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INSTRUCTION MANUAL FOR GUNN-DIODE MICROWAVE CAVITY AMMONIA MONITOR

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MASTER

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GUNN-DIODE MICROWAVE CAVITY AMMONIA MONITOR

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GUNN-DIODE MICROWAVE CAVITY AMMONIA MONITOR

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I. GENERAL INFORMATION

A. Introduction

The Gunn-diode microwave cavity instrument is a self-contained (the vacuum pump is external) microwave spectrometer for the specific detection and monitoring of ammonia gas in air. A solid state microwave source is used together with a high-Q resonant microwave cavity which is both the frequency selecting device for the source and the sample container through which the sampled gases pass.

The ammonia absorption transition at 23,870.1 MHz is monitored continuously with this instrument. The monitoring frequency is stable to one part in 10^9 so that the system only responds to NH_3 absorption - there are no known interfering gases.

The power input to the cavity absorption cell has been adjusted so that traces of NH_3 gas in mixture with air at a cell pressure of approximately 0.07 Torr will absorb the maximum possible microwave power. With this condition, the response of the instrument to trace quantities of NH_3 is linear over the dynamic range of minimum detectable to about 20 ppm.

Heterodyne detection and amplification is used with this instrument. Electric field modulation (Stark effect modulation) applied through the gas sample "chops" the absorption signal, thereby causing an amplitude modulation of the intermediate frequency. The intermediate frequency (IF) is subsequently demodulated after amplification and the resulting signal is synchronously detected with the Stark modulation reference frequency. The output is a dc signal which is amplified and R/C filtered with a time constant of 3 seconds, (or 100 sec.) then presented to a digital meter and a BNC recorder output.

Either a single-stage or a two-stage dimethyl-silicone membrane molecular separator are used to interface the microwave cavity to the atmosphere. The single-stage device is used for fastest response while the two-stage is used for maximum sensitivity. The output of the first stage is maintained at a pressure near 6 Torr by an external vacuum pump.

The output of the last stage is pumped directly through the cavity which is maintained at a pressure of about 0.07 Torr during operation. With these conditions, an enrichment factor of about 100 for NH_3 with respect to air is obtained within the microwave cavity.

A water dryer, consisting of a Teflon tube filled with Ascite, is supplied with the instrument. Its function is to remove most of the water vapor from the sampled gases without removing the NH_3 gas. This tube is at the inlet of the instrument and has a lifetime of approximately 48 hours of continuous operation before replacement is required. The tubes are available commercially and are either refillable or disposable.

The instrument has been designed for simple operation and easy calibration. Except for the calibration procedure, the instrument operates automatically from turn-on. A four-digit readout is supplied on the front panel and it reads the concentration of ammonia directly in parts-per-million over a range of from 0.00 to 20 ppm. A 0-10 volt output is also available at the rear panel for recording data on an external recorder.

B. Specifications

Molecule detected - gaseous N^{14}H_3 .

Interferences - none known.

Minimum detectable quantity - Approximately 0.01 ppm with S/N = 1 (tangential)

Detection Range - 0.00 to 20.00 ppm

Linearity - 1) Less than 10% deviation from linearity for all concentrations, when calibrated for full scale use.
2) Less than 5% deviation from linearity for concentrations within one order of magnitude from calibration point.

- Stability
- Zero Drift - less than 0.5% of full scale per per 24 hour period, after 24 hour warmup and at room temperature $\pm 3^{\circ}\text{F}$.
 - Frequency Stability - better than 1 part in 10^9 per day.
 - Peak Response Stability - less than 2% deviation from the peak maximum in 160 days.
- Temperature Range - 40°F to 100°F ambient.
- Response Time
- Single-stage - 90% response to step change in 2 min.
 - Dual-stage - 90% response to step change in 30 min.
- Modes of Operation
- 1) Continuous "sniffing" (minimum response time) used where fast response is a necessity but where minimum detectability is not necessary.
 - 2) Continuous "sniffing" (maximum sensitivity) used where minimum detectability is required.
 - 3) Batch sampling - (dynamic) - used where a batch sample can be continuously supplied to the monitor.
 - 4) Batch sampling - (static) - used where a minimum of sample is available.
- Outputs
- 1) 3-1/2 digit front panel readout in parts-per-million.
 - 2) 0 to 10 volt analog signal at BNC recorder output on back panel.
- Dimensions - Rack mountable 19" x 21" x 10-1/2" (vacuum pump external).
- Total Weight - (excluding vacuum pump) 100 pounds.
- Vacuum Connectors - Varian
- Sample Input Connectors - 1/4" Swage
- Power Requirements - 115V, 10 amps, 60H_z (approximately 250 W cont.).

II. INSTALLATION

A. Preparation for Use

- (1) The instrument can either be installed on a bench or removed from the blue enclosure and rack mounted in a 19" width rack.
- (2) It is recommended that the vacuum pump be connected to the instrument and started before power is applied to the instrument. A single corrugated stainless tube is supplied for connecting the pump to the instrument.
 - Connect the mechanical pump to the inlet connector on the back panel using a special metal gasket for the vacuum seal.
 - Be sure that the hand operated valve on the pump is closed (fully counter-clockwise) before starting the pump.
 - Plug the vacuum pump power cord into a suitable AC outlet.
 - The switch on the vacuum pump may be turned on at any time.
- (3) To prepare the instrument for operation, first make sure all four valves on the top of the instrument are closed (fully counter-clockwise).
- (4) The instrument requires an AC power source of 115V, 10A, 60 Hz. A three wire AC power cord is supplied with the instrument. Plug the cord into a suitable power outlet.

III. OPERATION

A. Description of Controls

The following is a list of controls on the instrument, their locations, and their functions:

<u>Control</u>	<u>Location</u>	<u>Function</u>
Panel Meter	Front Panel	Displays the quantity of detected ammonia in parts-per-million
0-250 ml/sec flow rate indicator	Front Panel	Allows adjustment of ambient air inlet flow when operated in the "sniffing" mode. Reads carrier gas flow rate for calibration purposes.
Two position hand valve	Front Panel	In the single stage position, this valve passes the inlet sample gas to the single stage separator. In the dual stage position it passes the sample to the first stage of the dual stage separator. It has a center "off" position.
"AC On-Off" pushbutton	Front Panel	Provides main power to the instrument. The external vacuum pump should always be connected to the monitor and pumping before the "on" button is pushed. Light is lit when instrument is powered. Push again to disrupt power to the instrument.

<u>Control</u>	<u>Location</u>	<u>Function</u>
"Cavity Pressure" gauge	Front Panel	This gauge displays the pressure (in microns) within the microwave cavity cell. The meter must always read below the red line for the instrument to operate. The green mark indicates optimal operating range.
"Cavity over temperature" panel lite (red)	Front Panel	Indicates an overtemperature condition of the microwave cavity. Data should not be taken when this light is on. The instrument should be shut down with this condition and must be restarted after a cool down period.
"Ready" panel lite (red)	Front Panel	Indicates that the monitor is functionally ready to take data. The normal start-up time from a cold start will be approximately 35 min.
"Dual stage rough outlet valve"	Top	The outlet valve to rough pump the center of the dual stage.
"Single stage inlet valve"	Top	The inlet valve to the microwave cavity from the single stage separator.
"Cavity outlet valve"	Top	The outlet valve from the microwave cavity to the vacuum pump.

<u>Control</u>	<u>Location</u>	<u>Function</u>
"Dual stage inlet valve"	Top	The inlet valve to the microwave cavity from the dual stage separator.
"Zero" knob	Front Panel	Used to zero the digital display meter.
"Calibration" knob	Front Panel	Used to set the digital display to the proper ppm value during the calibration procedure.
"Roughing Pump" connector (Varian)	Back Panel	Accepts the flexible tube from the mechanical pump.
"Sample inlet" connector (1/4" Swage)	Back Panel	Accepts tubing from calibration source or provides inlet for samples into the monitor.
"Vent" (1/4" Swage)	Back Panel	Provides a vent for the internal pump.
"AC" connector	Back Panel	Connects the 115V, 15A line service to operate the instrument.
"Time constant" Toggle switch "3 sec"-"100 sec"	Back Panel	Provides either a 3 second or 100 second time constant (signal average) for the detection system.
"Recorder output" connector	Back Panel	Connector for external recorder. Supplies 0-10V proportional to signal amplitude.

<u>Control</u>	<u>Location</u>	<u>Function</u>
"Dryer"	At Back Panel	Used to remove greater than 90% of the water in the air sample. Requires replacement after approximately 40 hours of instrument use. Dryer is expended when the gray material turns to a white color.
"Test Connector"	Back Panel	Connector for test meter to be used for testing the functional operation of the instrument.

B. Turn-on Procedure

- (1) After completing the procedure under Section II-A above, the instrument is ready to be turned on for operation.
- (2) Press the "AC on" push button on the front panel. The push button should light indicating the instrument has been energized.
- (3) A period of approximately 35 minutes is required for warm-up. During this time the system must be evacuated. The following procedure is recommended:
 - a) Slowly open the hand valve on the roughing pump. Let the system rough pump for a few minutes then open the valve on the top of the instrument marked "Cavity Outlet."
 - b) Note on the front panel pressure monitor that the cavity pressure drops below the "red" line. If not, re-check that the other valves on the top of the instrument are closed (fully clockwise) and check vacuum pump connection for leaks.

- (4) A red "ready" light on the front panel will light within one hour after turn-on and indicate that the instrument is functionally ready to detect ammonia. However, since the ultimate stability of the instrument is not reached until after a 10 hour warm-up period, it is recommended that the instrument not be calibrated for continuous use until this time period has elapsed. It is further recommended that the instrument be kept on even when not in use for short periods of time.
- (5) A choice can be made at this point to use either the single or dual stage separator. The single stage separator is used when fastest instrument response is desired but sensitivity is limited to 0.1 ppm. The dual stage has a much longer response but provides sensitivity to less than 0.01 ppm.
- (6) The single stage operation is activated by first setting the hand valve on the front panel to the "Single Stage" position, then opening the valve on the top of the instrument marked "Single Stage Inlet." The ready light should momentarily extinguish as the pressure within the cavity rises - but after 30 seconds the pressure should be below the red line on the meter face. If this does not occur, a leak in the single stage membrane is likely and reference should be made to Chapter V, Section D, for the procedure to replace the membrane.
- (7) The dual stage operation is activated by first setting the hand valve on the front panel to the "Dual Stage" position, then opening both the valves on the top of the instrument marked "Dual Stage Rough Outlet" and "Dual Stage Inlet" respectively. The ready light should momentarily extinguish but after 90 seconds the pressure should be below the red line on the meter face. If this does not occur, a leak in the separator is likely and reference should be made to Chapter V, Section D, for the procedure for replacing the membrane.

- (8) Check to insure that Ascarite dryer is in the sample inlet line to the instrument. Then adjust the valve marked "Cavity Outlet" until the pressure gauge on the front panel reads within the green zone.

C. Calibration

The instrument may be calibrated at any number of concentrations over its range. However, it has been found useful to calibrate at a single concentration about in the center of the concentration range of interest. The accuracy of measurements of concentrations above and below the calibration points can be predetermined from a more thorough calibration procedure done less often.

The following calibration procedure is recommended:

- 1) Zero the instrument. The instrument must be flushed with an ammonia free carrier gas and should be pumped for about an hour before a calibration is initialized. A true zero can be determined by first closing the "Single Stage Inlet" valve. Set the meter to read zero by adjusting the "zero" knob on the front panel then reopen the "Single Stage Inlet" valve. Any signal which appears after the "Inlet Valve" is reopened is from residual ammonia in the system. This signal should either be totally removed by flushing and pumping or it should be nulled out by resetting the zero with the "Zero" knob on the front panel.
- 2) Determine which mode of instrument operation is to be used and set the hand valves accordingly, as indicated under Section III-D. Also determine which time constant is desired and set the toggle on the rear panel accordingly.

NOTE: A small offset voltage occurs when the "time constant" toggle is switched from 3 sec. to 100 sec. This offset makes it necessary to re-zero the meter for operation at 100 sec. time constant.

- (3) Connect a source of known ammonia concentration to the rear panel "Sample Inlet" port. The carrier flow rate can be adjusted to any desired value up to 250 cc/min with the needle valve on the flow rate indicator.
- (4) Supply to the instrument a known concentration of ammonia (e.g. permeation tube source), in an appropriate carrier. Allow .5 min. for full response then adjust the "zero" knob on the front panel so that the meter reads the desired concentration of ammonia.
- (5) Further calibration points can be used to determine the instrument's linearity. Supply known concentrations of ammonia to the instrument and allow .5 min. for full response. The new meter reading establishes the instrument's response to the new calibration concentration.
- (6) After calibration, replace the calibration source with the unknown sample. Set the flow rate to the desired value as indicated on the front panel flow meter. The instrument will monitor the ammonia concentration in the sample.

D. Modes of Operation

This instrument has been principally designed to operate as a continuous "sniffing" monitor of ammonia in air. However, the instrument is capable of operating in any one of four different modes. The following discusses how to prepare the instrument for operation in each of these modes.

(1) Continuous "Sniffing" (Fast Response) Mode -

In this mode, the sample is presented to the detector cavity with minimum delay, therefore, resulting in the fastest response. Sensitivity is traded for the fast response so that this mode should only be used when levels of ammonia above .1 ppm are

known to present. A typical response time for this mode with the internal pump flow set at 250 cc/min and levels of NH_3 above 1 ppm, is 90% of peak response within 30 sec. after initiation of "sniff", (with a 3 second time constant for the electronics).

To prepare the instrument for operation in this mode, the following procedure is recommended:

- (a) A special adaptor is required to replace the single stage membrane. See section V for the procedure to replace the membrane.
- (b) Turn on the instrument exactly as described in B of this section. Open the "Outlet Valve" and close the "Single Stage Inlet" valve.
- (c) If a calibration is desired, proceed as indicated under C of this section but return all valves to the positions just indicated above after calibration.
- (d) Open the "Single Stage Inlet" valve and check that the cavity pressure settles in the "green" area on the meter. Adjust the flow rate to at least 200 cc/min. as read on the flow rate indicator on the front panel.
- (e) Set the "Zero" adjust to zero the meter while sniffing a pure reference sample or while sniffing a background sample. Note: to determine the true zero close the inlet valve and allow a 5 minute pump down.
- (f) The instrument is now ready to monitor in the "fast response" mode.

(2) Continuous "Sniffing" (Maximum Sensitivity) Mode -

In this mode the instrument is operated with maximum sensitivity for ammonia. To obtain maximum sensitivity the flow rate of gas through the microwave cell must be slowed by throttling so that a residual pressure of near 0.05 torr is maintained within the cavity. Since the flow rate is thus decreased the instrument response is slower to changes in ammonia concentration. A typical response time for this mode with the internal pump flow at 250 cc/min. and levels of NH_3 near 0.01 ppm is 50% of peak response within 5 minutes after initiation of "sniff".

To prepare the instrument for operation in this mode, the following procedure is recommended:

- (a) Turn on the instrument as described in B of this section.
- (b) If a calibration is desired, proceed as indicated under C of this section.
- (c) Set the hand valve on the front panel to the "Dual Stage" position and adjust the flow rate as read on the flow rate indicator by the valve on the indicator
- (d) Attach the sampling tube to the "Sample Inlet" port on the rear panel using appropriate fittings.
- (e) Set the "Zero" adjust to zero the meter while sniffing a pure reference or while sniffing a background sample. Note: To determine the true zero, close the inlet valve and allow 5 minutes pumping before setting the zero. Then open the inlet valve.
- (f) The instrument is now ready to monitor in the "maximum sensitivity" mode.

(3) Batch Sampling (Dynamic) Mode -

This mode is very similar in operation to those above, with the exception that the sample is considered to be expendable (e.g. a grab sample in a polyethylene bag). The sample container is attached to the instruments sample inlet port and its contents pulled through the detector with the internal pump. The instrument can be set to operate with either a fast or slow flow rate depending upon the sensitivity required.

- (a) Prepare the instrument the same as in 1 or 2 above depending upon the sensitivity required. Note that the internal pump flow rate may be reduced if desired.
- (b) Attach the sample container to the instruments inlet port.

(4) Batch Sampling (Static) Mode -

If a minimum sample is available, (less than 1 liter) this mode can be used. In this mode the cavity is isolated from the vacuum pumps so that the sample can expand into the cavity detector and not be pumped away. Caution must be used here to insure that there is no residual NH_3 in the cavity at the operating pressure before the sample is let in. The following procedure is recommended for this mode:

- (a) Turn on the instrument as described in B of this section.
- (b) If a calibration is desired, proceed as indicated under C of this section but note the pressure within the cavity during calibration. Allow the system to pump for at least 2 hours after NH_3 has been in the instrument.
- (c) Set the flow rate no higher than 150 cc/min.

- (d) Make a test for residual NH_3 in the cavity by closing the "outlet valve". The pressure inside the cavity will rise due to the gas supplied by the membrane. Monitor this pressure on the test meter vacuum gauge. When the pressure indicated is the same as that during calibration, close the "inlet valve". The signal output should be near zero and not rise if the cavity is free of NH_3 .
- (e) Open the "outlet valve" and allow the cavity to be pumped for at least 5 minutes.
- (f) Attach the sample container to the "sample inlet" port and wait for 1 minute. Close the "outlet valve". Monitor the cavity pressure. When the pressure indicated is the same as that during calibration, close the "inlet valve". The instrument now gives a measurement of the NH_3 content within the cavity.

E. Turn-Off Procedure

The following turn-off procedure is recommended so that the instrument may be restarted, when desired, in a minimum of time.

- (1) Close the "inlet valves".
- (2) Close the "outlet valve".
- (3) Press the "AC off" push button.
- (4) Close both hand valves on the vacuum pump (turn fully clockwise).
- (5) Set the "mechanical pump" switch to the off position.

NOTE: The microwave cavity operates continuously at a temperature near 100°C and is stabilized there by a feedback loop. If for some reason this loop loses control the cavity can heat up to about 108°C and activate a thermal switch which will light the "cavity over-temperature" indicator. If this happens, a cool-off period of at least 30 minutes is required. Turn off the instrument. Restart can be accomplished after cool off by pressing the "AC on" push button. If the cavity has not cooled off sufficiently, the "cavity over temperature" light will turn on when trying to restart. If this happens, wait a longer period then try again.

IV. PRINCIPLES OF OPERATION

A. Introduction

The instrument described in this manual is based on the principle of observing the absorption of microwave radiation which is in resonance with one of the quantized molecular rotations of gaseous ammonia molecules. Molecular rotations have low energies (much lower than vibrational energies) and at low pressures, they can cause very sharp absorptions of microwave radiation. The absorptions are so sharp, in fact, that a million single resonances from many different kinds of molecules can all be resolved from a spectrum taken over a 20 Gigahertz frequency range. The microwave frequencies, on the other hand, are produced from electronic oscillations, are already quite mono-energetic, and they can be continuously tuned. These properties are responsible for the very high qualitative specificity for detecting molecules in a mixture with others by this technique of microwave rotational spectrometry.

The properties described above are utilized to the fullest in this instrument. For example, the pressure of the sample gas is maintained low enough to assure that the ammonia's absorption width is less than 200 KHz in the detection cell. Since the sensitivity for detecting ammonia molecules is proportional to the effective radiation path length through the sample, a resonant cavity is used as the sample cell. Multiple reflections of the radiation occur in such a cavity, thus it offers the highest sensitivity for the smallest volume, of any kind of cell design. The cavity has two other distinct advantages; it acts as a filter to make the radiation in it even more mono-energetic, and it has a low surface to volume ratio which is desirable for good vacuum properties. The cavity used in this instrument is a transmission cavity, that is, microwave power can only pass through it at or near a resonance. It is made of two diametrically opposed reflectors. Such a structure is known to give high quality resonances at microwave frequencies.

The microwave energy needed to excite the molecular resonance of ammonia is supplied by a solid-state bulk semiconductor commonly known as a Gunn-effect oscillator. Its oscillations are stabilized by referring it to a very stable, oven controlled crystal oscillator. Its output frequency is thus made to exactly match that of the peak of the ammonia resonance. At the same time, the resonant peak of the microwave cavity is made to coincide exactly with both the oscillation frequency and the peak of the gas resonance, and it is stabilized there by a feedback loop.

For very small quantities of ammonia gas in a mixture, the actual amount of microwave power absorbed is very small. A means of relatively noise free amplification of such absorption is provided by "heterodyne" detection and amplification of the signals. Then a further signal to noise enhancement is gained by applying an on-off electric field through the sample. This modulates the absorption signal, resulting in an AC signal which is amplified then synchronously detected. A DC signal proportional to the ammonia absorption is then delivered to a digital meter and is made available for external recording.

Automatic control is always desirable in a monitoring instrument. In this instrument, a series of interlocks are provided to assure the user that the system is functioning properly. These interlocks provide for automatic operation while the instrument is in continuous use.

The basic sensitivity of the technique used here is limited to approximately .1 ppm levels by the very small absorption signals. To extend the detectability range, a rubber membrane, molecular separator device is used to enrich the ammonia sample that enters the microwave cell by more than 1 order of magnitude, thus extending the minimum detectability for formaldehyde to near 10 ppb.

A brief description of the functional circuits of the instrument is given in the following sections. References are made to the block diagram of the instrument (sheet 14 of the schematic diagrams) which can be used to follow the given descriptions.

B. Frequency Stabilization Circuits

A crystal controlled microwave oscillator, with a frequency of 2.3894265 GHz, and a basic stability of 1 part in 10 per day, is used to derive the frequency stability of the Gunn effect oscillator. The stable frequency is harmonically mixed with some of the power from the Gunn oscillator in a 1N26 silicon crystal. A search oscillator sweeps the Gunn oscillator frequency over a 80 MHz range by voltage tuning a varactor diode in the Gunn-diode package. When the tenth harmonic of the reference oscillator is 24.135 MHz above the Gunn oscillator output, a phase comparison is made with another stable reference oscillator at 24.135 MHz and an error signal is fed back to the tuning varactor to "phase lock" the Gunn-oscillator output to the crystal controlled reference oscillator. When this has been accomplished, the Gunn oscillator has an output frequency of $23.894265\text{GHz} - 24.135\text{MHz}$, or 23.870130GHz , which is the frequency of the resonance peak of the ammonia absorption line. This frequency is stable also to 1 part in 10 per day.

C. Cavity Resonance Stabilization Circuits

The cavity's resonance is stabilized to the operating frequency at 23.870 GHz by making use of the fact that the microwaves make a 180° phase change in passing through the cavity near a resonance. The microwaves entering the cavity on the input side are at a fixed phase (a phase determined by the phase angle of the 24.135 MHz reference oscillator). As the cavity resonance approaches the microwave frequency, the microwaves at the output of the cavity have a positive phase angle from that of the input. Very near resonance the phase shift is a maximum of 90° positive and changes with a very sharp slope to another maximum of 90° negative, passing through zero phase shift exactly when the cavity resonance matches the input frequency. This kind of a signal is called a discriminator curve and because of its characteristics it can be used to stabilize by a feedback mechanism.

The cavity resonant frequency is tuned by physically moving the two reflectors apart by the thermal expansion of copper spacers. As the cavity resonance approaches the Gunn oscillator frequency, more microwave power passes through the cavity to the detector at the output. At the output detector, the microwave power is mixed with the tenth harmonic of the reference oscillator again as in Part B above. In this case, their frequency difference is always exactly at 24.135 MHz because of the "phase lock" of the Gunn oscillator at the input side of the cavity. The 24.135 MHz signal at the output mixer is amplified and phase compared with the same 24.135 MHz reference oscillator as in Part B. However, a phase shifter is included so as to provide adjustment of the phase difference between the signal and the reference to be near zero when the cavity resonance matches the microwave frequency. The DC output from the phase detector is then amplified and controls the current being used to heat the copper spacers. The cavity resonance is thus forced by this feedback loop to stay, within some small error, at 23.870103GHz.

D. Signal Detection, Amplification and Presentation

Electric field (Stark effect) modulation, heterodyne RF detection, and phase sensitive detection are all used in this instrument to insure optimum signal to noise characteristics for the detected absorption.

A 10 KHz square-wave, zero based, 2kv peak-to-peak voltage is generated with a compact circuit (see sheet 10). This modulating field is applied to one reflector plate of the microwave cavity so that it appears through the sample within the cavity. When the field is on, the ammonia absorption is moved to another frequency. When the field is off, the ammonia absorption coincides with the oscillator frequency and can absorb power from the input. The effect of this on-off field is to amplitude modulate the microwaves in the cavity at a 10 KHz rate if ammonia molecules are present there. This amplitude modulation then also appears on the microwaves that enter the detector mixer crystal and then subsequently (after heterodyne detection) also on the intermediate or beat frequency at 24.135 MHz. The modulated IF frequency is amplified; then it is demodulated by a video detector crystal diode, leaving just the 10 KHz signal component. The 10 KHz signal is amplified more and then phase compared with a reference signal which is derived directly from the

Stark modulator circuit. The output of the phase detector is a DC signal which is proportional to the amplitude of the 10 KHz signal. This signal is further amplified and an RC time constant is applied to it before it is delivered to a digital voltmeter for readout or to an output connector to drive a recorder.

E. System Interlock Controls

The instrument is functional when all of four conditions are true. One, the Gunn-effect oscillator must be stabilized to the crystal controlled reference. Two, the cavity resonant frequency must be tuned to coincide with the stabilized microwave frequency and itself stabilized there. Three, the pressure in the cavity must be within the operating range. This also insures that the modulating Stark voltage is maintained on. Fourth, the cavity temperature must be stabilized at its operating point.

From turn-on, the instrument automatically controls itself to make the above conditions true. As each of the conditions becomes true, an enable signal is passed to a four-input gate. When all conditions are true, the four input gate is made and it turns on a "ready" lite on the front panel. Should any of these conditions change during the operation, the "ready" lite will extinguish and data should not be taken during that time.

NOTE: It is possible that transients can be generated which cause the Gunn-effect oscillator to momentarily unlock. The "ready" lite will momentarily extinguish while a search oscillator causes the Gunn-oscillator to find a lock again. This procedure takes less than 1 second time so that no significant loss of data occurs. A "glitch" will appear, however, during this unlocked time if output is observed on a recorder.

V. MAINTENANCE

A. Routine, Periodic Instrument Maintenance

The ammonia monitor should operate maintenance free on a continuous basis for several months. However, it is suggested that a routine maintenance procedure be carried out once each month of instrument operation. This procedure should include the following:

1. Change the separator membrane material.
2. Adjust the monitoring frequency.

After each six months of operation the following should be done:

3. Change the oil on the mechanical vacuum pump.
4. Bake out the molecular sieve trap.

The instrument need not be turned off, for this maintenance. The "down" time can be as short as a few hours, depending upon the length of time taken to bake out the molecular sieve trap.

Detailed procedures for each of the four maintenance operations listed above is given in the following sections.

B. Vacuum System Maintenance

Once every six months of continuous operation the oil should be changed in both the mechanical pump and the oil diffusion pump. The following procedure is recommended:

1. Close all valves on the instrument. (Fully clockwise).
2. Close the hand valve on the vacuum pump (fully clockwise).
3. Set "mechanical pump" toggle (located on the pump) to the off position.
4. After the vacuum pump has cooled off sufficiently drain and change the oil. Use Welch mechanical pump oil or equivalent.
5. After the oil has been changed and the pump is ready to be restarted, set the switch on the pump to the "on" position.

It is recommended as a part of the vacuum system maintenance procedure, that the molecular sieve trap be baked out. The following procedure can be used:

1. After changing the pump oil and restarting the pump, but before opening the hand valves on the vacuum pump, the sieve trap can be baked.

- CAUTION -

While the molecular sieve trap is being baked out, the hand valve on the vacuum pump must be fully closed (fully clockwise), or the gases given off from the trap will pass back into the instrument.

2. Make sure the hand valve on the vacuum pump is in the "closed" position and the pump is on. Plug the auxiliary AC cord (on the sieve trap heating element) into a suitable outlet. Let the trap bake for a minimum of 3 hours.

3. After a suitable bake-out period (3 hours minimum) remove the AC plug from the outlet and allow 15 minutes for the trap to cool.

C. Changing the Dryer

A properly filled dryer tube should adequately dry the input sample for 30 or more hours of continuous operation (slightly less for relative humidity levels above 80%). Visual inspection of the state of the dryer can be made by observing the color of the trapping material. Unused ascarite is a solid granular form where-as the used up dryer material will appear as a white substance in the tube. The tube should be changed when it is 90% or more used.

The dryer tube is provided with hose adapters. To change the dryer, simply disconnect the tubing from the two ends of the used dryer and reconnect them to a fresh tube. The old tube can be purged and refilled with commercial ascarite if desired.

- CAUTION -

The commercial tubes are delivered with filter pads inside and plastic plugs in each hose adapter, each of which should be removed before use with this instrument.

D. Changing the Silicone Membranes

Under normal operation and in normal environments, the silicone membranes (2) within the separator device should have an unlimited lifetime. However, in certain environments (e.g., high ozone content or particulate matter) the permeation characteristics of the membrane material can change significantly. Also, some silicone rubber material has been observed to rupture while in use, probably because of the expansion of pin holes under stressed conditions.

Indications of failure of one or both of the membranes used in the separator are as follows:

1. An unexplained loss in sensitivity.
2. The microwave cell pressure rises above 0.07 torr (the ready light will extinguish in this case).
3. An unexplained change in the flow rate indication on the front panel flow meter.

A large sheet of silicone-rubber membrane is included with the instrument. If replacement of the membrane material is required, the following procedure is recommended:

NOTE: It is recommended that both membranes be replaced during the operation.

a. The membranes can be changed without turning off the instrument. Turn off all hand valves on the top of the instrument (fully clockwise).

b. Locate the oven which protrudes from the rear of the instrument. Remove the oven end cover by loosening four screws that are visible from the rear of the instrument.

- CAUTION -

The exposed metal parts within the oven are at 100°C and can cause severe burns to the skin - use gloves.

c. With a 1/4" hexagonal wrench (supplied with the instrument) remove the aluminum "U" brackets from the two separators by turning the set screws counter clockwise until loose.

d. Pry off the ends of the separator where the edges of the used membrane are exposed to view.

e. Peel off the old membranes - then apply a new membrane over the screen so that extra membrane material extends over all edges of the smooth separator surface. Do not unduly stretch the membrane material; it should stick to the surface after slight pressure is applied against the smooth surface, all around.

f. Replace the end piece of the separator taking care that the membrane is not folded under it.

g. Replace the bracket and retighten the set screw.

h. Before replacing end oven cover, open the appropriate valves on the instrument top to insure that the pressure in the cell can be reduced to below the red line.

i. Replace end oven cover.

E. Adjustment of the Monitoring Frequency

The basic stability of the monitoring frequency is equal to that of the crystal controlled reference oscillator - or 1 part in 10^9 /day. 1 part in 10^9 /day of the microwave frequency at 23.8701GHz is approximately .1 KHz/day. It has been determined that the frequency of the microwave source must be within 30 KHz of the NH_3 resonant peak to give a response within 2% of the peak response. Therefore, the microwave frequency should be readjusted approximately every year to stay within 2% of the peak response.

Adjustment of the operating frequency requires a 50 MHz frequency counter.

- Remove the chassis from the blue enclosure and locate the 2" square silver oscillator in the left rear of the instrument.
- Connect the frequency counter to the cable which is connected to detector #1 - pin R at the middle front of the instrument. The counter should read approximately 24.135672MHz.
- Remove the small screw on the oscillator case.
- With a small screwdriver, turn the adjusting screw slowly until the counter reads exactly 24.135672MHz.

Note: The reference oscillator is somewhat temperature sensitive and may drift soon after adjustment. Readjust, if this happens, but minimize the time of contact between screwdriver and oscillator adjust.

- Replace the screw in the hole on the oscillator.
- Replace the BNC cable to the detector #1-pin R.

F. Use of Electronic Test Box

The electronic test box which accompanies the instrument is not required for the instrument to function as a monitor. It is, however, a handy indicator for testing the different functional circuits within the instrument.

VI. PARTS LIST

The following is a list of parts used in the instrument including the manufacturer and the approximate replacement cost.

<u>Item #</u>	<u>Name</u>	<u>Manufacturer & Model Number</u>	<u>Approx. Repl. Cost</u>
1	Panel Meter	Weston - AN2530L	80
2	Power Supply	Lambda LCS-B	220
3	IF Amplifiers (2)	RHG-EVT-3004	650
4	Temperature Controller	RFL-70	40
5	S-band Oscillator	Zeta Labs 4293-05	\$1,700
6	Air Pump	Metafram -81	10
7	S-band Splitter	Anaren 40266	80
8	RF Splitter (2)	Relcom H-2	90
9	RF Mixer (2)	Relcom M-1B	190
10	Fans (2)	Sprite - SP2A2	40
11	Flow Rater	Brooks 1355-07CIEAA	70
12	Card Bin	Control Logic	60
13	Reference Oscillator	Vectron CO-233-T	260
14	Gunn Diode	Varian VSK9210	150
15	Varactor Diode	Varian VAT110-N10	120
16	Mixer Diodes (2)	Microwave Assoc 1N53R	90
17	Thermo Electric Device	Borg Warner 940-31	30
18	Waveguide Isolator	E&M Labs RM13	350
19	Chassis	LLL	30
20	Enclosure Box	Bud	120
21	Solenoid Valves (5)	Skinner B1DA-9	60
22	Silicone Membrane	General Electric	20
23	Phase Shifter	Merrimac Res. PSM-3-30	300
	NOTE: The following items are supplied by LLL		
24	TED Power Supply	LLL	60
25	±15V Power Supply	LLL	30
26	Stark Modulator	LLL	100
27	Microwave Cavity	LLL	900
28	Gunn Diode Mount	LLL	360
29	Mixer Mount	LLL	160
30	Separator	LLL	350
31	Control Logic Cards	LLL	500
32	Misc. Electronic Parts	LLL	
	Including; Cables, Connectors, Fuses & Holders, Knobs, Trim Pots, Capacitors, Lamps Switches, Heat Sinks, Relays, & Temperature Sensors.		
33	Misc. Mech. Parts Inc- luding; Tubing, Fittings, Fasteners, Enclosures, Hand Valves, & O-rings		

GUNN DIODE MICROWAVE CAVITY
AMMONIA MONITOR

CALIBRATE

READY

ZERO

CAVITY OVER
TEMPERATURE

A C POWER

CAVITY PRESSURE

OFF

DUAL

SINGLE STAGE

MICROWAVE OVEN
!! DANGER HOT !!

ROAST : .7 min / LB.
TURKEY : .6 min / LB.
POTATOES : 90 sec.

VENT

SAMPLE
INPUT

FILTER
TIME CONSTANT
100 SEC.

TO
TEST
3 SEC. METER

6.25 A.S.B.

AC IN

RECORDER

SPRITE
MODEL SP2A2
115 VOLTS 50/60 Hz 9 WATTS

SPRITE
MODEL SP2A2
115 VOLTS 50/60 Hz 9 WATTS

#7

REV	1	DATE	10/1/74	APPROVED	
TITLE					
TEST METER NH ₃ SPECTROMETER					
GROUP	1	BASIC PACKAGE NO.	174-6132	SUB TYPE	REV
LAWRENCE LIVERMORE LABORATORY					
ELECTRONICS ENGINEERING DEPARTMENT					
UNIVERSITY OF CALIFORNIA, LIVERMORE, CALIF.					
SHEET 3 OF 11

REV	DATE	DESCRIPTION	DATE	DRAWN	APPROVED
1					
OPERATOR: MADDUX DRAWN: DATE: 5-11-78 CHECKED: DATE: 5-11-78 APPROVED: DATE: 5-11-78					
TITLE: RF CIRCUITS FOR NH3					
LAWRENCE LIVERMORE LABORATORY ELECTRONICS ENGINEERING DEPARTMENT University of California, Livermore, California			GROUP: BASIC PACKAGE NO. 1 SUB: TYPE REV LEA 74-6132 01-130 SHEET 5 OF 11

DESIGNER	GCA	REV	ZONE	DESCRIPTION	DATE	DRAWN	APPROVED
ORIGINATOR	MADDUX	INTERLOCK GATE					
DRAWN	J. COLLUM 1-18-74	GROUP BASIC PACKAGE NO. 01-50					
CHECKED	DATE	LAWRENCE LIVERMORE LABORATORY ELECTRONICS ENGINEERING DEPARTMENT University of California, Livermore, California					
APPROVED	DATE	SHEET 6 OF 11

NOTES:
1. ○---○ INDICATES JUMPER.

DESIGNER	DATE	REV	DATE	DESCRIPTION	DATE	DRAWN	APPROVED
W. C. A.				GUNN DIODE POWER SUPPLY			
ORIGINATOR	DATE	LAWRENCE LIVERMORE LABORATORY					
M. ADDUX	4-13-74	ELECTRONICS ENGINEERING DEPARTMENT					
CHECKED	DATE	GROUP/BASIC PACKAGE NO. BUS TYPE REV					
APPROVED	DATE	LEA 74-6132 01-S 0					
		SHEET 8 OF 11

NOTES

- 1 $R22 + R18 + R23 \cong 10K$
- 2 ALL RESISTORS ARE 1/2 W METAL FILM

DESIGNED BY	GCA	DATE	9-8-74
DRAWN BY	MAP/UX	DATE	9-8-74
CHECKED BY		DATE	
APPROVED BY		DATE	

TITLE		YIG OSCILLATOR TUNING COILS SUPPLY
LAURENCE LAMSON'S LABORATORY	GROUP/ASIC PACKAGE NO.	LEA 74-6132
ELECTRONICS RESEARCH & DEVELOPMENT	SUB	01-512
SHEET 11 OF 11

SAMPLE INLET AND VACUUM SYSTEM SCHEMATIC

LE D69-901132

LAWRENCE
RADIATION
LABORATORYELECTRONICS ENGINEERING
STANDARD
LIVERMORE, CALIFORNIAUNIVERSITY
OF
CALIFORNIA

LE D69-901132

REFER QUESTIONS TO:

C. C. Holben

APPROVED

CLC LOGIC MODULES
LOADED BOARDS

DATE

5/14/73

REV.

D

SHEET 1 OF 3

DUAL OPERATIONAL AMPLIFIER LEA68-906810

LRL STOCK NO.: 5975-57556

DECAL NO.: 5975-58315

Description

The LEA68-906810 board has two general purpose, fully-compensated, AD741K operational amplifiers, each connected in a pattern which allows the user to construct numerous types of analog circuit configurations.

The only components which are pre-loaded on the board are the IC operational amplifiers, zero adjust potentiometers, and bypassing capacitors. All other components are to be added by the user.

Specifications (25°C Ambient)

Open Loop Voltage Gain	100,000 typical
$R_L = 2 \text{ k} \quad V_{\text{out}} = \pm 10 \text{ V}$	50,000 minimum
Input Resistance	1 M Ω typical
$f = 20 \text{ Hz}$	300 k Ω minimum
Output Voltage Swing	$\pm 13 \text{ V}$ typical
$R_L = 2 \text{ k}$	$\pm$
Input Bias Current	200 nA typical
	500 nA maximum
Input Offset Current	30 nA typical
	200 nA maximum
Input Offset Current Drift	50 pA/°C typical
Input Offset Voltage	2.0 mV typical
	6.0 mV maximum
Input Offset Voltage Drift	6 $\mu\text{V}/^\circ\text{C}$ typical
$R_S = 10 \text{ k}\Omega$	
Power Supply Requirement ($V_{\text{out}} = 0$)	$\pm 15 \text{ Vdc}$ @ 12 mA
	(Total for both amplifiers)

EE Standards Manual, Section 11, "Microcircuits"
AD741k See LED68-907405

LE

CIRCUIT DIAGRAM

REFER QUESTIONS TO: S. A. Nielsen	LAWRENCE RADIATION LABORATORY	ELECTRONICS ENGINEERING STANDARD LIVERMORE, CALIFORNIA	UNIVERSITY OF CALIFORNIA	LE D69-901166	
DATE: C. C. Holben	CLC LOGIC MODULES LOADED BOARDS			DATE 2-15-73	REV. A
APPROVED <i>[Signature]</i>				SHEET 1 OF 2	

INSTRUMENTATION AMPLIFIER LEA68-906824

LRL STOCK NO.: 5975-58562

DECAL NO.: 5975-58563

Description

The LEA68-906824 Instrumentation Amplifier card contains two programmable operational amplifiers: an instrumentation amplifier $\mu A725C$, and a general purpose amplifier $MC1741C$. The $\mu A725C$ features high gain, low drift, low noise and excellent stability. The $MC1741C$ can be used as an output buffer; it features overload protection and no latch-up when the common mode range is exceeded.

The only components which are pre-loaded on the board are the IC operational amplifiers, zero adjust potentiometers, and bypassing capacitors.

The user may load additional resistors and capacitors to construct a variety of analog circuit configurations.

To obtain optimum gain and drift stability the use of $\pm 1\%$, ± 200 p/M/ $^{\circ}C$ (or less) metal film resistors is recommended. (LRL-stock metal film resistors are $\pm 1\%$, ± 100 p/M/ $^{\circ}C$.)

IC Specifications

EE Standards Manual, Section 11, "Microcircuits"

$\mu A725C$ See LED68-907412

$MC1741C$ See LED68-907405

Logic Diagram

LEA

CIRCUIT DIAGRAM

CARD OUTLINE
TOP VIEW

NOTE

1. SYMBOLS PER LEA68-903013
2. DESIGNATIONS PER LEA68-903014
3. UNLESS OTHERWISE SPECIFIED, ON ALL LEA68-903013 SEE BOARD
4. COMPONENTS TO BE NO GREATER THAN .250 MAX HEIGHT FROM BOARD WHEN LOADED.
5. IN THIS DRAWING NUMBER TO BE STENCILED ON CARD HANDLE, COMPONENT SIDE OF BOARD AS SHOWN ABOVE.
6. ALL RESISTORS 1/8W METAL FILM
7. ALL CAPACITORS .250 MAX DIA MYLAR UNLESS OTHERWISE SPECIFIED

PIN CONNECTIONS

A	1
B	2
C	3
D	4
E	5
F	6
G	7
H	8
I	9
J	10
K	11
L	12
M	13
N	14
P	15
Q	16
R	17
S	18
T	19
U	20
V	21
W	22
X	23
Y	24
Z	25

TEST TERMINALS

1	5
2	6
3	7
4	8

KEY POSITIONS

20

COMPONENT	DESIGNATION	QTY	DESCRIPTION	STOCK NO
R16	1	1	KOM CERMET TRIMMER (PER LEA68-903013)	5905-02
A1	1	1	LM745C OPER. AMP.	5941-01
A2	1	1	LM174C OPER. AMP.	5941-01
R18	1	1	10K 1/8W 1% METAL FILM	5905-02
R17	1	1	33.2K 1/8W 1% METAL FILM	5905-02
R29	1	1	10K 1/8W 1% METAL FILM	5905-02
C18, C12	2	2	10K 1/8W 1% METAL FILM	5905-02
C11	1	1	10K 1/8W 1% METAL FILM	5905-02
C9	1	1	10K 1/8W 1% METAL FILM	5905-02
C8, C10, C16, C17	4	4	10K 1/8W 1% METAL FILM	5905-02
C1	1	1	10K 1/8W 1% METAL FILM	5905-02
C2	1	1	10K 1/8W 1% METAL FILM	5905-02
C3	1	1	10K 1/8W 1% METAL FILM	5905-02
C4	1	1	10K 1/8W 1% METAL FILM	5905-02
C5	1	1	10K 1/8W 1% METAL FILM	5905-02
C6	1	1	10K 1/8W 1% METAL FILM	5905-02
C7	1	1	10K 1/8W 1% METAL FILM	5905-02
C13	1	1	10K 1/8W 1% METAL FILM	5905-02
C14	1	1	10K 1/8W 1% METAL FILM	5905-02
C15	1	1	10K 1/8W 1% METAL FILM	5905-02
C19	1	1	10K 1/8W 1% METAL FILM	5905-02
C20	1	1	10K 1/8W 1% METAL FILM	5905-02
C21	1	1	10K 1/8W 1% METAL FILM	5905-02
C22	1	1	10K 1/8W 1% METAL FILM	5905-02
C23	1	1	10K 1/8W 1% METAL FILM	5905-02
C24	1	1	10K 1/8W 1% METAL FILM	5905-02
C25	1	1	10K 1/8W 1% METAL FILM	5905-02
C26	1	1	10K 1/8W 1% METAL FILM	5905-02
C27	1	1	10K 1/8W 1% METAL FILM	5905-02
C28	1	1	10K 1/8W 1% METAL FILM	5905-02
C29	1	1	10K 1/8W 1% METAL FILM	5905-02
C30	1	1	10K 1/8W 1% METAL FILM	5905-02
C31	1	1	10K 1/8W 1% METAL FILM	5905-02
C32	1	1	10K 1/8W 1% METAL FILM	5905-02
C33	1	1	10K 1/8W 1% METAL FILM	5905-02
C34	1	1	10K 1/8W 1% METAL FILM	5905-02
C35	1	1	10K 1/8W 1% METAL FILM	5905-02
C36	1	1	10K 1/8W 1% METAL FILM	5905-02
C37	1	1	10K 1/8W 1% METAL FILM	5905-02
C38	1	1	10K 1/8W 1% METAL FILM	5905-02
C39	1	1	10K 1/8W 1% METAL FILM	5905-02
C40	1	1	10K 1/8W 1% METAL FILM	5905-02
C41	1	1	10K 1/8W 1% METAL FILM	5905-02
C42	1	1	10K 1/8W 1% METAL FILM	5905-02
C43	1	1	10K 1/8W 1% METAL FILM	5905-02
C44	1	1	10K 1/8W 1% METAL FILM	5905-02
C45	1	1	10K 1/8W 1% METAL FILM	5905-02
C46	1	1	10K 1/8W 1% METAL FILM	5905-02
C47	1	1	10K 1/8W 1% METAL FILM	5905-02
C48	1	1	10K 1/8W 1% METAL FILM	5905-02
C49	1	1	10K 1/8W 1% METAL FILM	5905-02
C50	1	1	10K 1/8W 1% METAL FILM	5905-02
C51	1	1	10K 1/8W 1% METAL FILM	5905-02
C52	1	1	10K 1/8W 1% METAL FILM	5905-02
C53	1	1	10K 1/8W 1% METAL FILM	5905-02
C54	1	1	10K 1/8W 1% METAL FILM	5905-02
C55	1	1	10K 1/8W 1% METAL FILM	5905-02
C56	1	1	10K 1/8W 1% METAL FILM	5905-02
C57	1	1	10K 1/8W 1% METAL FILM	5905-02
C58	1	1	10K 1/8W 1% METAL FILM	5905-02
C59	1	1	10K 1/8W 1% METAL FILM	5905-02
C60	1	1	10K 1/8W 1% METAL FILM	5905-02
C61	1	1	10K 1/8W 1% METAL FILM	5905-02
C62	1	1	10K 1/8W 1% METAL FILM	5905-02
C63	1	1	10K 1/8W 1% METAL FILM	5905-02
C64	1	1	10K 1/8W 1% METAL FILM	5905-02
C65	1	1	10K 1/8W 1% METAL FILM	5905-02
C66	1	1	10K 1/8W 1% METAL FILM	5905-02
C67	1	1	10K 1/8W 1% METAL FILM	5905-02
C68	1	1	10K 1/8W 1% METAL FILM	5905-02
C69	1	1	10K 1/8W 1% METAL FILM	5905-02
C70	1	1	10K 1/8W 1% METAL FILM	5905-02
C71	1	1	10K 1/8W 1% METAL FILM	5905-02
C72	1	1	10K 1/8W 1% METAL FILM	5905-02
C73	1	1	10K 1/8W 1% METAL FILM	5905-02
C74	1	1	10K 1/8W 1% METAL FILM	5905-02
C75	1	1	10K 1/8W 1% METAL FILM	5905-02
C76	1	1	10K 1/8W 1% METAL FILM	5905-02
C77	1	1	10K 1/8W 1% METAL FILM	5905-02
C78	1	1	10K 1/8W 1% METAL FILM	5905-02
C79	1	1	10K 1/8W 1% METAL FILM	5905-02
C80	1	1	10K 1/8W 1% METAL FILM	5905-02
C81	1	1	10K 1/8W 1% METAL FILM	5905-02
C82	1	1	10K 1/8W 1% METAL FILM	5905-02
C83	1	1	10K 1/8W 1% METAL FILM	5905-02
C84	1	1	10K 1/8W 1% METAL FILM	5905-02
C85	1	1	10K 1/8W 1% METAL FILM	5905-02
C86	1	1	10K 1/8W 1% METAL FILM	5905-02
C87	1	1	10K 1/8W 1% METAL FILM	5905-02
C88	1	1	10K 1/8W 1% METAL FILM	5905-02
C89	1	1	10K 1/8W 1% METAL FILM	5905-02
C90	1	1	10K 1/8W 1% METAL FILM	5905-02
C91	1	1	10K 1/8W 1% METAL FILM	5905-02
C92	1	1	10K 1/8W 1% METAL FILM	5905-02
C93	1	1	10K 1/8W 1% METAL FILM	5905-02
C94	1	1	10K 1/8W 1% METAL FILM	5905-02
C95	1	1	10K 1/8W 1% METAL FILM	5905-02
C96	1	1	10K 1/8W 1% METAL FILM	5905-02
C97	1	1	10K 1/8W 1% METAL FILM	5905-02
C98	1	1	10K 1/8W 1% METAL FILM	5905-02
C99	1	1	10K 1/8W 1% METAL FILM	5905-02
C100	1	1	10K 1/8W 1% METAL FILM	5905-02

PARTS LIST

FOLD

ORIGINATOR
POWER/NIELSEN
DRAWN
DMISCOVICH 5-29-70
CHECKED
DATE
APPROVED
DATE

C	-	R16 WAS CONNECTED TO -15V	1-6-71	Kerlin	1-6-71
B	-	R16 WAS 10K	1-6-71	Kerlin	1-6-71
A	-	R33 ADDED, R35 TO -15V WAS +15V X AND Y ADDED.	9-30-70	Kerlin	9-30-70
REV	ZONE	DESCRIPTION (SEE REVISION SHEET FOR HISTORY)	DATE	DRAWN	APPROVED
TITLE INSTRUMENTATION AMPLIFIER					
UNIVERSITY OF CALIFORNIA LAWRENCE RADIATION LABORATORY ELECTRONICS ENGINEERING DEPARTMENT LIVERMORE, CALIFORNIA 94550					
GROUP/BASIC PACKAGE NO.		SUB		TYPE/REV	
LEA 68-9068		24		-AC	
SHEET		SHEET		SHEET	
1		2		3	

L E D69-901148

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STANDARD
LIVERMORE, CALIFORNIAUNIVERSITY
OF
CALIFORNIA

L E D69-901148

REFER QUESTIONS TO:

C. C. Holben

APPROVED

CLC LOGIC MODULES
LOADED BOARDS

DATE

2-15-73

REV.

3

SHEET 1 OF 3

HIGH CURRENT AMPLIFIER LEA68-906822

LRL STOCK NO.: 5975-58234

DECAL NO.: 5975-58326

Description

The LEA68-906822 High Current Amplifier may be used for driving loads requiring more power than normally available from integrated circuits.

The input is an integrated circuit Operational Amplifier, MC1741C. This Operational Amplifier drives an NPN-PNP complimentary transistor amplifier. The output transistors, 2N4900 and 2N4912, are connected for pullup-pulldown operation, and have a rated output current of 1 A maximum @ V p-p of ± 10 V.

The input, output, and trim resistors are not loaded on the board so that the input and output impedances and gain can be tailored to fit the designers needs. It is also possible to use only the buffered output portion of the card.

Applications (See Note 7 on Page 3)

By the use of the following pins, one can tailor the function of this card:

Pin L:	remove OP-AMP and drive Booster directly. (OP-AMP should be cut out of circuit.)
Pins 19, 20, or X:	use OP-AMP as a follower with Booster.
Pins 13, 14, or P:	use OP-AMP as inverter with or without gain.
Pins K and M:	used to adjust idle current.
Pins 15 and W:	used to add resistance to load.

Specifications

Input Loading	See IC Specifications
Output	± 10 V @ 1 A maximum
Temperature	0 to 70°C T _A
Power Requirements	100 mA @ ± 15 V (idle); plus load current

IC Specifications

EE Standards Manual, Section 11, "Microcircuits"
MC1741C See LED68-907405

LED69-901148
2-15-73

Page 2

REC-001148
HIGH CURRENT AMPLIFIER LEA68-906822
(Continued)

Logic Diagram

RECORDED

LEA69-901148
2-15-73
Page 3

CIRCUIT DIAGRAM

NOTES CONT.

6. DASHED CIRCLES IN OUTLINE BELOW INDICATE CIRCUIT TEST POINTS, 2 TEST POINTS LOADED.

7. TO ADJ. BIAS, USE 10K POT (R16) CONNECTING PINS H & F TO K AND J TO M. CIRCUIT QUIESCENT BIAS CURRENT SHOULD BE APPROX. 50 MA. THIS CURRENT IS MEASURED VIA A CURRENT PROBE CONNECTED TO EITHER POWER SUPPLY LEAD WITH NO OUTPUT LOAD AND ZERO INPUT SIGNAL. DISTORTION CAN BE MINIMIZED BY INCREASING THE BIAS CURRENT.

CARD OUTLINE
TOP VIEW

NOTE

1. SYMBOLS PER LEA68-902013
2. DESIGNATIONS PER LEA68-902014
3. UNLESS OTHERWISE SPECIFIED, ON ALL LEA68-9070 XX BOARDS
(a) COMPONENT S TO BE NO GREATER THAN .800 MAX HEIGHT FROM BOARD WHEN LOADED
(b) THIS DRAWING NUMBER TO BE STENCILED ON CARD HANDLE, COMPONENT SIDE OF BOARD AS SHOWN ABOVE
4. SOLDER ONLY HOLES CONTAINING COMPONENTS DO NOT WAVE SOLDER
5. LOADED CARD STOCK NO. 5975-58234

R22	1	511A 1/8W METAL FILM	5905-42773
R12, R14	2	261A 1/8W METAL FILM	5905-44444
SOCKET	1	8 PIN AUGAT #8058-1C49 (FOR A1)	5975-48963
SPACER	2	M-ROSS #10032A (FOR Q3, Q4)	5961-79371
HEAT SINK	2	IERC #LB66B1B (FOR Q5, Q6)	5961-58226
SMALLER	2	M-ROSS #10042A (FOR Q1, Q2)	5961-79365
C5, C6	2	222 20V TANTALUM	5910-59553
R7, R18	1	10K CRYSTAL TRIMMOT ELECTRA #ET24P103	5905-51509
R13, R15	2	4563A 1/2W METAL FILM (PER LED21576)	5905-59617
R10, R17	2	1K 1/8W METAL FILM	5905-42780
R10, R16	2	511K 1/8W METAL FILM	5905-42797
Q6	1	2N4912	5961-57273
Q5	1	2N4900	5961-57274
Q4	1	2N2905A	5961-58008
Q3	1	2N2919A	5961-58006
Q2	1	2N2904	5961-45715
Q1	1	LED9623 OR 2N635	5961-45737
CR1, CR2	2	1N4148	5961-53273
C1, C2	2	0.01MFD 20V 100V RECT. CERAMIC	5910-56357
A1	1	MC1741C	5961-57514
	1	PC117 GROUND SCREW, CONTROL LOGIC NO 183 030	5975-36592
	1	SELF TAPPING SCREW, 3/16 X 1/2, BLACK ANODIZE	3303-37101
	1	TEST POINT PINS, CONTROL LOGIC NO 183 104	5975-36591
	1	CARD HANDLE, CONTROL LOGIC NO 183 032	5975-36876
	1	HANDOUT CARD, CONTROL LOGIC NO 183 038	5975-36876
	1	CAP, 100V 1000UF 50% RICH, 1/2" X 1/2" X 1/2"	5975-36876
	1	ELECTRICAL FAB SPEC	
	1	SOLDERING SPEC	
	1	PC BOARD PRODUCTION SPEC	
	1	PC EQUIPMENT SPEC	
COMPONENT UTILIZATION	811		
DRAWING BY SPECIFICATION	811		
		DESCRIPTION	
		STOCK NO	
		COMMENTS: PARTS LIST ENDS	

PIN CONNECTIONS			
A		1	
B		2	
C		3	
D		4	
E		5	
F		6	
G		7	
H		8	
I		9	
J		10	
K		11	
L		12	
M		13	
N		14	
P		15	
R		16	
S		17	
T	+15V	18	+15V
U	-15V	19	-15V
V		20	
W		21	
X		22	
Y		23	
Z	GND	24	GND
TEST TERMINALS			
1		5	
2		6	
3		7	
4		8	
KEY POSITIONS			
4		26	

NOTES:

1. BREAK INTERNAL EDGES .03 R. MAX.
2. HE LEAK CHECK WITH MASS REC. LEAK RATE NOT TO EXCEED 1×10^{-9} STD. ATMOS. CC/SEC.
3. BUFF INTERNAL WELDS & ELECTROPOLISH 100% TO BRIGHT FINISH.
4. REMOVE ALL WELD SCALE SPATTER & FLUX.
5. TAG WITH QWC NO.

4	PLANE	75 00 X 0.01	1	265	304	470-1420
5	PLANE	75 00 X 0.01	2	265		
6	PLANE	75 00 X 0.01	3	265		
7	75-112512	PLANE-REWORK	4	265		
8	75-112512	TUBE	5	265		
9			6	265		
10			7	265		
11			8	265		
12			9	265		
13			10	265		
14			11	265		
15			12	265		
16			13	265		
17			14	265		
18			15	265		
19			16	265		
20			17	265		
21			18	265		
22			19	265		
23			20	265		
24			21	265		
25			22	265		
26			23	265		
27			24	265		
28			25	265		
29			26	265		
30			27	265		
31			28	265		
32			29	265		
33			30	265		
34			31	265		
35			32	265		
36			33	265		
37			34	265		
38			35	265		
39			36	265		
40			37	265		
41			38	265		
42			39	265		
43			40	265		
44			41	265		
45			42	265		
46			43	265		
47			44	265		
48			45	265		
49			46	265		
50			47	265		
51			48	265		
52			49	265		
53			50	265		
54			51	265		
55			52	265		
56			53	265		
57			54	265		
58			55	265		
59			56	265		
60			57	265		
61			58	265		
62			59	265		
63			60	265		
64			61	265		

ITEM PART NO. DESCRIPTION

1. DIMENSIONS AND TOLERANCES ARE PER
USAS-714.

2. POSITIONAL AND FORM TOLERANCES APPLY
R. F. S. (REGARDLESS OF FEATURE SIZE).

3. SURFACE TEXTURE PER USAS-0461.

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APPROVAL NO.

AA 73-14651-00

JUN 21, 1977

REF GEN CLEM

DATE	TIME	LOCATION	DESCRIPTION	REMARKS
11-5-83	1:30 PM	8067	MILKOWAVE SPEC JOB #	
11-5-83	1:30 PM	8067	AMMONIA DETECTOR CASE

RED GEN CHEM

JOB NO.	73-112518-1
DATE	100322Z
TIME	160019Z
LOCATION	100322Z
REFLECTOR	100322Z
WATER DETECTOR MK II	100322Z
REFLECTOR	100322Z

ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	CLASSIFICATION	SPC. NO.	STOCK NO.
1.		DIMENSIONING AND TOLERANCING ARE PER UNAS-114.					
2.		POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE).					
3.		SURFACE TEXTURE PER UNAS-941.					
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NOTES:

1. H_2 LEAK CHECK WITH MASS SPEC. - LEAK RATE NOT TO EXCEED 1×10^{-9} STD ATMOS CC/SEC.
2. GOLD PLATE ITEMS 6 PER MIL-G-45204 CLASS 6

NOT SHOWN

11		SOC. HD CAP SCR #10-24NC x 1/4" LG	6	CRES		
10	73-114660-2	WINDOW	2			
9	73-114651	AMMONIA DETECTOR CASE	1			
8	73-112649-2	ROD	3			
7	73-114661	AMMONIA DETECTOR FLANGE	1			
6		GASKET VARIAN #953-5016	2	Cu-AU		
5		FLANGE VARIAN #954-5081	1	CRES		
4	73-112518-2	SPIDER	1			
3	73-112519	REFLECTOR	1			
2	73-114713	SPRING	3			
1	73-114711-2	COMPOUND SCREW	3			

ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.
------	----------	-------------	-----------	----------	-----------	-----------

1. DIMENSIONING AND TOLERANCING ARE PER USAS-Y14.5.
2. POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE).
3. SURFACE TEXTURE PER USAS-B46.1.

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RED GEN CHEM

JOB NO.

DATE	12/14/73
BY	J.W. SELEY
CHECKED	J.T. Kestner
APPROVED	1-7-74
DATE	6/22/96
BY	
CHECKED	
APPROVED	

MICROWAVE SPEC. JOB # 8067
AMMONIA DETECTOR

DETAIL

LET	DRN	CH	DATE	ZONE	CHANGE

NOTES:

1. VACUUM BRAZE ASSEMBLY.
2. LAP SURFACE A FLAT AFTER BRAZING
3. GOLD PLATE ALL OVER PER MIL-G-45204 CLASS 3

5	73-114660	WINDOW TAB-01	2	KOVAR		
4	73-114660	WINDOW TAB-02	2	MICA		
3	73-114657	HEATER	3	CU		
2	73-114656	STANDOFF	3	SST		
1	73-114655	MOD. FLANGE	1	KOVAR		
ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.

1. DIMENSIONING AND TOLERANCING ARE PER USASI-Y14.5.
2. POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE).
3. SURFACE TEXTURE PER USAS-B46.1.

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RED. GEN. CHEN

JOB NO.	
DATE	11-3-73
DR	J. WISELEY
ACT. NO.	6800-09
SHOWN ON	CH
APPROVED	
MATERIAL SPEC. NO. 8067	
SUB ASSEMBLY AMMO/DNA DETECTOR	
DETAIL FLANGE SUB ASSY	

LT	DR#	CH	DATE	ZONE	CHANGE
A1	10	10	1/3	D2	E.02 WAS OMITED
A2	10	10	1/2	B1	ADDED "HARD FIRED"

NOTES:

UNLESS OTHERWISE NOTED

1. FINISH STK OR $\checkmark$ ALL OVER.
2. BREAK EDGES .015 MAX.
3. TAG WITH DWG NO.

TABULATION	
TAB NO	χ^2 DOF
73-112649-1	6.47
73-112649-2	6.60

		ROD - HARD FIRED Δ		ALP O ₂			
ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.	
1. DIMENSIONING AND TOLERANCING ARE PER USAS-IY14.5. 2. POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZED). 3. SURFACE TEXTURE PER USAS-B46.1			CLASSIFICATION THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA, LAWRENCE LIVERMORE LABORATORY IT IS TO BE LOANED TO YOU IT IS TO BE RETURNED WITHOUT PERMISSION OF THE MACH. ENG. DEPT		LAWRENCE LIVERMORE LABORATORY University of California		
NO. REQ'D PER ASSEM. DO NOT SCALE			DRAWING NO. AAA 73-112649-0A		C SCALE 2X COPY		

RED GEN CHEM

[illegible]

LET	DRN	CH	DATE	ZONE	CHANGE

NOTES:

1. $\sqrt[63]{}$ F.A.O.
2. TAG WITH DWG NO.

TABULATION				
TAB NO.	MATERIAL	X	Y	
73-114660-1	KOVAR	.080	.035	
73-114660-2	MICA	NONE	.010	

ACTUAL SIZE

NO. REQ'D PER ASSEM.		DO NOT SCALE		SEE TAB BLOCK		CLASSIFICATION		LAWRENCE LIVERMORE LABORATORY University of California	
ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.	THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA, LAWRENCE LIVERMORE LABORATORY REPRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECH. ENGR. DEPT.		
1. DIMENSIONING AND TOLERANCING ARE PER USAS-Y14.5. 2. POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE). 3. SURFACE TEXTURE PER USAS-B46.1.							DRAWING NO. AAA 73-114660-00 SCALE 5X COPY		

RED GEN CHEM

JOB NO.		660196	
DATE	11-9-73	DATE	1-7-74
DR	J.W. SELEY	CHK	J.W. SELEY
SHOWN ON	73-114660-1	APPROVED	73-114670
THERMOBILANCE SKT JOB #80503		DETAIL WINDOW	
WATER DETECTOR FLANGE			

LET	DRN	CH	DATE	ZONE	CHANGE

NOTES:

UNLESS OTHERWISE NOTED

1. $\sqrt{125}$ F.A.O.
2. ELECTROPOLISH 100% TO BRIGHT FINISH.
3. TAG WITH DWG NO.

SPIRAL GROOVE -
.010 R. X .010 DP OR
90° VEE X .010 DP

ITEM		PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.
1. DIMENSIONING AND TOLERANCING ARE PER USAS-Y14.5.			ROD		COPPER	OFHC	
2. POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE).							
3. SURFACE TEXTURE PER USAS-B46.1							
NO. REQ'D PER ASSEM.							
DO NOT SCALE							

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RED GEN CHEM

JOB NO.		666196	
DATE	11-7-73	CHK	11-7-73
DR	5425-005	CHK	11-7-73
SHOWN ON	11-7-73	APPROVED	73-114657-00
THERMOBALANCE SYS. 108 # 80559		WATER DETECTOR FLANGE	
SUB ASSEMBLY		HEATER

NOTES:

UNLESS OTHERWISE NOTED--

1. FINISH STK OR $\sqrt{}$ ALL OVER

2. BREAK EDGES .015 MAX.

3. ALL DIAS $\sqrt{}$ AT .002

4. ELECTROPOLISH 100% TO BRIGHT FINISH

5. TAG WITH DWG NO.

LET	DRN	CH	DATE	ZONE	CHANGE

RED GEN CHEM.

JOB NO.	
666196	
DATE	11-7-73
BY	J. KESTNER
APPROVED	
POST NO.	5425-26
SHOWN ON	73-114676
THE BALANCE SYS JOB # 2058	
WATER DETECTOR MK II FLANGE	
STANDOFF	

ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.
		TUBE		CRES	304	
1. DIMENSIONING AND TOLERANCING ARE PER USAS-Y14.5.			CLASSIFICATION			
2. POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE).			OFFICIAL USE			
3. SURFACE TEXTURE PER USAS-B46.1.			REPRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECH ENG DEPT			
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			AAA 73-114656-00			
			SCALE 2X COPY			

LET	DRN	CH	DATE	ZONE	CHARGE

NOTES:
1. FINISH STK OR ⁶³✓ ALL OVER

ITEM		PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.
1.			FLANGE VARIAN 954-5080 TAP'D		CRES		
2.			1. DIMENSIONING AND TOLERANCING ARE PER USAS-Y14.5.				
3.			2. POSITIONAL AND FORM TOLERANCES APPLY R. F. 5. (REGARDLESS OF FEATURE SIZE).				
4.			3. SURFACE TEXTURE PER USAS-B46.1.				
5.			REPRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECH. ENG. DEPT.				
6.			NO. REQ'D PER ASSEM.				
7.			DO NOT SCALE				
8.			CLASSIFICATION				
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11.			DRAWING NO.				
12.			AAA 73-112516-00				
13.			C SCALE FULL				
14.			COPY				

RED GEN CHEM

JOB NO.		666196
DATE	5/2/68	12/2/73
BY	W. J. KELLEY	W. J. KELLEY
FOR	73-112516-00	73-112516-00
APPROVED		
THE LAWRENCE LIVEMORE LABORATORY	73-112516-00	73-112516-00
WATER DETECTOR MK II SHELL		
FLANGE REWORK		

LET	DRN	CH	DATE	ZONE	CHANGE
A	JW		12/13		GEN REV.

NOTES:
 UNLESS OTHERWISE NOTED-
 1. FINISH $\sqrt{125}$ ALL OVER.
 2. BREAK EDGES .015 MAX.

DETAIL A
NO SCALE

RED GEN CHEM

JOB NO.	
DATE	660196
DR	C. DISELEY 11.7.73
CHK	JT WESTER 1-4-74
APPROVED	
ASST. NO.	6600-08
SHOWN ON	73-11461
MICROWAVE SPEC. JOB # 9067	
AMMONIA DETECTOR FLANGE	
MOD. FLANGE	

ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.
1.		DIMENSIONING AND TOLERANCING ARE PER USAS-Y14.5.		ROVAR		
2.		POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE).				
3.		SURFACE TEXTURE PER USAS-B46.1.				

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NO. REQ'D PER ASSEM.
DO NOT SCALE

METRIC DRAWING

[illegible]

NOTES

1-REFER TO MEL-74-001247 FOR
CLARIFICATION OF LLL METRIC
DRAFTING POLICY

2-ALL DIMENSIONS & TOL'S. ARE IN
MM UNLESS OTHERWISE NOTED

THIRD ANGLE PROJECTION

The diagram illustrates the third angle projection of a truncated cone. On the left is the front view, a circle with a crosshair indicating the center. On the right is the top view, a truncated cone. A horizontal centerline, consisting of a solid line on the outside and a dashed line on the inside, passes through the center of both views to indicate their alignment.

[illegible]

4		"PARKER" TRIPLE-WOL				
3		MALE CONN. NO 4-FBTX-SS	2			
2	75-101469	VALVE	1			
2	75-101470	MANIFOLD	1			
		SINGLE STAGE FILTER				
ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.

1. DIMENSIONING AND TOLERANCING ARE PER
USAS-Y14.5.
2. POSITIONAL AND FORM TOLERANCES APPLY
R. F. S. (REGARDLESS OF FEATURE SIZE).
3. SURFACE TEXTURE PER USAS-B46.1.

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CLASSIFICATION

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University of California

DRAWING NO.

AAA75-101454-00

C	SCALE	Full	COPY
---	-------	------	------

JOB NO.

MAJOR UNIT	JOB	ACCT. NO.	DR	DATE
SINGLE STAGE SEPARATOR	8084	5680-08	SUMMERS	1-13-75
SUB ASSEMBLY		SHOWN ON	DR	
		—	McMurray	2-6-75
DETAIL			APPROVED	

[illegible]

5		MALE CONN. NO. 4FBTX-SS PARKER	2				
4		VALVE					
3	75-101457-00	2 ND STAGE FILTER					
2	75-101458-00	1 ST STAGE FILTER					
1	75-101456-00	MANIFOLD PLATE					
ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.	
1.	DIMENSIONING AND TOLERANCING ARE PER USAS-Y14.5.		CLASSIFICATION: ORIGINAL USE		LAWRENCE LIVERMORE LABORATORY <small>University of California</small>		
2.	POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE).		THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA - LAWRENCE LIVERMORE LABORATORY				
3.	SURFACE TEXTURE PER USAS-246.1		REPRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECH. ENG. DEPT.				
				DRAWING NO.		AAA75-101455-00	
				C SCALE FULL		COPY

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LABORATORY
University of California

DRAWING NO. AAA75-101455-001

G	SCALE	FILE	COPY
---	-------	------	------

MAJOR UNIT	JOB	ACCT. NO.	CR	DATE	JOB NO.
DUAL STAGE SEPARATOR	8084	5630-23	CR	1-8-75	
SUB ASSEMBLY		SHOW IN		2-6-75	
DETAIL				<i>J. Wisley</i>	
				APPROVED	

METRIC DRAWING

LET	DRN	CH	DATE	ZONE	CHANGE

NOTES

- 1- REFER TO MEL-74-001247 FOR CLARIFICATION OF LLL METRIC DRAFTING POLICY
- 2- ALL DIMENSIONS & TOL'S ARE IN MM UNLESS OTHERWISE NOTED

THIRD ANGLE PROJECTION

NO. REQ'D PER ASSEM.
DO NOT SCALE

ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.
<p>1. DIMENSIONING AND TOLERANCING ARE PER USAS-Y14.5.</p> <p>2. POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE).</p> <p>3. SURFACE TEXTURE PER USAS-B46.1.</p>						

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University of California

DRAWING NO.

AAA75-101477-00

C

SCALE FULL

COPY

JOB NO.

DATE	1-31-75
BY	W. W. W. W.
CHECKED BY	W. W. W. W.
APPROVED	W. W. W. W.
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METRIC DRAWING

LET	DRN	CH	DATE	ZONE	CHANGE

NOTES

1. REFER TO MEL-74-001247 FOR CLARIFICATION OF LLL METRIC DRAFTING POLICY.
2. ALL DIMENSIONS & TOLS. ARE IN MM UNLESS OTHERWISE NOTED

NO. REQ'D PER ASSEM.
DO NOT SCALE

ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.
1.		DIMENSIONING AND TOLERANCING ARE PER USASI-Y14.5.				
2.		POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE).				
3.		SURFACE TEXTURE PER USAS-B46.1.				

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