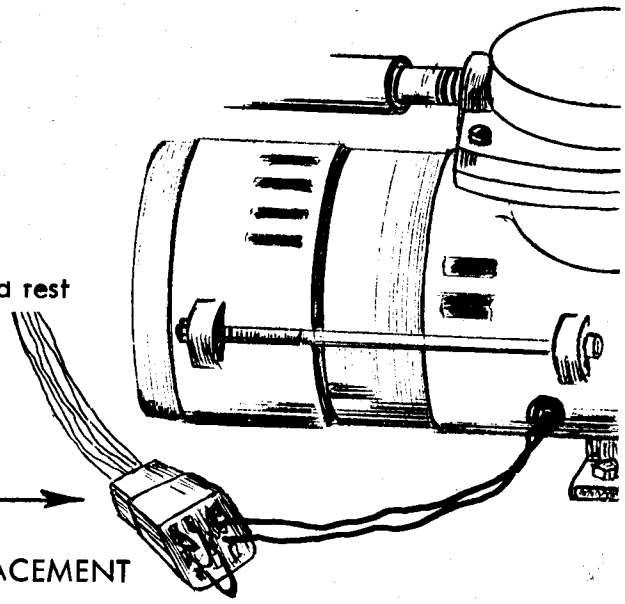
IT IS ASSUMED THAT THE EQUIPMENT HAS BEEN FUNCTIONING CORRECTLY AFTER INSTALLATION AND THAT THE UNIT HAS BEEN CORRECTLY ALIGNED AND RECALIBRATED. IN ADDITION, IT IS ASSUMED THAT THE EQUIPMENT HAS BEEN CONNECTED TO AN APPROPRIATE THREE WIRE AC VOLTAGE SOURCE WITH 115 VOLTS $\pm$10 VOLTS AC 60 HERTZ POWER.

CHECKING THE EXHAUST GAS HANDLING SYSTEMS IS ONE OF THE FIRST REQUIREMENTS IN DIAGNOSIS. IMPROPER FLOW MAY RESULT IN ERRATIC OPERATIONS, DOWNSCALE AS WELL AS UPSCALE READINGS, WITH NO EXHAUST GAS PRESENT, ETC.

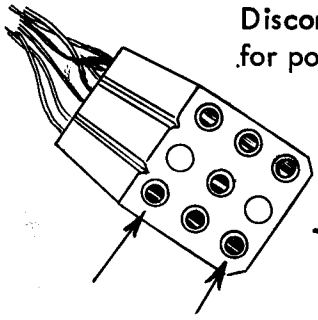
FLOW MEASUREMENTS

The first indication of restricted flow is erratic operation of the flow light or the flow light does not come on at all. With the use of a regular mechanic's vacuum gauge, the following procedure checks the entire system which will save valuable down time.

1. Check if the motor is running.



MOTOR NOT RUNNING



Disconnect the motor connector and test for power at the socket.

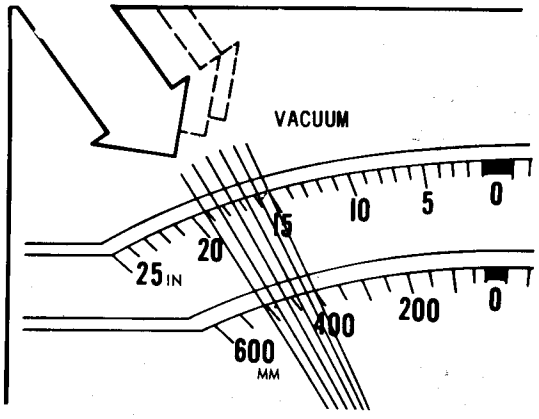
FOR MOTOR REPLACEMENT
SEE PAGE 28

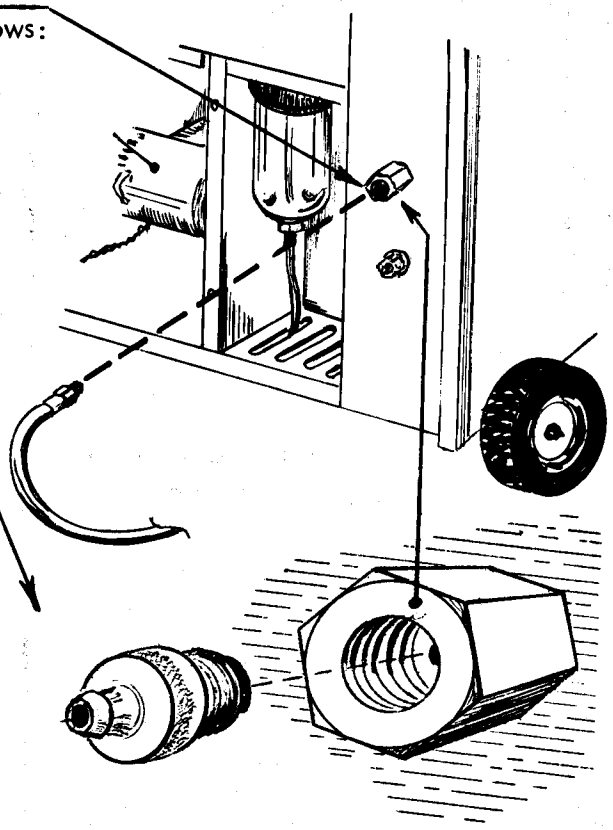
MOTOR RUNNING

2. Remove the sampling tube from the rear of the cabinet and check vacuum of the pump as follows:

For best results, use a vacuum adapter (Part #A-11591) which is supplied with most Allen equipment using a vacuum gauge.

Connect a vacuum gauge to the intake and observe the reading. The unit should draw approximately 15 to 20 inches of vacuum.

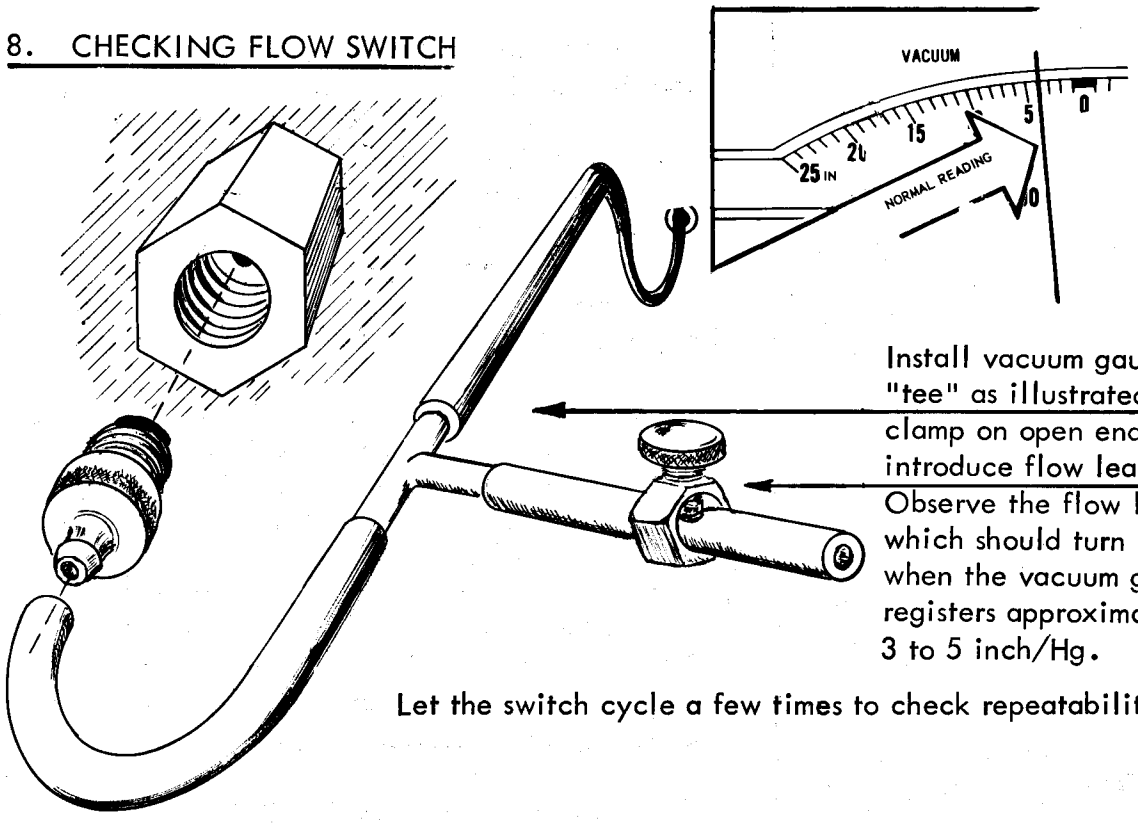




SYMPTOM	CORRECTIVE ACTION
Vacuum OK. No exhaust at exit port.	Check plumbing - See page 26. Check filter bowl.
Vacuum slowly creeping up, pump laboring.	(a) Restricted plumbing. (b) Check filter.
Severe oscillations on the vacuum gauge and low reading.	Clean pump - See page 28
Flow light going off when sample probe is connected	(a) Restricted probe - See page 27 (b) Improper filter used

FILTER AVAILABILITY	
SAMPLE TUBE FILTER	- HASTINGS # GF-22 - FILKO # FF-1 - ALLEN # 27548 (Do not use Rochester or A.C.)
WATER TRAP FILTER	- NORGREN # 3161-03 - ALLEN # 27326

8. CHECKING FLOW SWITCH



Install vacuum gauge with "tee" as illustrated. Use clamp on open end hose to introduce flow leakage. Observe the flow light which should turn "off" when the vacuum gauge registers approximately 3 to 5 inch/Hg.

Let the switch cycle a few times to check repeatability.

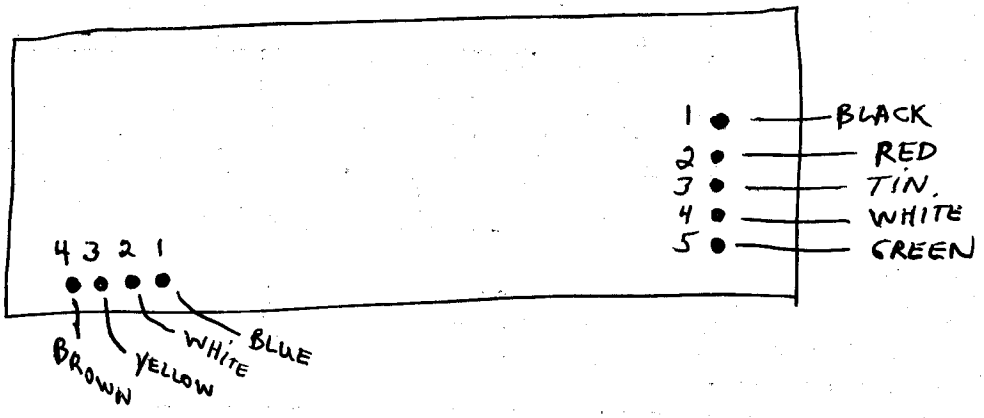
SYMPTOM	CORRECTIVE ACTION
A. Power does not turn ON when actuating power switch.	(a) Check for blown fuse. Replace with exact duplicate, 3 ampere, 3AG.
	(b) Check AC voltage at outlet for correct voltage. Reset breaker or switch to supply power to receptacle.
30154 4 of 1up 30086 ½ in	(c) Check power to terminal board (TB70) located inside cabinet. CAUTION: terminal board contains 115 volt line voltage which can be hazardous. Check for loose terminal to one of the terminal board lugs, replace as required.
	(d) Check that chopper motor is energized. If energized, check wiring to pilot light located on control panel.
B. Meter Pointer at Zero, No Zero Control	(a) Check that Power is ON and chopper motor energized.
	(b) Check that sync assembly connector (P301) is properly and securely mated. Reconnect. (P.C.B.A.)
	(c) Check for SIG sync pulse at TB 302 (oscilloscope). Pulse should be approximately 15 volts positive; negative swing should be approximately 15 volts negative. Replace sync assembly if required. See page 20.
	(d) Where only one meter does not move check for broken lead to meter. Correct wiring as required. See page 24 for connector repairs.
SOME UNITS HAVE TO BE SET HIGHER THAN -4 VOLTS OR THEY GO DEAD	(e) Check output of preamplifier (TP101/TP201). Peak to Peak voltage should be 1 volt. Adjust gain of preamp (R104 and R204) for one volt output. See page 10.
	(f) Check input to preamp with high impedance oscilloscope. Voltage swing should be about 100 millivolts for HC and 10 millivolts for CO channel. Replace detector assembly where either signal is absent.
	(g) Check for open diode CR104 (CR204). Replace if open.

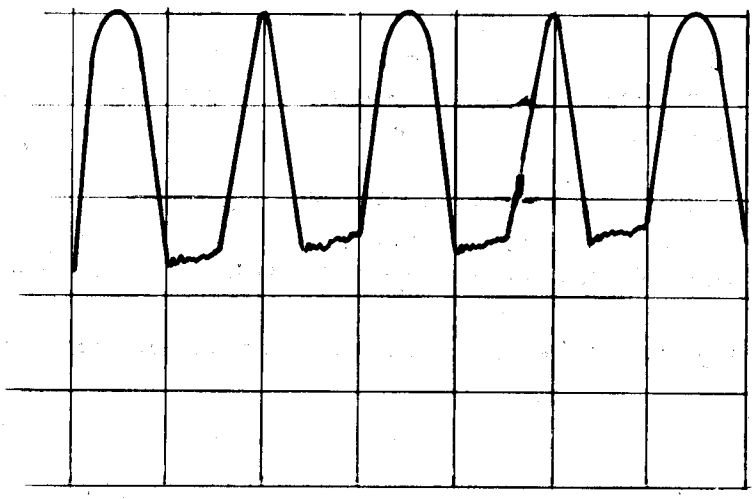
SYMPTOM	CORRECTIVE ACTION
C. Meter Pointer Below Zero.	(a) Adjust Zero panel control. (b) With Zero panel control centered adjust coarse zero (R123 HC and R223 CO). See page 11. (c) Check that infrared radiant source (L301) is glowing a dull orange color. Replace if burned out. See page 21. (d) Check that reference beam path is not obscured. Remove obstruction. Check position of CAL FLAG. Check for sync to TP 301-302. If no signal, replace or align the photo-diodes with photo transistor, see page 20.
D. Meter Pointer Up Scale	(a) Check zero controls. Adjust to bring pointer to zero. (b) Check for obstruction in sample beam path. Check that CAL FLAG does not obscure path. Remove foreign object. See page 22. (c) Check for excessive moisture in plumbing and sample tube. Clean and/or replace sample tube. Check plugged filter/watertrap.
E. Insufficient Span Control.	(a) Check that CAL FLAG is not operated and nested against rubber stopper. Check electrical circuit and power to CAL FLAG motor. Repair as required. (b) Check wave shape of signals with zero gas (N_2) flowing to ensure symmetry of reference and signal. Symmetry should be less than 100 millivolts difference between the two negative signals as measured on an oscilloscope at TP 101 (and TP 201). Check for an obstruction in sample beam optical path. Remove sample tube, replace with new one and check symmetry. Replace detector assembly. Check source for uniform appearing emission. Check mirrors for foreign matter or other deposits such as oil. See page 18. (c) Check for shorted output diodes CR106 (CR206) or CR107 (CR207). Replace if shorted.

SYMPTOM	CORRECTIVE ACTION
E. Insufficient Span Control Continued ADJ TP103 & 203 HIGHER IF SPAN NOT SUFFICIENT	(d) Check for shorted clipping diode CR 105 (CR205). Replace if shorted. (e) Check gain of last amplifier stage (A107, A207). Gain variation should be from 1x to 3x. Check for shorted Span potentiometer. Replace operational amplifier A107 (A207) if defective. (f) Check modulation factor using certified span gas. 1000 ppm HC should provide a minimum modulation of 12.5% or 125 millivolts shift in base line. 5% CO should provide a minimum modulation of 27.5% or 275 millivolts shift in the signal base line. Replace detector assembly if either modulation factor is less than these values. See page 19.
F. Noisy or Erratic Operation	<u>The most common sources of noise are:</u> (a) Reduced output of infrared source. (b) Noisy motor. (c) Noisy detector. (d) Correct grounding of printed circuit board. (e) Optical bench not grounded to cabinet. (f) Detector cable not secured to cable clamp at plug. (g) Faulty preamplifier. (h) Connector to control panel not properly mated. See page 24.
G. Flow Light erractic or off.	(a) Check vacuum at inlet. See page 31. (b) If vacuum is over 15", check flowlight adjustment - page 29. (c) If vacuum is under 15", check motor operation and/or clean pump. See page 28. (d) Check nylon tubing and plumbing for loose connections. (e) Check proper seating of filter bowl, missing gasket, etc.
H. Erratic needle movement on one scale only.	(a) Check connector for open or pushed out pins, see page 24.

SYMPTOM	CORRECTIVE ACTION
J. Meters drifting at or near zero while sampling no exhaust.	(a) Check AGC level - page 10. If too high and cannot be corrected, replace P.C.B.A. and recalibrate, page 9 through 14.
K. Meters not responding at all.	(a) Absence of flow. Check vacuum, page 31. Check exhaust port for flow. If no exhaust check for open plumbing. See "G" above.

ELECTRONIC PROCESSOR





As previously mentioned, the optical bench generates two independent sequential signals one representing a standard or reference for optical transmittance while the other beam undergoes an attenuation due to molecular absorption. (Figure 13) These optical signals are spectrally filtered and sensed by the detectors, one each for the two gases being sampled.

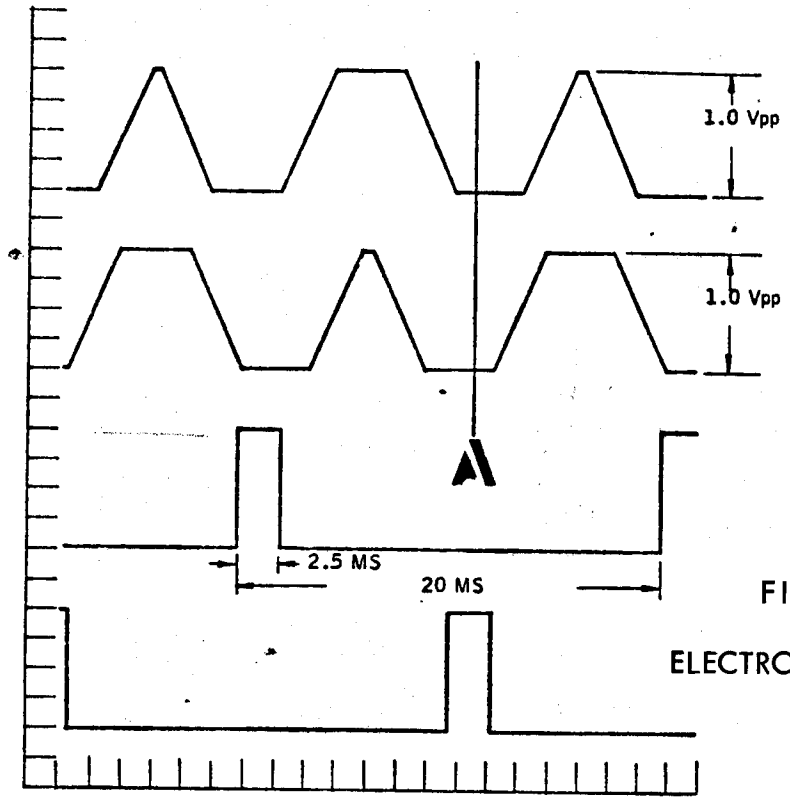
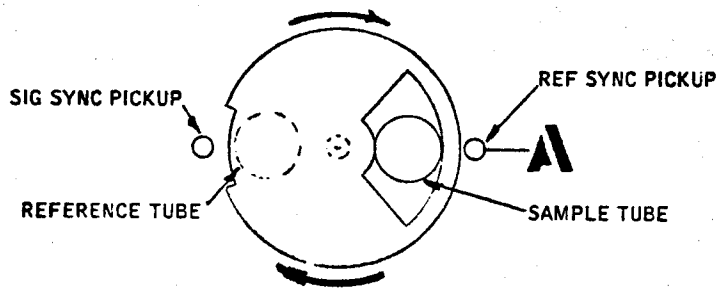


FIGURE 13

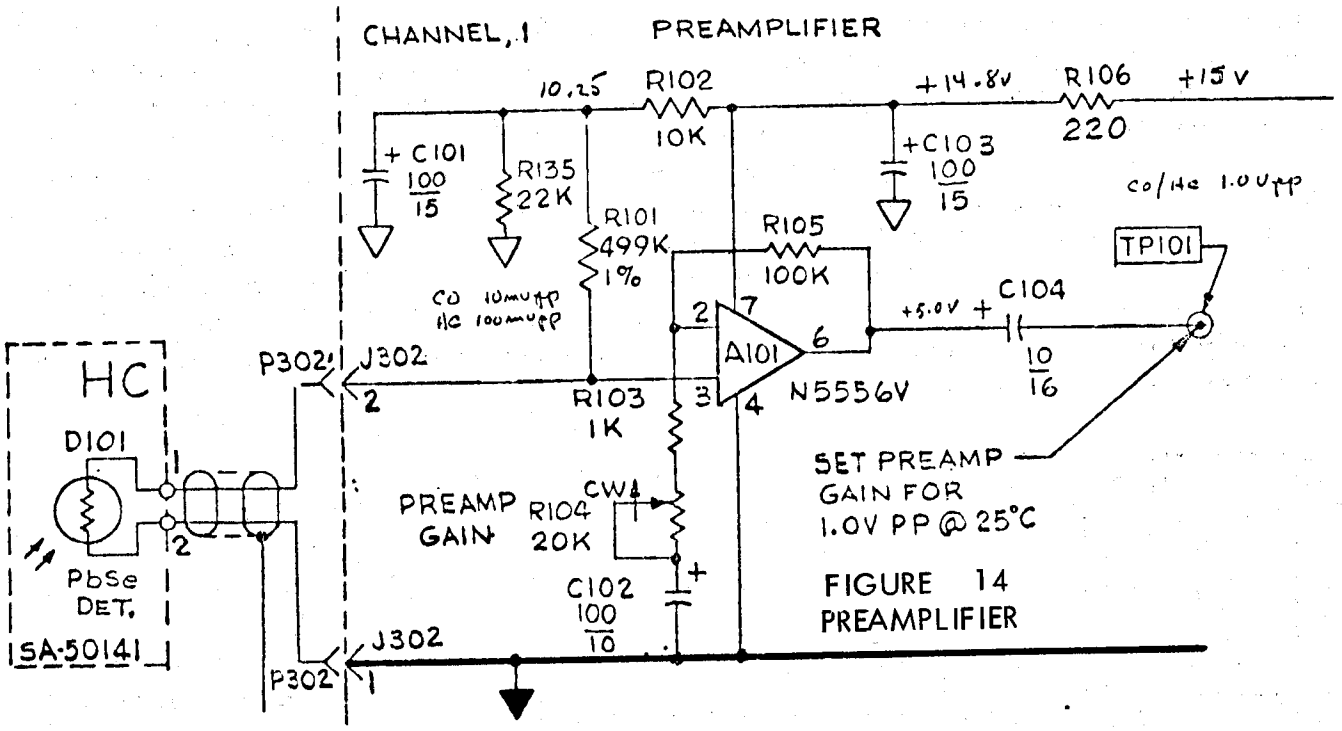
ELECTRONIC SIGNAL



The circuits for each channel are essentially the same. The circuit description is given for only one channel and where differences between channels occur, these differences are noted. Refer to schematic 50101.

The photoconductor detector (D101, HC) and load resistor (R101) form the potentiometric input to the DC coupled preamplifier (A101). The gain of the preamplifier is adjustable (R104) from 6x to about 100x (CO channel gain (R204) is adjustable from about 17 x to 470x). (Figure14)

The voltage across the load resistor-detector combination is filtered to minimize power supply ripple.



The output of the preamplifier is capacitively coupled to the AGC network consisting of R107, R108, and U101. R107 and U101 set the voltage level to the constant gain amplifier A102. U101 is an optically coupled photoconductor whose resistance changes as a function of the current through an LED (light emitting diode). R107 and U101 therefore act as a variable voltage divider to effect a constant reference AC signal of 0.1V peak to peak for all ambient and variable conditions such as temperature and aging of the source. R108 limits the input impedance to A102. A102 is a broadband AC coupled amplifier with a fixed gain of approximately 11x. (Figure 15)

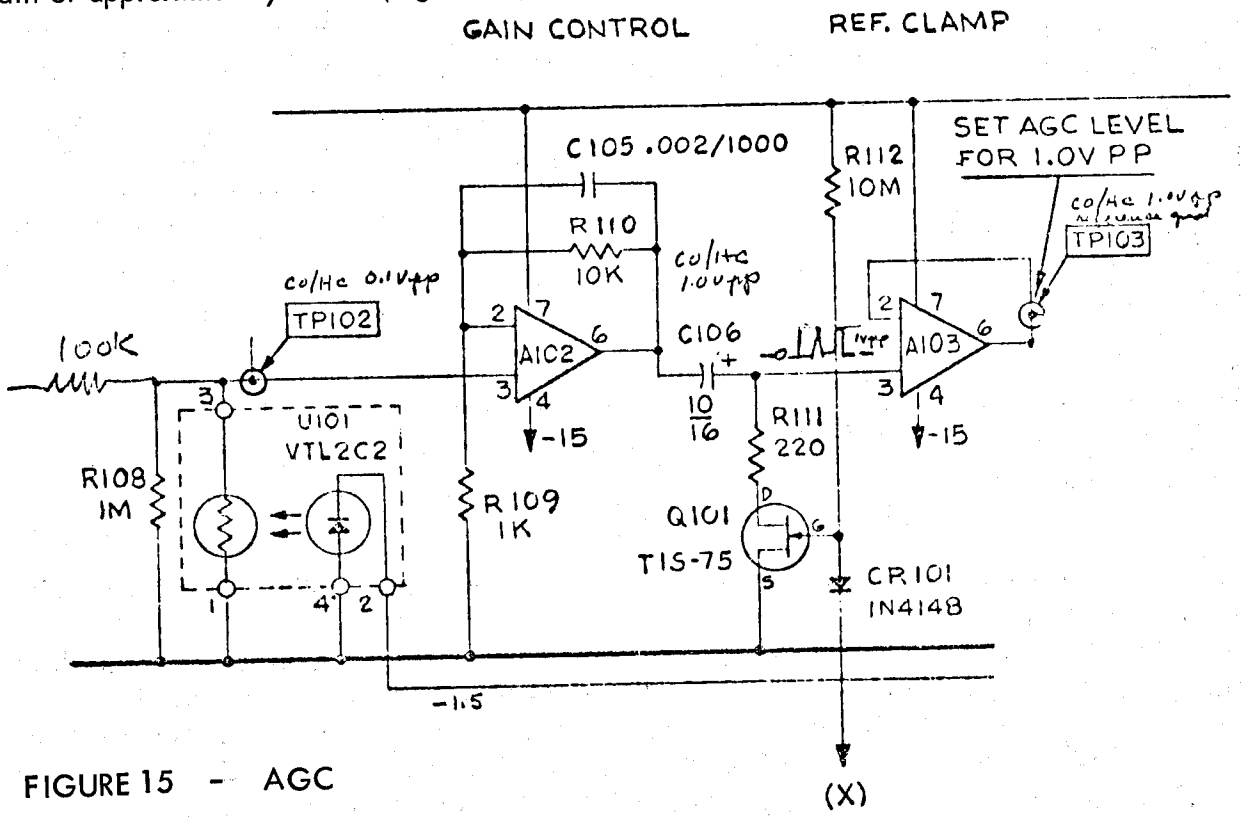


FIGURE 15 - AGC

The output of the constant gain amplifier couples to a "REF" (reference) clamp circuit. The reference clamp signal is generated from the chopper disc. (See Figure 13). A reference sync is generated each time the beam of infrared radiant energy is directed through the reference tube. The REF sync is a positive going signal and swings plus and minus the full power supply voltage. (Figure 16) During its negative swing, the gate of Q101 is highly negative providing a large impedance between drain and source and the output of A102 is coupled to the noninverting input to A103 without attenuation. During the positive cycle of the REF sync plus, the diode, CR101 is back biased and the gate of Q101 is positively charged providing a low impedance between the drain and the source of Q101. The input to A103 is then essentially shorted to ground providing a firm ground reference level for the reference signal at the output of the buffer amplifier A103.

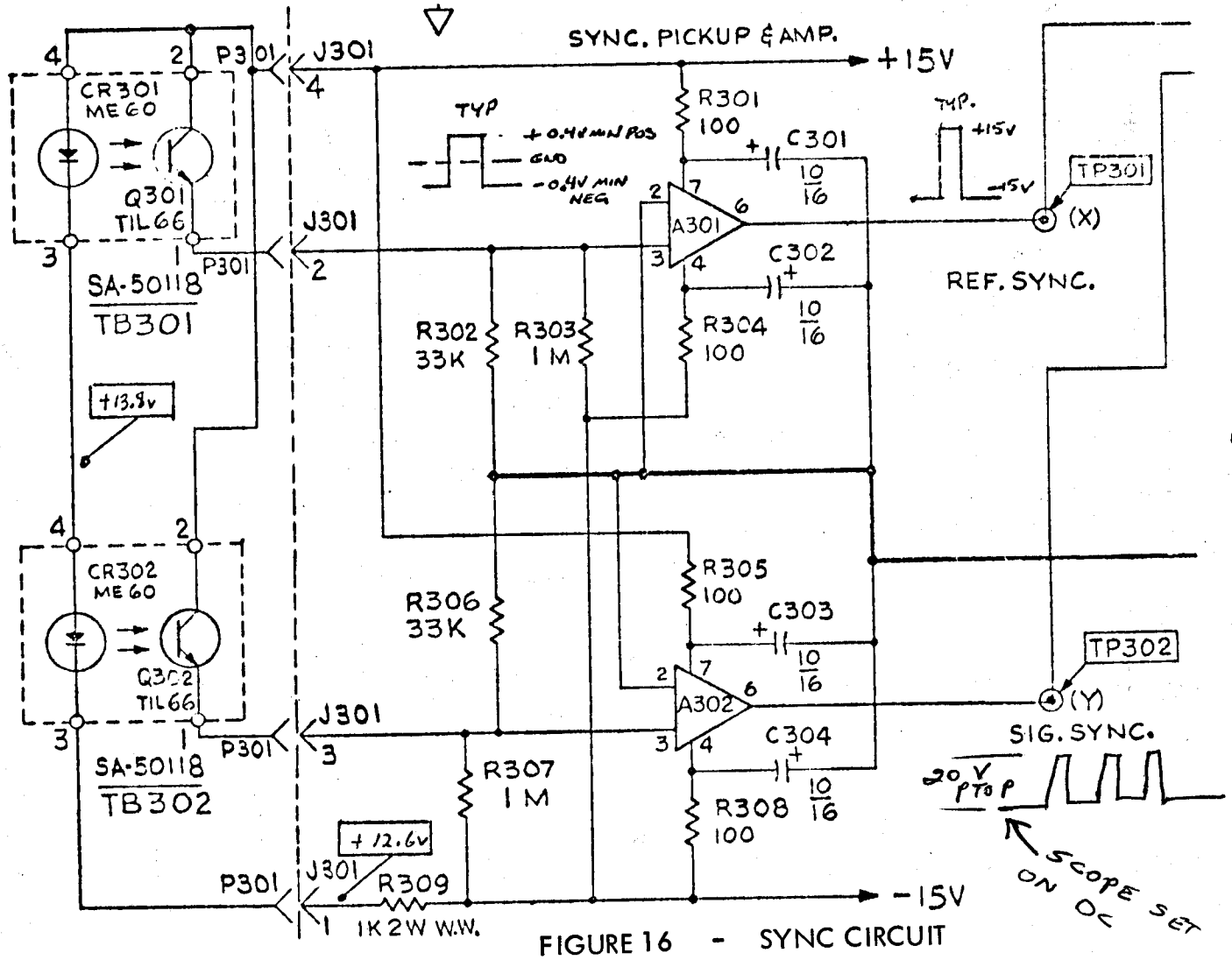


FIGURE 16 - SYNC CIRCUIT

The output of the buffer amplifier at TP 103 couples to two circuits, the Automatice Gain Control (AGC) and the output circuits. All circuits after the buffer amplifier are DC coupled to preserve the reference level. The AGC level, as established by the AGC level control (R116) and the output the buffer amplifier are summed into amplifier A104. (Figure17) The output of A104 then is the resultant sum of the amplified AC signal riding on the variable negative DC signal from the AGC level control. The AGC level in effect biases the input negatively such that only a small portion of the positive tips of the signal

are above ground reference. Amplifier A104 is an inverting amplifier with a gain of approximately 40. The slightly positive tips as biased off by the AGC level control are amplified and inverted at the output. Nominally these tips after amplification are approximately one volt negative at the amplifier output. The AGC detector (CR102) passes these negative tips, which are stored and integrated by capacitor C107. The stored value on C107 is amplified by noninverting amplifier A105. The output of A105 is used to drive the light emitting diode of U101, the AGC control network. The approximate DC level at the output of A105 is -1.5 volts.

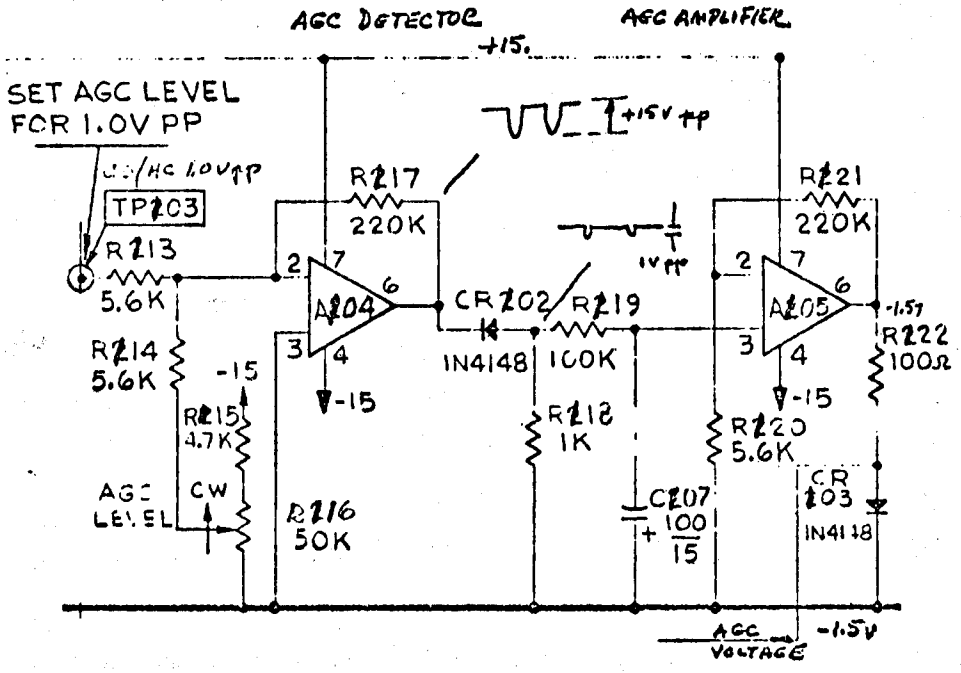


FIGURE 17

AGC DETECTOR

Any change in the amplitude of the AC signal to A104 results in a change in the output of the AGC detector. The output of A105 is then modified to restore the level of the AGC detector to its nominal value.

Buffer amplifier (A103) besides driving the AGC control, drives the two output stages A106 and A107. (Figure 18) Amplifier A106 is a post amplifier for the input AC signal and provides for a coarse zero adjust (R123) for the output. The output of A106 couples to the drain of the gating field effect transistor Q102. The gate of Q102 is connected to the "SIG" (signal) sync pulse which is generated from the chopper disc similar to the "REF" (reference) sync. The signal sync is generated each time the beam of infrared radiant energy is directed through the sample tube. The signal sync is a positive going signal and swings plus and minus the full power supply voltage. During the negative swing, the gate of Q102 is negative and the field effect transistor is cut off, providing a high impedance between drain and source. During the positive sync pulse period, the gate is highly positive and the drain to source impedance is low. In essence then, Q102 acts as a peak synchronous demodulator during the signal sync period to extract dignal data against a reference level established by the reference clamp. The output from Q102 is integrated by capacitor C108 and amplified by A107. Amplifier A107 drives the meter circuits through current limiting resistor R132.

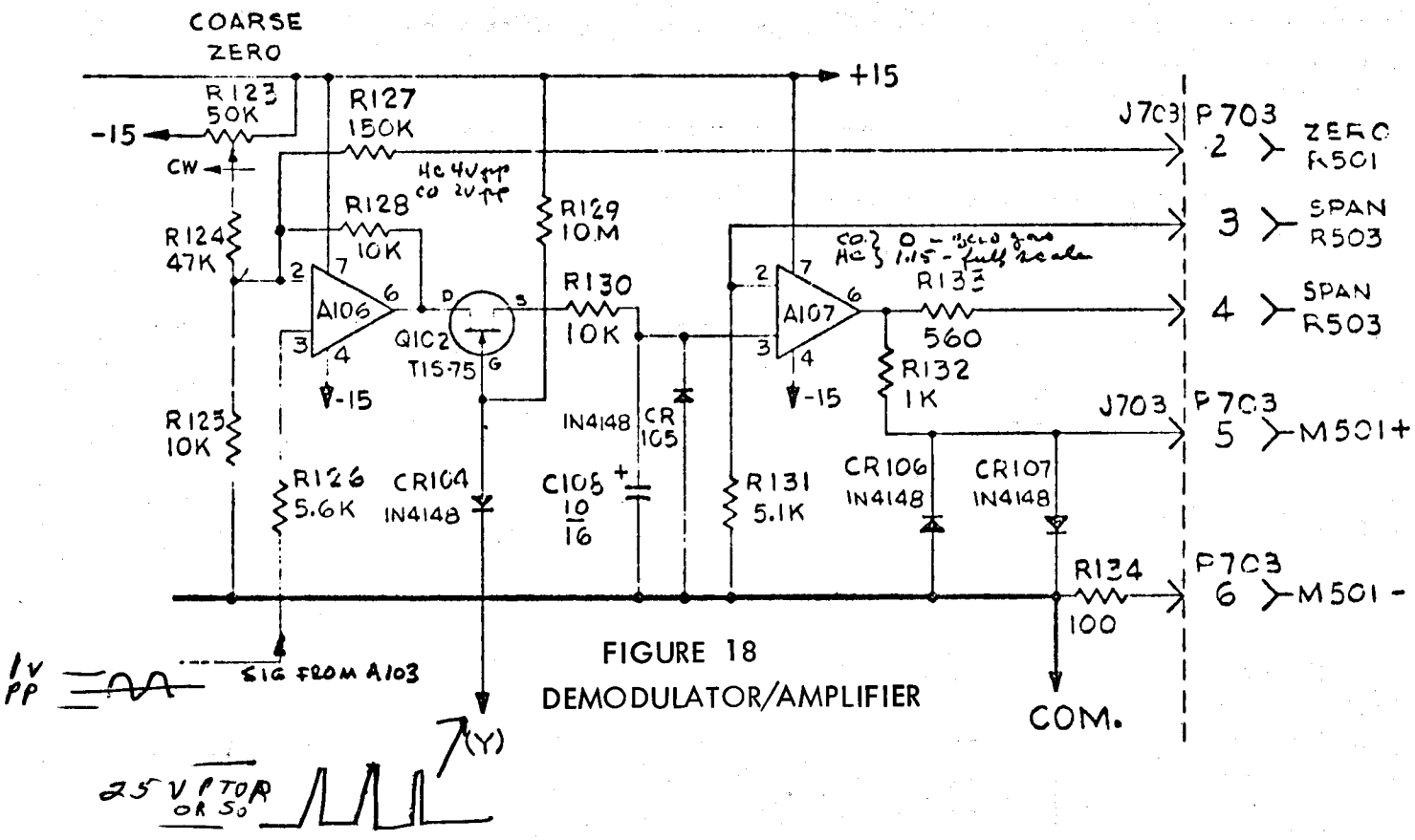


FIGURE 18
DEMODULATOR/AMPLIFIER

External controls are provided which control ZERO and SPAN from the front panel. The Zero control ties to the summing junction of A106 while the Span control varies the feedback resistor of A107 to control the gain of the last amplifier.

The function of the trim potentiometers "LOW", CAL 1 and CAL 2 are to normalize the meter output. The "LOW" potentiometer adjusts for any differences between the HI and LO scales due to variations in resistor values when changing the gain of the last stage A107. The scale switch provides for an approximate change of 2x in the gain of A107. The "LOW" potentiometer permits adjusting that gain change to exactly 2x. This control is only in the circuit when the scale switch is in the LO scale position.

CAL 1 adjusts the meter scale reading for an exact match between a known certified span gas reading and that provided by the mechanical CAL FLAG. The CAL 1 control provides a known output signal across the meter for a specific SPAN potentiometer position. In this manner, the SPAN potentiometer can be returned to the same position each time the CAL FLAG is energized for the original ambient conditions.

CAL 2 adjustment is an internal normalization of the gas modulation against industry accepted standards for NDIR analyzers. This latter adjustment is a factory setting and should not be changed in the field.

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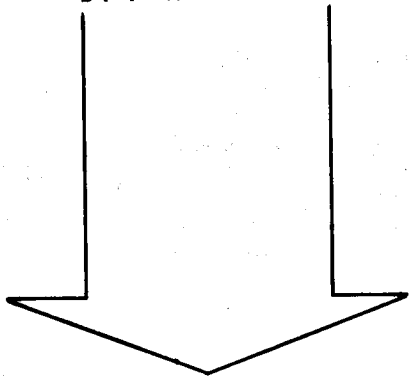

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A102	AMPLIFIER, OPERATIONAL	30001				
A103	AMPLIFIER, OPERATIONAL	30001				
A104	AMPLIFIER, OPERATIONAL	30001				
A105	AMPLIFIER, OPERATIONAL	30001				
A106	AMPLIFIER, OPERATIONAL	30001				
A107	AMPLIFIER, OPERATIONAL	30001				
A201	AMPLIFIER, OPERATIONAL	30000				
A202	AMPLIFIER, OPERATIONAL	30001				
A203	AMPLIFIER, OPERATIONAL	30001				
A204	AMPLIFIER, OPERATIONAL	30001				
A205	AMPLIFIER, OPERATIONAL	30001				
A206	AMPLIFIER, OPERATIONAL	30001				
A207	AMPLIFIER, OPERATIONAL	30001				
A301	AMPLIFIER, OPERATIONAL	30001				
A302	AMPLIFIER, OPERATIONAL	30001				
B301	MOTOR, AC CHOPPER	30075				
B302	MOTOR, AC CAL FLAG	30075				
	CAPACITOR					
C101	ELEC. 100 MFD, 15V	30002				
C102	ELEC. 100 MFD, 15V	30002				
C103	ELEC. 100 MFD, 15V	30002				
C104	ELEC. 10 MFD, 16V	30003				
C105	CERAM. 002 MFD, 1000V	30004				
C106	ELEC. 10 MFD, 16V	30003				
C107	ELEC. 100 MFD, 15V	30002				
C108	ELEC. 10 MFD, 16V	30003				
C109	ELEC. 10 MFD, 16V	30003				
C201	ELEC. 100 MFD, 15V	30002				
C202	ELEC. 100 MFD, 15V	30002				
C203	ELEC. 100 MFD, 15V	30002				
C204	ELEC. 10 MFD, 16V	30003				
C205	CERAM. 002 MFD, 1000V	30004				
C206	ELEC. 10 MFD, 16V	30003				
C207	ELEC. 100 MFD, 15V	30002				
C208	ELEC. 10 MFD, 16V	30003				
C209	ELEC. 10 MFD, 16V	30003				
C301	ELEC. 10 MFD, 16V	30003				
C302	ELEC. 10 MFD, 16V	30003				
C303	ELEC. 10 MFD, 16V	30003				
C304	ELEC. 10 MFD, 16V	30003				

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	CAPACITOR					
C401	ELEC. 1000 MFD, 25V	30005				
C402	ELEC. 1000 MFD, 25V	30005				
C403	CERAM. 01 MFD, 500V	30006				
C404	CERAM. 01 MFD, 500V	30006				
C405	ELEC. 10 MFD, 16V	30003				
C406	ELEC. 100 MFD, 15V	30002				
CR101	DIODE	30007				
CR102	DIODE	30007				
CR103	DIODE	30007				
CR104	DIODE	30007				
CR105	DIODE	30007				
CR106	DIODE	30007				
CR107	DIODE	30007				
CR201	DIODE	30007				
CR202	DIODE	30007				
CR203	DIODE	30007				
CR204	DIODE	30007				
CR205	DIODE	30007				
CR206	DIODE	30007				
CR207	DIODE	30007				
CR301	DIODE, INFRARED EMITTER	30009				
CR302	DIODE, INFRARED EMITTER	30009				
CR401	DIODE	30010				
CR402	DIODE	30010				
CR403	DIODE	30010				
CR404	DIODE	30010				
D101	DETECTOR, HC	30049				
D102	DETECTOR, CO	30050				
J301	CONNECTOR, PIN WAFER	30057				
J302	CONNECTOR, PIN WAFER	30058				
L 301	SOURCE, 240V 225W ELEM	30051				
P301	CONNECTOR	30059				
P302	CONNECTOR	30060				
P702	CONNECTOR, PIN	30061				

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Q101	TRANSISTOR, FIELD EFFECT	30011				
Q102	TRANSISTOR, FIELD EFFECT	30011				
Q201	TRANSISTOR, FIELD EFFECT	30011				
Q202	TRANSISTOR, FIELD EFFECT	30011				
Q401	TRANSISTOR	30012				
Q402	TRANSISTOR	30013				
	RESISTOR					
R101	499K 1% 1/4W MET FLM	30014				
R102	10K 5% 1/4W CARB. COMP	30015				
R103	1K 5% 1/4W CARB. COMP	30016				
R104	POT. 50K CERMET	30017				
R105	100K 5% 1/4W CARB. COMP	30018				
R106	220Ω 5% 1/4W CARB. COMP	30019				
R107	100K 5% 1/4W CARB. COMP	30018				
R108	1M 5% 1/4W CARB. COMP	30020				
R109	1K 5% 1/4W CARB. COMP	30016				
R110	10K 5% 1/4W CARB. COMP	30015				
R111	220Ω 5% 1/4W CARB. COMP	30019				
R112	10MΩ 5% 1/4W CARB. COMP	30021				
R113	5.6K 5% 1/4W CARB. COMP	30022				
R114	5.6K 5% 1/4W CARB. COMP	30022				
R115	4.7K 5% 1/4W CARB. COMP	30023				
R116	POT. 50K CERMET	30017				
R117	220K 5% 1/4W CARB. COMP	30024				
R118	1K 5% 1/4W CARB. COMP	30016				
R119	100K 5% 1/4W CARB. COMP	30018				
R120	5.6K 5% 1/4W CARB. COMP	30022				
R121	220K 5% 1/4W CARB. COMP	30024				
R122	100Ω 5% 1/4W CARB. COMP	30025				
R123	POT. 50K CERMET	30017				
R124	47K 5% 1/4W CARB. COMP	30026				
R125	10K 5% 1/4W CARB. COMP	30015				
R126	5.6K 5% 1/4W CARB. COMP	30022				
R127	150K 5% 1/4W CARB. COMP	30027				
R128	10K 5% 1/4W CARB. COMP	30015				
R129	10M 5% 1/4W CARB. COMP	30021				
R130	10K 5% 1/4W CARB. COMP	30015				
R131	5.1K 5% 1/4W CARB. COMP	30028				
R132	1K 5W 1/4W CARB. COMP	30016				
R133	560Ω 5% 1/4W Carb. COMP	30029				
R134	100Ω 5% 1/4W CARB. COMP	30025				
R135	22K 5% 1/4W CARB. COMP	30030				
R136	22K 5% 1/4W CARB. COMP	30030				
R137	22K 5% 1/4W CARB. COMP	30030				

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	RESISTOR					
R201	499K 1% 1/4W METAL FLM	30014				
R202	10K 5% 1/4W CARB. COMP	30015				
R203	680Ω 5% 1/4W CARB. Comp	30031				
R204	POT. 50K CERMET	30017				
R205	470K 5% 1/4W CARB. COMP	30032				
R206	220Ω 5% 1/4W CARB. COMP	30019				
R207	100K 5% 1/4W CARB. COMP	30018				
R208	1MΩ 5% 1/4W CARB. COMP	30020				
R209	1K 5% 1/4W CARB. COMP	30016				
R210	10K 5% 1/4W CARB. COMP	30015				
R211	220Ω 5% 1/4W CARB. COMP	30019				
R212	10MΩ 5% 1/4W CARB. COMP	30021				
R213	5.6K 5% 1/4W CARB. COMP	30022				
R214	5.6K 5% 1/4W CARB. COMP	30022				
R215	4.7K 5% 1/4W CARB. COMP	30023				
R216	POT. 50K CERMET	30017				
R217	220K 5% 1/4W CARB. COMP	30024				
R218	1K 5% 1/4W CARB. COMP	30016				
R219	100K 5% 1/4W CARB. COMP	30018				
R220	5.6K 5% 1/4W CARB. COMP	30022				
R221	220K 5% 1/4W CARB. COMP	30024				
R222	100Ω 5% 1/4W CARB. COMP	30025				
R223	POT. 50K CERMET	30017				
R224	47K 5% 1/4W CARB. COMP	30026				
R225	22K 5% 1/4W CARB. COMP	30030				
R226	5.6K 5% 1/4W CARB. COMP	30022				
R227	150K 5% 1/4W CARB. COMP	30027				
R228	10K 5% 1/4W CARB. COMP	30015				
R229	10MΩ 5% 1/4W CARB. COMP	30021				
R230	10K 5% 1/4W CARB. COMP	30015				
R231	5.1K 5% 1/4W CARB. COMP	30028				
R232	1K 5% 1/4W CARB. COMP	30016				
R233	560Ω 5% 1/4W CARB. COMP	30029				
R234	100Ω 5% 1/4W CARB. COMP	30025				
R235	22K 5% 1/4W CARB. COMP	30030				
R236	22K 5% 1/4W CARB. COMP	30030				
R237	22K 5% 1/4W CARB. COMP	30030				
R301	100Ω 5% 1/4W CARB. COMP	30025				
R302	33K 5% 1/4W CARB. COMP	30033				
R303	1MΩ 5% 1/4W CARB. COMP	30020				
R304	100Ω 5% 1/4W CARB. COMP	30025				
R305	100Ω 5% 1/4W CARB. COMP	30025				

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	RESISTOR					
R306	33K 5% 1/4W CARB. COMP	30033				
R307	1MΩ 5% 1/4W CARB. COMP	30020				
R308	100Ω 5% 1/4W CARB. COMP	30025				
R309	1K 2W WW 5%	30034				
R310	33Ω 12W 5% WW RADIAL	30035				
R401	100Ω 5% 1/4W CARB. COMP	30025				
R402	100Ω 5% 1/4W CARB. COMP	30025				
R403	4.7Ω 5% 1/4W CARB. COMP	30036				
R404	2.7Ω 10% 1/4W CARB. COMP	30037				
T301	POWER TRANSFORMER	30045				
U101	PHOTO ISOLATOR	30044				
U102	PHOTO ISOLATOR	30044				
U401	DUAL VOLTAGE REGULATOR	30043				
Q301	PHOTO TRANSISTOR	30042				
Q302	PHOTO TRANSISTOR	30042				
	CABINET ASSEMBLY & METER HOUSING ASSEMBLY					
B701	PUMP AND MOTOR	30074				
DS701	LAMP, INDICATING	30052				
DS702	LAMP, INDICATING	30052				
DS703	LAMP, INDICATING	30052				
F701	FUSE, 3AG 3 AMP	30053				
J702	CONNECTOR (10 PIN)	30067				
J704	CONNECTOR (9 PIN)	30068				
J705	CONNECTOR (20 PIN) WITHOUT PINS	30069				
M501	METER, HC	20707				
M601	METER, CO	20708				
	METER COVER	20481				

CO/HC ANALYZER

ALLEN TESTPRODUCTS DIVISION
SERVICE PARTS LIST

MODEL		23-060	23-060	23-060	23-070	23-070
SERIES		A	B	C	A	B
PLEASE ORDER BY PART NUMBER						
KEY NO.	PART DESCRIPTION	PART NUMBER	PART NUMBER	PART NUMBER	PART NUMBER	PART NUMBER
P701	CONNECTOR	30062				
P703	CONNECTOR (18 PIN) } without pins	30063				
P704	CONNECTOR (9 PIN) } without pins	30064				
P705	CONNECTOR (20 PIN) } without pins	30065				
P706	POWER OUTLET, 3 WIRE 110V	30066				
P707	POWER OUTLET, 3 WIRE 110V	30066				
R501	POT. 10K 1/2W VARIABLE	30038				
R502	POT. TRIMITS 200 Ω	30039				
R503	POT. 10K 1/2W VARIABLE	30038				
R504	POT. TRIMITS 10K	30041				
R505	POT. TRIMITS 5K	30083				
R601	POT. 10K 1/2W VARIABLE	30038				
R602	POT. TRIMITS 1 K	30110				
R603	POT. 10K 1/2W VARIABLE	30038				
R604	POT. TRIMITS 10K	30041				
R605	POT. TRIMITS 10K	30041				
S701	SWITCH, POWER	30046				
S702	CALIBRATION SWITCH	30047				
S703	FLOW SWITCH	30073				
S704	SWITCH, RANGE	30046				
TB701	TERMINAL STRIP	30055				
TB702	TERMINAL STRIP	30056				
XF701	FUSE HOLDER	30054				
Y101	CABLE, POWER	30070				
Y102	CABLE, INTERCONNECTING CABLE ONLY, 25 FEET	30071				
H101	GAS SAMPLE HOSE (20 ft.)	30072				
H102	GAS SAMPLE HOSE (30 ft.)				30109	
H103	15 FT. HOSE EXTENSION	30113				
H104	25 FT. HOSE EXTENSION	30114				
H105	SAMPLING PROBE	30115				
(1)	HASTINGS OR PHILCO GAS LINE FILTER FOR GM CARS	27548				
~~(2)~~	~~HOSE FERRULE (END METAL CAP FOR FILTER)~~	~~30115~~ ← OBSOLETE				

CO/HC ANALYZER

ALLEN TESTPRODUCTS DIVISION
SERVICE PARTS LIST

MODEL SERIES PLEASE ORDER BY PART NUMBER		23-060 A	23-060 B	23-060 C	23-070 A	23-070 B
KEY NO.	PART DESCRIPTION	PART NUMBER	PART NUMBER	PART NUMBER	PART NUMBER	PART NUMBER
B303	CHOPPER DISC	30076				
B305	CAL FLAG ASSEMBLY	30077				
G103	END CAP	30078				
D105	FILTER & DETECTOR HC & CO WIRING ASSEMBLY	30079				
D103	FILTER & DETECTOR ASSEM.	30080				
D104	FILTER & DETECTOR ASSEM.	30081				
E101	FILTER BOWL, TRANSPARENT	30082				
E102	FILTER ELEMENT	27326				
K101	MIRROR	30084				
K102	MIRROR HUB	30085				
PC101	PC BOARD ASSEMBLY	30086				
B702	PUMP DIAPHRAGM, HYPALON	30087				
B304	RING-COMPRESSION CHOPPER DISC	30088				
L302	RING, RETAINING, SOURCE	30089				
K103	RING, RETAINING, MIRROR	30090				
B306	RUBBER BUMPER	30091				
L303	SOURCE MOUNT	30092				
B307	SPRING EXTENSION	30093				
V101	SYNC & REF WIRING ASSEMBLY	30094				
G102	WINDOW SILICON	30095				
G101	SAMPLE TUBE ASSEMBLY	30096				
G201	REFERENCE TUBE ASSEMBLY	30097				
Z100	CONDENSER MODIFIED	30098				
Z101	BULKHEAD FITTING	30099				
Z102	TEE FITTING (PLASTIC)	30100				
Z103	MALE ADAPTER 1/8" (PLASTIC)	30101				
Z104	3/8" - 1/4" (PLASTIC)	30102				
Z105	3/8" - 9/16" (METAL)	30103				
Z106	ADAPTER 3/8"-1/8" (PLASTIC)	30104				
Z107	JAM NUT 9/16"	30105				
Z108	1/2" O. D. TUBE (10 FT)	30106				
Z109	3/8" O. D. TUBE (10 FT)	30107				
Z110	1/4" O. D. TUBE (10 FT)	30108				
Z111	FILTER DRAIN TUBE ASSEM.	30116				
Z112	WIRE BRACKET	30117				
Z113	HANDLE (CABINET)	26378				

ALWAYS GET THIS

NOW USE 30154 PCBA

THIS IS ONLY GOOD FOR UNITS WHERE LO SCALE IS 1/2 UPPER SCALE

THIS BOARD CAN BE USED FOR EITHER THE OLD TYPE WHERE LOWER SCALE IS 1/2 UPPER SCALE BUT HAS TO BE USED FOR ALL TYPES WHERE LO SCALE IS 1/4 UPPER SCALE.

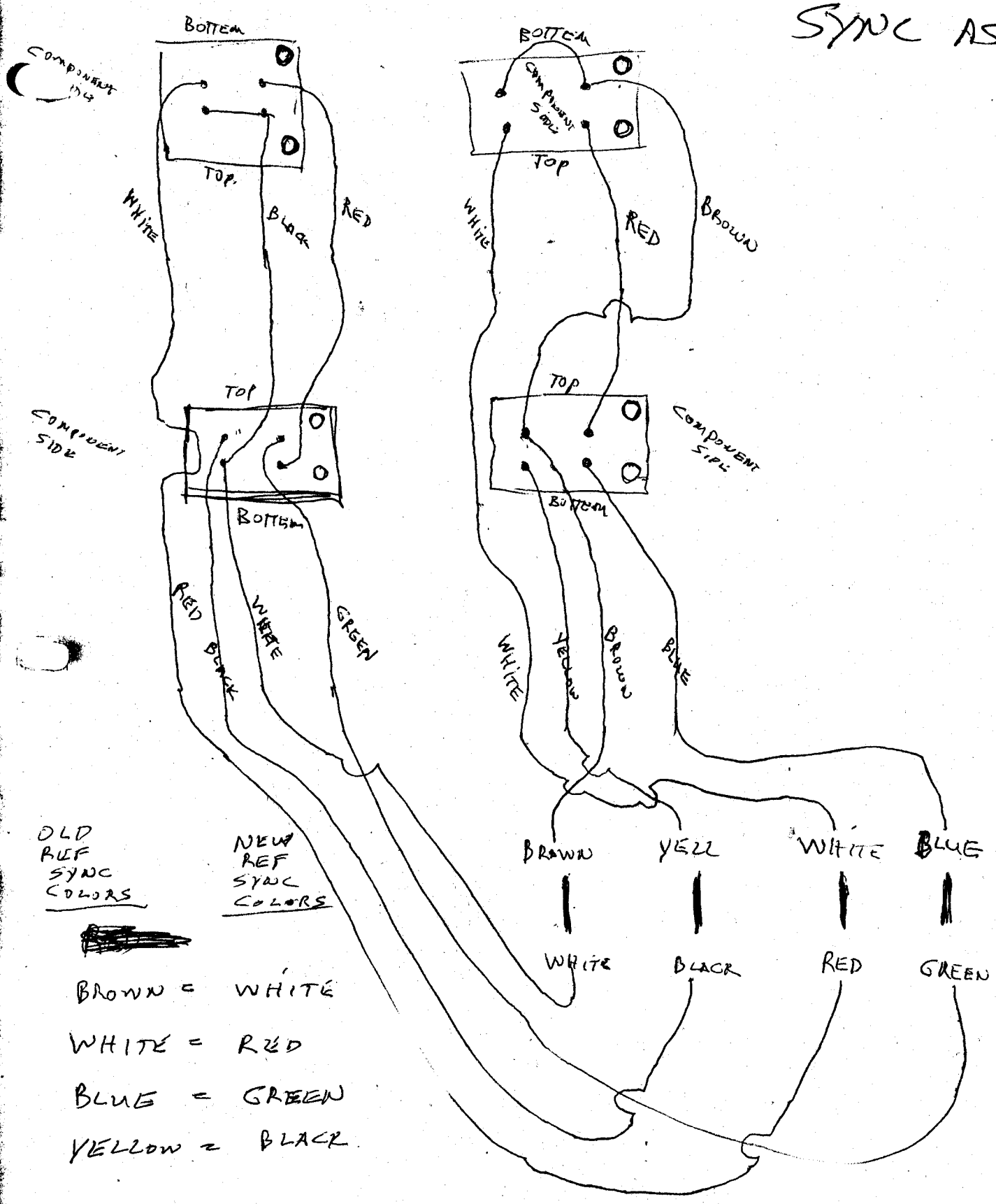
PCBA SAYS 50150 ON TOP IT'S THE OLD STYLE PART # 30086

COMPONENT SIDE

NEW

OLD

NEW REF & SYNC ASSY



OLD REF SYNC COLORS

NEW REF SYNC COLORS

BROWN = WHITE

WHITE = RED

BLUE = GREEN

YELLOW = BLACK

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TESTPRODUCTS DIVISION

PART NO. 25512

AUG. '73

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