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LOCKHEED-GEORGIA COMPANY

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

FINAL REPORT
LH₂ QUALITY METER

October 1968

This report is furnished for the fulfillment of Paragraph C, Part VI, of the Scope of Work, Exhibit A of Contract NAS8-20518. Accompanying this report is one complete set of reproducible drawings for the fulfillment of Part II of the Scope of Work, Exhibit A of Contract NAS8-20518.

LOCKHEED GEORGIA NUCLEAR LABORATORY
Lockheed-Georgia Company - A Division of Lockheed Aircraft Corporation

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1.0 SUMMARY

Contract NAS8-20518 was originally awarded to Lockheed Georgia Nuclear Laboratory for the design, fabrication, testing, calibration, and delivery of two each pre-production models and four each production models of a two-phase hydrogen quality meter. Several modifications were subsequently added to the contract; including the design and testing of a more accurate version (1%) of the quality meter; however, as finally amended, the contract required only the two pre-production models of Phase I of the original contract. The designation of these two models was changed from "pre-production" models to "engineering test" models. One of the units was fabricated from aluminum, while the other was fabricated from 347 stainless steel as required by contract modification.

The two engineering test models were tested in accordance with a NASA approved Quality Test Program (QTP-301), and their performance satisfied the requirements set forth in all tests.

The engineering test models were designed and tested in accordance with NASA specifications (Appendix C) with no exceptions taken to the specifications.

The entire program was conducted in accordance with a NASA approved Quality Assurance Plan with one exception; i.e., at the time that the pre-production designation was changed to the engineering test model designation, the required quality of workmanship was waived and the DCASR was only responsible for quality in instrument performance, and for adherence to requirements governing the use of components and parts.

Monthly progress reports were written for the entire duration of the program.

All data on parahydrogen properties were taken from Reference 1.

1. Thermodynamics and Related Properties of Parahydrogen from the Triple Point to 100°k at Pressures to 340 Atmospheres, NBS Monograph 94, August 1965.

2.0 THEORY OF OPERATION

The objective of the program was to design, fabricate, test, and calibrate a device which would, under specified operating conditions and accuracy, indicate the ratio of dry vapor to wet vapor being vented through the device itself.

In order to determine the quality of a wet vapor it is sufficient to know the density of the dry vapor, the density of the liquid, and the density of the wet vapor. Quality is defined as follows:

$$Q = \frac{m_v}{m_v + m_l}$$

where m_v = mass of dry vapor.
 m_l = mass of wet liquid.

The assumption that the saturated vapor pressure-temperature relationship is valid was made throughout the analysis. This assumption permits the saturated vapor density and the liquid density to be obtained from a measurement of pressure.

Quality can also be written:

$$Q = \frac{\rho_v V_v}{\rho_v V_v + \rho_l (V - V_v)} = \frac{\rho_v V_v}{\rho_a V}$$

where ρ_v = density of vapor.
 V_v = volume of vapor.
 ρ_l = density of liquid.
 V = total volume.
 ρ_a = density of vapor-liquid mixture.

The above equation can be reduced to the following:

$$Q = \frac{\rho_v}{\rho_a} \left(\frac{\rho_a - \rho_l}{\rho_v - \rho_l} \right)$$

ρ_v is measured directly with a pressure transducer while ρ_a is measured directly with a beta gage. The parenthetical term in the above equation is not equated to 1 as originally proposed, but ρ_a is corrected to a function G_c which greatly reduces the formula error over the ranges of all parameters. Appendix A gives a treatise on G_c and the results of its use. Q is electronically computed from the individual parameters ρ_v and G_c .

ρ_v is approximated as a straight-line function of the vent tube pressure as shown in Figure 1, thus considerably simplifying the hardware involved in the measurement. A pressure transducer having a linear output with pressure is used.

The ρ_a beta gage used TL-204 as the beta ray source and a diffused junction silicon diode as the detector. The desired slope for the count rate versus ρ_a curve is obtained by:

- (1) choosing an appropriate beta ray energy and
- (2) properly determining the source to detector separation distance.

TL-204 was chosen as the pure beta emitter with an energy nearest to satisfying the requirements of this instrument. Sources that emit gamma rays in addition to betas give unwanted detector backgrounds. The source to detector separation distance was determined such that the count rate versus ρ_a curve provides equal statistical accuracy in ρ_a at both minimum and maximum ρ_a . The count rate versus the corrected ρ_a is given in Figure 2.

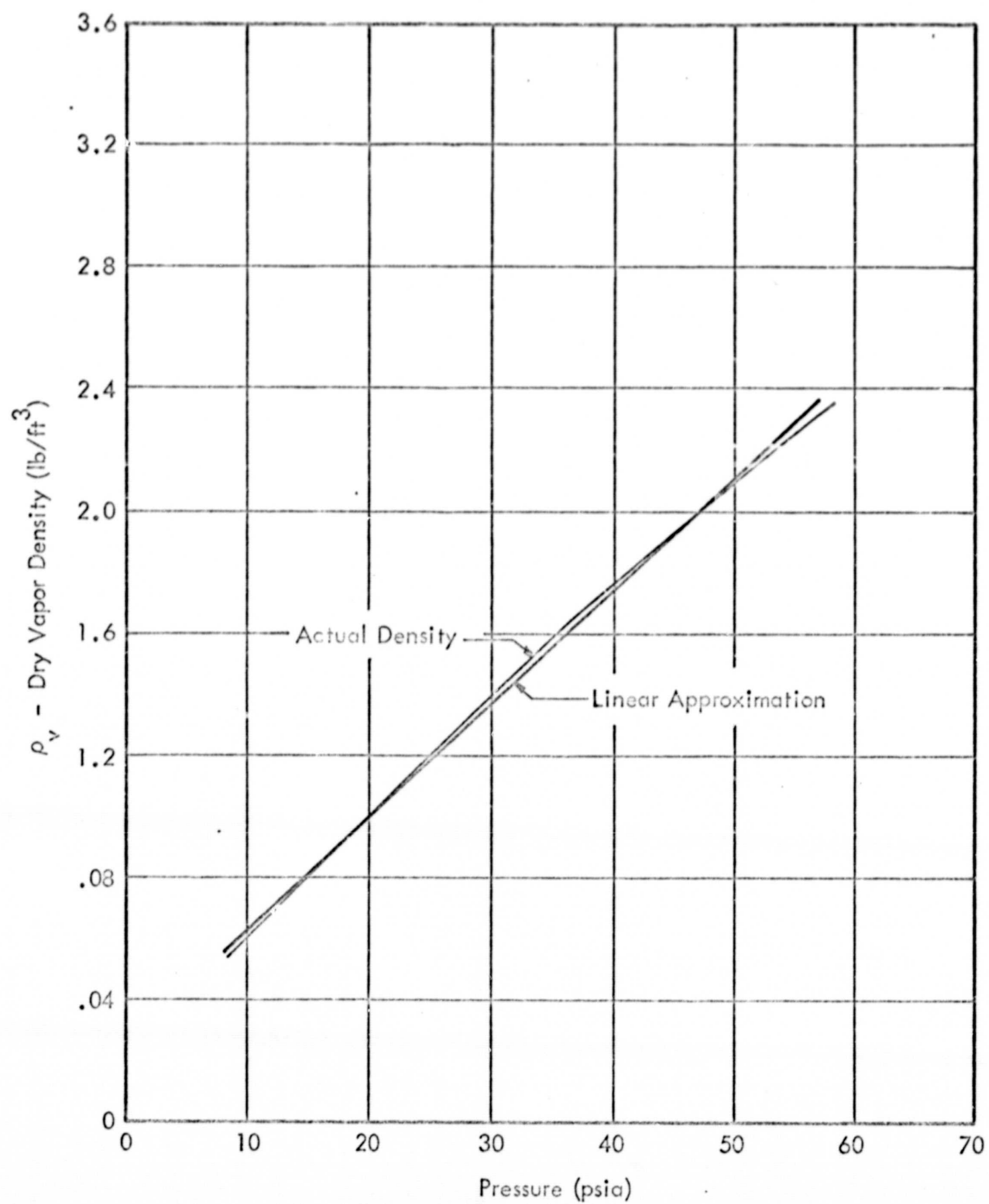


FIGURE 1 DRY VAPOR DENSITY VERSUS PRESSURE FOR LH₂

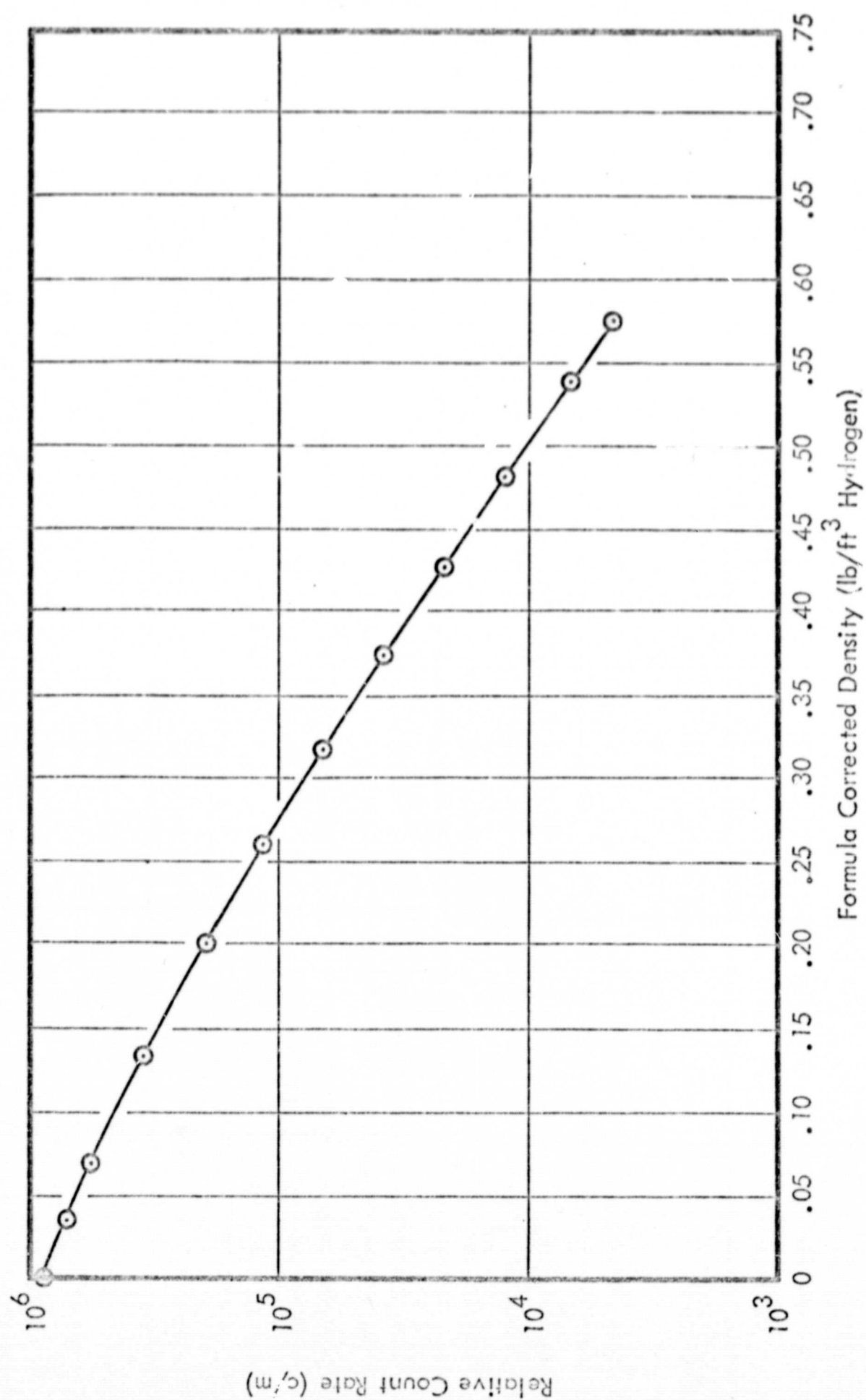


FIGURE 2 QUALITY METER COUNT RATE VERSUS HYDROGEN DENSITY

The ρ_v/ρ_a division is accomplished by an arithmetic amplifier that provides a 0 to 5 VDC signal representing quality from 0 to 100%. A block diagram showing major components and component characteristics is shown in Figure 3.

Fundamentally, the diffused junction detector is a large p-n junction diode consisting of a thin diffused layer on one side of a high purity p-type silicon wafer. When charge carriers created by a charged particle incident on the detector are separated by the electric field in the depletion region, they attain a drift velocity. The motion of these carriers in the field induces a voltage in an external circuit. Pulse rise times on the order of nanoseconds are typical.

Pulse height stability over a wide temperature range is not real good with diffused junction detectors. For applications such as this temperature control of the detector is required. Pulse height stability is essential for proper performance of this instrument.

The beta gage section of the quality meter is constructed to be incorporated in series with a vent line. It is of rectangular cross section which permits precise flush mounting of the detector-source windows with the tube wall. 100% "viewing" of the hydrogen flow is attained with the beta gage. Detector and source windows are rectangular. This feature permits incremental volumes of flowing hydrogen to spend equal time in the viewing area, regardless of position. Of course it is desirable that the flowing liquid be in the form of very fine droplets distributed uniformly throughout the vapor; however, it is expected that needle-like drops may exist at times. If needle-like drops do exist, their effect on the beta gage count rate is dependent upon the position of the drop between the source and detector. An analysis of the variation in gage sensitivity to liquid drop position in the viewing volume was performed. The results of this analysis are shown in Figure 4 in the form of iso-sensitivity lines. The probability of observing a drop with a sensitivity between any two iso-sensitivity lines divided by the total $\alpha \beta$ area. α and β are the rectangular

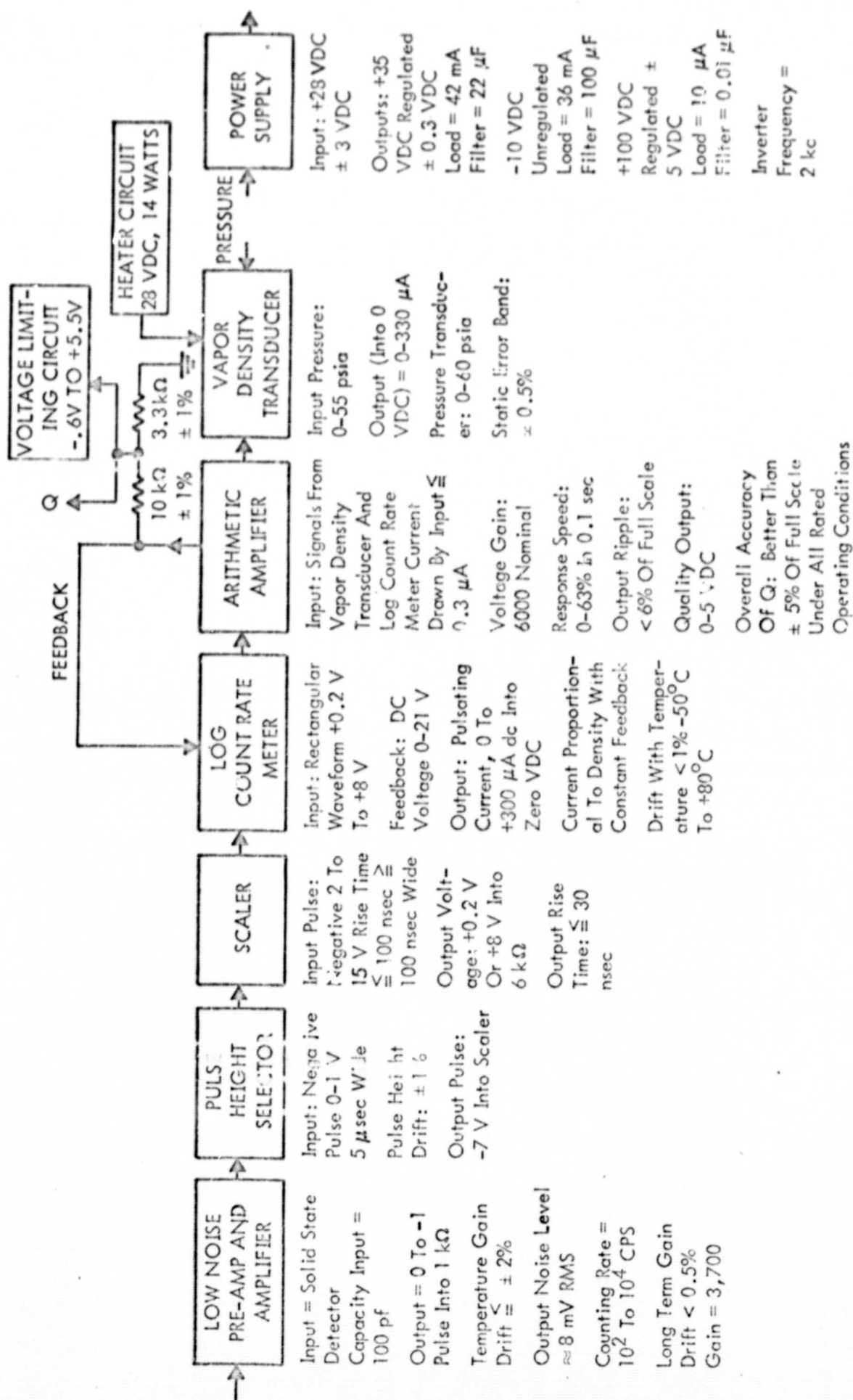


FIGURE 3 BLOCK DIAGRAM OF ELECTRONIC SYSTEM

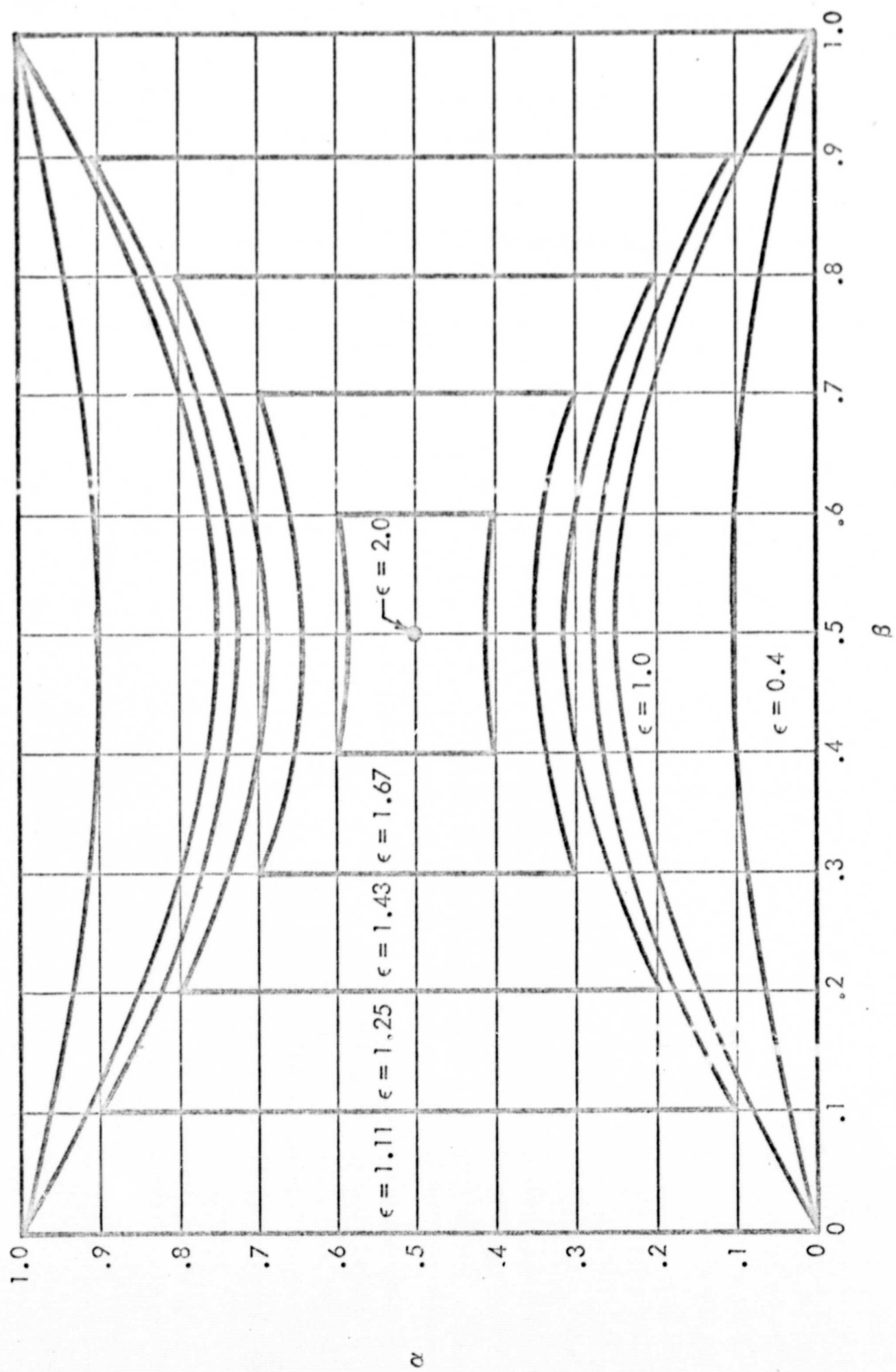


FIGURE 4 ISO-SENSITIVITY PLOT

coordinates of the detector window.

The error analysis as shown in Appendix A was the theoretical error analysis presented at the design review in late 1965. The finally tested instrument was much more accurate than this analysis predicted, because of the following reasons:

- (1) The parenthetical term in the equation,

$$Q = \frac{\rho_v}{\rho_a} \left(\frac{\rho_a - \rho_l}{\rho_v - \rho_l} \right),$$

is not equated to 1, but a correction is actually made as discussed in Appendix A; hence, greatly reducing the formula error.

- (2) The Bourns 441 pressure transducer was not used; instead, a temperature controlled strain gage pressure transducer manufactured by Statham was used. This greatly decreased the pressure transducer error. Figure 5 shows the strain gage transducer error in comparison with error introduced by the Bourns 441.

During the preliminary design phase of this program the problem of possible liquid hydrogen filming of source and detector windows was given careful consideration. Very thin films of liquid on the windows could give tremendous errors in the measurement of ρ_a and; thus, in quality. It was suspected that some type of liquid separator might be required at the quality meter flow inlet to uniformly distribute the liquid throughout the flow volume to discourage filming on walls and windows. The design of an effective separator is not straightforward. Phenomena occurring under gravitational forces cannot be used to predict happenings under zero gravitational forces, but it was decided that information concerning the existence of a film under 1 g would be beneficial. If a film did occur under 1 g force, then some type of gas-liquid mixer would have been essential. Because of increased rates of capillarity, film problems

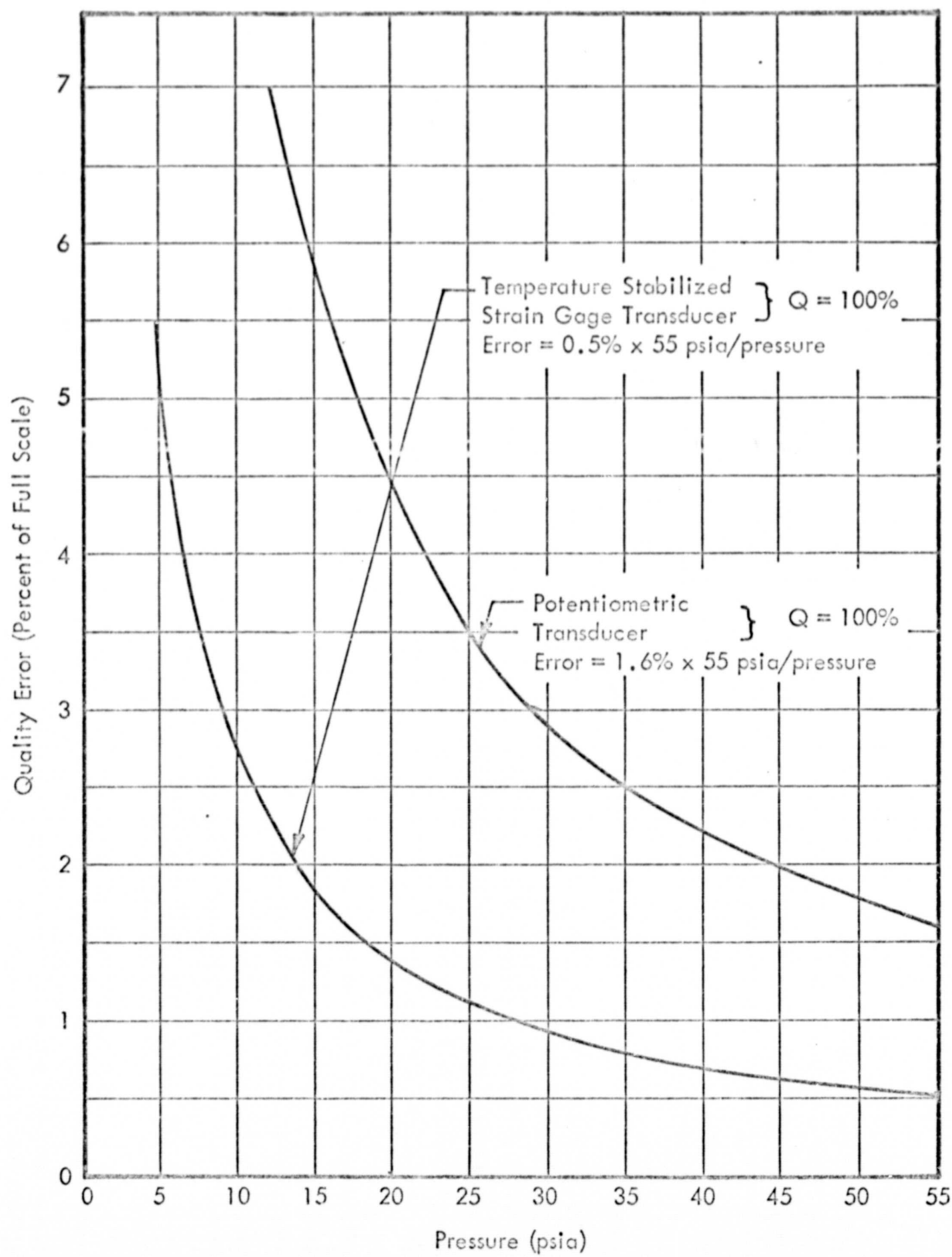


FIGURE 5 QUALITY ERRORS RESULTING FROM PRESSURE ERRORS

are expected to be enhanced under zero gravity.

An experiment to determine whether or not a LH_2 film was present either on the detector face or the face of the source during the flow of hydrogen mixtures of less than 100% quality was designed. Results showed that no hydrogen film existed on the windows in this 1 g experiment. A detailed description of the experiment is given in Appendix D.

Instrument specifications insinuate an instrument operating pressure range of ~ 0 to 55 psia with an accuracy of $\pm 5\%$ over the 50% to 100% quality range. Obviously as the operating pressure approached 0 psia, the error in p_v and; thus, in quality becomes very large. Because of the type of the equation to be solved for quality ($Q \cong p_v/p_a$), errors in p_v and p_a must be considered as percent of value, and not percent of range or percent of full scale. A given value of Q can be gotten from an infinite number of combinations of p_v and p_a . As a result of these considerations 10 psia was taken as the minimum operational pressure, and accuracy requirements were met down to and below this pressure. The range of p_a is then computed to be 0.06 lb/ft^3 (10 psia, 100% quality) to 0.54 lb/ft^3 (55 psia, 50% quality).

3.0 INSTRUMENT DESCRIPTION

A complete set of drawings is furnished with this report.

Two versions of the quality meter have been fabricated. One has the beta gage vent flow section constructed of aluminum while the other has this same section constructed of 347 stainless steel.

Overall instrument length is approximately 13 inches, and its weight is about 15 pounds. The electronic compartment, which also contains the temperature stabilized pressure transducer, is 220 cubic inches in volume, contains some 250 electronic parts on 5 printed circuit boards, and is attached to the beta gage section with a thermally insulating Kel-F ring. Heat loss through this ring is approximately 3.5 watts with a 500°F temperature differential across it.

As shown in the block diagram the electronic circuitry consists of a pre-amplifier, an amplifier, an integral pulse height selector circuit, a scaler, a log count rate meter, an arithmetic amplifier, and a power supply. The unit has a power consumption of 5.6 watts when neither the pressure transducer heater nor the detector heater is on. The pressure transducer heater dissipates 16.4 watts during its "on" period; however, during normal operation with LH_2 this heater has a 30% on, 70% off duty cycle. This gives an average power consumption for the pressure transducer heater of about 4.9 watts. The detector heater dissipates 4 watts of power during its "on" period - its "on" period during operation; i.e., LH_2 flow, is about 40% of the time giving an average power consumption of approximately 1.6 watts. This gives an average total power consumption of 12.1 watts for the instrument.

Input voltage to the power supply is 28 VDC. The power supply provides a +35 VDC and a -12 VDC for operation of pulse and computing circuitry, and +100 VDC for detector bias. The pressure transducer amplifier, the pressure transducer heater, and

the detector heater all operate from the 28 VDC input. The pre-amplifier, amplifier, and pulse height selector circuits are each in individual compartments within the electronic compartment. This was required to keep mutual interference to a minimum.

As required by specifications, the 28 VDC minus, the signal output minus, and the case ground are all isolated from each other.

The beta source consists of TL-204 deposited and bound to an area of approximately 2.1 cm. The deposit is of such thickness that self absorption is of very little concern. The source was fabricated by Monsanto Research Corporation using techniques especially developed for this program.

Source activity is a nominal 30 millicuries at the time of purchase. The source housing assembly allows a manual "window" adjustment to account for source decay. This adjustment is designed for decay corrections for a period of at least 4 years.

The source is covered with 0.001" monel.

The detector is a diffused junction silicon type, approximately 300 millimeters thick, partially depleted with 100 volts bias. Detector capacity is a nominal 75 picofarads. Room temperature leakage current is approximately 0.5 microamperes. The detector was furnished by the Solid State Department of Harshaw Chemical Company.

The detector is assembled into a housing for temperature control purposes. This housing utilizes vacuo and Kel-F for thermal insulation, while the detector control temperature is about 20°C. Power required for this temperature control with a ΔT of 270°C is an average of about 1.6 watts. The detector housing is sealed with a vacuum of about 10^{-4} min Hg. No real effort was made to reach a high vacuum in this case. The arrangement of detector, heater, and thermostat inside the detector housing was carefully designed to minimize noise "pickup" on the detector leads.

During manufacture and instrument preparation for calibration, certain procedures were established to simulate actual operational conditions. Two of these manufacturers' test procedures (MTP309A and MTP309B) have particular significance to any user of the instrument; therefore, they are given in Appendix E.

The ρ_g measurement is made by a beta source and silicon detector, the detector having about 100 PF of junction capacitance. The source is thallium 204 which is not monoenergetic but emits an energy spectrum. The maximum energy in the spectrum is 760 KeV, but the peak of the spectrum is at about 250 KeV. All of the betas lose energy before they reach the detector because of the windows and the hydrogen they pass through before they reach the detector. The lower energy betas lose more energy than the higher energy betas. As a result the pulse height spectrum is typically that shown in Figure 6.

The signal from the detector is fed through a preamplifier, amplifier, and discriminator to obtain a count rate representing the density of the hydrogen mixture. Referring to Figure 6, it was decided to discriminate approximately at channel 22 since this gave maximum count rate without having significant noise counts. Channel 22 corresponds to about 90 KeV.

At $.061 \text{ lb/ft}^3$ and channel 22, counts per channel = 1,340
counts above channel = 119,000

At $.54 \text{ lb/ft}^3$ and channel 22, counts per channel = 1,550
counts above channel = 74,000

Thus, at $.061 \text{ lb/ft}^3$, 1% change in discriminate level = .2 channel = 268 counts
= .225% of 119,000

At $.54 \text{ lb/ft}^3$, 1% change in discriminate level = .2 channel = 318 counts
= .43% of 74,000

Discriminating at 50 KeV, the count rate versus hydrogen mixture density is as shown

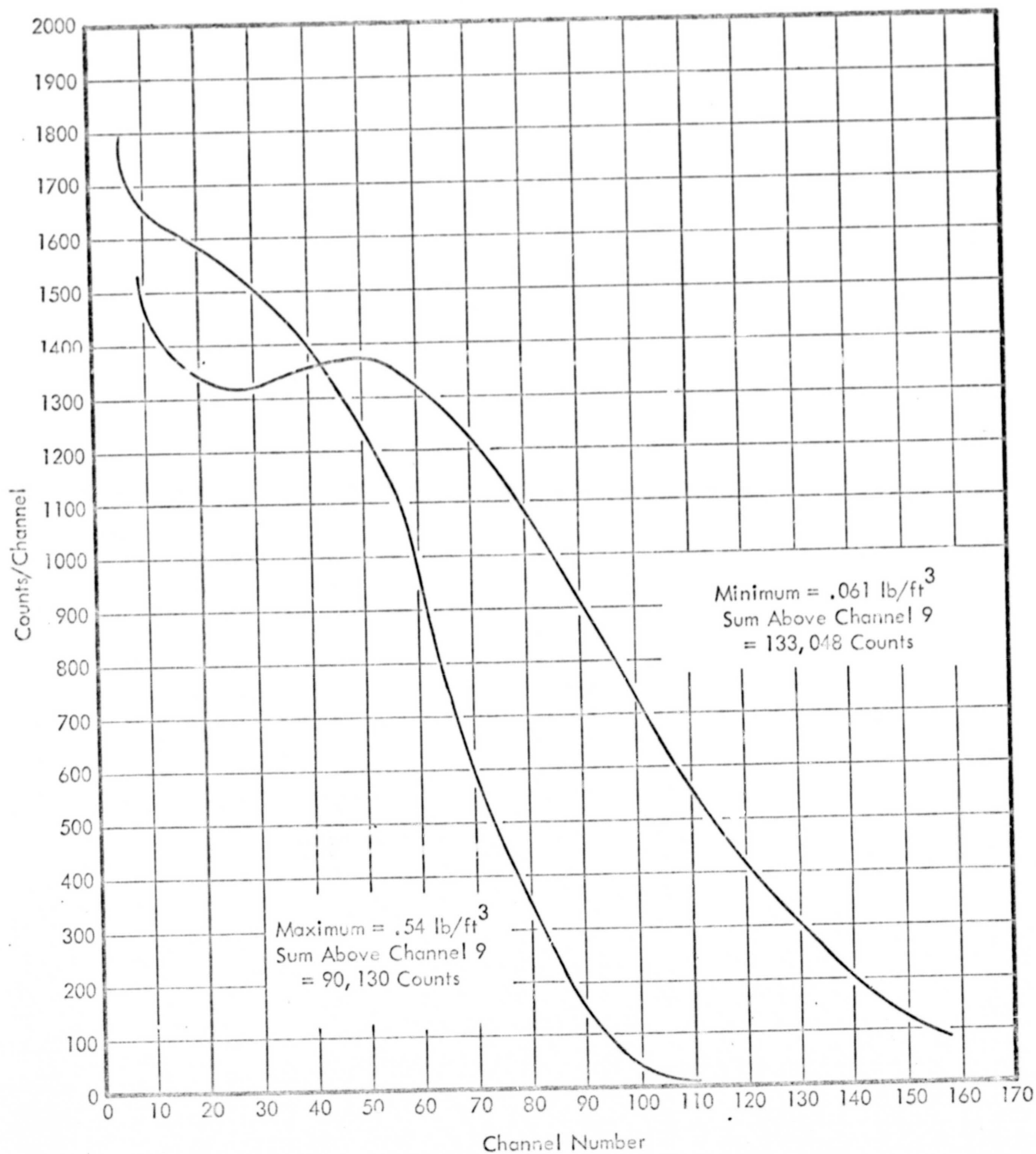


FIGURE 6 PULSE HEIGHT SPECTRUM OF ρ_a CHANNEL AT MINIMUM AND MAXIMUM ρ_a

in Figure 2. From this figure it may be seen that near minimum density; i.e., $.061 \text{ lb/ft}^3$, the slope of the curve is 1% change in count rate per 3% change in density. Furthermore, at maximum density; i.e., $.54 \text{ lb/ft}^3$, the slope of the curve is 1% change in count rate per .13% change in density.

It follows from the above relationships that if the pulse height discrimination level drifts 1% the mixture density error will be .68% at minimum density and will be .056% at maximum density. Since the ρ_a preamplifier amplifier discriminator section of the quality meter cannot be allowed to contribute more than about 2% to the total 5% instrument error, this part of the circuit must have a discrimination level stability of about 3% over the entire temperature range -55°C to $+80^\circ\text{C}$; i.e., a temperature coefficient of $220 \text{ PPM}/^\circ\text{C}$. This stability pushes the state-of-the-art as far as the preamplifier is concerned. The preamplifier must be an ultra-low noise circuit because the noise would otherwise be larger than the signal. The preamplifier also has to be extremely fast because of the high counting rate, and this makes noise even more of a problem. The first satisfactory transistor preamplifier for accomplishing the required stability, speed, and low noise was developed in 1964 by T. V. Blalock (IEEE Trans. Nucl. Sci., NS-11, No. 3, 365) and further improved in 1966 (IEEE Trans. Nucl. Sci., NS-13, No. 3, 457). These amplifiers were developed with the advent of Texas Instruments' ultra low noise 2N3823 field effect transistor, which is still the lowest noise device available. Both of the amplifiers developed by Blalock were laboratory amplifiers, very much subject to instability and oscillation problems except under laboratory conditions with massive shielding of the input from the intermediate and output stages of amplification.

Lockheed Nuclear Laboratory developed for the LH_2 Quality Meter a flight model amplifier employing the same input transistor used by Blalock and displaying the same low noise, high speed, and temperature stability which characterize Blalock's amplifier. However, the Lockheed preamplifier uses fewer components and takes up much less space. Because the quality meter detector is fully depleted, its capacitance is

very temperature stable, and thus Lockheed was able to use a voltage sensitive rather than a charge sensitive preamplifier. The fact that the amplifier is voltage sensitive was in part responsible for Lockheed's ability to package the unit in such tight quarters. The preamplifier, main amplifier, and discriminator were all packaged in a 5" x 9.5" x 1" box, with partition shields to isolate the preamp from the remaining circuitry and the discriminator from the remaining circuitry. The preamplifier was connected to the detector through a miniature coax cable, the shield of which was kept isolated from ground except at the one point where it ties to the preamp printed circuit board. This procedure is necessary to prevent ground currents in the coax shield. External to the electronics compartment the coax was fed through an evacuated cavity to the detector. The walls of this cavity were at case ground, thus forming in a sense a triax cable. The detector of course is kept in an evacuated cavity to prevent moisture condensation on the detector. However, another coax cable carrying the 28 volt dc supply voltage for the detector capsule heater also passes through the cavity. Filters are incorporated to keep the 28 volt dc at near ac ground potential.

Generally speaking, the preamplifier and the two stages of the main amplifier are patterned after the high stability circuit presented by Kenneth F. Hatch in IEEE Transactions on Nuclear Science NS13, No. 1, p. 351. Since the operation of these circuits is described in detail in that article we shall omit the analysis here. The schematics of the preamplifier and amplifier appear in Appendix B. Note that an RC-RC shaping network consisting of R7, R12, R17, C9, C12, and C13 is used between the two stages of the main amplifier to shape the pulse. The effective time constants of differentiation and integration are .845 microseconds and 3.47 microseconds.

The RMS noise level of the preamp-amplifier combination was found to be 10.4 KeV rms referred to the input, which is roughly the value achieved by Blalock in the articles mentioned earlier, with a 100 PF silicon detector. The pulse height discriminator consists of a Schmidt trigger which is driven by a 2N3424. The 2N3424 is a matched pair of 2N913 high speed transistors. The base of the input half of the 2N3424

is normally biased 150 millivolts above the base of the other half. This bias is generated by a 5 volt zener diode and a precision voltage divider. Whenever an input pulse of 150 millivolts or greater amplitude occurs, the base voltages on the 2N3424 become equal and their collector currents thus become equal, which switches the Schmidt trigger and gives an output pulse. Hysteresis within the circuit assures that the output pulse duration is sufficient to trigger the bistable flip-flop which it drives. The output is a negative 10 volt pulse. The base-emitter voltage mismatch of the 2N3424 transistor has a temperature variation of not more than 3.6 millivolts over the range -55°C to $+125^{\circ}\text{C}$.

Referring again to Figure 2, it is noted that at minimum ρ_a ; i.e., $.06 \text{ lb/ft}^3$, the count rate is 846,000 counts per minute and the slope is 3% density change per 1% count rate change. The circuit response time constant is 100 milliseconds, so these parameters combine to give a one sigma statistical fluctuation of 6% quality. At maximum density; i.e., $.54 \text{ lb/ft}^3$, the count rate is 8,500 counts per minute and the slope is .13% density change in count rate, so the one sigma statistics at this density is 2.5% quality.

The part of the quality meter circuitry which has been described in this section required more development time than any other part of the circuitry. This was LGNL's first experience in designing circuitry for such a low level detector, and many things were learned from this experience. The major problem with this circuitry is that extreme measures have to be taken to make it stable. The preamplifier input pulse is only 45 microvolts to trigger the discriminator and yet the discriminator output is 10 volts in amplitude. This, coupled with the fact that the preamp input impedance is a 100 PF capacitor, means that extreme shielding is necessary just to keep the amplifier from feeding its own input sufficiently to oscillate much less remain temperature stable. Among the steps taken to achieve satisfactory shielding of the output from the input were the following:

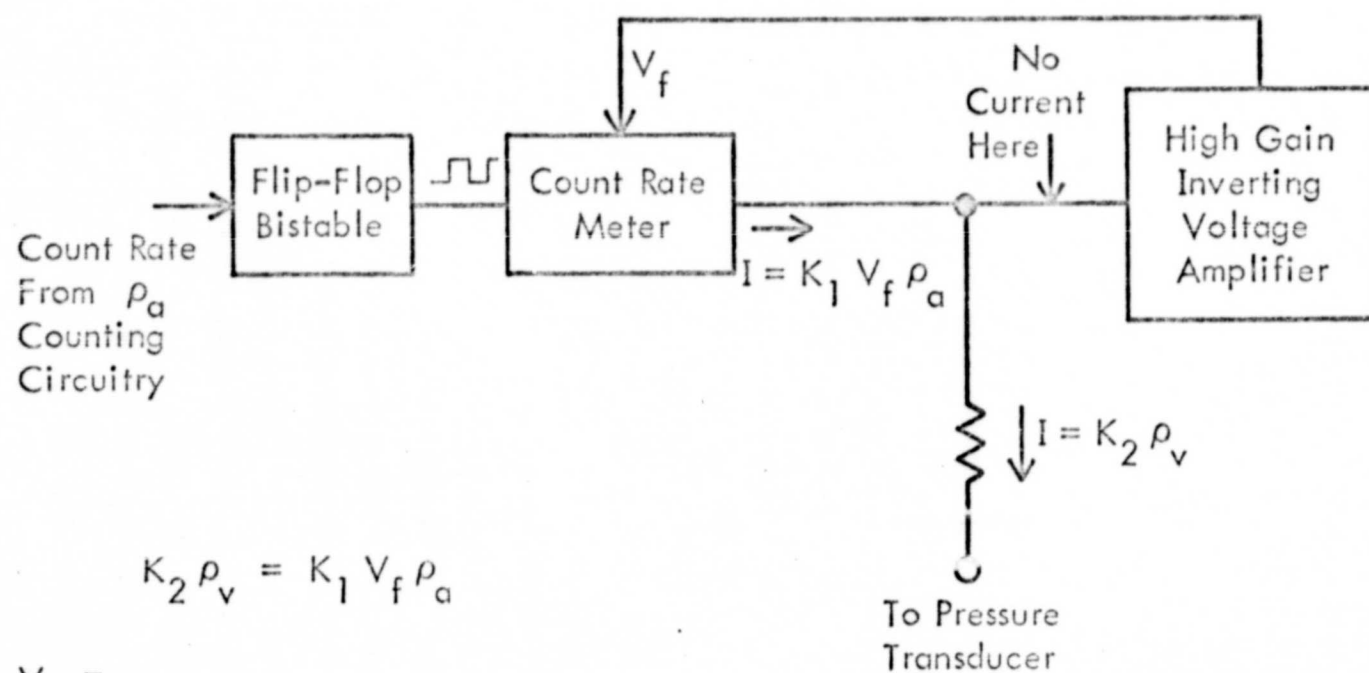
- (1) The detector coax shield had to be grounded at one and only one point - namely on the preamp printed circuit board near the source of the 2N3823 transistor.
- (2) The circuitry was mounted in a heavy aluminum box with "T" shaped partitions welded into place between the preamp and amplifier, and between the amplifier and pulse height discriminator. The cover for the box was also heavy aluminum bolted down to the box with a multitude of machine screws placed all around the periphery of the lid and down into the "T" partitions. The box was welded to the partitions well enough to hold water. A small grommet hole is in each partition to feed the signal and supply voltage wires from one compartment to the next.
- (3) The power supply voltages entered the box at the pulse height discriminator compartment and with the exception of the high voltage lead were filtered in each compartment before passing to the next with a 100 ohm resistor and a large electrolytic capacitor. The high voltage lead was heavily filtered as it entered the preamp compartment. The heavy filtering was necessary since the high voltage lead ties more or less directly to the preamp input, and because this lead picks up a lot of signal not only from its proximity to the power supply inverter and the pulse height discriminator but also from the high voltage zener regulator which is an extremely noisy device.
- (4) Each printed circuit board had only one ground connection - namely a short piece of wire from the printed circuit ground down to the chassis. This was to prevent the ground loops and chassis currents to as great a degree as possible.
- (5) The signal leads connecting from the output of one board to the input of the next were kept as short as possible, including the wire from the output of the pulse height discriminator to the counting circuit.

After the temperature drift of the amplifier-discriminator system was narrowed down to about 3%, a 1K thermistor was added to the discriminator bias circuit to eliminate the temperature drift of a typical circuit.

The maximum temperature and long term drifts of the entire circuit as built is $\pm .002$ lbs/ft³ referred to equivalent density change.

The function of the computing printed circuit board is to take the count rate input from the ρ_a counting circuitry and to take the 0 - -5 volt dc output of the pressure transducer and generate a 0 - +5 volt dc signal proportional to the quality.

The general manner in which the computing board accomplishes its function is best explained by use of a block diagram. The block diagram of this board is shown below.



$$K_2 \rho_v = K_1 V_f \rho_a$$

$$V_f = \frac{\rho_v}{\rho_a} \times \frac{K_2}{K_1} = \frac{\rho_v}{\rho_a} \times 5 \text{ volts.}$$

The pulses coming from the pulse height discriminator trigger the bistable flip-flop alternately from one state to the other. This signal feeds into the count rate network. The internal nature of the count rate network will be explained later, but for now it is sufficient to say that this circuit has an output dc current equal to K_1 times the product of the feedback voltage V_f and the mixture density ρ_a determined from the count rate. The pressure transducer feeds in a current which is equal to K_2 times ρ_v . Actually the output of the pressure transducer is a voltage, but the high gain amplifier automatically adjusts V_f so that the input voltage to the amplifier is zero, therefore, the current out of the pressure transducer is proportional to its output voltage. Since the amplifier draws no input current, it follows that $K_1 V_f \rho_a$ must equal $K_2 \rho_v$, which means mathematically that $V_f = K_2/K_1 \times \rho_v / \rho_a$. K_2/K_1 is made equal to 5 volts, which means V_f is a 0-5 volt signal proportional to ρ_v / ρ_a . For all practical purposes ρ_v / ρ_a is the Quality*.

The schematic diagram of the computing printed circuit board is presented in drawings NL010001 which is the count ratemeter, NL010005, which is the high gain amplifier shown in the block diagram, and NL010007, which is the bistable flip-flop shown on the block diagram. Actually, in order to make the schematic diagrams correspond to the block diagram of Figure 3, components CR6, CR7, R28, R29, R30, and R31 on drawing NL010005 must be considered part of the count rate network.

The count rate network, being an unconventional circuit deserves additional explanation. Referring to drawing NL010001, when the input from the flip-flop (called a scaler on the drawing) is positive, Q11 is turned on and Q10 is turned off. This causes the collectors of these two transistors to go to near ground potential. Diode CR12 turns off and diode CR11, the anode of which is held at ground potential turns on and carries the current that starts discharging capacitors C20 through C24. When the input from the flip-flop switches negative, Q11 is turned off and Q10 is turned on. This causes the collectors of these two transistors to go positive to approximately the emitter voltage of Q5. Capacitors C20 through C24 start charging through CR12 and

*See Appendix A for analysis of formula error.

CR11 is cut off. For any given value of voltage at the emitter of Q5, V_o , the average dc current through CR11 is determined by the frequency. The component values of C20 through C24 together with the resistors in series with them are called the log network and their values are selected so that the average dc current through CR11 varies linearly with ρ_a . In fact, if the current through CR11 is combined with the constant current through R28, the combined current is proportional to ρ_a ; i.e., at a fixed count rate, the average dc current through CR11 is proportional to the amplitude of the ac voltage across the log network. The amplitude of this ac voltage is equal to the dc emitter voltage of Q5 less the sum of the forward voltage drops of CR11 and CR12. R31 is adjusted so that the ac voltage amplitude across the log network exactly equals the dc voltage at the cathode of CR6. In other words the combined current through CR11 and R28 is directly proportional to the feedback voltage V_f which is the voltage at the cathode of CR6. The combined current of CR11 and R28, which is the count rate meter current is therefore equal to a constant times ρ_a times V_f .

Because silicon diodes having roughly the same currents flowing through them have very near the same forward voltage drop, the voltage at the cathode of CR9 is very nearly equal to the voltage V_f at the cathode of CR6. This voltage is applied directly across a voltage divider to generate the output Quality.

The only significant problem encountered in the design of the computing circuit was in making the count rate meter temperature stable. The output quality is proportional to the effective resistance of the count rate meter; i.e., for a fixed feedback voltage it is inversely proportional to the output current of the count rate meter. The output current of the count rate meter is equal to the difference between the currents of CR11 and R28. The problem arises from the fact that the currents of R28 and CR11 at low values of ρ_a become very large compared to the difference between the currents - in fact at minimum ρ_a the absolute current through R28 is about 6 times the difference or resultant current.

Obviously then at minimum ρ_a a 1% temperature drift of R28 results in 6% drift in the resultant current and thus 6% drift in the Quality output. This problem was corrected by the use of ultra stable components for R28, R29 and the count rate network. The value of R31 must also be adjusted very carefully to assure an accurate voltage match.

The circuit which converts from count rate to G_c is initially accurate to $\pm .001$ lb/ft³ and experiences a maximum temperature drift of $\pm .001$ lb/ft³.

The accuracy of the ρ_v measurement is analyzed in the error analysis.

4.0 QUALIFICATION TESTING

Qualification Testing of the two models of the Quality Meter was performed in accordance with the NASA approved Quality Test Program (QTP-301). Appendices F and G are copies of QTP-301 appropriately documented for the aluminum quality meter and the stainless steel quality meter, respectively. It should be noted that the aluminum unit did not go through the electromagnetic interference test, but that all "fixes" on the stainless steel unit associated with the EMI test were performed on the aluminum unit also.

5.0 PROBLEM AREAS

During qualification testing several failures occurred on both the aluminum and the stainless steel quality meters. These failures occurred basically during vibration testing, electromagnetic interference testing, and when the original ORTEC surface barrier detector was cycled with liquid hydrogen.

Failures associated with vibration testing were primarily a result of insufficient printed circuit board support in the electronic compartment. Additional support in the form of added mounting brackets provided adequate strength for subsequent passage of the vibration test.

As the result of failure of the electromagnetic interference test, two modifications of the existing circuitry were necessary before the units passed. One of the problems was encountered with audio conducted susceptibility, where the +28 volt dc input is tied in series with a 3 volt RMS ac voltage source. The test places a heavy burden on the power supply dc to dc converter since the secondary filter capacitors have to be charged abruptly during the positive peak of the input a.c. The large transient currents resulting caused problems and the secondary filter capacitors, which had previously been made generously large, had to be reduced in value to allow them to track.

The other problem encountered with EMI was that the 2N3424 transistor in the pulse height discriminator circuit had a 500 megacycle parasitic oscillation. The addition of a 100 pf capacitor, C5, from the base to the emitter was necessary to eliminate this oscillation.

Problems were encountered with the ORTEC surface barrier detector mounting rings cracking when cooled to liquid hydrogen temperature. When this cracking occurred, the detectors completely failed in their performance. Lockheed did a detector evaluation

study with liquid hydrogen*. In the final analysis a diffused junction detector proved to be best for this application.

*Low Temperature Investigations of some Large Area Junction Detectors, J. M. Palms and H. H. Nichols, July 1968, Unpublished.

APPENDIX A

ERROR ANALYSIS

Let

Q	$=$	Quality expressed as a ratio of mass of vapor to total mass
M_v	$=$	Mass of vapor
M_t	$=$	Total mass
V_v	$=$	Volume of vapor
V	$=$	Total volume
V_l	$=$	Volume of liquid
ρ_v	$=$	Vapor density
ρ_l	$=$	Liquid density
ρ_a	$=$	Average or mixture density

Then

$$Q = \frac{M_v}{M_t} = \frac{\rho_v V_v}{\rho_a V} \quad (1)$$

$$V_l = V - V_v \quad (2)$$

$$\rho_a V = \rho_l V_l + \rho_v V_v \quad (3)$$

Substituting (2) into (3) gives

$$\rho_a V = \rho_l (V - V_v) + \rho_v V_v \quad (4)$$

Rearranging (4) gives

$$\frac{V_v}{V} = \left(\frac{\rho_l - \rho_a}{\rho_l - \rho_v} \right) \quad (5)$$

Substituting (5) into (1) yields

$$Q = \frac{\rho_v}{\rho_a} \times \left(\frac{\rho_\ell - \rho_a}{\rho_\ell - \rho_v} \right) \quad (6)$$

Equation (6) is the exact formula for quality. If the vent tube contains liquid in equilibrium with gas, the value of pressure determines the values of ρ_v , ρ_ℓ , and temperature since saturation exists. Since ρ_ℓ is a function of ρ_v , it follows that Q is a function of ρ_v and ρ_a only.

Equation (6) can be written as follows:

$$Q \rho_a \rho_\ell - Q \rho_a \rho_v = \rho_v \rho_\ell - \rho_v \rho_a \quad (7)$$

Solving (7) for ρ_v , we have

$$\rho_v = \frac{Q \rho_a \rho_\ell}{\rho_\ell - \rho_a + Q \rho_a} \quad (8)$$

Define a function G by the following equation:

$$G \equiv \frac{Q}{\rho_v} \text{ or } Q = G \rho_v \quad (9)$$

G can be written as a function of Q and ρ_a by substituting (8) into (9) or written as a function of ρ_v and ρ_a by substituting (6) into (9) as follows:

$$G = \frac{\rho_\ell - \rho_a + Q \rho_a}{\rho_a \rho_\ell} \quad (10)$$

$$G = \frac{1}{\rho_a} \left(\frac{\rho_\ell - \rho_a}{\rho_\ell - \rho_v} \right) \quad (11)$$

Since ρ_ℓ is at least 10 times larger than ρ_v or ρ_a , G is primarily a function of ρ_a in fact it is very nearly equal to the reciprocal of ρ_a . In other words, for a given value of ρ_a , G is pinned down to a very narrow range of values, and very little error results in the calculation of Q if G is set to a value in the middle of this range, neglecting the small amount that it deviates one way or the other. This is the approach that is taken to electronically generate Q .

The difference between G and $1/\rho_a$ is given by equations (12) and (13) and plotted in Figure 7, for extreme values of Q and ρ_v . The area enclosed by the four curves is the only region of interest.

From equations (10) and (11) we can obtain directly

$$G - \frac{1}{\rho_a} = \frac{\rho_\ell - \rho_a + Q\rho_a}{\rho_a \rho_\ell} - \frac{1}{\rho_a} = \frac{\rho_\ell - \rho_a + Q\rho_a - \rho_\ell}{\rho_a \rho_\ell} = \frac{Q - 1}{\rho_\ell} \quad (12)$$

$$G - \frac{1}{\rho_a} = \frac{1}{\rho_a} \left(\frac{\rho_\ell - \rho_a}{\rho_\ell - \rho_v} \right) - \frac{1}{\rho_a} = \frac{1}{\rho_a} \left(\frac{\rho_\ell - \rho_a - \rho_\ell + \rho_v}{\rho_\ell - \rho_v} \right) = \frac{1}{\rho_a} \left(\frac{\rho_v - \rho_a}{\rho_\ell - \rho_v} \right) \quad (13)$$

Figure 7 shows the range of values of G for each value of ρ_a . In between the two extreme values of G lies a quantity G_c which is that value of G which will be used to electronically calculate the approximate value of Q . Line ABCD in Figure 7 is a plot of $G_c - 1/\rho_a$. G_c is selected in each case so that the error in quality is the same at each extremity of G .

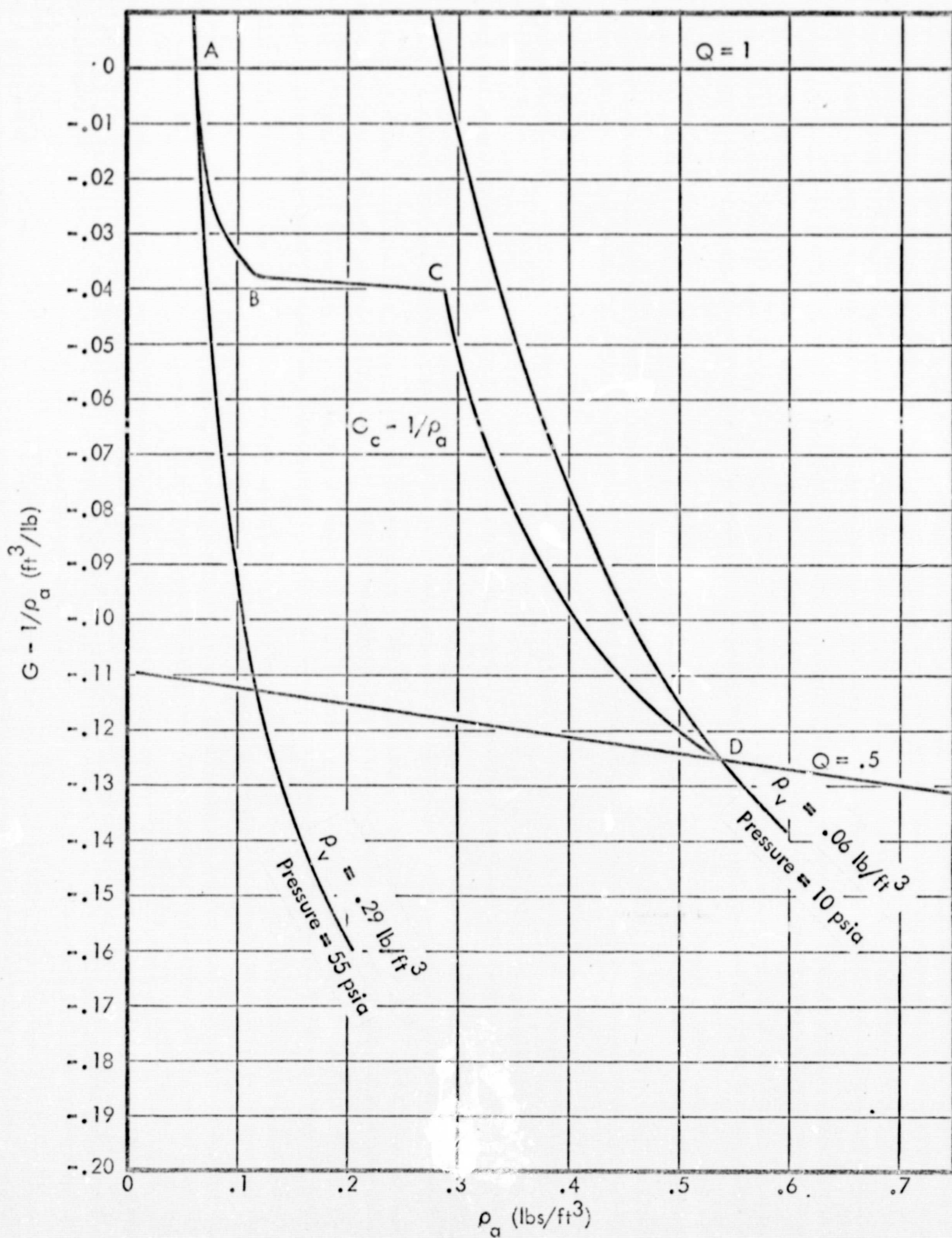


FIGURE 7 PLOT OF THE DIFFERENCE BETWEEN G AND RECIPROCAL OF ρ_a VERSUS ρ_a

Obviously the greatest error in the electronic calculation occurs approximately at point C, where G is assumed to be $.04 + 1/.29 = 3.49 \text{ ft}^3/\text{lb}$. The value of Q instead of reading 100% would read $3.49/3.49 \times 100\% = 101\%$, which is 1% high.

Where Q = .5, G is actually $.118 + 1/.29 = 3.57 \text{ ft}^3/\text{lb}$. The value of Q instead of reading the correct value of 50% would then read $3.49/3.57 \times 50\% = 49\%$, which is 1% low.

In addition to the errors that result from the approximation $Q = \rho_v \times G_c$, there are errors due to the accuracy in the measurement of ρ_v , the measurement of G_c , and the multiplying circuit.

ρ_v MEASUREMENT

Referring to the latest liquid hydrogen data published by the National Bureau of Standards, at saturation the vapor density of parahydrogen is given to an accuracy of a fraction of 1% by the equation:

$$\rho_v = .005129 \frac{\text{lb}}{\text{ft}^3 - \text{psia}} P + .0078 \text{ lb/ft}^3$$

over the range from 10 psia to 55 psia. The ρ_v measurement is based on this relationship, and P is measured by a Statham Instruments, Inc. Model RA438TC absolute pressure transducer temperature controlled at 200°F. This transducer has the following characteristics:

Full Scale Pressure:	60 psia
Non-Linearity and Hysteresis:	$\pm .5\% \text{ F.S.} = \pm 0.3 \text{ psia}$
Vibration Error:	Negligible
Temperature Coefficient:	$.01\% \text{ F.S./}^\circ\text{F}$

Thus the value of ρ_v is measured to an accuracy of $.00154 \text{ lb/ft}^3$.

ρ_a MEASUREMENT

As shown earlier, G_c is a function of ρ_a , and is in fact approximately equal to the reciprocal of ρ_a . The value of ρ_a is measured by a nuclear beta gage, and neither ρ_a nor G_c is a linear function of the count rate (see Figure 2). As explained earlier, the temperature and long term drift of the counting circuit corresponds to a maximum error in the ρ_a measurement of $.002 \text{ lbs/ft}^3$. Since G_c is approximately the reciprocal of ρ_a , the error in $1/G_c$ is approximately $.002 \text{ lbs/ft}^3$.

Referring to the section on electronic computation of Quality, the drift and inaccuracies of the count rate meter are each a maximum of $\pm .001 \text{ lb/ft}^3$.

Since $Q = \rho_v \cdot G_c = \rho_v / D_c$, where $D_c \equiv 1/G_c$,

$$\frac{dQ}{Q} = \frac{d\rho_v}{\rho_v} - \frac{dD_c}{D_c}.$$

Using RMS addition of errors,

$$\left(\frac{dQ}{Q}\right)^2 = \left(\frac{d\rho_v}{\rho_v}\right)^2 + \left(\frac{dD_c}{D_c}\right)^2$$

$$\left(\frac{dQ}{Q}\right)^2 = \left(\frac{1}{\rho_v}\right)^2 (d\rho_v)^2 + \left(\frac{1}{D_c}\right)^2 (dD_c)^2 =$$

$$\left(\frac{1}{\rho_v}\right)^2 \left[(d\rho_v)^2 + Q^2 (dD_c)^2 \right]$$

$$(dQ)^2 = \left(\frac{Q}{\rho_v}\right)^2 \left[(d\rho_v)^2 + Q^2 (dD_c)^2\right]$$

$$d\rho_v = .00154 \text{ lb/ft}^3; (dD_c)^2 = (.001 \text{ lb/ft}^3)^2 + (.001 \text{ lb/ft}^3)^2 + (.002 \text{ lb/ft}^3)^2 = 6 \times 10^{-6} \text{ lbs}^2/\text{ft}^6$$

$$dQ = \frac{Q}{\rho_v} \left[2.37 \times 10^{-6} + 6 \times 10^{-6} Q^2\right]^{1/2} \text{ lb/ft}^3$$

This error does not include the formula error, which must be added in. Figure 8 is a plot of the error versus pressure and quality, including error due to the approximation $Q = \rho_v / G_c$.

HALF LIFE EFFECTS

Although a freshly calibrated system has no half life error, as the source ages half life errors develop. The half life of the Thallium 204 source used in the ρ_a measurement is 3.8 years. This means that the source decays 1.52% per month. This causes a drift in quality of anywhere from .2% to 4.5%, depending upon the value of ρ_a . Because of the significance of half life, provision has been made to adjust the effective source strength prior to flight.

STATISTICS

The statistical randomness of nuclear isotope decay causes a characteristic ripple in the output of all nuclear gages. The variations in this ripple are not in general considered to be error since they can be averaged out. However, the magnitude of the ripple is of interest and is determined as follows:

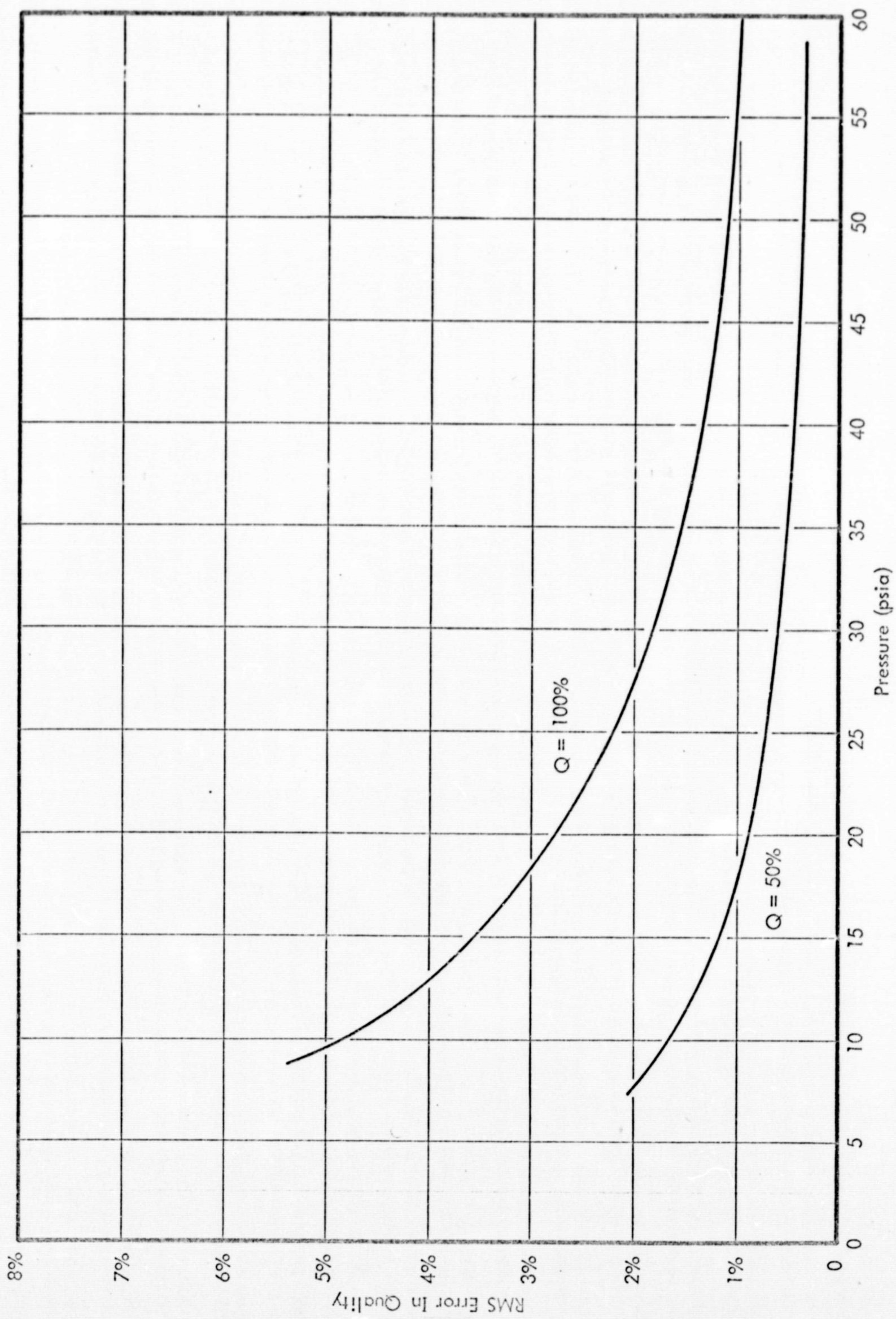
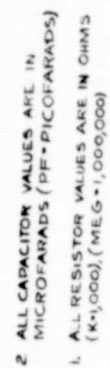


FIGURE 8 ACCURACY OF QUALITY METER AS A FUNCTION OF PRESSURE AND QUALITY

At $\rho_a = .06 \text{ lb/ft}^3$, count rate = 846,000 counts per minute
 counts in .2 second = 2820
 statistics = $1/2820 = 1.9\%$ count rate
 = 6% quality, one sigma statistics

At $\rho_a = .54 \text{ lb/ft}^3$, count rate = 8500 counts per minute
 counts in .2 second = 28
 statistics = $1/28 = 19\%$ count rate
 = 2.5% quality, one sigma

APPENDIX B
SCHEMATICS OF ELECTRONICS
5% QUALITY METER



NOTES

HIGHEST REFERENCE DESIGNATIONS USED	R39	C24	CR13	Q11
REFERENCE DESIGNATIONS NOT USED	CR1	C1	CR1	Q1
	THU	THU	THU	THU
	Q3	C16	CR3	Q3

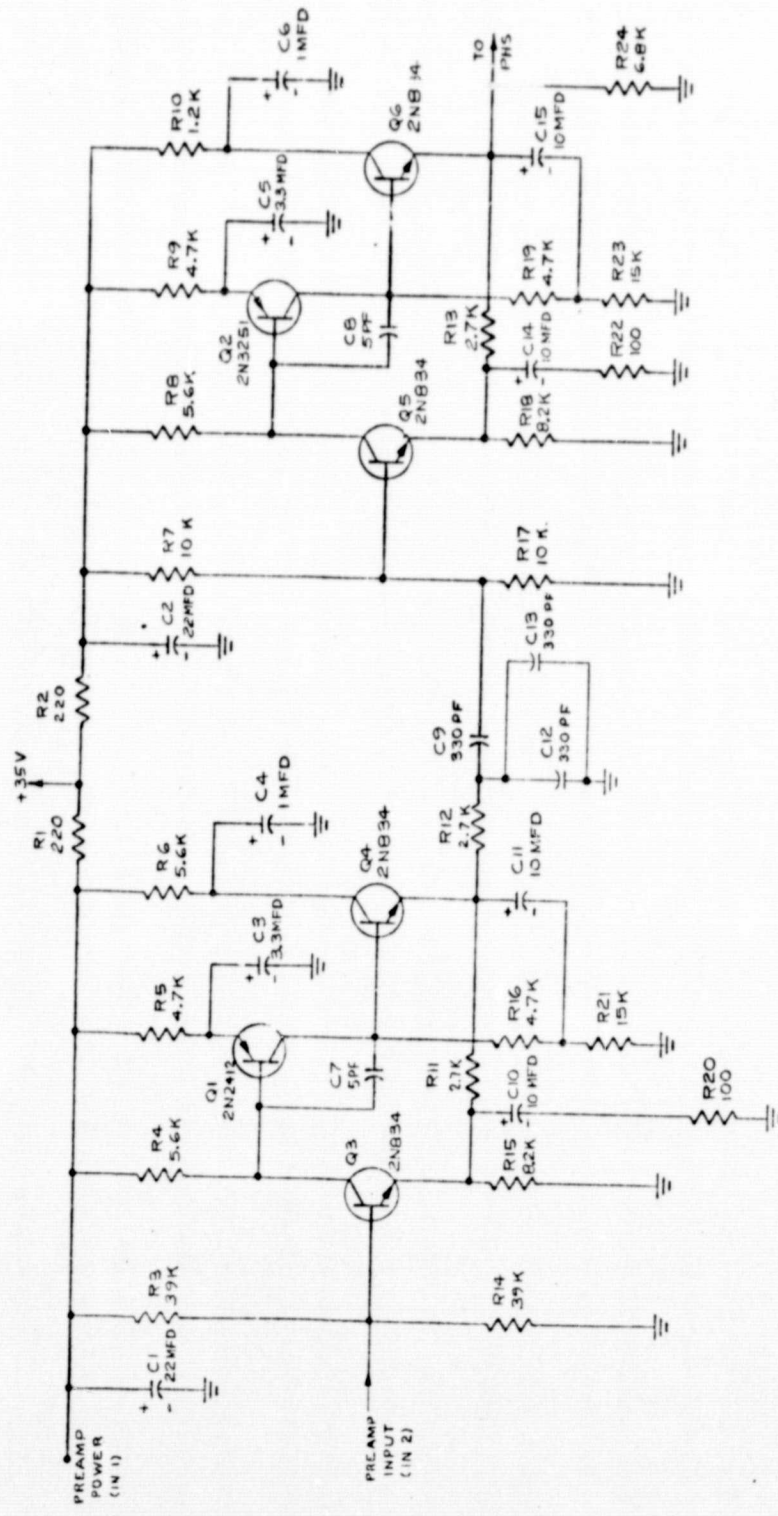
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REF DES	PAC	NO.	DESCRIPTION	VALUE	TOL	RATING
R23,R29	K07SF	222J	RESISTOR	2.2 K	± 5%	¼ W
R4,R35,R36	RN4SE	3302 F	RESISTOR	3.3K	± 1%	¼ W
R37	N12		RESISTOR	10 K	± 1%	¼ W
C17	C02M03R46		CAPACITOR	3.3MFD	± 10%	50V
C18	CS13AF100K			10MFD	± 10%	35V
C21	PJ48B J			100MFD	± 5%	100V
C19	JOTCC-T15			150 PF	± 5%	1000V
C20	PJ22 J			22 MF	± 5%	100V
C22,C23	4C3022BH3			3000PF	± 2%	200V
C24	4C3922BH3		CAPACITOR	3900PF	± 2%	200V
CR10,CR11, CR12,CR13	1N91GB		DIODE			
Q10	2N3251		TRANSISTOR			
Q11	2N834		TRANSISTOR			

REQD	PART NO.	ZONE	DESCRIPTION	LIST OF MATERIAL
			DATE DESIGN E.G. JAL. PART BY CHK'D CITY TYPED APPROV. APPROV. APPROV.	GEORGIA NUCLEAR LABORATORIES LOCATED AIRPORT CAMP MARIETTA, GEORGIA SCHEMATIC DIAGRAM, LOG COUNT RATE METER-QUALITY METER, UH, MARK I
			QUANTITY	TOLERANCES FRACTIONS ANGLES
				SCALE INCHES FEET
				DRAWN BY CHECKED BY CITY TYPED APPROV. APPROV. APPROV.
				UNITS, INCHES NO. OF SHEETS MARKING
				NIL000000

REVISIONS	DESCRIPTION & SIGNATURES	DATE	APPROVAL
1			

HIGHEST REFERENCE DESIGNATION USED	R24
REFERENCE DESIGNATIONS NOT USED	C15 - Q6



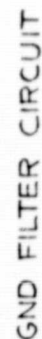
REF DES	PART NO	DESCRIPTION	VALUE	W	RATING
R1, R2	RC07GF22J	RESISTOR	220	±5%	1/4 W
R3, R14	393J		39K		
R4, R5, R8	562J		5.6K		
R9, R10, R19	472J		4.7K		
R10	122J		1.2K		
R15, R18	153J		15K		
R21, R23	RC07GF68J	RESISTOR	6.8K	±5%	1/4 W
R7, R17	N12	RESISTOR	10K	±1%	1/4 W
R11, R12, R13	N12	RESISTOR	2.7K	±1%	1/4 W
R20, R22	N12	RESISTOR	100	±1%	1/4 W
C1, C2	CS13AG220R	CAPACITOR	22nF	±10%	50V
C3, C5	CS13AG563K		5.6nF	±10%	50V
C4, C6	CS13AG105K		10nF	±10%	50V
C7, C8	107CC-V50		5pF	±5%	1000V
C9, C12, C13	YY09C33J		330pF	±5%	50V
C10, C11, C14, C15	CS13AF100K	CAPACITOR	10nF	±10%	35V
Q1	2N2412	TRANSISTOR			
Q2	2N2412	TRANSISTOR			
Q3, Q4	2N834	TRANSISTOR			
Q5, Q6	2N814	TRANSISTOR			

REF	PART NO	DESCRIPTION	LIST OF MATERIAL
			GEORGIA NUCLEAR LABORATORIES
			LOCKHEED AIRCRAFT CORP
			SCHEMATIC DIAGRAM, AMPLIFIER-QUALITY METER, LH, MARK I
			SCALE
			FRAC TIONS 1/16 3/16 1/2 3/4 1
			ANGLES 15° 30° 45° 60° 75° 90° 105° 120° 135° 150° 165° 180°
			SCALE NONE
			EWG NO NLO10002

2. ALL CAPACITOR VALUES ARE IN MICROFARADS (MF = PICO FARADS)
 1. ALL RESISTOR VALUES ARE IN OHMS (K = 1000), (MEG = 1,000,000)

NOTES

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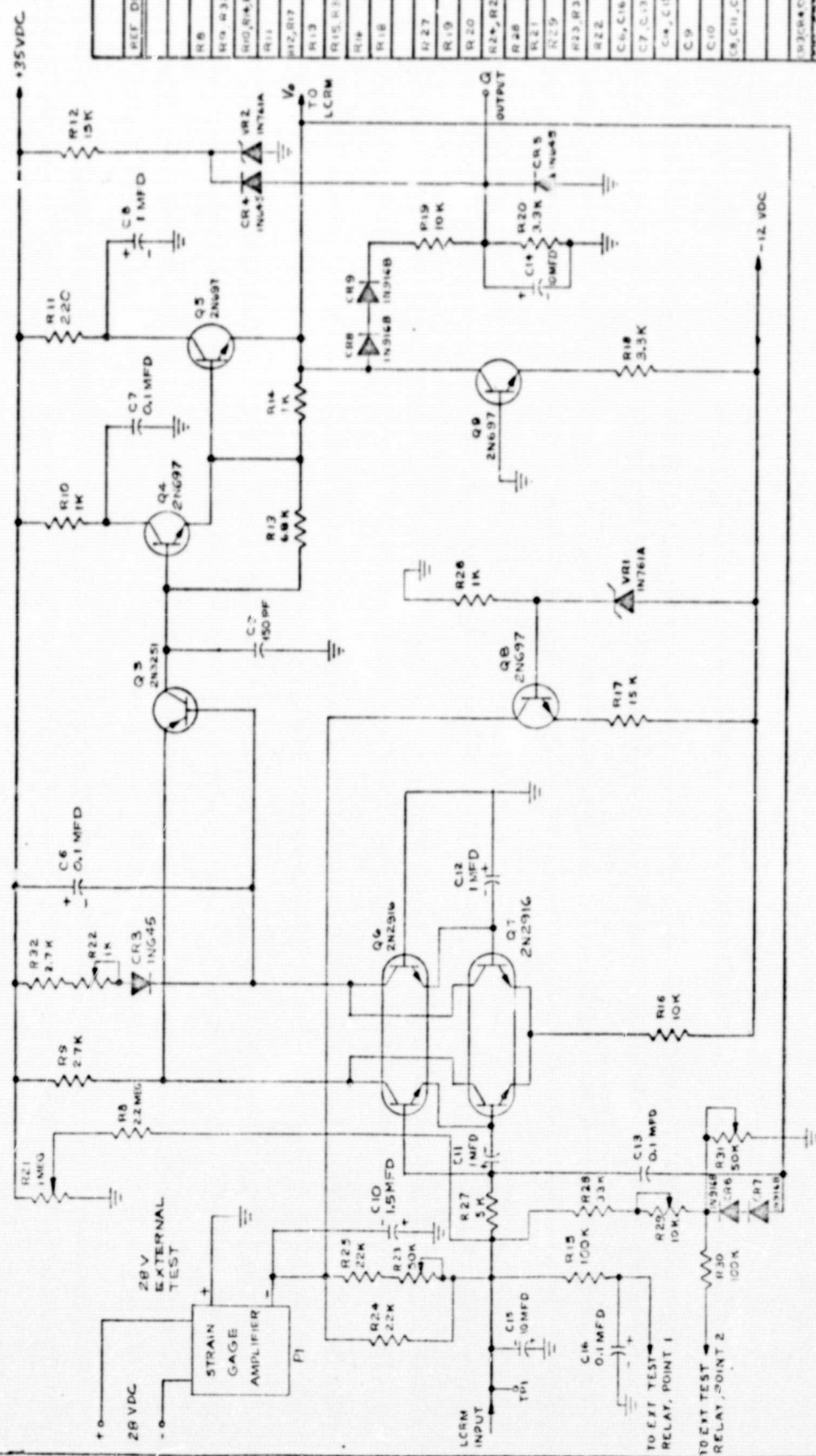
2. ALL CAPACITOR VALUES ARE IN MICROFARADS (PF = PICO FARADS)
1. ALL RESISTOR VALUES ARE IN OHMS (K = 1,000) (MEG = 1,000,000)

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REFERENCE DATA				
REF ID'S	PART NO	DESCRIPTION	VALUE	TOL
R1, R2	RC07GF221J	RESISTOR	220	±5% 1/4 W
R3, R4, R5, R6	RC07GF125J	RESISTOR	1.25K	±5% 1/4 W
R7, R8	RC07GF332J	RESISTOR	3.3K	±5% 1/4 W
R9, R10	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R11, R12	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R13, R14	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R15, R16	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R17, R18	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R19, R20	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R21, R22	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R23, R24	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R25, R26	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R27, R28	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R29, R30	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R31, R32	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R33, R34	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R35, R36	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R37, R38	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R39, R40	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R41, R42	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R43, R44	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R45, R46	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R47, R48	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R49, R50	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R51, R52	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R53, R54	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R55, R56	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R57, R58	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R59, R60	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R61, R62	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R63, R64	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R65, R66	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R67, R68	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R69, R70	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R71, R72	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R73, R74	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R75, R76	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R77, R78	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R79, R80	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R81, R82	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R83, R84	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R85, R86	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R87, R88	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R89, R90	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R91, R92	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R93, R94	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R95, R96	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R97, R98	RC07GF100J	RESISTOR	10K	±5% 1/4 W
R99, R100	RC07GF100J	RESISTOR	10K	±5% 1/4 W
C1	CS1000K	POTENTIOMETER	10K	±5% 1 W
C2	CS1000K	POTENTIOMETER	10K	±5% 1 W
C3	CS1000K	POTENTIOMETER	10K	±5% 1 W
C4	CS1000K	POTENTIOMETER	10K	±5% 1 W
C5	CS1000K	POTENTIOMETER	10K	±5% 1 W
C6	CS1000K	POTENTIOMETER	10K	±5% 1 W
C7	CS1000K	POTENTIOMETER	10K	±5% 1 W
C8	CS1000K	POTENTIOMETER	10K	±5% 1 W
C9	CS1000K	POTENTIOMETER	10K	±5% 1 W
C10	CS1000K	POTENTIOMETER	10K	±5% 1 W
C11	CS1000K	POTENTIOMETER	10K	±5% 1 W
C12	CS1000K	POTENTIOMETER	10K	±5% 1 W
C13	CS1000K	POTENTIOMETER	10K	±5% 1 W
C14	CS1000K	POTENTIOMETER	10K	±5% 1 W
C15	CS1000K	POTENTIOMETER	10K	±5% 1 W
C16	CS1000K	POTENTIOMETER	10K	±5% 1 W
C17	CS1000K	POTENTIOMETER	10K	±5% 1 W
C18	CS1000K	POTENTIOMETER	10K	±5% 1 W
C19	CS1000K	POTENTIOMETER	10K	±5% 1 W
C20	CS1000K	POTENTIOMETER	10K	±5% 1 W
C21	CS1000K	POTENTIOMETER	10K	±5% 1 W
C22	CS1000K	POTENTIOMETER	10K	±5% 1 W
C23	CS1000K	POTENTIOMETER	10K	±5% 1 W
C24	CS1000K	POTENTIOMETER	10K	±5% 1 W
C25	CS1000K	POTENTIOMETER	10K	±5% 1 W
C26	CS1000K	POTENTIOMETER	10K	±5% 1 W
C27	CS1000K	POTENTIOMETER	10K	±5% 1 W
C28	CS1000K	POTENTIOMETER	10K	±5% 1 W
C29	CS1000K	POTENTIOMETER	10K	±5% 1 W
C30	CS1000K	POTENTIOMETER	10K	±5% 1 W
C31	CS1000K	POTENTIOMETER	10K	±5% 1 W
C32	CS1000K	POTENTIOMETER	10K	±5% 1 W
C33	CS1000K	POTENTIOMETER	10K	±5% 1 W
C34	CS1000K	POTENTIOMETER	10K	±5% 1 W
C35	CS1000K	POTENTIOMETER	10K	±5% 1 W
C36	CS1000K	POTENTIOMETER	10K	±5% 1 W
C37	CS1000K	POTENTIOMETER	10K	±5% 1 W
C38	CS1000K	POTENTIOMETER	10K	±5% 1 W
C39	CS1000K	POTENTIOMETER	10K	±5% 1 W
C40	CS1000K	POTENTIOMETER	10K	±5% 1 W
C41	CS1000K	POTENTIOMETER	10K	±5% 1 W
C42	CS1000K	POTENTIOMETER	10K	±5% 1 W
C43	CS1000K	POTENTIOMETER	10K	±5% 1 W
C44	CS1000K	POTENTIOMETER	10K	±5% 1 W
C45	CS1000K	POTENTIOMETER	10K	±5% 1 W
C46	CS1000K	POTENTIOMETER	10K	±5% 1 W
C47	CS1000K	POTENTIOMETER	10K	±5% 1 W
C48	CS1000K	POTENTIOMETER	10K	±5% 1 W
C49	CS1000K	POTENTIOMETER	10K	±5% 1 W
C50	CS1000K	POTENTIOMETER	10K	±5% 1 W
C51	CS1000K	POTENTIOMETER	10K	±5% 1 W
C52	CS1000K	POTENTIOMETER	10K	±5% 1 W
C53	CS1000K	POTENTIOMETER	10K	±5% 1 W
C54	CS1000K	POTENTIOMETER	10K	±5% 1 W
C55	CS1000K	POTENTIOMETER	10K	±5% 1 W
C56	CS1000K	POTENTIOMETER	10K	±5% 1 W
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C58	CS1000K	POTENTIOMETER	10K	±5% 1 W
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C70	CS1000K	POTENTIOMETER	10K	±5% 1 W
C71	CS1000K	POTENTIOMETER	10K	±5% 1 W
C72	CS1000K	POTENTIOMETER	10K	±5% 1 W
C73	CS1000K	POTENTIOMETER	10K	±5% 1 W
C74	CS1000K	POTENTIOMETER	10K	±5% 1 W
C75	CS1000K	POTENTIOMETER	10K	±5% 1 W
C76	CS1000K	POTENTIOMETER	10K	±5% 1 W
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C79	CS1000K	POTENTIOMETER	10K	±5% 1 W
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C86	CS1000K	POTENTIOMETER	10K	±5% 1 W
C87	CS1000K	POTENTIOMETER	10K	±5% 1 W
C88	CS1000K	POTENTIOMETER	10K	±5% 1 W
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C184	CS1000K	POTENTIOMETER	10K	±5% 1 W
C185	CS1000K	POTENTIOMETER	10K	±5% 1 W
C186	CS1000K	POTENTIOMETER	10K	±5% 1 W
C187	CS1000K	POTENTIOMETER	10K	±5% 1 W
C188	CS1000K	POTENTIOMETER	10K	±5% 1 W
C189	CS1000K	POTENTIOMETER	10K	±5% 1 W
C				

RQTS	PART NO.	DWG.	SUBSTITUTION	MATERIAL
				LIST OF MATERIAL
				GEORGIA NUCLEAR LABORATORIES ENCLOSURE AREA/CITY COMP. MARIETTA, GAIO USA
				SCHEMATIC DIAGRAM, POWER SUPPLY- QUALITY METER, LHZ, MARK I
				TOLERANCES SCALE DIMS. IND.
			FRACTIONS / INCHES ANGLES	XR ± .05 NONE XPS ± .000
				NLOV004



REF. DES.	PART NO.	DESCRIPTION	VALUE	TOL.	RATING
R8	REC07F 225J	RESISTOR	2.2 MEG	±5%	1/4 W
R9, R32	272J		27 K	±5%	
R10, R14, R24	102J		1 K	±5%	
R11	221J		220	±5%	
R12, R17	153J		15 K	±5%	
R13	562J		56 K	±5%	
R15, R10	104J		100 K	±5%	
R14	103J		10 K	±5%	
R18	REC07F 332J		3.3 K	±5%	
R27	N12		5 K	±5%	
R19	N12		10 K	±5%	
R20	N12		3.3 K	±5%	
R21, R25	N12		2.2 K	±5%	
R28	RHE58 3302F	RESISTOR	33 K	±5%	1/4 W
R21	255P-1-105	POTENTIOMETER	10 K	±5%	1 W
R29	222P-1-105	POTENTIOMETER	10 K	±5%	1 W
R23, R31	222P-1-105	POTENTIOMETER	10 K	±5%	1 W
R22	222P-1-105	POTENTIOMETER	10 K	±5%	1 W
C5, C16	500P-1-105	CAPACITOR	0.001 MFD	±5%	35V
C7, C13	CA-104		0.001 MFD	±5%	50V
C4, C15	CS344-00A		0.001 MFD	±5%	50V
C9	107CC-115		0.001 MFD	±5%	50V
C10	CS13AE-1R5A		0.001 MFD	±5%	50V
C8, C11, C12	CS344-00A		0.001 MFD	±5%	50V
Q3, Q4, Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q12, Q13, Q14, Q15, Q16, Q17, Q18, Q19, Q20, Q21, Q22, Q23, Q24, Q25, Q26, Q27, Q28, Q29, Q30, Q31, Q32, Q33, Q34, Q35, Q36, Q37, Q38, Q39, Q40, Q41, Q42, Q43, Q44, Q45, Q46, Q47, Q48, Q49, Q50, Q51, Q52, Q53, Q54, Q55, Q56, Q57, Q58, Q59, Q60, Q61, Q62, Q63, Q64, Q65, Q66, Q67, Q68, Q69, Q70, Q71, Q72, Q73, Q74, Q75, Q76, Q77, Q78, Q79, Q80, Q81, Q82, Q83, Q84, Q85, Q86, Q87, Q88, Q89, Q90, Q91, Q92, Q93, Q94, Q95, Q96, Q97, Q98, Q99, Q100					

HIGHEST REFERENCE DESIGNATIONS USED	DESIGNATIONS NOT USED
R32, C16, R22, R24, Q3, Q4	R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R14, R15, R16, R17, R18, R19, R20, R21, R23, R25, R26, R27, R28, R29, R30, R31, R33, R34, R35, R36, R37, R38, R39, R40, R41, R42, R43, R44, R45, R46, R47, R48, R49, R50, R51, R52, R53, R54, R55, R56, R57, R58, R59, R60, R61, R62, R63, R64, R65, R66, R67, R68, R69, R70, R71, R72, R73, R74, R75, R76, R77, R78, R79, R80, R81, R82, R83, R84, R85, R86, R87, R88, R89, R90, R91, R92, R93, R94, R95, R96, R97, R98, R99, R100

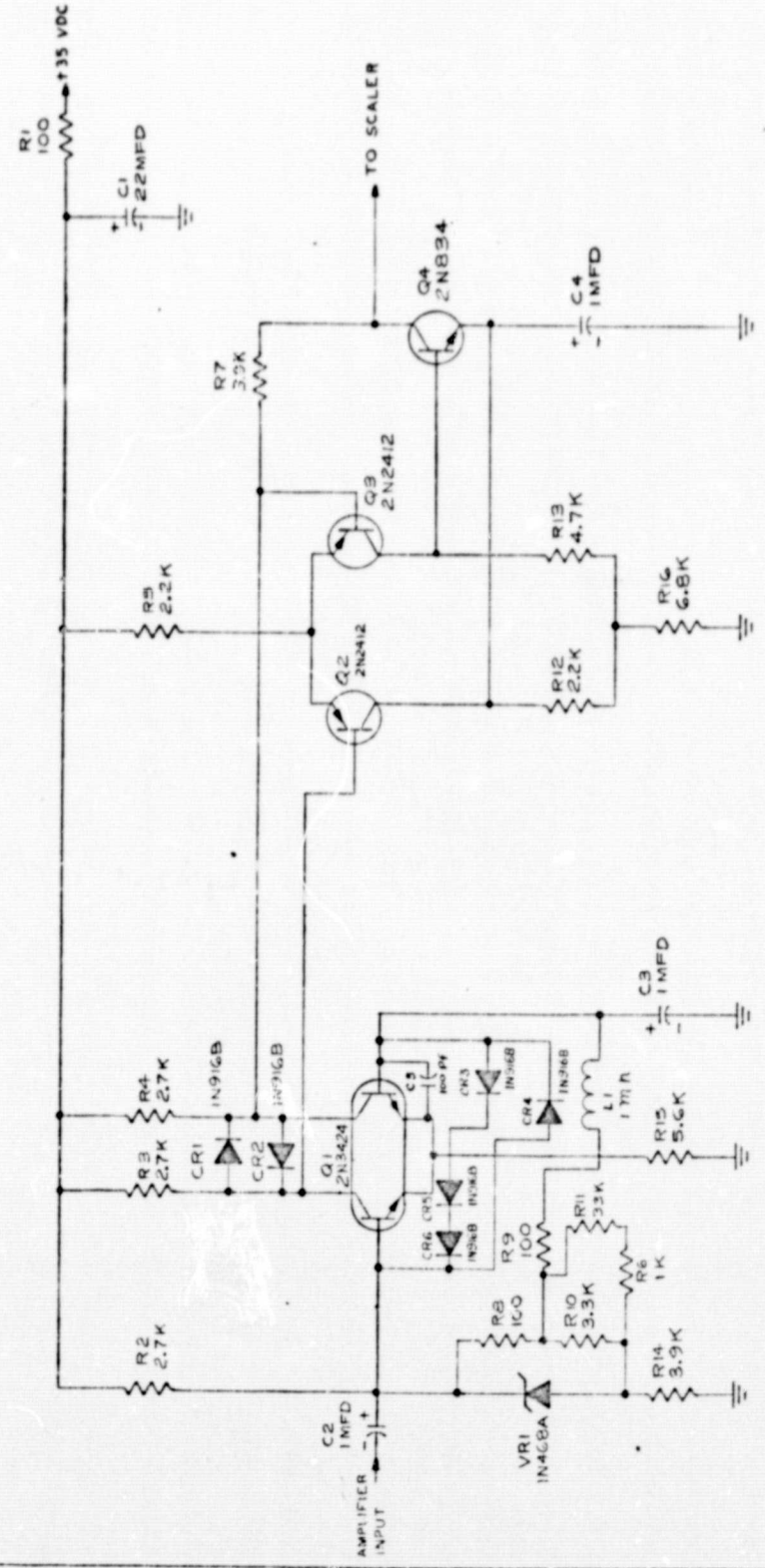
2. ALL CAPACITOR VALUES ARE IN MICROFARADS (PP-PICOFARADS)
 1. ALL RESISTOR VALUES ARE IN OHMS
 (K=1,000), (M=1,000,000)

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REF DES	PART NO	DESCRIPTION	VALUE	TOL	RATING
R1, R9	RC076P10J	RESISTOR	100	±5%	1/4 W
R2	272J		2.7K		
R3, R4	222J		2.2K		
R5, R12	RC076P10J	RESISTOR	3.3K	±5%	1/4 W
R6	RC076P10J	RESISTOR	4.7K	±5%	1/4 W
R7	392J		3.9K		
R8	682J		6.8K		
R10	RC076P10J	RESISTOR	5.6K	±5%	
R11	N12		3.3K	±1%	
R13, R14	N12		2.7K		
R15	N12		100		
R16	N12		3.3K	±1%	1/4 W
R17	31A19	THERMISTOR	1K		
C1	CS3AG220K	CAPACITOR	22MFD	±20%	50V
C2, C3, C4	CS3AF010K	CAPACITOR	1MFD	±10%	35V
C5	V10C101K	CAPACITOR	100PF	±10%	50V
Q1, Q2, Q3, Q4	IN916B	DIODE			
VR1	1N468A	ZENER DIODE			
Q1	2N3424	TRANSISTOR			
Q2, Q3	2N2412	TRANSISTOR			
Q4	2N834	TRANSISTOR			
L1	TYPE 4662	CHOKES	JUL MILLER		

HIGHEST REFERENCE DESIGNATIONS USED	
REF	DESIGNATION
R16	C5
VR1	Q1
Q4	L1



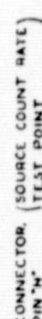
LIST OF MATERIAL	
REF	DESIGNATION
R16	C5
VR1	Q1
Q4	L1

2. ALL CAPACITOR VALUES ARE IN MICROFARADS (PF = PICO FARADS)

1. ALL RESISTOR VALUES ARE IN OHMS (K=1,000), (MEG=1,000,000)

NOTES

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REFERENCE DATA

HIGHEST REFERENCE DESIGNATION USED	97	25	002
REFERENCE DESIGNATION NOT USED			

1. ALL REGRESSOR VARIABLES ARE IN QUARTS
(K-1000), (MIG-1000000)

ALL INFORMATION CONTAINED HEREIN IS UNCLASSIFIED EXCEPT WHERE SHOWN OTHERWISE. THIS DOCUMENT IS CONTINUING TO BE DECLASSIFIED BY THE NATIONAL ARCHIVES. FOR MORE INFORMATION, CONTACT THE NATIONAL ARCHIVES AT COLLEGE PARK, MARYLAND 20740-6001. (301) 837-1113. WWW.NATIONALARCHIVES.GOV

REQ	PART NO.	ZONE	DESCRIPTION	LIST OF MATERIALS	MATERIAL
				GEORGIA CONCRETE	
				SCHMATIC	
				METER, L.H.	
				TOLERANCE	
				FRACTIONS 1/8"	
				ANGLE 1/2"	
				QTY REQD	
				APPROX	
				APPLICATION	

APPENDIX C

DESIGN REQUIREMENTS

The measuring device developed for this application must meet the following requirements:

- (1) Quality measuring range - 0 to 100%.
- (2) Measuring accuracy - From 50 - 100% to within $\pm 5\%$ of range.
- (3) Repeatability - The measuring device shall have a repeatability to within $\pm 1\%$ over the range of 50% to 100% of quality.
- (4) Response time - With a step change from 100% to 50% quality, the quality meter system must indicate 63% of this change within 100 milliseconds.
- (5) Output - The output signal from the device shall be 0-5 VDC and must be conditioned to be fed to telemetering. Its output impedance shall not exceed 5000 ohms and the system shall operate satisfactorily when 100,000 ohms load ($\pm 1\%$) is applied across the output terminals.
- (6) Power available - The voltage available for any flight hardware will be 28 ± 3 VDC. The design goal for the power consumption is to 10 watts maximum.
- (7) Electromagnetic interference - The measuring device shall conform to the electromagnetic interference requirements of Specification MIL-I-6181D.
- (8) Grounding procedure - The following circuits shall be isolated from each other: 28 VDC, minus; signal output, minus; signal input; transducer excitation voltage; and case ground.
- (9) Mounting - The source of radiation and sensor portion of this device shall be incorporated into a section of the vent tube. This section of tube shall be furnished by the Contractor. It will be compatible and will be capable of mating with the remainder of the venting system. It shall be equipped with flanges in order that it may be fixed and sealed into position. The signal conditioning equipment shall be located in the surrounding area

but not necessarily in contact with the tube.

- (10) Vent tube size - 2.5 inches ID with 0.0625 inch wall thickness.
- (11) Vent tube material - Aluminum alloy, 6061-T6.
- (12) Vapor flow rate range - 0.08 lb m/s to 0.4 lb m/s.
- (13) Size limitation - The design goal for the section of the vent tube to be supplied by the Contractor is not to exceed 18 inches in length. The overall size of the entire package of flight hardware shall be kept to a minimum.
- (14) Weight limitation - The weight of the flight hardware, including source shielding, shall not exceed fifteen (15) pounds.
- (15) Safety - In the design of the measuring device provisions must be made for the necessary shielding to meet radiation health safety requirements.
- (16) Interchangeability - The measuring device shall be designed to allow the source of radiation to be readily removed and reinserted into the same instrument or inserted into another instrument without difficulty.
- (17) Operational temperature range - The temperature range along the inside wall of the tube will be -260°C to $+60^{\circ}\text{C}$. The temperature range in the surrounding area, external but not in contact with the tube, will be -50°C to $+80^{\circ}\text{C}$.
- (18) Operational pressure - The maximum vent tube pressure will be 55 psia. The pressure range in the external and surrounding area will be 2×10^{-7} psia to sea level atmospheric.
- (19) Thermal shock - The measuring device shall operate as specified when cycled between -50°C and $+80^{\circ}\text{C}$ for a minimum of 10 cycles.
- (20) Humidity - The measuring device shall operate as specified when exposed to a relative humidity of 100%.
- (21) Acceleration - 0 to 30 g's.
- (22) Shock - The measuring device shall be capable of operating without failure after being subjected to 6 shocks of either 10 (triangular wave), 8 (sine wave), or 6 (square wave) milliseconds duration at 100 g in each of the three major axes.

(23) Vibration - The measuring device shall be capable of operating without failure after being subjected to the following sinusoidal vibrations in each of the major axes:

- (a) 5-65 hertz (Hz) at 0.04 inches D.A. displacement,
- (b) 65-110 Hz at 9.0 g's peak,
- (c) 110-200 Hz at 0.015 inches D.A. displacement, and
- (d) 200-2000 Hz at 32 g's peak.

The frequency shall be swept logarithmically from 5 Hz to 2000 Hz and from 2000 Hz to 5 Hz at the rate of one octave per minute.

APPENDIX D

LH₂ FILM EXPERIMENT

A prototype gauging section was constructed identical to production model gauging sections. A semiconductor detector was installed in one wall of the gauging section and a 2-millicurie TL-204 source was installed on a movable rod through the opposite wall. A position indicator was mounted on the movable rod, and the source could be positioned with an accuracy of better than 0.005 inches. The gauging section was installed in the LH₂ test car facility utilizing a 10^{-1} mm Hg vacuum around the gauging section for insulation. The gauging section was oriented so that hydrogen flow through the section was vertical.

After installation, count rate versus argon density curves were run with two different source to detector distances to obtain the count rate versus density functions under positively no-film conditions. This was done at ambient temperature. These data are represented by the solid curves in Figure 9 and are designated $f(d)$ and $g(d)$ for the smallest and greatest source to detector distances, respectively. The difference in the source to detector distances for $f(d)$ and $g(d)$ was approximately 0.8 inches.

The system was then flushed and various LH₂ - GH₂ mixtures were flowed through the gauging section and counts were taken at the same two source to detector distances as above. The points taken at the greatest source to detector distance were purposefully placed on $g(d)$. These points are indicated by the circular points and are designated by letters. The corresponding points taken with the same hydrogen quality and density as the lettered points, but at the smallest source to detector distance are also indicated by circular points and are designated by primed letters. With no film the primed lettered points would have fallen on $f(d)$, but with a film the points would have been very far from $f(d)$ with the discrepancy from $f(d)$ being proportional to the film thickness.

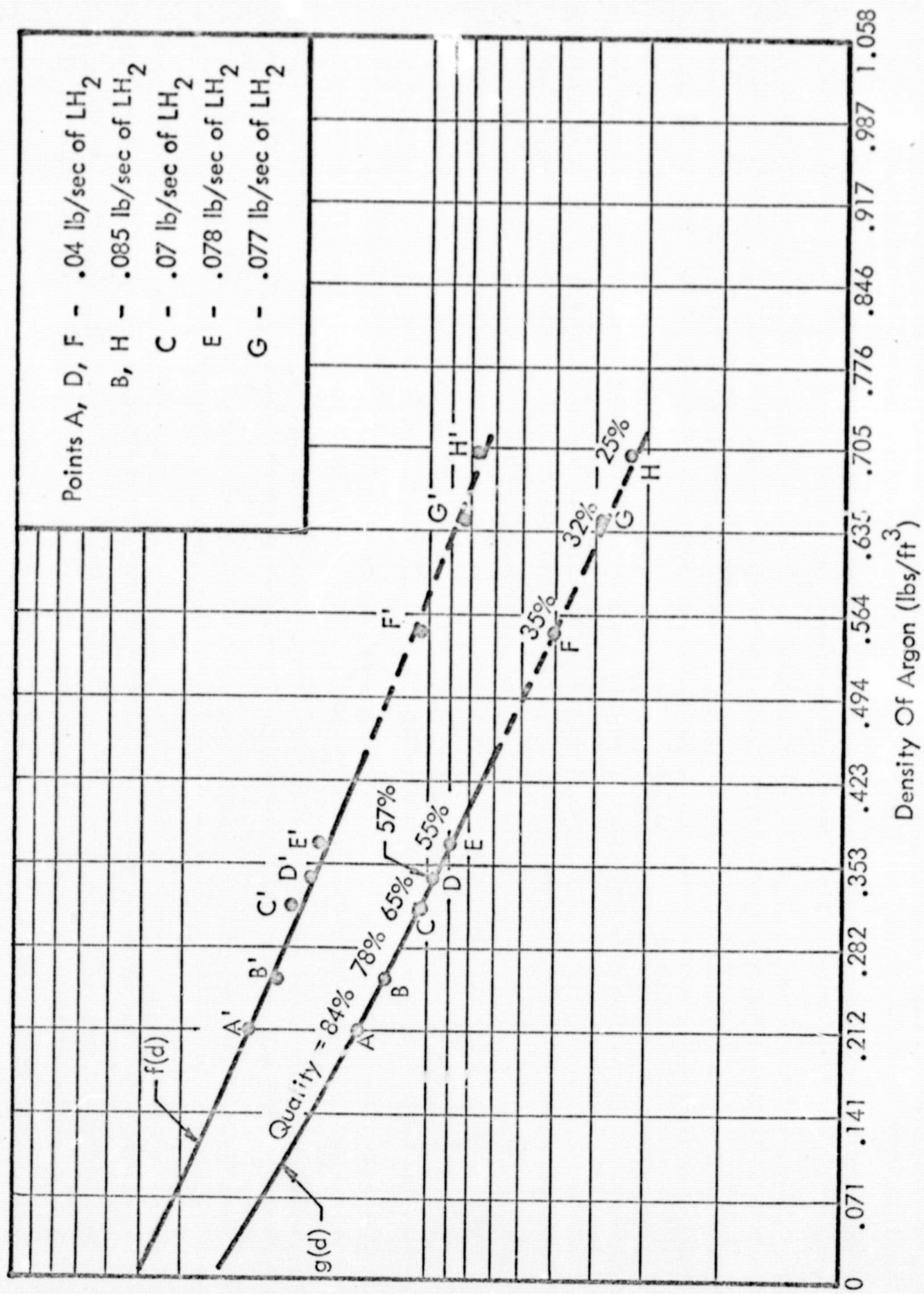


FIGURE 9 BETA ATTENUATION VERSUS DENSITY

The LH_2 was introduced into the gauging section with a specially designed nozzle approximately 5 inches from an imaginary line drawn from the source to the detector. GH_2 was introduced annularly about the LH_2 .

Percent quality indicated at the various points in Figure 9 was obtained by converting the abscissa of the lettered points on $g(d)$ to equivalent hydrogen density and dividing this into the hydrogen vapor density, which was gotten from a pressure measurement in the gauging section. Equivalent hydrogen density was obtained by dividing argon density by the ratio of the relative mass stopping power of hydrogen to argon.

Since the primed lettered points fall, within experimental error, on $f(d)$, it was concluded that no LH_2 film existed in this 1 g experiment.

APPENDIX E
MTP-309A AND MTP-309B

Revisions			
Sym	Description	Date	Approval

1

Changed Rejection Limits
Para. 7.2

11-15-66

ABB

Next Assy

Used on

Application

Original Release Date

Date

Chk/Supv

Engr

Engr

Engr

Engr

Approved

D/73-68

Engr

Q.A.

TEST PROCEDURE
(Approval Sheet)

Electronic Bench
Adjustments

MPP 309A

Scale None

Lockheed-Georgia Co.
A Division of Lockheed
Aircraft Corporation
Lockheed Georgia
Nuclear Laboratory
Dawsonville, Georgia

Code

Sheet 1 of 7

1. REFERENCE

- 1.1 Dwg. No. NLO10032, Printed Wiring Board Assembly Pre-Amplifier.
- 1.2 Dwg. No. NLO10033, Printed Wiring Board Assembly Amplifier.
- 1.3 Dwg. No. NLO10034, Printed Wiring Board Assembly Pulse Height Selector.
- 1.4 Dwg. No. NLO10017, Printed Wiring Assembly Computing Board.
- 1.5 Dwg. No. NLO10008, Printed Wiring Board Assembly, Power Supply.

2. GENERAL DESCRIPTION

- 2.1 The electronic package conditions pulses from a beta gauge and algebraically combines them with pressure to arrive at a LH_2 quality expressed in volts.

3. TEST FACILITIES

- 3.1 Instrumentation (as specified or equivalent).
 - 3.1.1 Digital Voltmeter, Digitec Model Z200A, P/N _____.
 - 3.1.2 Pressure Gage, Mfg. _____, P/N _____.
 - 3.1.3 Random Pulse Generating System
 - 3.1.3.1 Pulse Generator - General Radio 1217B,
P/N _____.
 - 3.1.3.2 Amplifier, Hamner N302, P/N _____.
 - 3.1.3.3 Power Supply, Tennelec Model 900 P/N _____.
 - 3.1.3.4 Low Noise Preamplifier, Tennelec Model 100A, P/N _____.
 - 3.1.3.5 Surface Barrier Detector/Beta Source Assembly,
GNL P/N _____.
 - 3.1.3.6 Voltage Divider consisting of (1) 100 ohm resistor
and (1) 5.6K ohm resistor P/N _____, input
to pulse generator.

- 3.1.4 Oscilloscope - Tektronix Model _____, P/N _____
 - 3.1.4.1 Preamp, Tektronix Type _____, P/N _____
- 3.1.5 Scaler, Mfg. _____, Model _____, P/N _____
- 3.1.6 Power Supply, Harrison Labs., Model 810B, P/N _____
- 3.1.7 Leak Detector CEC Model 24-110, P/N _____
- 3.1.8 Capacitor 1000 uf $\pm 100\%$ / -30% P/N _____
- 3.1.9 Resistor 100K $\pm 5\%$ P/N _____
- 3.1.10 Resistor 910 ohm $\pm 5\%$ P/N _____
- 3.1.11 Voltage Divider consisting of (1) 5.6 K ohm resistor and
(1) 220 ohm resistor P/N _____
- 3.2 Fixtures
 - 3.2.1 Vent Tube End Closure, P/N _____
P/N _____

4. PRECAUTIONS

- 4.1 Reversed polarity will damage the printed circuit board components.
- 4.2 Do not exceed 55 psia internal vent tube pressure.

5. VISUAL INSPECTION

- 5.1 Verify that each electronic unit to be tested conforms to the applicable drawings.
- 5.2 Verify that the test equipment has been calibrated to Quality Assurance standards and is within the calibration period.
- 5.3 Verify that the pulse height selector input to the computer board is not connected.

6. PRESSURE, ZERO AND SPAN POT(s), ADJUST

6.1 Preparatory Procedure

- 6.1.1 Connect Quality Meter as shown in Figures 1 and 2 using the scaler as the E-put meter (Note: Yellow wire and 910 ohm not used during this portion of test.)
- 6.1.2 Evacuate Quality Meter Vent Tube to 10 psia $\pm$ 0.5 psia.
- 6.1.3 Turn electronic equipment on and allow warm-up.
- 6.1.4 Disconnect test specimen from pulse generator. Turn on the ac switches on all instruments in the pulse generating system, and allow at least 2 minutes warm-up. Also turn on scaler. Set the low noise preamp gain to X 1. Set the power supply H. V. switch to INT. Set the detector voltage adjustment to its zero position. Set the amplifier switches to LOCAL, INTEGRAL, X 15 multiplier IN, INPUT POLARITY NEG., helipot labelled "E" to 480, COARSE GAIN to 16, fine gain to approx. 1.8. Set the output polarity switch on rear of amplifier to NEG OUT. Set the pulse generator pulse width adjustment to 3 microseconds. Set PRF switch to 3 KC, and adjust amplitude knob until the output pulse between the negative terminal and ground terminal is negative 5 volts as viewed on scope. Remove scope probe, and set PRF knob to EXT DRIVE. Turn scaler input selector to AMP. Turn scaler to manual count. Turn power supply dc switch on, and adjust detector voltage knob to 50 volts. The PRF calibrate knob on the pulse generator will cause the scaler to count or not count as it is rotated through its range. Set the

knob to approximately the center of the region over which the scaler will count. By adjusting source position relative to the detector, and by adjusting the helipot labelled "E" on the amplifier, obtain a count rate of $5.70 \pm .03 \times 10^5$ counts over a one minute interval as obtained using the scaler timer.

6.2 R-21 and R-23 Pot Procedure

6.2.1 Turn 28 volt power supply on and adjust to 28 ± 3 VDC. Connect "PMS IN" (wire #8) of computer board to the pulse generating system.

6.2.2 Adjust Pot R-21 for a quality output of 5.000 ± 025 VDC averaged at 10 second intervals for 5 minutes.

6.2.3 Change random count rate to $9.25 \pm .06 \times 10^4$ counts per minute.

6.2.4 Raise vent tube pressure to 55 psia $\pm \frac{1}{2}\%$.

6.2.5 Adjust Pot R-23 for a quality output of 5.000 ± 025 VDC.

6.2.6 Reduce vent tube pressure to 10 psia $\pm .05$ psia.

6.2.7 Change count rate to $5.70 \pm .03 \times 10^5$ counts per minute.

6.2.8 Repeat paragraphs 6.2.3 to 6.2.7 until no Pot adjustments are necessary after changing both count rates and pressures.

7. SOURCE SHUTTER ADJUSTMENT

7.1 Preparatory Procedure

7.1.1 Connect the Quality Meter as shown in Figures 1 and 2.

(Note: Scaler now connected to yellow wire and "PMS IN" disconnected from pulse generator.)

- 7.1.2 Turn on scaler to allow warm-up.
- 7.1.3 Evacuate the vent tube to 30 microns of Hg or less.
- 7.1.4 Set source shutter aperture to approximately $\frac{1}{2}$ opening.
- 7.1.5 Flush source housing with helium and seal. (Note: All available sealing screws must be used.)
- 7.1.6 Turn power supply on and adjust to 28 ± 3 VDC.
- 7.1.7 Operate scaler and obtain a one minute count. Warm Count _____ c/m
- 7.1.8 After obtaining warm count, partially submerge the vent tube in liquid air taking care that printed circuit boards are not subjected to liquid air temperatures.
- 7.1.9 When the vent tube reaches a stable temperature (liquid air ceases to boil violently), log a cold count rate _____ c/m
- 7.1.10 Remove the vent tube from the liquid air and return to room temperature. Compute the warm count to cold count ratio _____
- 7.1.11 Adjust the source aperture to obtain $8.47 \pm 05 \times 10^5$ X ratio (para. 7.1.10) counts per minute. Note: After each adjustment the source housing must be flushed with helium and all sealing screws must be tight while making the scaler measurement. Final setting _____ c/m.
- 7.1.12 When the count in para. 7.1.11 is obtained, evacuate the source housing with the helium leak detector. Spray the exposed surfaces of the source housing with helium. Any indication of leaks on the X 10 scale shall be cause for remedial action.

7.1.13 After completing 7.1.12 return the source housing internal pressure to Lab ambient by breaking the vacuum with helium. Disconnect the supply line and quickly cap the source housing fitting.

7.1.14 Recheck for a scaler reading of $8.47 \pm 05 \times 10^5$ X ratio (para. 7.1.10) _____ c/m.

7.1.15 Repeat para. 7.1.8 and 7.1.9. A cold count of more than 8.54×10^5 or less than 8.40×10^5 shall be cause to repeat para. 7.1.1 to 7.1.14.

7.2 External Test Circuit Check

With the same circuitry used in para. 7.1.15, and with the vent tube internal pressure at Lab ambient, push the external test pushbutton and log the quality output averaged for 5 minutes. A quality output average of more or less than 2.65 ± 0.25 VDC shall be cause for rejection.

8. QUALITY ASSURANCE

8.1 Quality Assurance shall assure that the test specified in this Manufacturing Test Procedure is performed and the equipment meets the performance requirements specified.

8.2 In the event rework is required, Quality Assurance shall assure that all necessary steps are taken to bring the printed circuit board back to print.

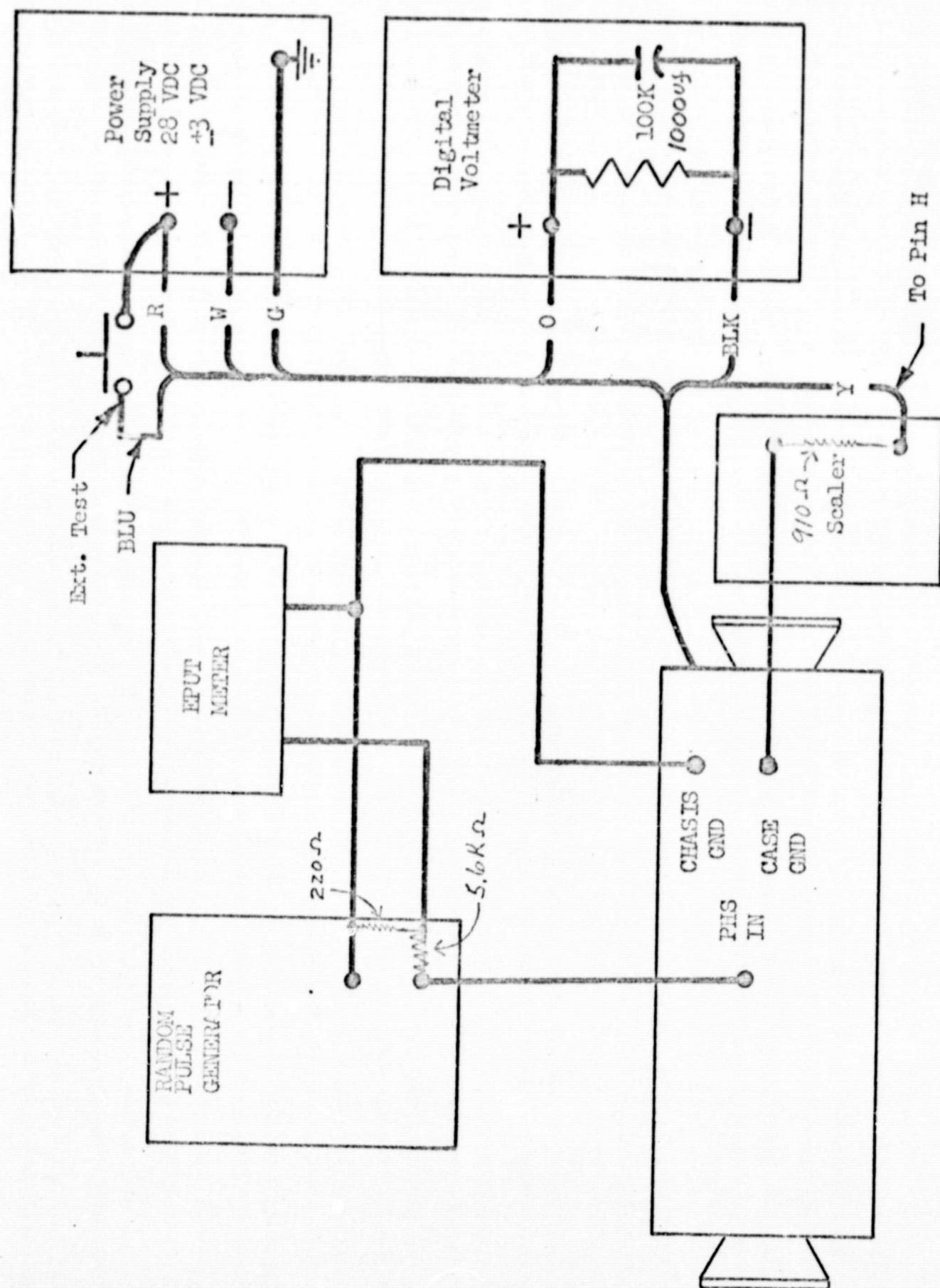


FIGURE 1. ZERO AND SPAN POTS ADJUST

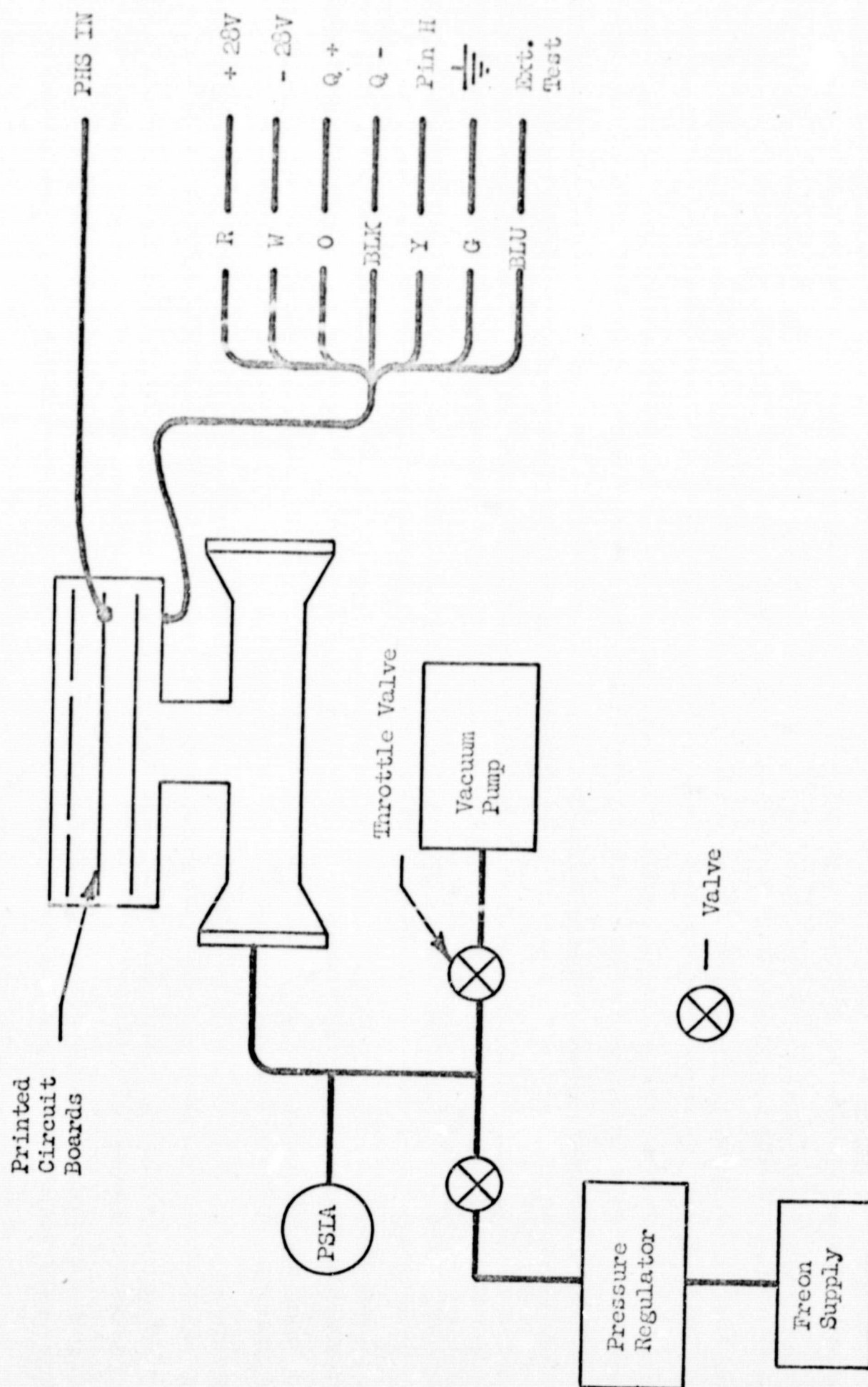


FIGURE 2 PRESSURE ZERO AND SPAN POTS ADJUST

[illegible]

1. REFERENCE

- 1.1 Dwg. No. N1010032, Printed Wiring Board Assembly Pre-Amplifier.
- 1.2 Dwg. No. N1010033, Printed Wiring Board Assembly Delay Line Amplifier.
- 1.3 Dwg. No. N1010034, Printed Wiring Board Assembly Pulse Height Selector.
- 1.4 Dwg. No. N1010017, Printed Wiring Assembly Computing Board.
- 1.5 Dwg. No. N1010008, Printed Wiring Board Assembly, Power Supply.

2. GENERAL DESCRIPTION

- 2.1 The electronic package conditions pulses from a beta gauge and algebraically combines them with pressure to arrive at a LH₂ Quality expressed in volts.

3. TEST FACILITIES

- 3.1 Instrumentation (as specified or equivalent).
 - 3.1.1 Digital Voltmeter, Digitec Model Z200A, P/N _____
 - 3.1.2 Pressure Gage, Mfg. _____, P/N _____
 - 3.1.3 Power Supply, Harrison Lab. Model 810B, P/N _____
- 3.2 Fixtures
 - 3.2.1 Vent Tube End Closures, P/N _____
P/N _____

4. PRECAUTIONS

- 4.1 Reversed polarity will damage the printed circuit board components.
- 4.2 Do not exceed 55 psia internal vent tube pressure.

5. VISUAL INSPECTION

5.1 Verify that each electronic unit to be tested conforms to the applicable drawings.

5.2 Verify that the test equipment has been calibrated to Quality Assurance standards and is within the calibration period.

6. PREPARATORY PROCEDURE

6.1 Connect Quality Meter as shown in Figure 1.

Caution: Reversed polarity will damage the printed circuit board.

6.2 Turn electronic equipment on and allow warm up.

7. TEST PROCEDURE

7.1 With the vent tube at room ambient temperature, turn power supply on and adjust to 28 ± 3 VDC.

7.2 Apply the following internal pressure to the vent tube and record the quality output for each pressure

Caution: Do not exceed 55 psia at any time.

Vent Tube Pressure (In. Hg.)	Quality Output VDC	Acceptable Quality Output*	
		Min.	Max.
$20.36" \pm .05"$ Freon plus $9.20" \pm .05$ He		2.35	2.85
$61.08 \pm .1"$ Freon plus $21.42" \pm .1$ He		2.35	2.85
$80.00 \pm .1"$ Freon plus $29.45 \pm .1$ He		2.58	3.08

*Good as long as $1.06 > \frac{\text{count COLD}}{\text{count HOT}} > 0.98$.

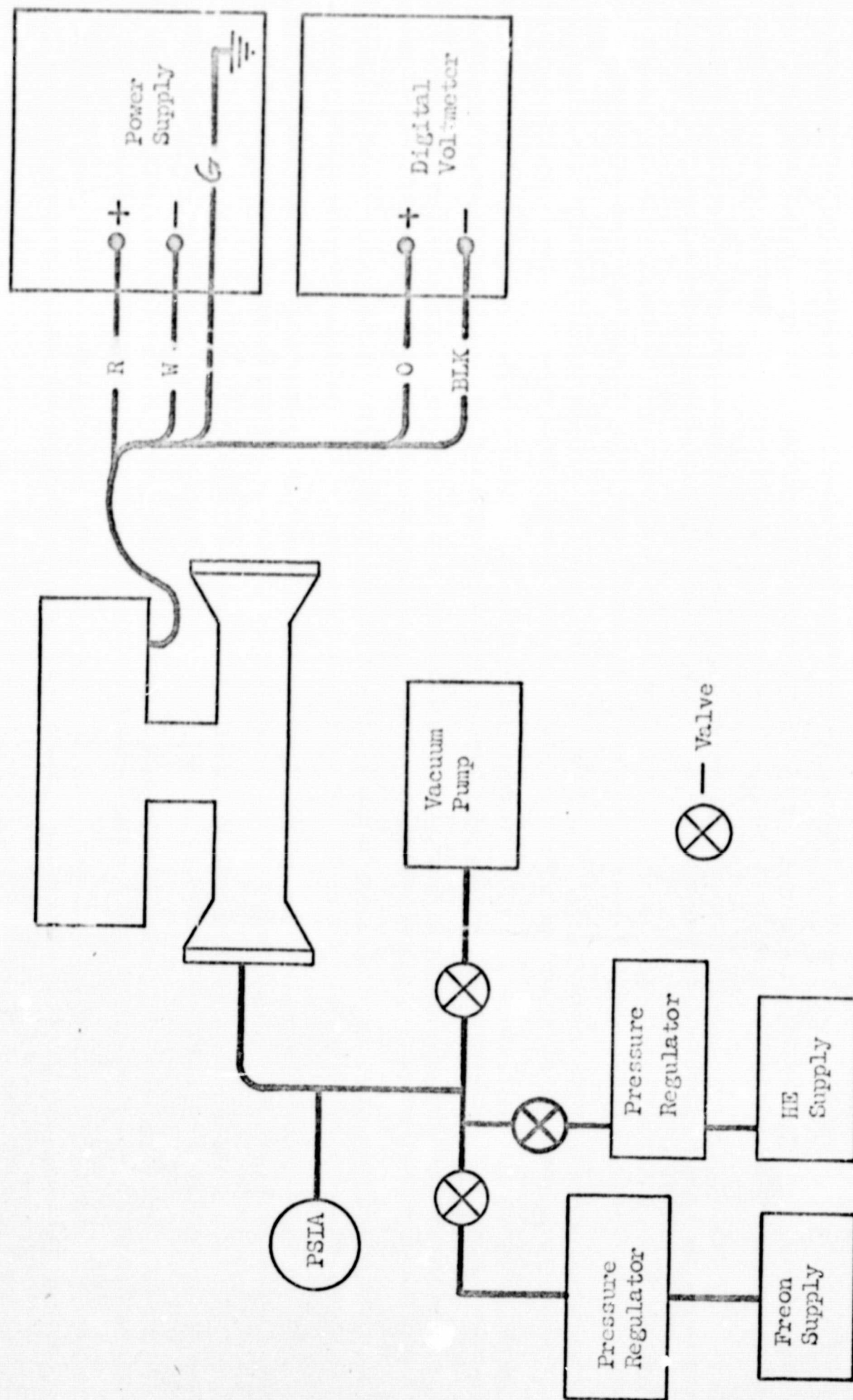


FIGURE 1 - QUALITY OUTPUT VS FREON PRESSURE AT LAB AMBIENT TEMPERATURE

APPENDIX F

QTP-301 FOR UNIT 0002-P

[illegible]

1. REFERENCE

1.1 NASA Contract NAS8-20518

2. GENERAL DESCRIPTION

2.1 Function - The LH₂ Quality Meter measures the ratio of the mass of gaseous Hydrogen to the total mass of liquid Hydrogen and gaseous Hydrogen. The meter is a section of the vent tube and meters the quality of Hydrogen vented.

The output voltage is from 0 to 5 volts and is capable of modulating satellite telemetry systems.

2.2 The Qualification tests consists of nine (9) separate parts:

- 2.2.1 Temperature Cycle
- 2.2.2 Pressure Cycle
- 2.2.3 Thermal Shock
- 2.2.4 Humidity
- 2.2.5 Acceleration
- 2.2.6 Mechanical Shock
- 2.2.7 Vibration
- 2.2.8 Electromagnetic Interference Test
- 2.2.9 LH₂ Calibration Check Test
- 2.2.10 Inspection (Quality Assurance Provisions)

2.3 Pre-environmental tests consist of two (2) parts:

2.3.1 Repeatability:

2.3.1.1 Instrumentation (as specified or equivalent).

- (a) D. C. Power Supply, Property # 616273.
- (b) Strip Chart Recorder, Property # Not used.
- (c) Digital Voltmeter, Property # 51015-2.
- (d) D. C. Voltmeter, Property # 13531.
- (e) Pressure Gage, Property # 59113.

- (f) Pressure Regulator, Property # 59105.

2.3.1.2 Fixtures:

- (a) Density Simulator, Property # N/A 30" Hg Freon
 (b) End Cap Seals, Property # constant throughout test.
 Property # 14019812, and
 Property # 14019808.

2.3.1.3 Test Procedure:

- (a) Install end cap seals and density simulator and purge vent tube helium.
 (b) Connect Quality Meter to instrumentation as shown in Figure 1. Monitor Quality Meter output with 28 VDC power supply voltage.
 (c) When Quality Meter output has stabilized, vary the vent tube internal pressure to simulate a different quality between 50% and 100%. Adjust the pressure to five different values and record the output at each pressure. Monitor the Quality Meter output for 30 minutes at the final pressure. Repeat each pressure and record Quality Meter output at each pressure. Quality Meter output must duplicate the output at each pressure within $\pm 1\%$.

Pressure <u>10.4" Hg</u>	Output <u>2.61</u>
Pressure <u>14.0" Hg</u>	Output <u>2.83</u>
Pressure <u>20.0" Hg</u>	Output <u>3.26</u>
Pressure <u>30.0" Hg</u>	Output <u>3.94</u>
Pressure <u>40.0" Hg</u>	Output <u>4.63</u>
Pressure <u>10.4" Hg</u>	Output <u>2.62</u>
Pressure <u>14.0" Hg</u>	Output <u>2.83</u>
Pressure <u>20.0" Hg</u>	Output <u>3.25</u>
Pressure <u>30.0" Hg</u>	Output <u>3.96</u>
Pressure <u>40.0" Hg</u>	Output <u>4.64</u>

2.3.2 Response Time:

2.3.2.1 Instrumentation (as specified or equivalent)

- (a) D. C. Power Supply, Property # 616273.
 (b) Digital Voltmeter, Property # 510152.

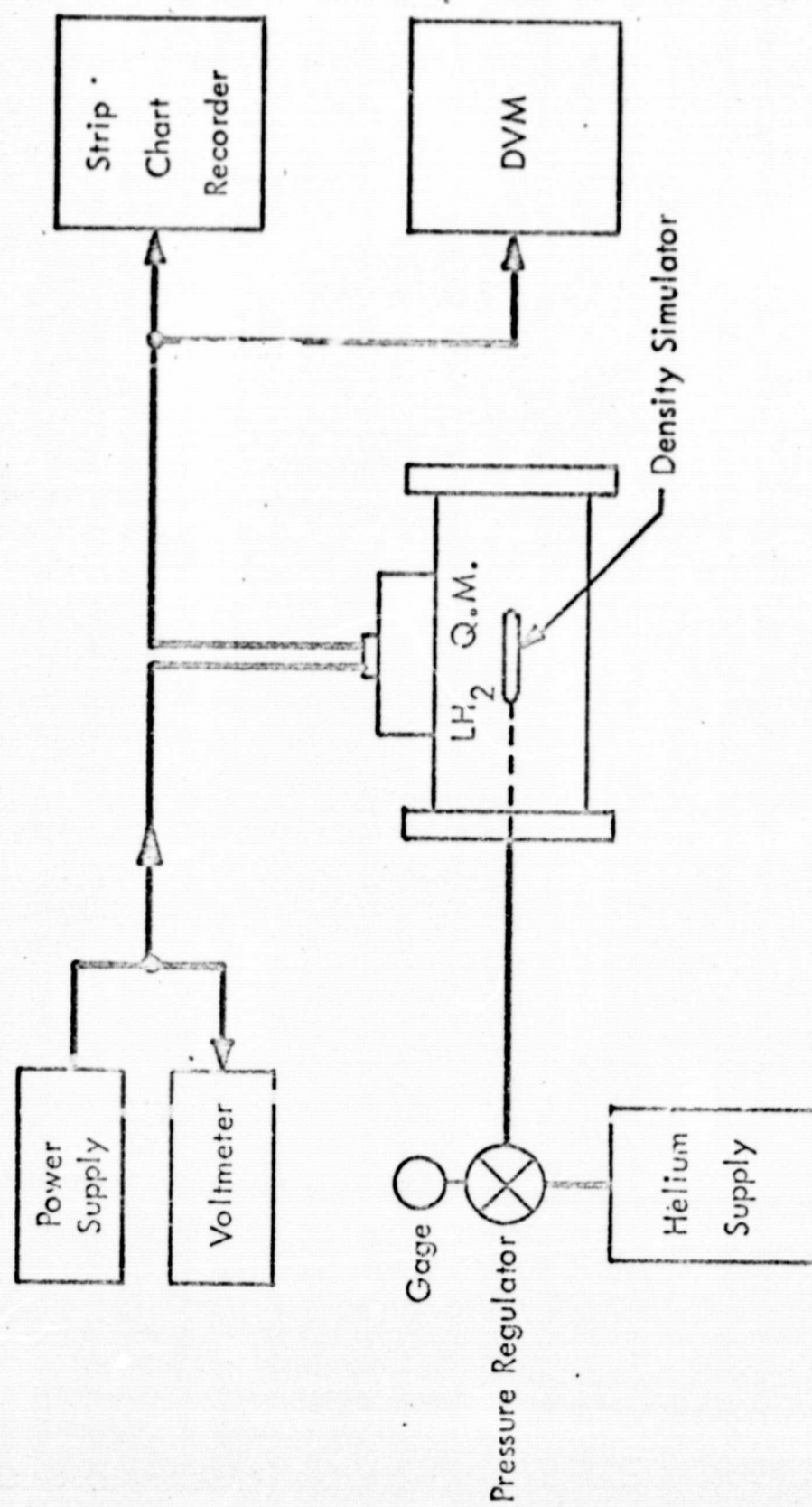


FIGURE 1 REPEATABILITY TEST

- (c) D. C. Voltmeter, Property # N13531.
- (d) Oscilloscope, Property # N1273;
- (1) Pre-amp, Property # 214359.
- (2) Camera, Property # N1556.

2.3.2.2 Fixtures:

- (a) Density Simulators, Property # N19826,
Property # N/A.

2.3.2.3 Test Procedure:

- (a) Connect Quality Meter to instrumentation as shown in Figure 2. Adjust density simulators to provide an output equal to $50\% \pm 5\%$ quality. Allow Quality Meter to stabilize for 30 minutes.
- (b) After 30 minutes stabilization, remove a density simulator from the venturi and trigger the oscilloscope sweep within 10 milliseconds or less. Obtain a pictorial record of the Quality Meter output change. The change must be more than $[\ .63 \times \text{the final value } (100\% \pm \frac{0}{5})]$ after 100 milliseconds.

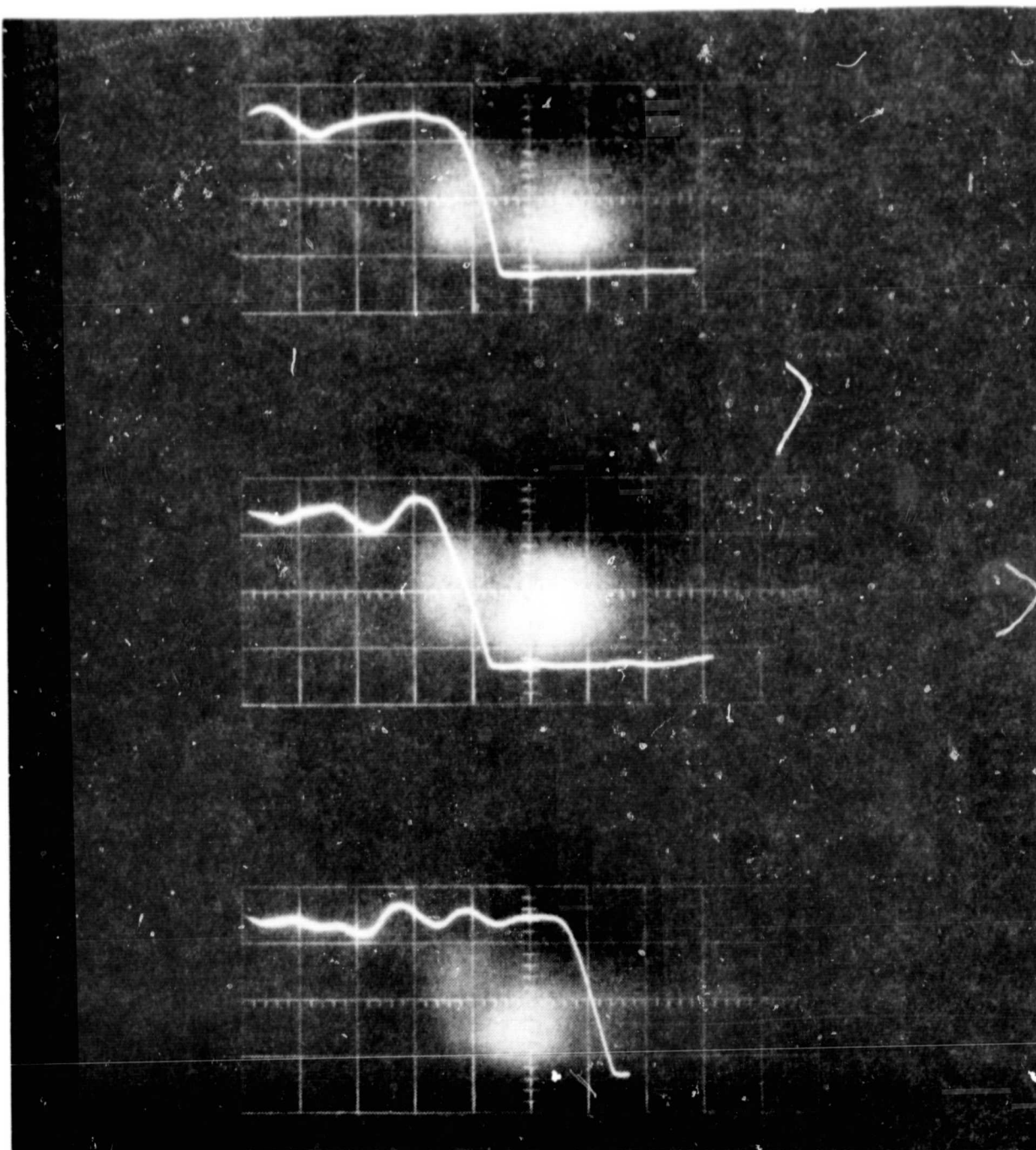
3. TEST FACILITIES

3.1 Temperature Cycle Test:

3.1.1 Instrumentation (as specified or equivalent) Figure 3.

- 3.1.1.1 Temperature Chamber, American Instrument Co., Model 4-3356, Property # F11732.
- 3.1.1.2 Temperature Controller, Leeds & Northrup, Type G, Property # N1285.
- 3.1.1.3 Temperature Monitor, Leeds & Northrup, Type G, 1.5 mV span, -10 to +10 mV range, with six (6) each Copper Constantan Thermocouples, 6 ft. minimum length. Temperature Monitor Property # N1543.

Property # 510345A ControlProperty # 510345BProperty # 510345CProperty # 510345DProperty # 510345EProperty # 510345FProperty # 510345G



RESPONSE TIME PER PARAGRAPH 2.3.2.3

100 ms/cm

1 volt/cm With 10 to 1 Probe

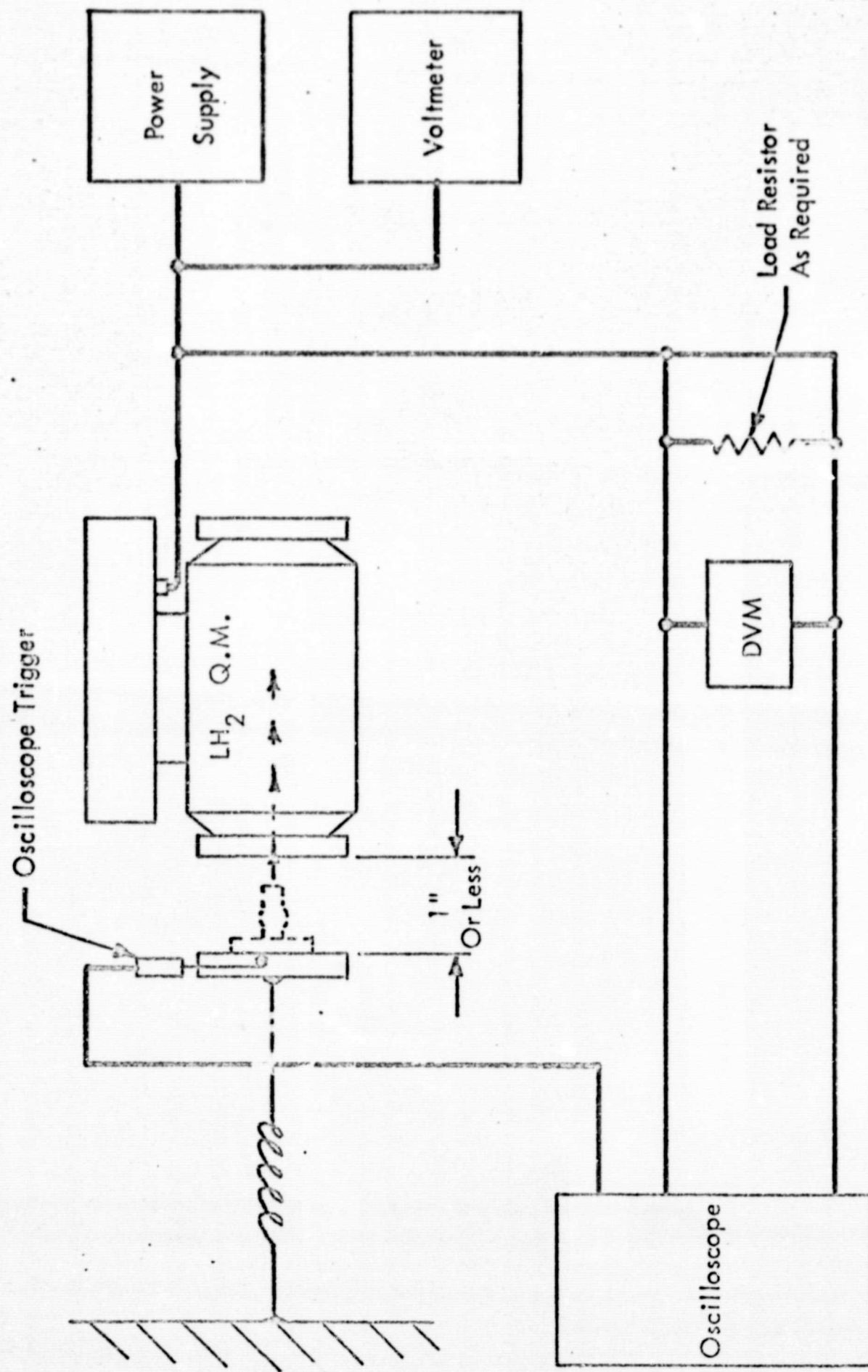


FIGURE 2 RESPONSE TIME TEST

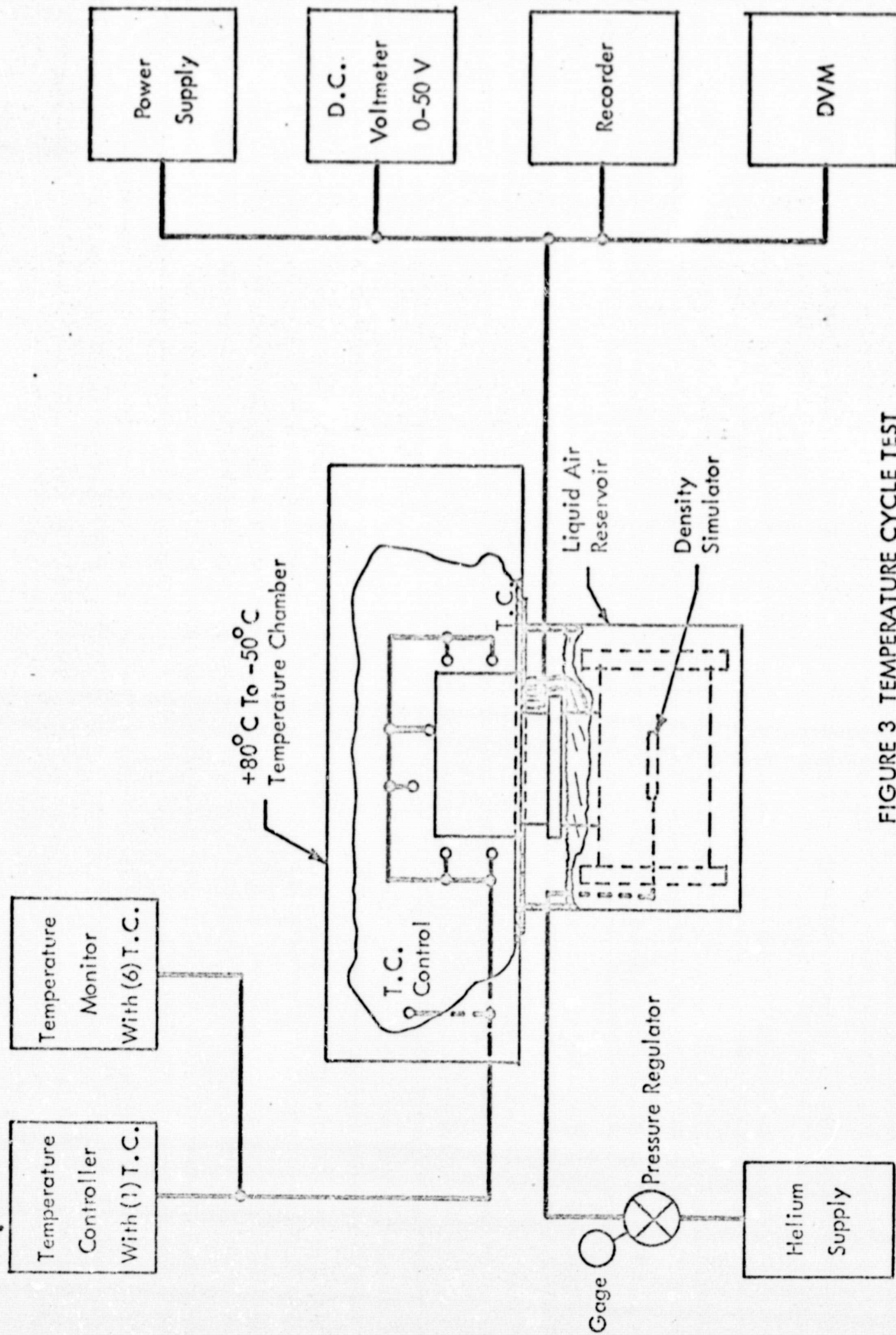


FIGURE 3 TEMPERATURE CYCLE TEST

- 3.1.1.4 Ice Reference, LGNL, Property # N/A.
- 3.1.1.5 Liquid Air Reservoir, Property # N/A.
- 3.1.1.6 Pressure Regulator, Property # 59114.
- 3.1.1.7 CO₂ Supply, LGNL, Property # N/A.
- 3.1.1.8 D. C. Power Supply, Hewlett-Packard, Model 726, Property # C16273.
- 3.1.1.9 Recorder, 2-channels, Sanborn Model 152-100A, Property # N770.
- 3.1.1.10 Digital Voltmeter, Digitec Model Z-200A, Property # 510152.
- 3.1.1.11 D. C. Voltmeter, Property # N3531.
- 3.1.2 Fixtures, LGNL, Property # N6019808; N6019812.
- 3.1.3 Temperature Cycle Test:

The LH₂ Quality Meter will be subjected to an environment of temperatures from $-50^{\circ}\text{C} \pm 3^{\circ}\text{C}$ to $+80^{\circ}\text{C} \pm 3^{\circ}\text{C}$. Specimens will be monitored during testing. Deviation of more than ± 150 mV shall be cause for rejection.

 - 3.1.3.1 Quality Meter Hydrogen simulation required as follows:
 - (a) Convenient and constant pressure between 14 and 55 psia.
 - (b) Density - Special fixture with a determined attenuation constant.
 - 3.1.3.2 Quality Meter temperature requirements as follows:
 - (a) Vent tube - Partially submerged in liquid air throughout test.
 - (b) Electronic compartment - Cycled between -50°C and $+80^{\circ}\text{C}$.
 - 3.1.3.3 Temperature monitoring - The following are points of temperature measurements:
 - (a) Electronics Enclosure Box - 5 thermocouples in surrounding air, 1 thermocouple contacting box top.
 - 3.1.3.4 Electronic test equipment application:

- (a) Digital Voltmeter (Para. 3.1.1.10) - output measurements.
- (b) D. C. Voltmeter (Para. 3.1.1.11) - power supply monitor.
- (c) Strip Chart Recorder (Para. 3.1.1.9) - Quality Meter output.

3.1.3.5 Environmental Test Procedure:

- (a) Connect LH₂ Quality Meter as shown in Figure 3.
- (b) Set D. C. Power Supply output to 28V $\pm$ 3V dc.
- (c) Record ambient temperature and pressure.
- (d) After test equipment has stabilized, record output voltage of Quality Meter. Record temperature for ambient reference.
- (e) Lower air temperature in temperature chamber to -50°C $\pm$ 3°C.
- (f) Record Quality Meter output each 5 minutes until desired temperature is reached. Record air temperature indicated.
- (g) When the air temperature reaches -50°C $\pm$ 3°C, let Quality Meter remain at this temperature for a minimum of 30 minutes. Take output readings every 5 minutes.
- (h) After 30 minutes at -50°C $\pm$ 3°C, raise the chamber air temperature to +80°C $\pm$ 3°C. Record output and air temperature each 5 minutes.
- (i) Let electronics box remain at 80°C $\pm$ 3°C for 1 1/2 hours. Record output each 5 minutes.
- (j) Reduce temperature to ambient.
- (k) When air temperature reaches ambient, allow electronics box temperature to stabilize for 30 minutes. Record output every 5 minutes.

This completes the temperature cycle test.

3.2 Pressure Cycle Test:

Date Started 12-13-66	Test Facility GNL	Operator J. H. Debbins
Date Completed 12-13-66	Test Item STAINLESS STEEL LH ₂ Q.M.	Inspector J. M. Irby
Normal Lab. Temp. 24°C	Type Of Test TEMPERATURE CYCLE TEST	
Humidity 39%	Mfg.	
Unit Number 0002-P	Test Condition PARA. 3.1.3	

Input Volts	Time	Temp.	Output Volts	Time	Temp.	Output Volts	Time	Temp.	Output Volts
28.0	15:00	0°C	3.52	16:35	80°C	3.46	18:02	80°C	3.51
28.0	15:10	-20°C	3.54	Start	+80°C Test.		18:07	80°C	3.51
28.0	15:15	-30°C	3.54	16:37	80°C	3.47	End of +80°C Test.		
	Start	-50°C Test		16:42		3.46	18:12	75°C	3.50
28.0	15:17	-50°C	3.55	16:47		3.47	18:17	50°C	3.60
	15:25	-50°C	3.49	16:52		3.48	18:22	25°C	3.55
	15:32	-50°C	3.46	16:57		3.47	Start Test at Amb.		
	15:37	-50°C	3.44	17:02		3.49	18:27	25°C	3.58
	15:42	-50°C	3.51	17:07		3.47	18:32		3.60
	15:47	-50°C	3.48	17:12		3.53	18:37		3.56
28.0	15:52	-50°C	3.52	17:17		3.53	18:42		3.53
	End of -50°C Test			17:22		3.52	18:47		3.53
28.0	15:57	-30°C	3.54	17:27		3.47	18:52	25°C	3.47
	16:02	+5°C	3.45	17:32		3.52			
	16:07	25°C	3.45	17:37		3.49			
	16:12	25°C	3.41	17:42		3.52			
	16:20	+30°C	3.46	17:47		3.48			
	16:25	55°C	3.45	17:52		3.51			
28.0	16:30	65°C	3.47	17:57	80°C	3.52			

 Lab. Supervisor
 Inspector

 J. H. Debbins
 J. M. Irby

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3.2.1 Instrumentation (as specified or equivalent) Figure 4.

- 3.2.1.1 Evacuation System; LGNL 24-inch vacuum system, Property # 339.
 - (a) Ionization gauge, cold cathode, NRC equipment, Type 0724, Property # 59105.
 - (b) Ionization gauge and thermocouple gauge, Veeco RG31A, Property # 59105.
- 3.2.1.2 Pressure gauge, 0-100 psi, Mfg. Kellman, Type B08395, Property # 59113.
- 3.2.1.3 Hydrogen regulated supply, LGNL.
- 3.2.1.4 D. C. Power Supply, Hewlett-Packard, Model 726, Property # 16273.
- 3.2.1.5 Digital Voltmeter, Digitec Model Z-200A, Property # 510152.
- 3.2.1.6 D. C. Voltmeter, Property # N3531.
- 3.2.1.7 Recorder, strip chart, Sanborn Model 152-100B, Property # N770.
- 3.2.2 Fixtures, LGNL, Property # N4019812, Density simulator.
- 3.2.3 Fixture, LGNL, Property # N4019808, End cap seal.
- 3.2.4 Pressure Cycle Test:

The LH₂ Quality Meter will be subjected to an environment of internal pressure from laboratory ambient to 55 psia in vent tube and external pressure of 2×10^{-7} psia to ambient on outer structures. Test shall be operational. The Quality Meter output will be corrected to laboratory ambient pressure and density. Deviations of more than ± 150 mV in the corrected output shall be cause for rejection.

- 3.2.4.1 Quality Meter Hydrogen simulation required as follows:
 - (a) Pressure:
 - (1) Vent tube laboratory ambient to 55 psia internal.

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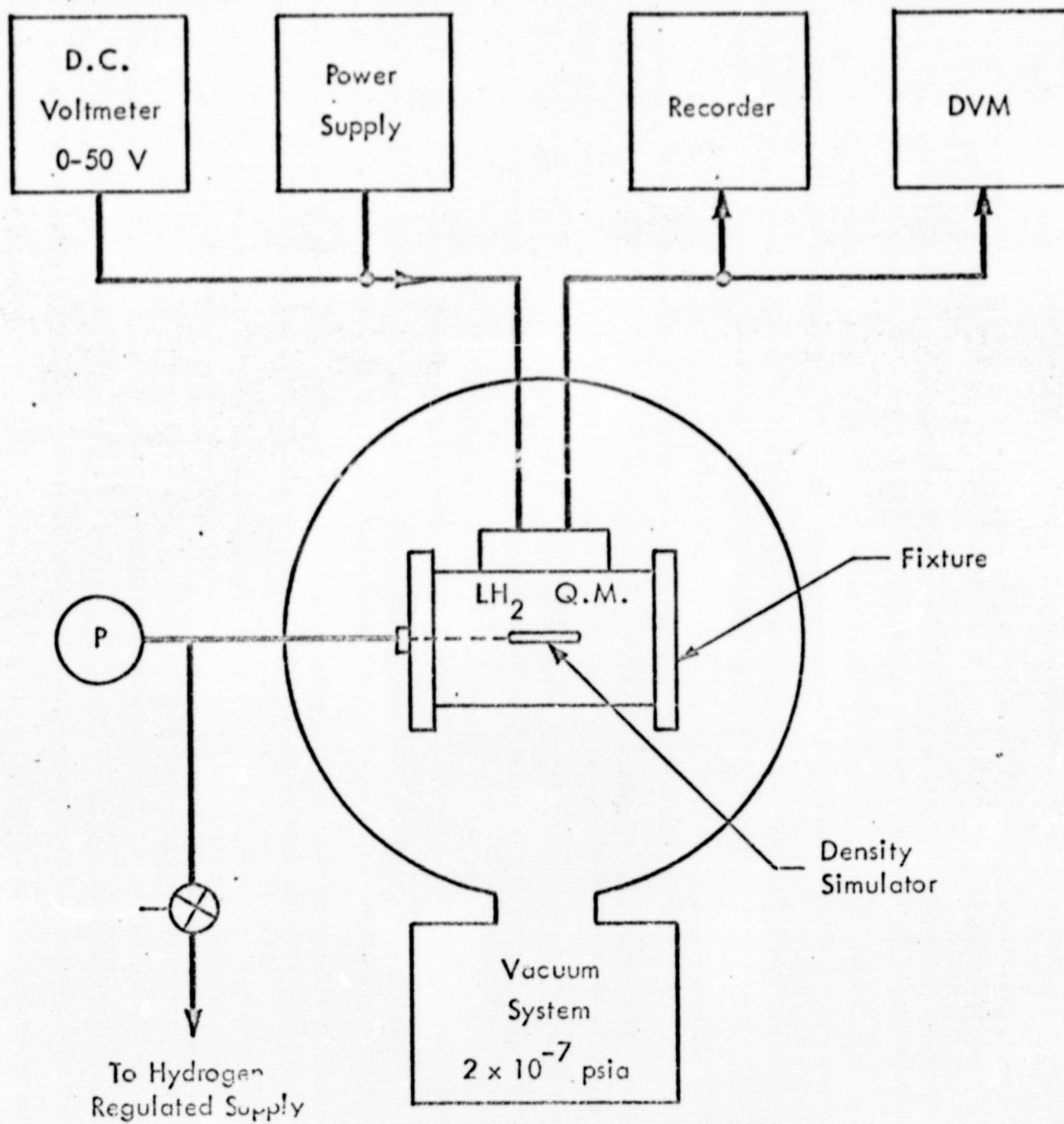


FIGURE 4 PRESSURE CYCLE TEST

- (2) External vent tube structure 2×10^{-7} psia (.01 microns of mercury) to ambient pressure.
- (b) Density - Special fixture. (Para. 3.2.2)
- 3.2.4.2 Quality Meter temperature requirements: Laboratory ambient.
- 3.2.4.3 Electronic equipment applications:
 - (a) Digital Voltmeter (Para. 3.2.1.5) - output measurements.
 - (b) D.C. Voltmeter (Para. 3.2.1.6) - power supply monitor.
 - (c) Strip chart recorder (Para. 3.2.1.7) - output monitoring.
- 3.2.4.4 Environmental Test Procedure:
 - (a) Install cap seal fixture (Para. 3.2.3) and density simulator fixture (Para. 3.2.2).
 - (b) Install Quality Meter and connect as shown in Figure 4.
 - (c) Adjust D.C. Power Supply output to $28 \text{ V} \pm 3 \text{ V dc}$.
 - (d) Record ambient temperature and ambient pressure.
 - (e) After test equipment has stabilized, record the Quality Meter output for ambient internal and external pressure. Condition for 15 minutes minimum. Record data each 5 minutes.
 - (f) After the ambient pressure test, apply 55 ± 2 psia internal to vent tube in 5 or more steps at a rate pressure change not to exceed 2 psia/second. When 55 ± 2 psia is obtained, maintain pressure for a minimum of 30 minutes. Record pressure and Quality Meter output for each pressure step and each 5 minutes at 55 ± 2 psia.
 - (g) Reduce vent tube pressure at a rate not to exceed 8 psia/second. Record Quality Meter

output at ambient pressure.

- (h) With vent tube internal pressure at ambient (line vented) start vacuum system (Para. 3.2.1.1)
- (i) Take pressure and Quality Meter output data at 1000 microns of mercury and each decade lower or reading each 5 minutes, whichever is less, until an external pressure of 2×10^{-7} psia (.01 microns of mercury) is reached.
- (j) At a pressure of 2×10^{-7} psia (.01 microns of mercury) let Quality Meter stabilize for 30 minutes. Record data each 5 minutes.
- (k) After 30 minutes at an external pressure of 2×10^{-7} psia, apply internal pressure to vent tube of Quality Meter in 5 steps of pressure. Pressure rate change not to exceed 2 psia/second. Record Quality Meter output, and indicated pressures.
- (l) When internal vent pressure is 55 ± 2 psia, let the Quality Meter stabilize for 30 minutes. Record all data each 5 minutes.
- (m) After 30 minutes stabilization, reduce vent tube internal pressure from 55 ± 2 psia to ambient pressure at a rate not to exceed 8 psia/second.
- (n) When vent tube internal pressure has reached ambient pressure, let the Quality Meter stabilize for 20 minutes. Record Quality Meter output and ambient pressure every 5 minutes.
- (o) After 20 minutes, close off all vacuum valves and vent the pressure chamber to ambient pressure at an optional rate.
- (p) After Quality Meter has reached ambient internal and external pressures, let Quality Meter stabilize for 30 minutes. Record ambient temperatures, pressure, and humidity. Record Quality Meter output every 5 minutes.

This completes the Pressure Cycle Test.

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ITEM - TEST DATA

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Date Started 12-14-66	Test Facility GNL	Operator J.H.D. Ellis
Date Completed 12-15-66	Test Item STAINLESS STEEL LH2 Q.M.	Engineer J.M. Truby
Normal Lab. Temp. 74°F	Type Of Test PRESSURE CYCLE	
Humidity 32%	Mfg.	
Unit Number 002-P	Test Condition PARA. 3.2.4	

Time	Vent Tube Pressure External	Vent Tube Pressure Internal	Quality Meter Output Volts	Time	Vent Tube Pressure External	Vent Tube Pressure Internal	Quality Meter Output Volts
14:28	AMBIENT	AMBIENT	1.37	16:25	1000 ⁴ / ₁₀ Hg	AMBIENT	1.41
14:33	"	"	1.35	16:30	100	"	1.40
14:38	"	"	1.36	16:35	50	"	1.44
14:43	"	"	1.36	16:40	40	"	1.42
14:47	"	40.2 "Hg	1.80	16:45	35	"	1.42
14:53	"	50.6	2.23	16:50	28	"	1.40
14:58	"	60.3	2.65	16:55	25	"	1.43
15:03	"	70.0	3.04	17:00	22	"	1.40
15:08	"	80.0	3.38	17:05	21	"	1.42
15:13	"	90.3	3.82	17:10	20	"	1.40
15:18	"	100.0	4.15	17:15	19	"	1.44
15:26	"	112.0	4.55	17:20	22	"	1.45
15:31	"	112.0	4.55	17:25	25	"	1.44
15:36	"	112.0	4.55	17:30	100	"	1.45
15:41	"	112.0	4.53	17:35	40	"	1.43
15:46	"	112.0	4.52	17:40	31	"	1.45
15:51	"	112.0	4.50	17:45	26	"	1.45
15:56	"	112.0 "Hg	4.53	17:50	22	"	1.43
16:04	AMBIENT	AMBIENT	1.41	17:55	20 ⁴ / ₁₀ Hg	AMBIENT	1.45

Lab. Supervisor C. Whiting

Date Started 12-14-66	Test Facility GNL		Operator J. H. Dobbins				
Date Completed 12-15-66	Test Item STAINLESS STEEL LH ₂ Q.M.		Engineer J. M. Trby				
Normal Lab. Temp. 75°F	Type Of Test PRESSURE CYCLE						
Humidity 29%	Mfg.						
Unit Number 002-P	Test Condition PARA. 3.2.4						

Time	Vent Tube Pressure External	Vent Tube Pressure Internal	Quality Meter Output Volts	Time	Vent Tube Pressure External	Vent Tube Pressure Internal	Quality Meter Output Volts
18:00	20.44 Hg	AMBIENT		09:33	.30X10 ⁻⁵ mm Hg	112.0 "Hg	4.85
18:05	18 ↑	"		09:38	.30X10 ⁻⁵ mm Hg	112.0 ↑	4.86
18:10	18 ↓	"		09:43	.40X10 ⁻⁵ mm Hg	112.0	4.86
18:15	17.44 Hg	AMBIENT		09:48	.40X10 ⁻⁵ mm Hg	112.0	4.84
BETWEEN 18:15 (12-14-66) AND 08:15 (12-15-66) THE QUALITY OUTPUT READINGS CONTINUED TO READ 1.45 - 1.46 (REF. SANDORN CHART)				09:53	.40X10 ⁻⁵ mm Hg	112.0	4.86
08:15	.95X10 ⁻⁵ mm Hg	75°F/22°K 29.18" Hg	1.43	09:58	.40X10 ⁻⁵ mm Hg	112.0 "Hg	4.87
08:20	.83X10 ⁻⁵ mm Hg	AMBIENT	1.44	09:59	.40X10 ⁻⁵ mm Hg	29.4 "Hg	1.51
08:25	.70X10 ⁻⁵ mm Hg	"	1.44	10:04	.40X10 ⁻⁵ mm Hg	29.4 ↑	1.51
08:30	.45X10 ⁻⁵ mm Hg	"	1.46	10:09	.40X10 ⁻⁵ mm Hg	29.4	1.51
08:35	.40X10 ⁻⁵ mm Hg	"	1.46	10:14	.40X10 ⁻⁵ mm Hg	29.4	1.51
08:40	.40X10 ⁻⁵ mm Hg	"	1.44	10:19	.40X10 ⁻⁵ mm Hg	29.4 "Hg	1.51
08:45	.40X10 ⁻⁵ mm Hg	"	1.45	ALLOWING TIME FOR COOLING DOWN OF DIFFUSING PUMP.			
08:50	.45X10 ⁻⁵ mm Hg	"	1.46	10:45	AMBIENT	AMBIENT	1.53
08:58	.40X10 ⁻⁵ mm Hg	60.3 "Hg	2.81	10:50	"	"	1.50
09:06	.40X10 ⁻⁵ mm Hg	70.0 "Hg	3.22	10:55	"	"	1.50
09:14	.30X10 ⁻⁵ mm Hg	82.0 "Hg	3.27	11:00	"	"	1.49
09:21	.30X10 ⁻⁵ mm Hg	95.0 "Hg	4.30	11:05	"	"	1.49
09:28	.30X10 ⁻⁵ mm Hg	112.0 "Hg	4.85	11:10	"	"	1.49
				11:15	AMBIENT	AMBIENT	1.49

Lab. Supervisor

Inspector

3.3 Thermal Shock Test:

3.3.1 Instrumentation (as specified or equivalent) Figure 5A and 5B.

3.3.1.1 Temperature Environmental Chamber, American Instrument Co., Model 4-3356, Property # G11732.(a) Temperature Controller, Leeds & Northrup, Type G, (with a Copper Constantan Thermocouple), Property # N1785.(b) Temperature Monitor, Leeds & Northrup, Type G, Property # N1543.

(c) Copper Constantan Thermocouples

Property # S10345-BProperty # S10345-EProperty # S10345-CProperty # S10345-FProperty # S10345-DProperty # S10345-G(d) CO₂ System, LGNL, Property # N/A.3.3.1.2 Ice Reference, LGNL, Property # N/A, Property # N/A.3.3.1.3 Temperature Environmental Chamber, American Instrument Co., Model 4-3356, Property # G11733.(a) Temperature Controller, Leeds & Northrup, Type G, (with a Copper Constantan Thermocouple), Property # N1765.(b) Temperature Monitor, Leeds & Northrup, Type G, Property # N1803.

(c) Copper Constantan Thermocouples

Property # S10325-AProperty # S10325-DProperty # S10325-BProperty # S10325-EProperty # S10325-CProperty # S10325-H3.3.1.4 D.C. Power Supply, Hewlett-Packard, Model 726, Property # G11273.3.3.1.5 Digital Voltmeter, Digitec Model Z-200A, Property # S10152.3.3.1.6 D.C. Voltmeter, Property # N3531.3.3.1.7 Recorder, 2-channels, Sanborn Model 152-10GB, Property # N770.

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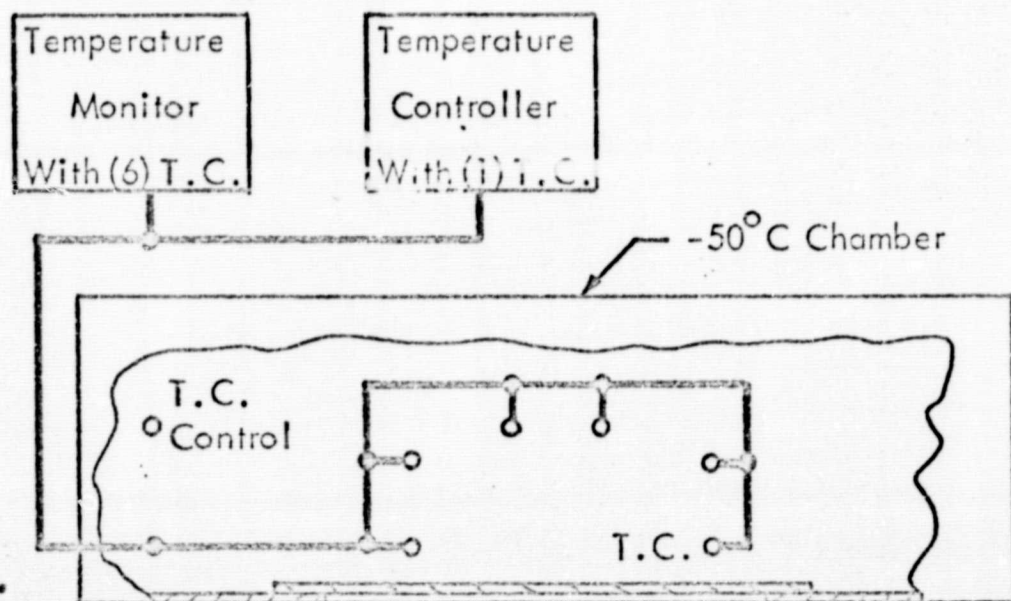
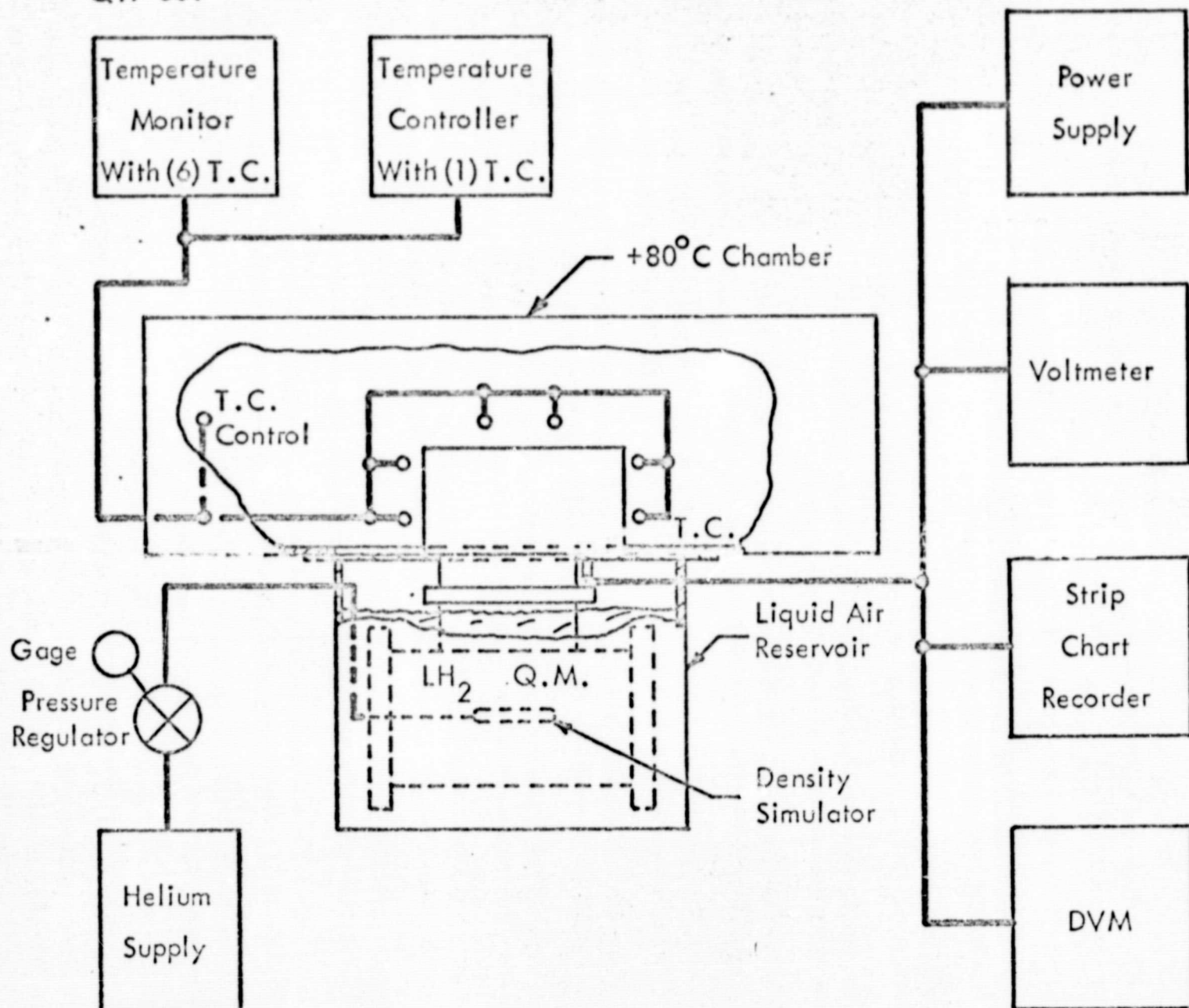


FIGURE 5 THERMAL SHOCK TEST

3.3.1.8 Pressure Regulator, Property # 59114.

3.3.2 Fixtures:

3.3.2.1 Density Simulator, Property # N6019812

3.3.2.2 End Cap, Property # N6019808.

3.3.2.3 Liquid Air Reservoir, Property # N/A.

3.3.3 Thermal Shock Test:

The electronics compartment will be subjected to an environment of rapid temperature changes from -50°C to $+80^{\circ}\text{C}$. The vent tube section will be partially submerged in a bath of liquid air throughout the test. Each cycle consists of 4 temperature steps. Test item will be cycled 10 times. Test item will be operational during the thermal shock test. Deviations of more than 150 mV will be cause for rejection.

3.3.3.1 Quality Meter Hydrogen simulation required as follows:

- (a) Pressure - Convenient and constant pressure between 14 and 55 psia.
- (b) Density - Density simulator, Property # N6019812.

3.3.3.2 Electronics compartment temperature requirements:

- (a) $80^{\circ}\text{C} \pm 3^{\circ}\text{C}$ for 30 minutes. Step 1
- (b) Laboratory ambient for 15 minutes. Step 2
- (c) $-50^{\circ}\text{C} \pm 3^{\circ}\text{C}$ for 30 minutes. Step 3
- (d) Ambient for 15 minutes. Step 4

3.3.3.3 Electronic test equipment requirement and application.

- (a) Digital Voltmeter (Para. 3.3.1.5) - output measurements.
- (b) D. C. Voltmeter (Para. 3.3.1.6) - power supply monitor.
- (c) Strip Chart Recorder (Para. 3.3.1.7) - Quality Meter output monitor.
- (d) D. C. Power Supply (Para. 3.3.1.4) - Hewlett-Packard, Model 726, Property # 616273.

3.3.3.4 Environmental Test Procedure:

"REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR."

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ITEM - TEST DATA

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Date Started 12-16-66	Test Facility GNL	Operator J.H. Dillards
Date Completed 12-17-66	Test Item STAINLESS STEEL LH2 Q.M.	Engineer J.M. Trby
Normal Lab. Temp. 25°C	Type Of Test THERMAL SHOCK	
Humidity 30%	Mfg. (INTERNAL PRESSURE 81.0"Hg THROUGHOUT TEST)	
Item Number .002-P	Test Condition PARA. 3.3.3 CYCLE (1)	

Time	Step	Output	Time	Step	Output
START			START		
9:26	3.3.3.4A	3.52	10:48	COLD 3.3.3.4E	3.55
9:31	"	3.53	10:53	"	3.53
9:36	"	3.50	10:58	"	3.58
9:41	"	3.52	11:03	"	3.54
9:46	"	3.47	11:08	"	3.46
9:51	"	3.55	11:13	"	3.56
9:56	"	3.51	11:18	"	3.50
START	Hot		START AMBIENT		
10:02	3.3.3.4C	3.50	11:19	3.3.3.4F	3.50
10:07	"	3.46	11:24	"	3.45
10:12	"	3.53	11:29	"	3.49
10:17	"	3.52	11:34	"	3.50
10:22	"	3.47			
10:27	"	3.54			
10:32	"	3.53			
START AMBIENT					
10:32	3.3.3.4D	3.53			
10:37	"	3.48			
10:42	"	3.51			
10:47	"	3.55			

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Date Started 12-16-66	Test Facility GNL	Operator J. H. Robbins
Date Completed 12-17-66	Test Item STAINLESS STEEL LH ₂ Q.M.	Engineer J. M. Irby
Normal Lab. Temp. 25°C	Type Of Test THERMAL SHOCK	
Humidity 30%	Mfg.	
Unit Number 002-P	Test Condition PARA. 3.3.3 Cycle (5)	

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Lab. Supervisor C. Whiting

ITEM - TEST DATA

Date Started 12-16-66	Test Facility GNL	Operator J. H. Dobbins
Date Completed 12-17-66	Test Item STAINLESS STEEL LH2 Q.M.	Engineer J. M. Tryby
Normal Lab. Temp. 25°C	Type Of Test THERMAL SHOCK	
Humidity 30%	Mfg.	
Unit Number 002-P	Test Condition PARA. 3.3.3. CYCLE (9)	

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- (a) Install Quality Meter vent tube in liquid air bath as shown in Figure 3. Turn on electronic equipment. After stabilization, monitor Quality Meter output each 5 minutes for 30 minutes.
- (b) Turn on both temperature environmental chambers.
- (c) After both environmental chambers have reached their selected temperatures and are stabilized install the electronics compartment in the $80^{\circ}\text{C} \pm 3^{\circ}\text{C}$ chamber.
- (d) After 30 minutes, remove the electronics compartment from the $80^{\circ}\text{C} \pm 3^{\circ}\text{C}$ chamber and store at ambient temperature.
- (e) After the electronics compartment has been at ambient temperature for 15 minutes, install the electronics compartment in the $-50^{\circ}\text{C} \pm 3^{\circ}\text{C}$ chamber.
- (f) After 30 minutes remove the electronics compartment from the $-50^{\circ}\text{C} \pm 3^{\circ}\text{C}$ chamber and store at ambient temperature.
- (g) After 15 minutes this will have completed one thermal shock cycle. Repeat these steps for a total of 10 cycles.

This completes the thermal shock test.

3.4 Humidity Test:

3.4.1 Instrumentation (as specified or equivalent) Figure 6.

3.4.1.1 Humidity Environment Chambers, Tenney Model A.
(modified for 100% humidity), Property # 510256.

3.4.1.2 Temperature Monitor, Leeds & Northrup, Type G,
with six (6) each Copper Constantan Thermocouples,
6 ft. minimum length. Leeds & Northrup Temperature
Monitor, Property # 510728.

Property # 510375-A

Property # 510375-B

Property # 510375-C

Property # 510375-D

Property # 510375-E

Property # 510375-H

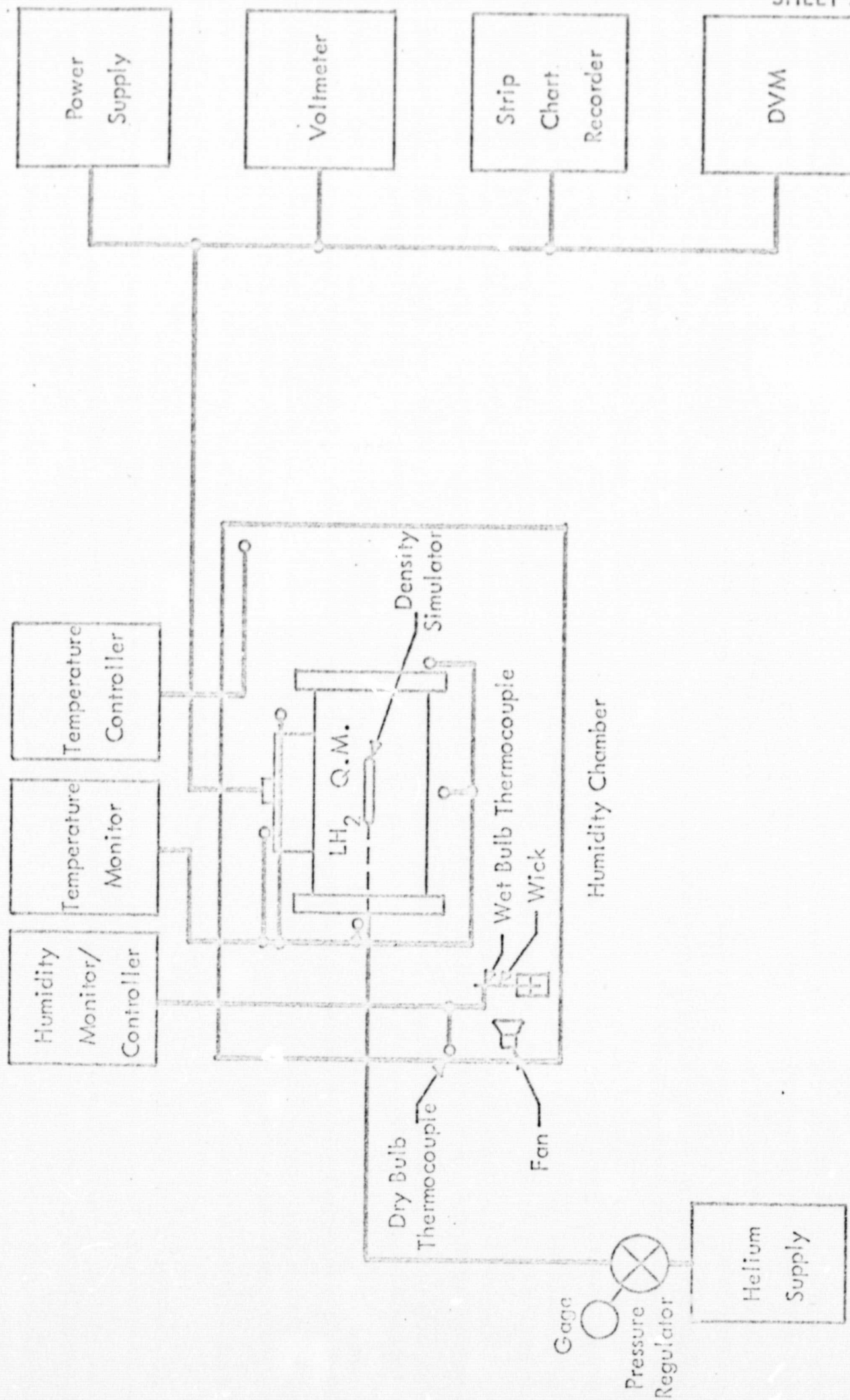


FIGURE 6 HUMIDITY TEST

- (a) Humidity Monitor, Leeds & Northrup, Type G, Property # 522573.
- (b) Copper Constantan Thermocouple wet bulb, Property # 513968.
- (c) Copper Constantan Thermocouple dry bulb, Property # 513969.
- 3.4.1.3 Ice Reference, LGNL, Property # N/A.
- 3.4.1.4 Power Supply, Hewlett-Packard, Model 726, Property # 616273.
- 3.4.1.5 Digital Voltmeter, Digited Model 7-200A, Property # 510152.
- 3.4.1.6 D. C. Voltmeter, 0-50 V, Mfg. Weston, Type 622, Property # 113531.
- 3.4.1.7 Strip Chart Recorder, Sanborn Model 152-100B, Property # 11770.
- 3.4.2 Fixture, density simulator, LGNL, Property # 119826.
- 3.4.3 Fixture, end cap seal, LGNL, Property # 11119808.
- 3.4.4 Humidity Test:

The LH₂ Quality Meter will be subjected to an environment of 98% - 100% humidity at 50°C temperature for a period of 4 hours. Quality Meter will be operational during test. Deviations of more than ± 150 mV shall be cause for rejection.

NOTE: Do not use data obtained in 3.4.4.1 (b) as base line data.

3.4.4.1 Pre-Test Requirements:

- (a) The humidity environmental equipment shall be calibrated to comply with Quality Assurance procedures.
- (b) Quality Meter shall be operated and monitored each 5 minutes for a period of 30 minutes.

3.4.4.2 Quality Meter Hydrogen simulation required as follows:

- (a) Pressure - Convenient and constant pressure between 14 and 55 psia.

(b) Density - Special fixture (Para. 3.4.2)

3.4.4.3 Quality Meter temperature requirements as follows:

(a) Humidity test, $+50^{\circ}\text{C} \pm 3^{\circ}\text{C}$ for 4 hours.

3.4.4.4 Electronic test equipment requirements and application:

(a) Digital Voltmeter (Para. 3.4.1.5) - output measurement.

(b) D. C. Voltmeter (Para. 3.4.1.6) - power supply monitor.

(c) Strip Chart Recorder (Para. 3.4.1.7) - Quality Meter output monitor.

(d) D. C. Power Supply (Para. 3.4.1.4).

3.4.4.5 Environment Test Procedure:

(a) Install Quality Meter in humidity chamber as shown in Figure 6. Set power supply voltage to 28 VDC and monitor Quality Meter output with strip chart recorder and digital voltmeter.

(b) Set humidity chamber temperature control to $50^{\circ}\text{C} \pm 3^{\circ}\text{C}$.

(c) Set humidity control to 100%.

(d) When the temperature stabilizes at $50^{\circ}\text{C} \pm 3^{\circ}\text{C}$ with the relative humidity greater than 98%, readjust the vent tube pressure to obtain an output in the 50% to 100% quality range. Monitor this output for 4 hours at $50^{\circ}\text{C} \pm 3^{\circ}\text{C}$ and 98% - 100% relative humidity. Deviations of more than $\pm 150\text{ mV}$ shall be cause for rejection.

(e) After 4 hours lower the temperature and relative humidity to laboratory ambient. Output deviations shall not be cause for rejection during this portion of test. (Detector temperature not constant).

This completes the humidity test.

3.5 Acceleration Test:

3.5.1 Instrumentation (as specified or equivalent) Figures 7A and 7B.

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Date Started 12-19-66	Test Facility GNL	Operator J. H. Debbies
Date Completed 12-19-66	Test Item STAINLESS STEEL LH2 Q.M.	Engineer J. M. Tidy
Normal Lab. Temp. 25°C	Type Of Test Humidity	
Humidity 30%	Mfg.	
Unit Number 002-P	Test Condition INTERNAL PRESS. 52.0" Hg PARA. 3.4.4	

Time	Output	Time	Output
START AMBIENT 10:15.6	3.72	12:05	3.87
10:16	3.77	12:10	3.87
10:16	3.80	12:15	3.82
10:12	3.74	12:20	3.85
10:17	3.76	12:25	3.87
10:22	3.72	12:30	3.86
CHANGING CONDITIONS		12:35	3.85
START HUMIDITY 100% 50°C 11:05	3.82	12:40	3.84
11:10	3.82	12:45	3.84
11:15	3.84	12:50	3.83
11:20	3.86	12:55	3.82
11:25	3.85	13:00	3.86
11:30	3.82	13:05	3.84
11:35	3.85	13:10	3.83
11:40	3.87	13:15	3.82
11:45	3.85	13:20	3.82
11:50	3.88	13:25	3.85
11:55	3.87	13:30	3.85
12:00	3.85	13:35	3.82

Lab. Supervisor

Inspector C. Whiting

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ITEM - TEST DATA

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Date Started 12-19-66	Test Facility GNL	Operator J. H. Dobbins
Date Completed 12-19-66	Test Item STAINLESS STEEL LH2 Q.M.	Engineer J. M. Irby
Normal Lab. Temp. 25°C	Type Of Test HUMIDITY	
Humidity 30%	Mfg.	
Unit Number 002-P	Test Condition INTERNAL PRESS. 82.0" Hg PARA. 3.44	

Time	Output	Time	Output
HUMIDITY 100% -50°C 13:46	3.84		
13:45	3.87		
13:50	3.87		
13:55	3.85		
14:00	3.86		
14:05	3.85		
14:10	3.85		
14:15	3.86		
14:20	3.87		
14:25	3.84		
14:30	3.83		
14:35	3.83		
14:40	3.86		
14:45	3.87		
14:50	3.83 3.85		
14:55	3.85		
15:00	3.85		
15:05	3.85		
COMPLETED			

Lab. Supervisor *C. M. Irby*

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- 3.5.1.1 Accelerator, ^{H/B Counter} Genisco-Model 521 A, Property #N2393.
- 3.5.1.2 D. C. Power Supply, Hewlett-Packard, Model 726, Property #Q16273.
- 3.5.1.3 Digital Voltmeter, Digitec Model Z-200A, Property #510152.
- 3.5.1.4 D. C. Voltmeter, 0-50 V, Mfg Weston, Type 622, Property #N3531.
- 3.5.1.5 Strip Chart Recorder, Sanborn Model 152-100B, Property #N770.
- 3.5.1.6 Pressure Regulator, Property #59105.
- 3.5.2 Fixtures, density, Property #N6119898.
- 3.5.3 Fixture, mounting, Property #N6019896.
- 3.5.4 Acceleration Test:

The LH₂ Quality Meter will be subjected to an environment of six (6) acceleration of 0-30 g's for 5 minute duration each. The specimen will be accelerated twice in each of its 3 axis. Quality Meter will have power supplied but not monitored for output during test. Deviation of more than ± 150 mV from pre-test output shall be cause for rejection.

3.5.4.1 Pre-Test Requirements:

- (a) The acceleration test machine shall be calibrated to comply with Quality Assurance procedures.
- (b) Quality Meter shall be operated and monitored each 5 minutes for a 30 minute period.

3.5.4.2 Quality Meter Hydrogen simulations required as follows:

- (a) Pressure - Convenient and constant pressure between 14 and 55 psia.
- (b) Density - Special fixture (Para. 3.5.2).

3.5.4.3 Environmental Test Procedure:

- (a) Each acceleration test will be conducted with $28V \pm 3V$ supplied to the test specimen as

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0-30 g's
Centrifuge

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Acceleration Monitor
Instrumentation & Control

Slip Rings

Voltmeter

Power
SupplyLH₂ Q. M.

Mounting Fixture

A

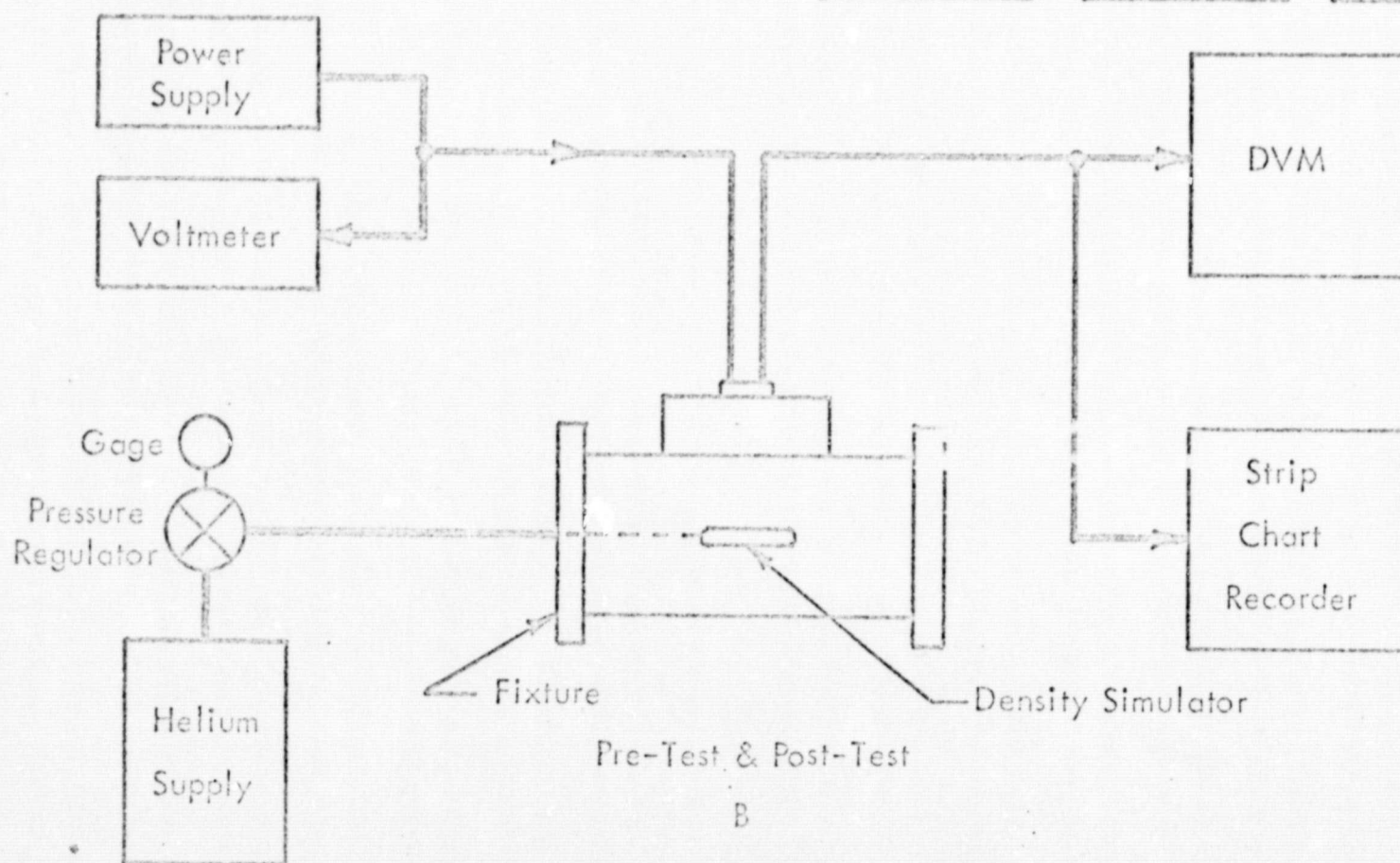


FIGURE 7 ACCELERATION TEST

shown in Figure 7A.

- (b) Install the specimen mounting fixture (Para. 3.5.3) on the accelerator.
- (c) Mount the test specimen on the mounting fixture in one of the two planes of the lateral axis. (For record purposes this will be known as the +X axis test) Accelerate for 5 minutes.
- (d) Remount the test specimen to the opposite plane of the lateral axis (-X axis). Accelerate for 5 minutes.
- (e) Remount the test specimen to one of the two planes of the vertical axis (For record purposes this will be known as the +Y axis) Accelerate for 5 minutes.
- (f) Remount the test specimen to the opposite plane of the vertical axis (-Y axis). Accelerate for 5 minutes.
- (g) Remount the test specimen to one of the two planes of the longitudinal axis (For record purposes this will be known as the +Z axis) Accelerate for 5 minutes.
- (h) Remount the test specimen to the opposite plane of the longitudinal axis (-Z axis). Accelerate for 5 minutes.
- (i) Remove the specimen from the accelerator and connect as shown in Figure 7B.
- (j) Monitor the specimen output each 5 minutes for a period of 30 minutes.

This completes the acceleration test.

3.6 Mechanical Shock

3.6.1 Instrumentation (as specified or equivalent), Figures 8A and 8B.

3.6.1.1 Shock Test Machine, AVCO Model SM010, Property #G13040.

"REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR."

ITEM - TEST DATA

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Started	Test Facility	GNL		Operator	J. H. Debbins
Completed	Test Item	STAINLESS STEEL LH2 Q.M.		Engineer	J. M. Irby
Lab. Temp:	Type Of Test	ACCELERATION			
25°C					
Moisture	Mfg.				
30%					
Item Number	Test Condition	INTERNAL PRESS. 31.0" Hg			
002-P		PARA. 3.5.4			
1-31-67	Pre-Test	2-6-67	Post-Test		
Time	Output	Time	Output		
14:55	3.45	09:12	3.63		
15:00	3.51	09:17	3.59		
15:05	3.54	09:22	3.58		
15:10	3.50	09:27	3.61		
15:15	3.48	09:32	3.53		
15:20	3.48	09:37	3.59		
15:25	3.46	09:42	3.53		
		NOTE: THESE READINGS ABOVE ARE RECORDED WITH UNIT HAVING ONLY RUN ONE AXIS (X) BOTH DIRECTION. REF: RECORD OF FAILURE SHEET.			
SECOND RUN - PRE-TEST		SECOND RUN		POST-TEST	
2-8-67		2-14-67			
15:36	3.52	09:36	3.46		
15:41	3.48	09:41	3.37		
15:46	3.60	09:46	3.46		
15:51	3.60	09:51	3.39		
15:56	3.52	09:56	3.45		
16:01	3.54	10:01	3.38		
16:06	3.51	10:06	3.48		

Lab. Supervisor

Inspector C. Whiting

- 3.6.1.2 D. C. Power Supply, Hewlett-Packard, Model 726, Property # C16273.
- 3.6.1.3 Digital Voltmeter, Digitec Model Z-200A, Property # 510152.
- 3.6.1.4 D. C. Voltmeter, 0-50 V, Mfg. Weston, Type 622, Property # N3531.
- 3.6.1.5 Strip Chart Recorder, Sanborn Model 152-10001, Property # 1700.
- 3.6.1.6 Pressure Regulator, Property # 59105.
- 3.6.2 Fixture, density, Property # 16019808.
- 3.6.3 Fixture, mounting, Property # 16019816.
- 3.6.4 Mechanical Shock Test:

The LH2 Quality Meter will be subjected to an environment of 18 mechanical shocks of 0 to 100 g's for 8 millisecond duration. The specimen will be shock tested 6 times in each of 3 axis. Quality Meter will not be monitored during test. Deviations of more than ± 150 mV from pre-test output shall be cause for rejection.

3.6.4.1 Pre-Test Requirements:

- (a) The shock test machine shall be calibrated with a dummy specimen of the same weight as the test item. Calibration will be made in accordance with Quality Assurance procedures.
- (b) Quality Meter output shall be monitored every 5 minutes for 30 minutes.

3.6.4.2 Quality Meter Hydrogen simulation requirements:

- (a) Pressure - Convenient and constant pressure between 14 and 55 psia.
- (b) Density - Special fixture, (Para. 3.6.2).

3.6.4.3 Quality Meter temperature requirements:

- (a) Ambient

3.6.4.4 Electronic test equipment application:

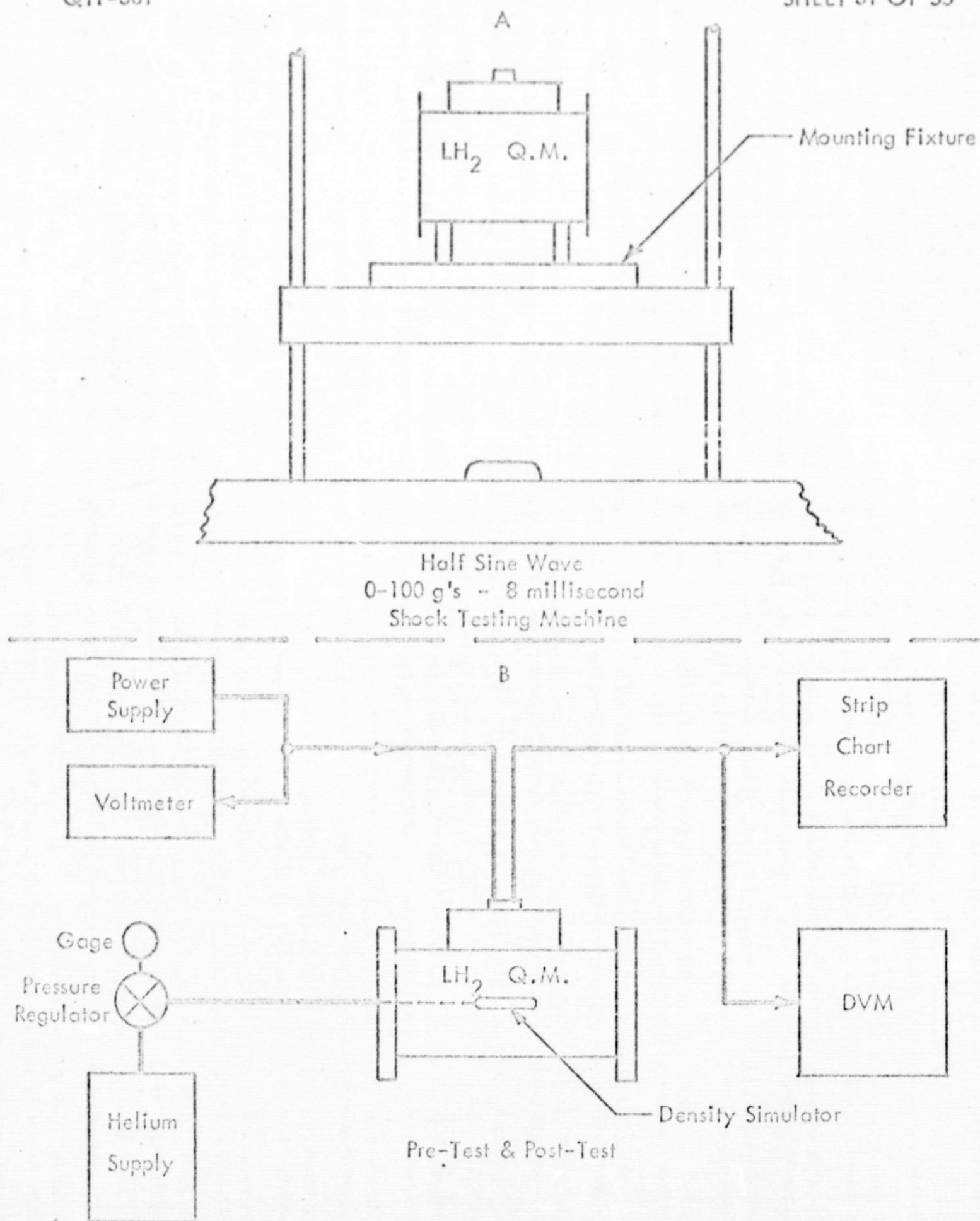


FIGURE 8 MECHANICAL SHOCK TEST

- (a) Digital Voltmeter (Para. 3.6.1.3) - output measurements.
- (b) D. C. Voltmeter (Para. 3.6.1.4) - power supply monitor.
- (c) Strip Chart Recorder (Para. 3.6.1.5) - output monitor.
- (d) D. C. Power Supply, (Para. 3.6.1.2) - 28V dc.

3.6.4.5 Environmental Test Procedures:

- (a) All shock tests will be made by raising the test specimen to the height of 25.66" inches and pushing machine test switch.
- (b) Mount the test specimen on the special test fixture (Para. 3.6.3) in one of the two planes of the lateral axis (For record purposes this will be known as the +X axis test). Shock test three (3) times.
- (c) Remount the test specimen to the opposite plane of the lateral axis (-X axis). Shock test three (3) times.
- (d) Remount the Test specimen to one of the two planes of the vertical axis (For record purposes this will be known as +Y axis). Shock test three (3) times.
- (e) Remount the test specimen to the opposite plane of the vertical axis (-Y axis). Shock test three (3) times.
- (f) Remount the test specimen to one of the two planes of the longitudinal axis (For record purposes this will be known as the +Z axis). Shock test three (3) times.
- (g) Remount the test specimen to the opposite plane of the longitudinal axis (-Z axis). Shock test three (3) times.

"REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR."

ITEM - TEST DATA

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[illegible]

Lab. Supervisor

Inoculate *C. albicans*

3.6.4.6 Post-Performance Test:

- (a) Connect Quality Meter as shown in Figure 8B.
- (b) Adjust D. C. Power Supply to $28V \pm 3V$ dc.
- (c) Let Quality Meter stabilize for 1 hour. Record output each 5 minutes.

This completes the mechanical shock test.

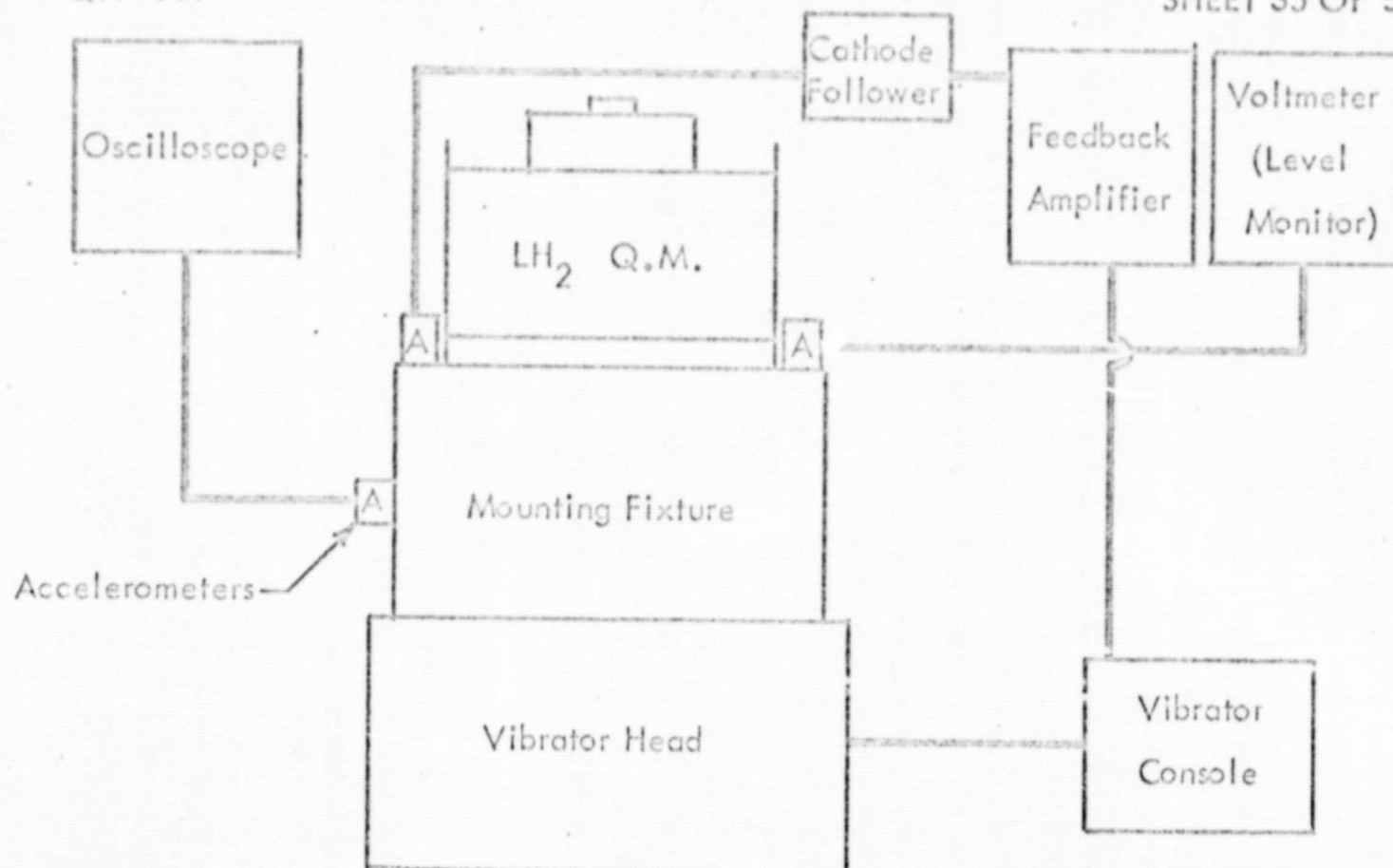
3.7 Vibration Tests:

3.7.1 Instrumentation (as specified or equivalent), Figures 7A and 9B.

- 3.7.1.1 Vibration Console, MB Electronics Manufacturing Company, Model T 251, Property # 5101285.
- 3.7.1.2 Vibration Heat, MB Electronics Manufacturing Company, Model C10D, Property # 510382.
- 3.7.1.3 Voltmeter, Ballantine 300 B (Vibration Level Monitor), Property # 510358.
- 3.7.1.4 Oscilloscope, Tektronix Model 502 (Cross-Talk Monitor), Property # 510729.
- 3.7.1.5 D. C. Power Supply, Endevco Model 2622 (Feed-Back amplifier), with Cathode Follower, Model 2208, Property # 52346.
- 3.7.1.6 Accelerometer, Endevco Model 22-15, Property # 510583.
- 3.7.1.7 Accelerometer, Endevco Model 22-15, Property # 510584.
- 3.7.1.8 Accelerometer, Endevco Model 22-15, Property # 50585.
- 3.7.1.9 D. C. Power Supply, Hewlett-Packard, Model 726, Property # E16273.
- 3.7.1.10 Digital Voltmeter, Digitec Model Z-200A, Property # 51052.

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A

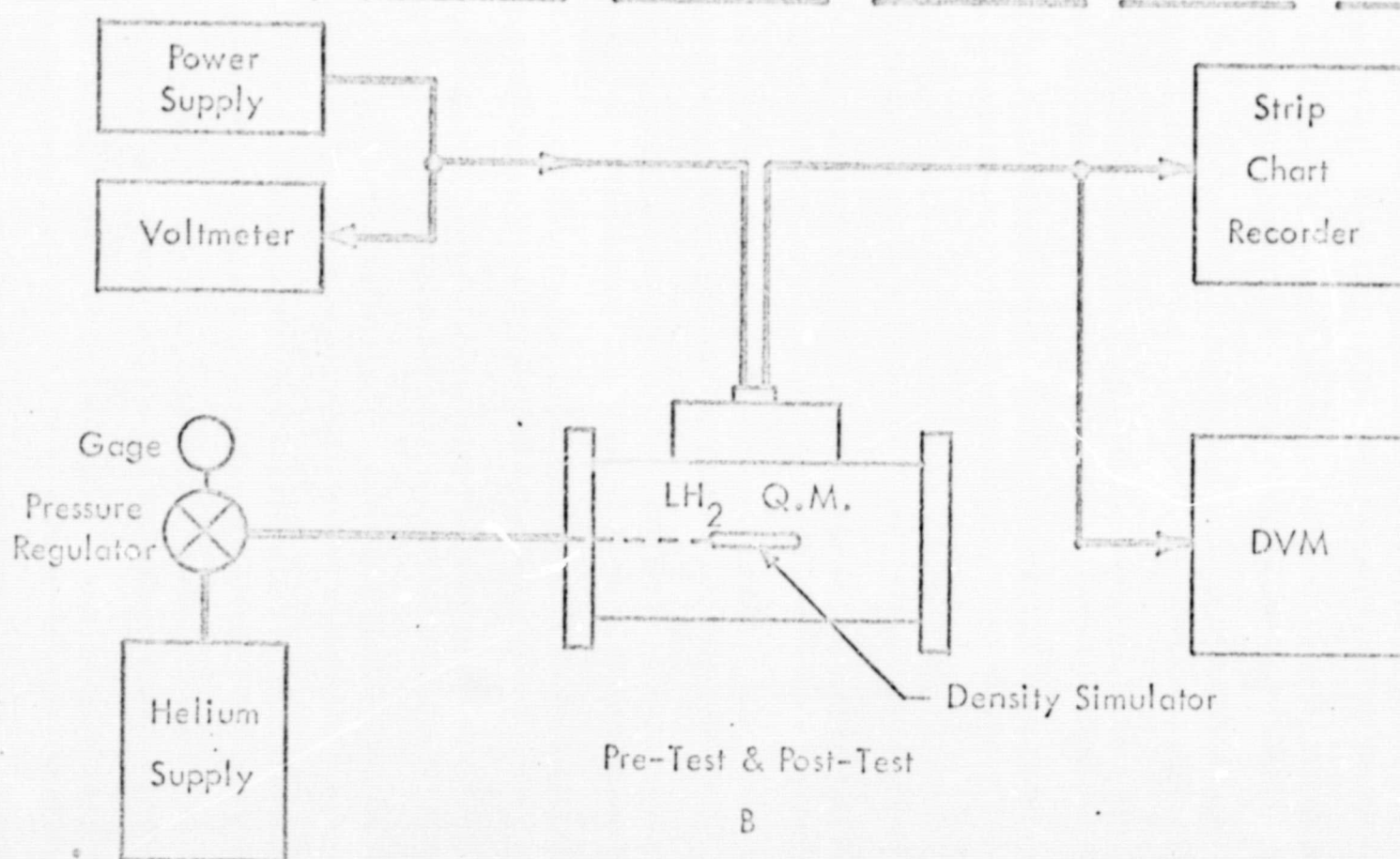


FIGURE 9 VIBRATION TEST

- 3.7.1.11 D. C. Voltmeter, 0-50 V, Mfg. Weston,
Type 622, Property # 113231.
- 3.7.1.12 Strip Chart Recorder, Sanborn Model 152-1108,
Property # 11299.
- 3.7.1.13 Pressure Regulator, Property # 59105.
- 3.7.2 Fixture, density simulator, LGNL, Property # 116019818.
- 3.7.3 Fixture, mounting, LGNL, Property # 116019816.
- 3.7.4 Vibration Test:

The Li_2 Quality Meter will be subjected to an environment of vibration as follows:

- (a) 5 to 65 hertz (Hz) at 0.04 inches D. A. displacement.
- (b) 65 to 110 Hz at 9.0 g's peak.
- (c) 110 to 200 Hz at 0.015 inches D. A. displacement.
- (d) 200 to 2000 Hz at 32 g's peak.

The frequency will be sweep logarithmically from low to high hertz's and back at the rate of one octave per minute. One complete cycle required. Specimen will have $28 \text{ V} \pm 3 \text{ V}$ dc supplied but not monitored during vibration test. Deviations of more than $\pm 150 \text{ mV}$ from pre-test output will be cause for rejection.

3.7.4.1 Quality Meter Hydrogen simulation required as follows:

- (a) Pressure - Convenient and constant pressure between 14 and 55 psia.
- (b) Density - Special fixture, (Para. 3.7.2).

3.7.4.2 Quality Meter temperature requirements:

- (a) Ambient.

3.7.4.3 Electronic test equipment application as follows:

- (a) Digital Voltmeter (Para. 3.7.1.10) - output measurements.

- (b) D. C. Voltmeter (Para. 3.7.1.11) - power supply monitor.
- (c) Strip Chart Recorder (Para. 3.7.1.12) - Quality Meter output monitor

3.7.4.4 Pre-Test Requirements:

- (a) Vibration testing equipment will be calibrated with a dummy specimen of equal weight as the Quality Meter. Calibration will be made in accordance with Quality Assurance procedure.
- (b) Specimen pre-test requirements as shown in Figure 9B.
- (c) Specimen will be monitored each 5 minutes for a period of 30 minutes.

3.7.4.5 Environmental Test Procedure:

- (a) Install specimen mounting fixture on the vibration head.
- (b) Mount the specimen on the mounting fixture in the lateral axis. (For record purposes this will be known as "X" axis.)
- (c) Set scanning speed at one (1) octave per minute.
- (d) Set power supply voltage to $28\text{ V} \pm 3\text{ V}$ dc.
- (e) For test environment of 5 hertz to 110 hertz at a constant "G" force of 9 and a displacement of 0.04 inches peak to peak set the following controls:
 - (1) Crossover control to 65 hertz.
 - (2) Acceleration to 9 g's.

- (3) Displacement to 0.04 inches peak to peak.
- (4) Scanning speed to one (1) octave per minute.
- (5) Set scanning limits, lower 5 hertz, upper 2000 hertz.
- (f) Start vibration and continue from 5 hertz to 110 hertz at one (1) octave per minute.
- (g) Stop vibration at 110 hertz. Set crossover control to 200 Hertz; set acceleration control to 32 g's; set displacement control to .015 inches D.A.. Restart vibration and continue vibrating from 110 hertz to 2000 hertz and from 2000 hertz to 110 hertz at the rate of one (1) octave per minute. Stop vibration at 110 hertz. Set crossover control to 65 hertz; set acceleration control to 9 g's; set displacement control to 0.04 inches D.A.. Restart vibration and continue vibrating from 110 hertz to 5 hertz at the rate of one (1) octave per minute.
- (h) Remount the specimen to its vertical axis (Y axis). Repeat same as lateral axis test (X axis).
- (i) Remount the specimen to its longitudinal axis (Z axis). Repeat same as lateral axis (X axis).

3.7.4.6 Post-Test:

- (a) Remove specimen and connect as shown in Figure 9B.
- (b) Monitor specimen each 5 minutes for a period of 30 minutes. Record data.

This completes the Vibration Test.

3.8 Electromagnetic Interference Test:

3.8.1 Instrumentation (as specified or equivalent).

3.8.1.1 D.C. Power Supply, Hewlett-Packard, Model 726, Property # 616273.

3.8.1.2 D.C. Voltmeter, 0-50 V, Mfg. Weston.

Type 622, Property # 11700.

3.8.1.3 Digital Voltmeter, Digitec Model Z-200A, Property # 510152.

3.8.1.4 Strip Chart Recorder, Sanborn Model 1327100A, Property # 11770.

3.8.1.5 Ground Plane, Property # N/A.

3.8.1.6 Power Line Stabilizer, Property # N/A.

3.8.1.7 Screen Room, Property # N/A.

3.8.1.8 Test Sample Leads, Property # N/A, Property # N/A.

3.8.1.9 Coax Lead, Double Shield, Property # N/A.

3.8.1.10 Interference Measuring Instruments:

(a) Stoddart Model NM 20B, Radio Interference and Field Intensity Meter 0.15 - 25 Mc, Property # 510513.

(b) Stoddart Model NM 30A, Radio Interference and Field Intensity Meter 20 - 400 Mc, Property # 510514.

3.8.1.11 Audio Oscillator, Mfg. N/A, Type N/A, Property # 510536.

3.8.1.12 Audio Power Amplifier, Mfg. N/A, LGNL, Property # 510537.

3.8.1.13 Isolation Transformer, Mfg. N/A, Type N/A, Property # N/A.

3.8.1.14 A.C. Voltmeter Broad Band, Mfg. N/A, Type N/A, Property # 510519.

3.8.1.15 Radio-Frequency Signal Source, Property # 510128.

3.8.2 Fixture, Density, Property # 116019808.

3.8.3 Electromagnetic Interference Test:

The LH₂ Quality Meter will be subjected to the following interference and susceptibility tests as prescribed in MIL16181D:

(a) Conducted Interference - 0.15 - 25 Mc.

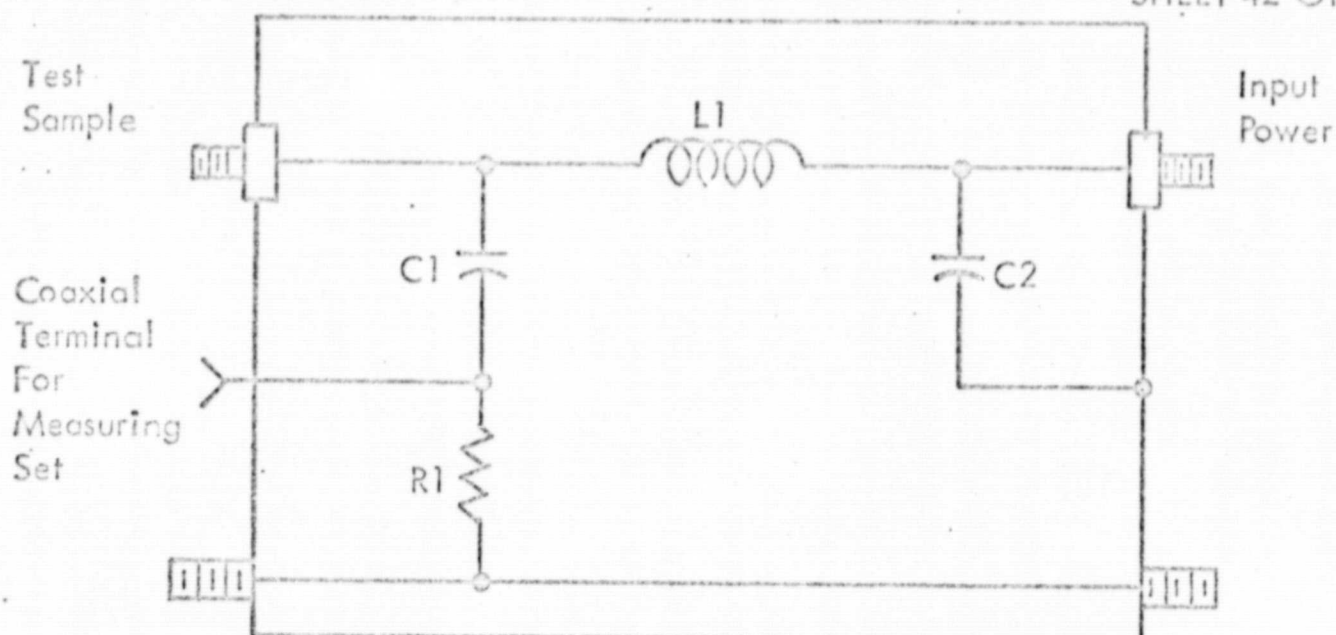
(b) Radiated Interference - 0.15 - 400 Mc.

- (c)* Conducted Susceptibility - 50 cps - 15,000 cps
and 0.15 - 400 Mc.
- (d)* Radiated Susceptibility - 0.15 - 400 Mc.
- 3.8.3.1 Pre-Test Requirements:

All test equipment shall be calibrated to comply with Quality Assurance procedures.
- 3.8.3.2 Quality Meter Hydrogen simulation required:
 - (a) Pressure - Laboratory ambient.
 - (b) Density - Special fixture, (Para. 3.8.2)
- 3.8.3.3 Quality Meter Output Loading:
 - (a) 100 k Ω $\pm$ 1% resistive.
- 3.8.3.4 Suspect Interference Frequencies:
 - (a) 1.9 kcps and odd harmonics of 1.9 kcps.
- 3.8.3.5 Environmental Test Procedure:
 - (a) The specimen will be placed in an radio-frequency shielded room on a .01 inch thick copper ground plane greater than 12 feet square and 30 inches wide. The ground plane will be bonded to the shielded room at intervals of less than 3 feet and at both ends. The top surface of the electronics box will be located 4 inches $\pm$ 1/2 inch from the edge of the ground plane.

Power input to the specimen will be applied through a power line stabilization network (Figure 10) bonded to the ground plane. The test sample leads to the stabilization network will be 24 inches $\pm$ 1 inch in length and so arranged that the distance between each lead and from each lead to ground will be 2 inches at all points more than 6 inches from the Quality Meter. The ambient interference level in the screen room will be measured with a sample specimen de-energized.

*Susceptibility measurements above 400 Mc are deleted due to the fact that the Quality Meter's electronic equipment is not capable of sensing frequencies greater than 100 Mc.



7. Resistor Data: $R1 = 1000 \text{ Ohm}$, 1 Watt Carbon
6. Capacitor Data: $C1 = .1\mu\text{F}$, 600 Volt dc, Bathtub
 $C2 = 1\mu\text{F}$, 600 Volt dc, Bathtub
5. Capacitors Shall Be Mounted On 1-Inch Insulating Blocks
4. Coil Data: $L1 = 5 \text{ Microhenries}$, 13 Turns Single Layer,
4 Inches Winding Length
3. Wire Data: Awg 6, 600 Volt, .310 Inch Dia. (OD)
2. Form Data: 5-1/4 Inches Length, 3 Inches Dia. (OD), .125 Inch
Wall Drill 3/8 Inch Hole 7/16 Inch From Each End
1. Enclosure Data: 14 Gauge (B & S) Aluminum Suggested Size
9-3/8 Inches x 4 Inches x 4 Inches

FIGURE 10 POWER LINE STABILIZATION NETWORK SCHEMATIC DIAGRAM

- (b) The specimen will be subjected to the radio interference tests in the frequency ranges specified by slowly scanning each octave and using the frequencies at which maximum interference or susceptibility occurs as test frequencies. A minimum of 3 measurements per octave will be made.

All measurements on the radio interference tests, unless otherwise noted, will be made with $28\text{ V} \pm 3\text{ V}$ dc applied to the dc input terminals through a line stabilization network.

- (c) Conducted interference measurements on the input dc power leads to the specimen will be made over a frequency range of 0.15 Mc to 25 Mc. The interference measuring instruments will be connected to the noise meter coaxial terminal on the line stabilization network. The connecting cable will be 50 ohm double-shielded coaxial cable, 6 feet long or less. Insertion losses will be neglected. Measurements will be made in accordance with Paragraph (b).

- (d) Radiated interference emitting from the specimen will be measured over a frequency range of 0.15 Mc to 400 Mc using the appropriate noise meters and antenna. A vertical rod antenna will be used for frequencies up to 25 Mc. The rod antenna will be placed so that the instrument panel or counterpoise is 6 inches below the level of the ground plane. The antenna will be located at the point where maximum interference indications are obtained when it is moved along a line parallel with the edge of the ground plane. The measuring distance from the specimens above 1 Mc will be 3 feet.

From 25 to 35 Mc, a resonant dipole antenna tuned to 35 Mc will be used for the radiated interference measurements. The dipole antenna will be positioned parallel with the front edge of the ground plane. Its height will be $12\text{ inches} \pm 1\text{ inch}$ above the level of the

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Date Started 5-12-67	Test Facility	Operator S. Johnson
Date Completed 5-12-67	Test Item 55 Quality Meter	Engineer J. M. Irby
Normal Lab. Temp. 78°F	Type Of Test Electromagnetic Interference per paragraph 3.8.3	
Humidity 32%	Mtg.	
Unit Number 5/N 0002-P	Test Condition Radiated Interference	

Frequency - Mc	Arbitrary Units	
	Noise level measured	Spec. limit
.15	71	77
.16	71	77
.18	69	77
.27	69	74
.45	63	71
.58	60	70
.85	63	69
1.75	61	69
2.5	54	68
5	56	67.5
7	53	67
10	50	67
15	47	66
25	47	66
33	40	50
60	37	51
100	35	53
150	34	55
200	34	56

Lab. Supervisor _____
Inspector C. Whiting

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Lab. Supervisor _____
Inspector C. Whiting

Date Started 5-12-67	Test Facility	Operator S. Johnson
Date Completed 5-12-67	Test Item 55 Quality Meter	Engineer J. M. Irby
Normal Lab. Temp. 78°F	Type Of Test Electromagnetic Interference per paragraph 3.8.3	
Humidity 32%	Mfg.	
Unit Number S/N 0002-P	Test Condition Conducted Interference	

Frequency - Mc	Arbitrary Units	
	Noise level measured	Noise Voltage - mV spec. limit
.15	96	115
.16	96	114.5
.22	100	107
.45	90	101
.58	84	97
.85	82	92
1.75	73	83
2.3	63	81
5.0	58	81
7.0	37	81
10.0	70	81
15.0	64	81
25.0	66	81

Lab. Supervisor

Inspector

C. Whiting

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Lab. Supervisor _____
Inspector C. Whiting

ground plane and its center adjacent to the geometrical center of the specimen under test. At least 12 inches clearance will be allowed between antenna extremities and the wall of the shielded room.

For frequencies above 35 Mc, the dipole antenna will be adjusted to the proper length so as to be tuned to the test frequencies. When the dimensions of the dipole antenna become smaller than the test layout, the antenna will be moved parallel to the edge of the ground plane to keep its sensitive elements adjacent to the point of maximum leakage. The radiated interference measurements will be performed in accordance with Paragraph (b). The noise meter coaxial terminal on the line stabilizing network will be terminated with a 50 ohm termination.

- (e) Conducted susceptibility of the specimen to radio-frequency will be tested by inserting a radio-frequency signal into the noise meter coaxial terminal of the line stabilization network. The signal level will be 100,000 μ V over a frequency range of 0.15 to 400 Mc.

The radio-frequency signal source to be used has an impedance of 50 ohms. A matching network suitable for use at the test frequencies will be used to obtain the proper source impedance. The specified voltage will be that which exists across the output terminals of the signal source when no load other than that necessary to meet the source impedance requirements is connected to the signal generator.

The conducted susceptibility test will be performed in accordance with Paragraph (b).

- (f) Conducted susceptibility of the specimens to audio frequency will be determined by applying an audio-frequency signal of 3 V rms over the frequency range of 50 to 15,000 cps to the

dc power leads of the specimen. The signal will be supplied by an audio-frequency signal generator and audio-frequency power amplifier of sufficient gain to furnish the specified level. An isolation transformer with the secondary in series with the positive dc lead to the specimen will be used to inject the audio-frequency signal. The transformer will carry all currents, including the dc when power is applied to the specimen, without saturation.

The output signal will be monitored for any malfunctions, degradation, or other effects from the introduced audio signal.

- (g) Susceptibility of the specimen to radio frequency radiation will be accomplished by similar procedures and stipulations of Paragraph (d), with the exception that radio-frequency signal sources will be used to drive the antenna. The frequency range will be 0.15 to 400 Mc, with a 100,000 μ V input signal measured at the antenna terminals.

The set-up for the 35 Mc tuned dipole antenna and the tuned dipole for frequencies above 35 Mc will be essentially the same. But for the rod antenna used with frequencies below 25 Mc, it will be necessary to have a 20 inch square counterpoise mounted on the antenna base. The counterpoise will be held at the proper level and bonded to the ground plane. Also proper termination at both ends of the 50 ohm cable connecting the rod antenna and signal generator will be necessary. Resistive pads will be used as required for the proper termination.

The specimen output will be monitored for any effects of the radio frequency fields.

This completes the Electromagnetic Interference Test.

3.9 LH₂ Calibration Check Test:

- 3.9.1 Instrumentation (as specified or equivalent) Figure 11.
- 3.9.1.1 D.C. Power Supply, Hewlett-Packard, Model 726, Property # 616273.
 - 3.9.1.2 D.C. Voltmeter, 0-50 V, Mfg. Western, Type 622, Property # N/A.
 - 3.9.1.3 Digital Voltmeter, Digitec Model Z-200A, Property # 510152.
 - 3.9.1.4 Strip Chart Recorder, Sanborn Model 152-100A, Property # N770.
 - 3.9.1.5 Beta Gage Test Section, LGNL, Property # 520538.
 - 3.9.1.6 Preamplifier, Tennelec Model 100A, Property # N/A.
 - 3.9.1.7 D.C. Power Supply (Preamp. Filaments and B⁺), Property # 510459.
 - 3.9.1.8 D.C. Power Supply, Hewlett-Packard, Model 711A, Property # 510382.
 - 3.9.1.9 Linear Amplifier, ORTEC, Model 201, Property # N/A.
 - 3.9.1.10 One Mc Scale, RIDL, Model 210, Property # 510257.
 - 3.9.1.11 Gas Flow Measuring Orifice, LGNL, Property # 61520.
 - 3.9.1.12 Gas Flow Differential Pressure Transducer, ± 60 psid, Statham, Model N/A, Property # 61559.
 - 3.9.1.13 Pressure Transducer Voltage Divider, LGNL, Property # N/A.
 - 3.9.1.14 Liquid Flow Measuring Orifice, LGNL, Property # 510258.
 - 3.9.1.15 Liquid Flow Differential Pressure Transducer, $\pm$ psid, Statham, Model N/A, Property # 61543.
 - 3.9.1.16 Pressure Transducer Voltage Divider, LGNL, Property # N/A.
 - 3.9.1.17 Beta Gage Test Section Pressure Transducer, Statham,

Model N/A, Property # 510329

- 3.9.1.18* Quality Meter Gaging Section, Pressure Transducer, Statham, Model N/A, Property # 510330.
- 3.9.1.19 Beta Gage Pressure Transducer Voltage Divider, LGNL, Property # N/A.
- 3.9.1.20 Quality Meter Pressure Transducer Voltage Divider, LGNL, Property # N/A.
- 3.9.1.21 Gas Flow Readout, Leeds & Northrup, Speedomax G, Property # 510128.
- 3.9.1.22 Liquid Flow Readout, Leeds & Northrup, Speedomax G, Property # 510129.
- 3.9.1.23 Beta Gage Pressure Readout, Leeds & Northrup, Speedomax G, Property # 510131.
- 3.9.1.24 Quality Meter Pressure Readout, Leeds & Northrup, Speedomax G, Property # 510132.
- 3.9.1.25 Liquid Hydrogen Test System, LGNL.

3.9.2 Calibration Check Test:

The Liquid Hydrogen Quality Meter will be placed inside an evacuated enclosure along with a beta gage calibration section. Liquid and gaseous hydrogen will be vented to the atmosphere through the beta gage and Quality Meter. The output of the Quality Meter will be monitored continuously. Beta counts will be taken at not less than ten different qualities between 50% and 100%. At each calibration point the Quality Meter output and pressure*, beta gage count and pressure and total hydrogen flow will be recorded. Hydrogen Quality will be calculated from the Quality Meter data and the beta gage data, and the Quality readings compared. Deviation of more than 5% Quality in the 50 - 100% quality range shall be cause for rejection.

*Quality Meter Gaging Section Pressure will be measured only on the first specimen tested. Since the quality readout is an integrated signal consisting of pressure and count rate, if pressure is known, then count rate can be established and compared to count rate in the beta gage calibration section. Any change in quality between the calibration section and Quality Meter due to pressure drop, flashing due to heat input, or any other variable between the two units would thereby be indicated.

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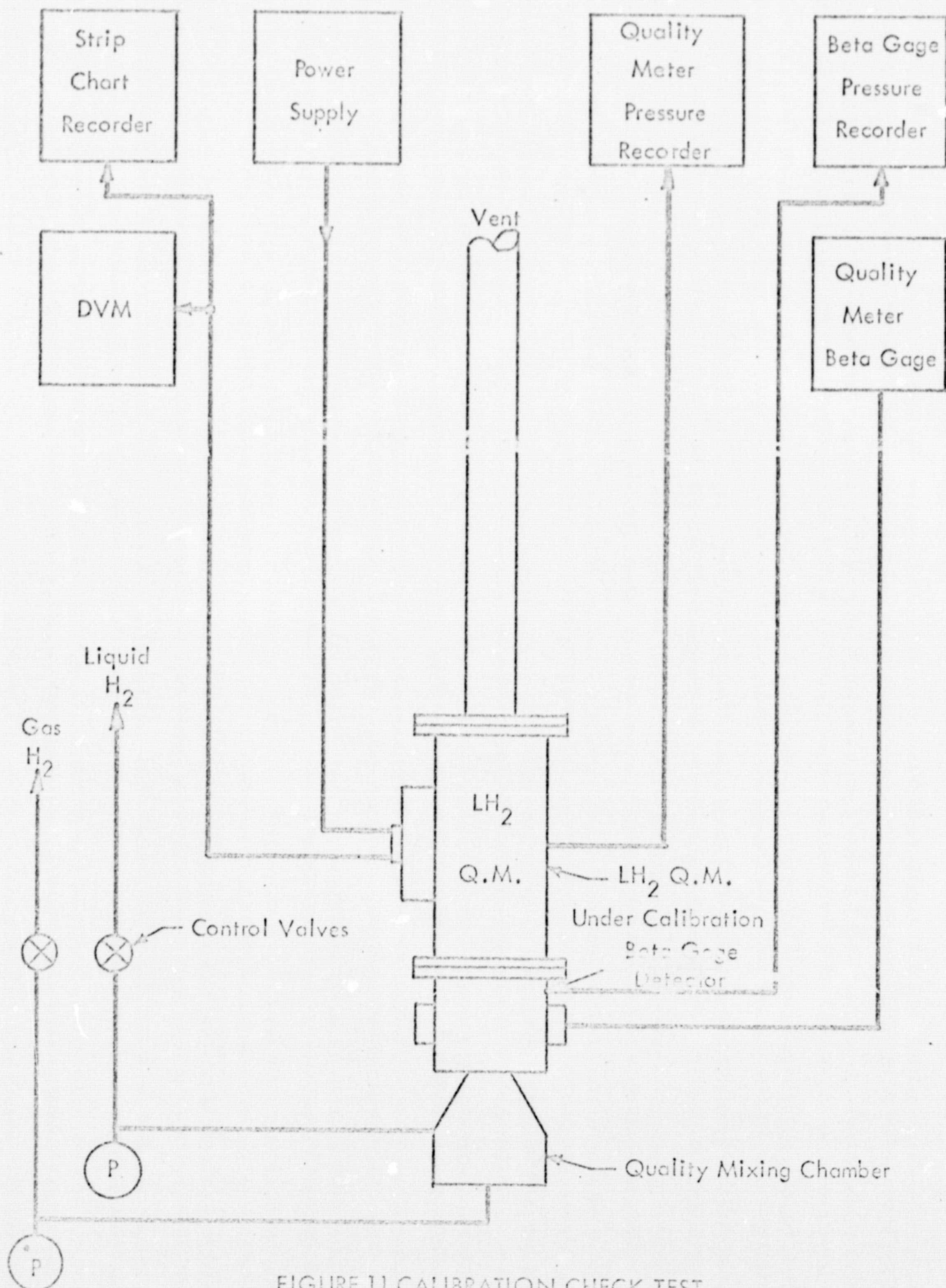


FIGURE 11 CALIBRATION CHECK TEST

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR.

QTP-301

ITEM - TEST DATA

SHEET 53 OF 55

Date Started 3-22-68	Test Facility 6Hz Facility	Operator S. B. Moore
Date Completed 3-22-68	Test Item SS Quality meter	Engineer H. H. Nichols
Normal Lab. Temp. 75°F	Type Of Test Calibration check per paragraph 3.9.2	+ S. B. Moore
Humidity 60%	Mfg.	
Unit Number 5/N 0002-P	Test Condition	

[illegible]

Lab. Supervisor,

Inspector T. F. Sanger

3.9.3 Pre-Test Requirement:

Calibrate instrumentation to comply with Quality Assurance Procedures.

3.9.4 Calibration Check Procedure:

3.9.4.1 Install Quality Meter in Hydrogen vent line and connect to instrumentation as shown in Figure 11.

3.9.4.2 Close and evacuate the test tank. Apply 28 ± 3 V dc to Quality Meter. Turn on all electronic instrumentation to allow warm-up.

3.9.4.3 When the test tank pressure reaches approximately 30 microns of mercury, open Hydrogen control valves to allow liquid and gaseous Hydrogen flow. Adjust flow of liquid and gas to give a combined flow of .08 to .4 pounds mass per second.

3.9.4.4 Allow flow rates and beta gage pressure to stabilize for 30 seconds. Record output of Quality Meter for 1 minute and simultaneously obtain a 1 minute beta count from the beta gage. Record beta gage pressure. At the end of the 1 minute period, turn off all Hydrogen flow and calculate the Hydrogen quality from the beta gage data. Calculate the Hydrogen quality from output data of Quality Meter. Record the two qualities on the data sheet.

3.9.4.5 Repeat the procedure to obtain data at 10 different Hydrogen qualities between 50% and 100%.

This completes the LH_2 Calibration Check Test.

3.10 Inspection (Quality Assurance Provisions)

3.10.1 New Units- Quality Assurance shall assure the tests specified in this QTP are performed and that the equipment meets the requirements specified herein.

3.10.2 In the event rework is required, Article 7.0 of Quality Assurance Plan, NQD 5001, will be adhered to.

3.10.3 One copy of the completed QTP shall be shipped with the Quality Meter and one copy shall be placed in LGNL files.

3.10.4 Inspect for finish, workmanship, required identification, and

dimensional conformance to reference drawings.

3.10.5 Verify that the Quality Meter weighs less than 15 pounds.

Part No.	_____	Test Engineer	<u>J. M. Trby</u>
Serial No.	<u>0002-P</u>	Operator	<u>T. H. Debbias</u>
Date	<u>4-1-68</u>	Inspector	<u>C. Whiting</u>

APPENDIX G

QTP-301 FOR UNIT 001-P

Revisions			
Sym	Description	Date	Approval

Next Assy

Used on

Application

Original Release Date

Date 4-1-68

4-1-68

Chk/Supv. H.H. Nichols

Engrg W.B. Blodsee

Engrg T. J. Duncan

Engrg

Engrg

Approved

W. L. Walker

Engrg

Q.A. J. F. Songer

TEST PROCEDURE
(Approval Sheet)

LH₂ QUALITY METER

S/N 001-F

Scale None

Lockheed-Georgia Co.
A Division of Lockheed
Aircraft Corporation
Lockheed Georgia
Nuclear Laboratory
Dawsonville, Georgia

QUALIFICATION
QTP-301

Code

Sheet 2 of 55

1. REFERENCE

- 1.1 NASA Contract NAS8-20518

2. GENERAL DESCRIPTION

- 2.1 Function - The LH
- ₂
- Quality Meter measures the ratio of the mass of gaseous Hydrogen to the total mass of liquid Hydrogen and gaseous Hydrogen. The meter is a section of the vent tube and meters the quality of Hydrogen vented.

The output voltage is from 0 to 5 volts and is capable of modulating satellite telemetry systems.

- 2.2 The Qualification tests consists of nine (9) separate parts:

- 2.2.1 Temperature Cycle
- 2.2.2 Pressure Cycle
- 2.2.3 Thermal Shock
- 2.2.4 Humidity
- 2.2.5 Acceleration
- 2.2.6 Mechanical Shock
- 2.2.7 Vibration
- 2.2.8 Electromagnetic Interference Test
- 2.2.9 LH₂ Calibration Check Test
- 2.2.10 Inspection (Quality Assurance Provisions)

- 2.3 Pre-environmental tests consist of two (2) parts:

- 2.3.1 Repeatability:

- 2.3.1.1 Instrumentation (as specified or equivalent).

- (a) D. C. Power Supply, Property # 616273.
- (b) Strip Chart Recorder, Property # Not used.
- (c) Digital Voltmeter, Property # 510152.
- (d) D. C. Voltmeter, Property # N3531.
- (e) Pressure Gage, Property # 59113.

(f) Pressure Regulator, Property # 59105.

2.3.1.2 Fixtures:

- (a) Density Simulator, Property # N/A 30" Hg Freon
 (b) End Cap Seals, Property # Constant throughout test.
NL019812, and
 Property # NL019808.

2.3.1.3 Test Procedure:

- (a) Install end cap seals and density simulator and purge vent tube helium.
 (b) Connect Quality Meter to instrumentation as shown in Figure 1. Monitor Quality Meter output with 28 VDC power supply voltage.
 (c) When Quality Meter output has stabilized, vary the vent tube internal pressure to simulate a different quality between 50% and 100%. Adjust the pressure to five different values and record the output at each pressure. Monitor the Quality Meter output for 30 minutes at the final pressure. Repeat each pressure and record Quality Meter output at each pressure. Quality Meter output must duplicate the output at each pressure within $\pm 1\%$.

Pressure	<u>10.4" Hg</u>	Output	<u>2.56 V</u>
Pressure	<u>14.0" Hg</u>	Output	<u>2.83 V</u>
Pressure	<u>20.0" Hg</u>	Output	<u>3.26 V</u>
Pressure	<u>30.0" Hg</u>	Output	<u>4.06 V</u>
Pressure	<u>40.0" Hg</u>	Output	<u>4.87 V</u>
Pressure	<u>10.4" Hg</u>	Output	<u>2.56 V</u>
Pressure	<u>14.0" Hg</u>	Output	<u>2.83 V</u>
Pressure	<u>20.0" Hg</u>	Output	<u>3.28 V</u>
Pressure	<u>30.0" Hg</u>	Output	<u>4.07 V</u>
Pressure	<u>40.0" Hg</u>	Output	<u>4.87 V</u>

2.3.2 Response Time:

2.3.2.1 Instrumentation (as specified or equivalent)

- (a) D. C. Power Supply, Property # 616273.
 (b) Digital Voltmeter, Property # 510152.

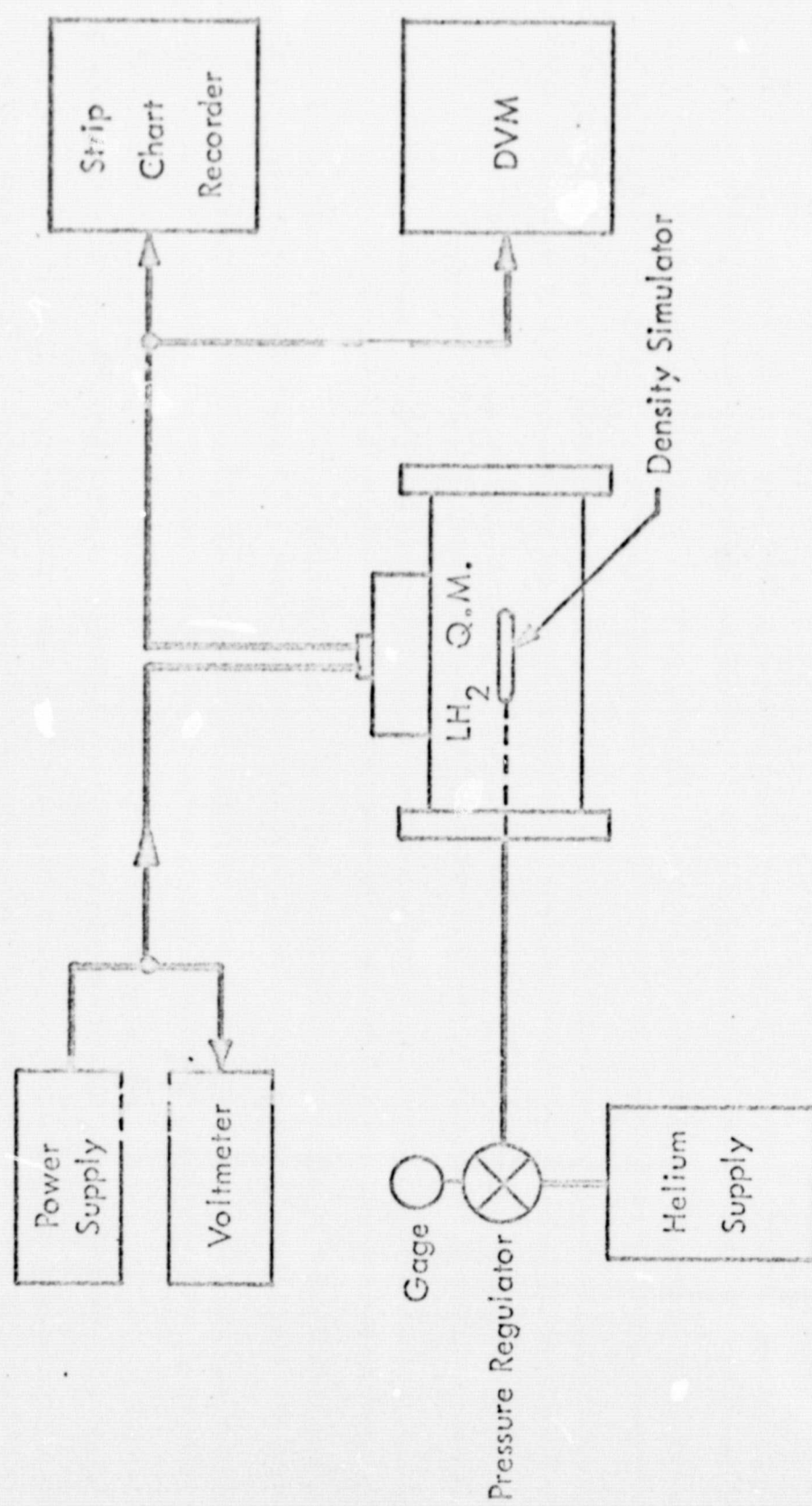


FIGURE 1 REPEATABILITY TEST

- (c) D. C. Voltmeter, Property # N/3531.
- (d) Oscilloscope, Property # N/1273;
- (1) Pre-amp, Property # 214359.
- (2) Camera, Property # N/656.

2.3.2.2 Fixtures:

- (a) Density Simulators, Property # 019826,
Property # N/A.

2.3.2.3 Test Procedure:

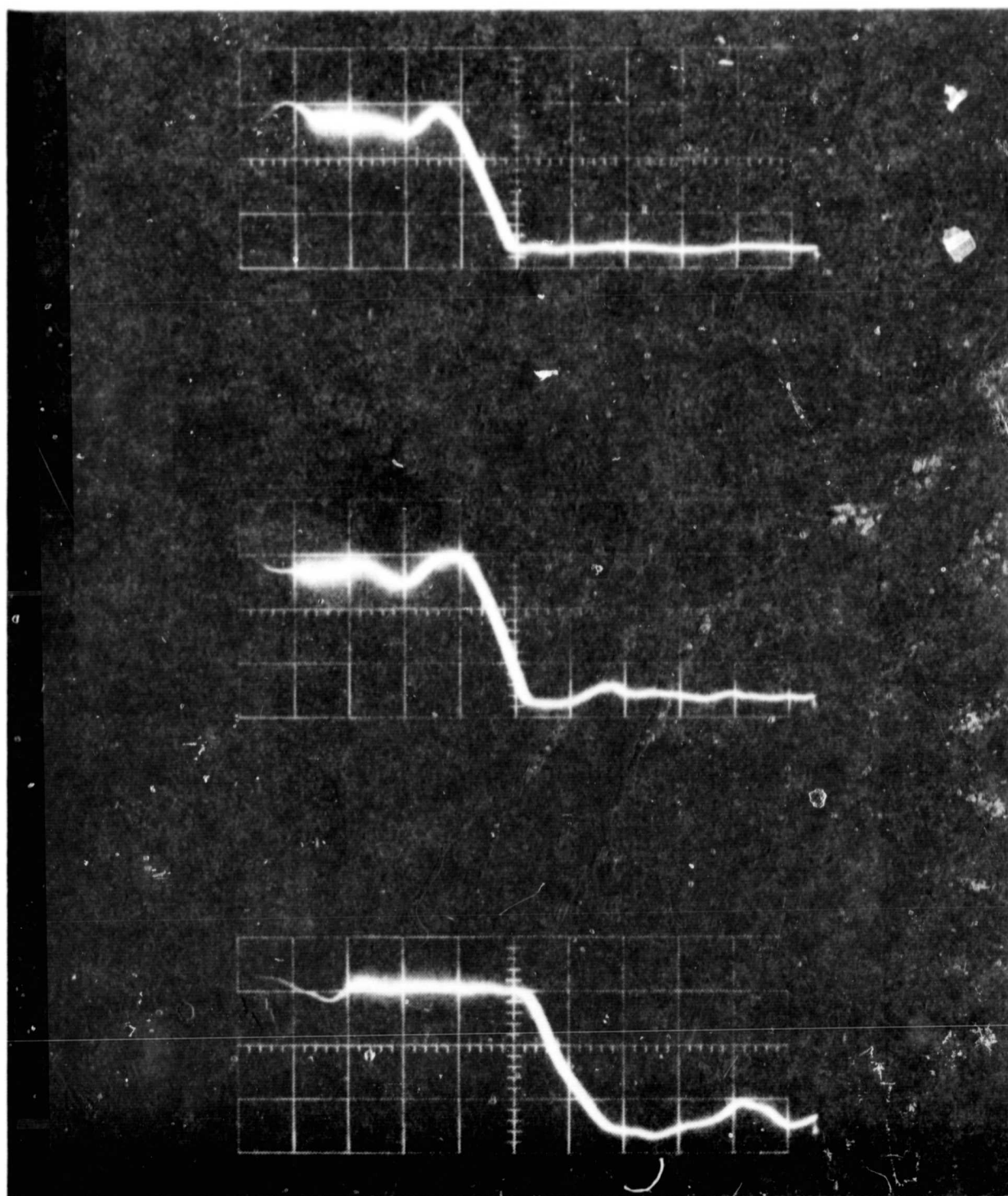
- (a) Connect Quality Meter to instrumentation as shown in Figure 2. Adjust density simulators to provide an output equal to $50\% \pm 5\%$ quality. Allow Quality Meter to stabilize for 30 minutes.
- (b) After 30 minutes stabilization, remove a density simulator from the venturi and trigger the oscilloscope sweep within 10 milliseconds or less. Obtain a pictorial record of the Quality Meter output change. The change must be more than $[\ .63 \times \text{the final value } (100\% \pm \frac{0}{5})]$ after 100 milliseconds.

3. TEST FACILITIES

3.1 Temperature Cycle Test:

3.1.1 Instrumentation (as specified or equivalent) Figure 3.

- 3.1.1.1 Temperature Chamber, American Instrument Co., Model 4-3356, Property # 611732.
- 3.1.1.2 Temperature Controller, Leeds & Northrup, Type G, Property # N/1785.
- 3.1.1.3 Temperature Monitor, Leeds & Northrup, Type G, 1.5 mV span, -10 to +10 mV range, with six (6) each Copper Constantan Thermocouples, 6 ft. minimum length. Temperature Monitor Property # N/1543.
 Property # 510345A Control
 Property # 510345B
 Property # 510345C
 Property # 510345D
 Property # 510345E
 Property # 510345F
 Property # 510345G



RESPONSE TIME PER PARAGRAPH 2.3.2.3

100 ms/cm

1 volt/cm With 10 to 1 Probe

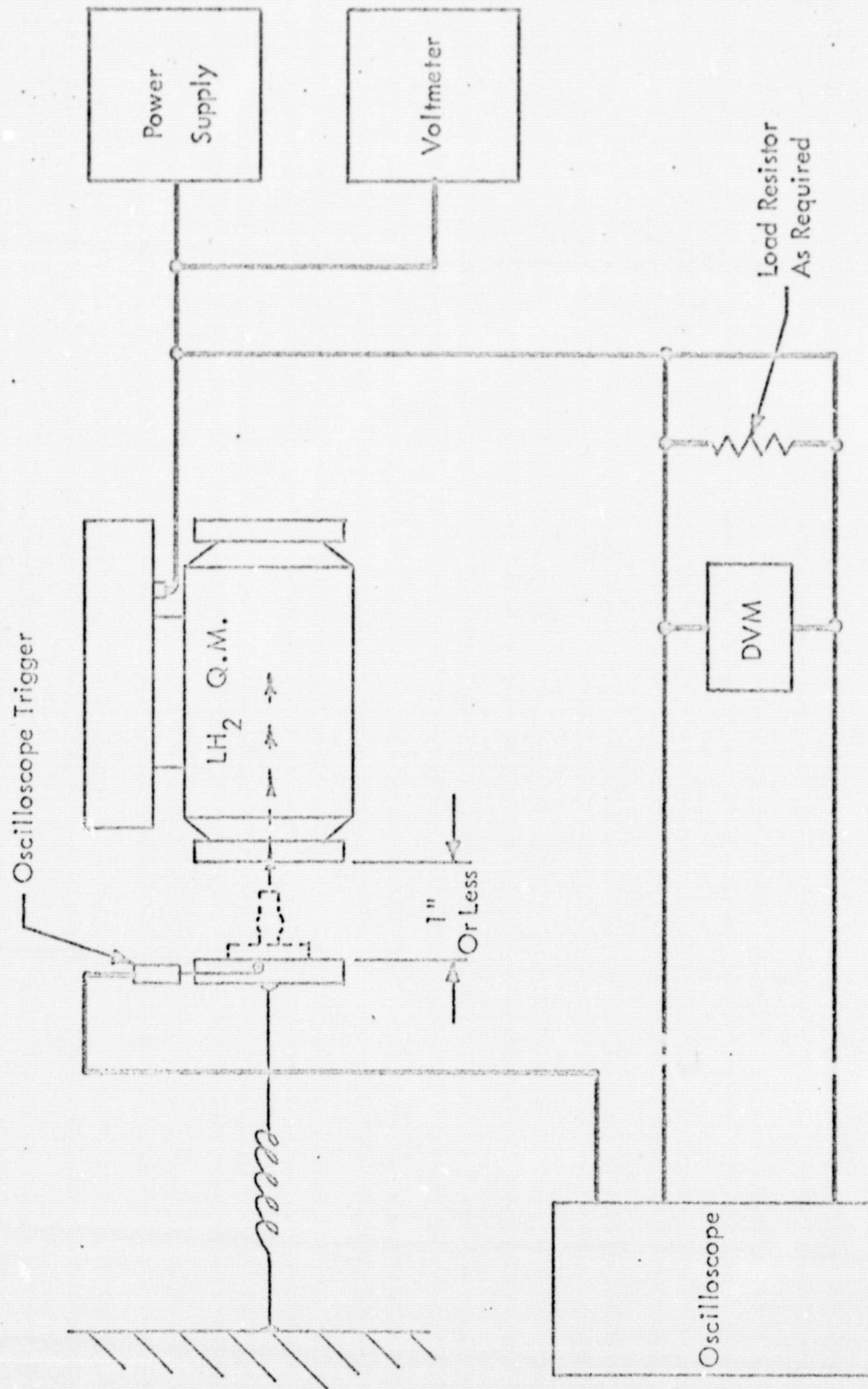
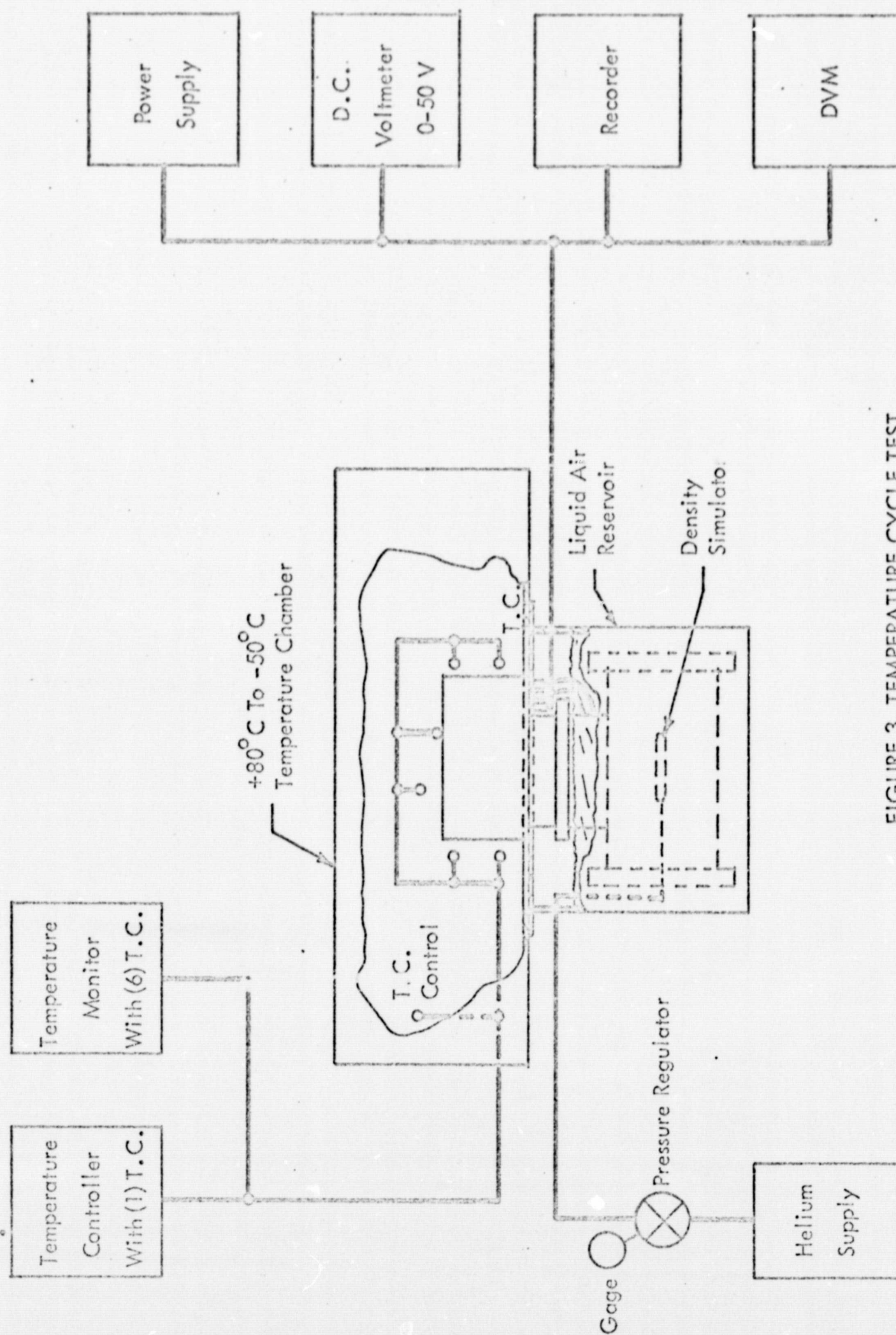


FIGURE 2 RESPONSE TIME TEST



- 3.1.1.4 Ice Reference, LGNL, Property # N/A.
- 3.1.1.5 Liquid Air Reservoir, Property # N/A.
- 3.1.1.6 Pressure Regulator, Property # 59114.
- 3.1.1.7 CO₂ Supply, LGNL, Property # N/A.
- 3.1.1.8 D. C. Power Supply, Hewlett-Packard, Model 726, Property # 616273.
- 3.1.1.9 Recorder, 2-channels, Sanborn Model 152-100B, Property # N720.
- 3.1.1.10 Digital Voltmeter, Digitec Model Z-200A. Property # 510152.
- 3.1.1.11 D. C. Voltmeter, Property # N3531.
- 3.1.2 Fixtures, LGNL, Property # N4019808; N4019812.
- 3.1.3 Temperature Cycle Test:

The LH₂ Quality Meter will be subjected to an environment of temperatures from $-50^{\circ}\text{C} \pm 3^{\circ}\text{C}$ to $+80^{\circ}\text{C} \pm 3^{\circ}\text{C}$. Specimens will be monitored during testing. Deviation of more than ± 150 mV shall be cause for rejection.

- 3.1.3.1 Quality Meter Hydrogen simulation required as follows:
 - (a) Convenient and constant pressure between 14 and 55 psia.
 - (b) Density - Special fixture with a determined attenuation constant.
- 3.1.3.2 Quality Meter temperature requirements as follows:
 - (a) Vent tube - Partially submerged in liquid air throughout test.
 - (b) Electronic compartment - Cycled between -50°C and $+80^{\circ}\text{C}$.
- 3.1.3.3 Temperature monitoring - The following are points of temperature measurements:
 - (a) Electronics Enclosure Box - 5 thermocouples in surrounding air, 1 thermocouple contacting box top.
- 3.1.3.4 Electronic test equipment application:

- (a) Digital Voltmeter (Para. 3.1.1.10) - output measurements.
- (b) D. C. Voltmeter (Para. 3.1.1.11) - power supply monitor.
- (c) Strip Chart Recorder (Para. 3.1.1.9) - Quality Meter output.

3.1.3.5 Environmental Test Procedure:

- (a) Connect LH₂ Quality Meter as shown in Figure 3.
- (b) Set D. C. Power Supply output to $28V \pm 3V$ dc.
- (c) Record ambient temperature and pressure.
- (d) After test equipment has stabilized, record output voltage of Quality Meter. Record temperature for ambient reference.
- (e) Lower air temperature in temperature chamber to $-50^{\circ}C \pm 3^{\circ}C$.
- (f) Record Quality Meter output each 5 minutes until desired temperature is reached. Record air temperature indicated.
- (g) When the air temperature reaches $-50^{\circ}C \pm 3^{\circ}C$, let Quality Meter remain at this temperature for a minimum of 30 minutes. Take output readings every 5 minutes.
- (h) After 30 minutes at $-50^{\circ}C \pm 3^{\circ}C$, raise the chamber air temperature to $+80^{\circ}C \pm 3^{\circ}C$. Record output and air temperature each 5 minutes.
- (i) Let electronics box remain at $80^{\circ}C \pm 3^{\circ}C$ for 1 1/2 hours. Record output each 5 minutes.
- (j) Reduce temperature to ambient.
- (k) When air temperature reaches ambient, allow electronics box temperature to stabilize for 30 minutes. Record output every 5 minutes.

This completes the temperature cycle test.

3.2 Pressure Cycle Test:

Date Started 1-20-67	Test Facility	Operator J. H. Doherty
Date Completed 1-20-67	Test Item Aluminum Quality meter s/n 001 P	Engineer J. M. Erby
Normal Lab. Temp. 70°F	Type Of Test Temperature Cycle per paragraph 31.3.5	
Humidity 32%	Mfg.	
Unit Number s/n 001 P	Test Condition	

Input Volts	Time	Temp.	Output Volts	Time	Temp.	Output Volts	Time	Temp.	Output Volts
28.0	1035	Ambient	3.33	1210	78°C	3.31	1345	80°C	3.38
28.0	1040	0°C	3.37	1215	80°C	3.31	1350	cooling	
28.0	1045	-20°C	3.26	1220	80°C	3.33	1355	cooling	
28.0	1050	-35°C	3.28	1225	80°C	3.36	1400	cooling	
28.0	1055	-50°C	3.27	1230	80°C	3.33	1415	Amb	3.40
28.0	1100	-50°C	3.26	1235	80°C	3.35	1410	Amb	3.40
28.0	1105	-50°C	3.28	1240	80°C	3.36	1415	Amb	3.38
28.0	1110	-50°C	3.25	1245	80°C	3.35	1420	Amb	3.41
28.0	1115	-50°C	3.26	1250	80°C	3.36	1425	Amb	3.38
28.0	1120	-50°C	3.25	1255	80°C	3.34	1430	Amb	3.40
28.0	1125	-50°C	3.26	1300	80°C	3.38	1435	Amb	3.44
28.0	1130	-35°C	3.23	1305	80°C	3.34			
28.0	1135	-15°C	3.25	1310	80°C	3.36			
28.0	1140	0°C	3.24	1315	80°C	3.36			
28.0	1145	20°C	3.24	1320	80°C	3.37			
28.0	1150	40°C	3.21	1325	80°C	3.37			
28.0	1155	55°C	3.24	1330	80°C	3.33			
28.0	1200	65°C	3.26	1335	80°C	3.33			
28.0	1205	75°C	3.28	1340	80°C	3.36			

Lab. Supervisor _____
Inspector C. Whiting

3.2.1 Instrumentation (as specified or equivalent) Figure 4.

3.2.1.1 Evacuation System; LGNL 24-inch vacuum system, Property # 329.(a) Ionization gauge, cold cathode, NRC equipment, Type 0724, Property # 59105.(b) Ionization gauge and thermocouple gauge, Veeco RG31A, Property # 59105.3.2.1.2 Pressure gauge, 0-100 psi, Mfg. Kellman, Type B08395, Property # 59113.

3.2.1.3 Hydrogen regulated supply, LGNL.

3.2.1.4 D. C. Power Supply, Hewlett-Packard, Model 726, Property # 616223.3.2.1.5 Digital Voltmeter, Digitec Model Z-200A, Property # 510152.3.2.1.6 D. C. Voltmeter, Property # 113531.3.2.1.7 Recorder, strip chart, Sanborn Model 152-100B, Property # 11720.3.2.2 Fixtures, LGNL, Property # 116018812, Density simulator.3.2.3 Fixture, LGNL, Property # 116018808, End cap seal.

3.2.4 Pressure Cycle Test:

The LH₂ Quality Meter will be subjected to an environment of internal pressure from laboratory ambient to 55 psia in vent tube and external pressure of 2×10^{-7} psia to ambient on outer structures. Test shall be operational. The Quality Meter output will be corrected to laboratory ambient pressure and density. Deviations of more than ± 150 mV in the corrected output shall be cause for rejection.

3.2.4.1 Quality Meter Hydrogen simulation required as follows:

(a) Pressure:

(1) Vent tube laboratory ambient to 55 psia internal.

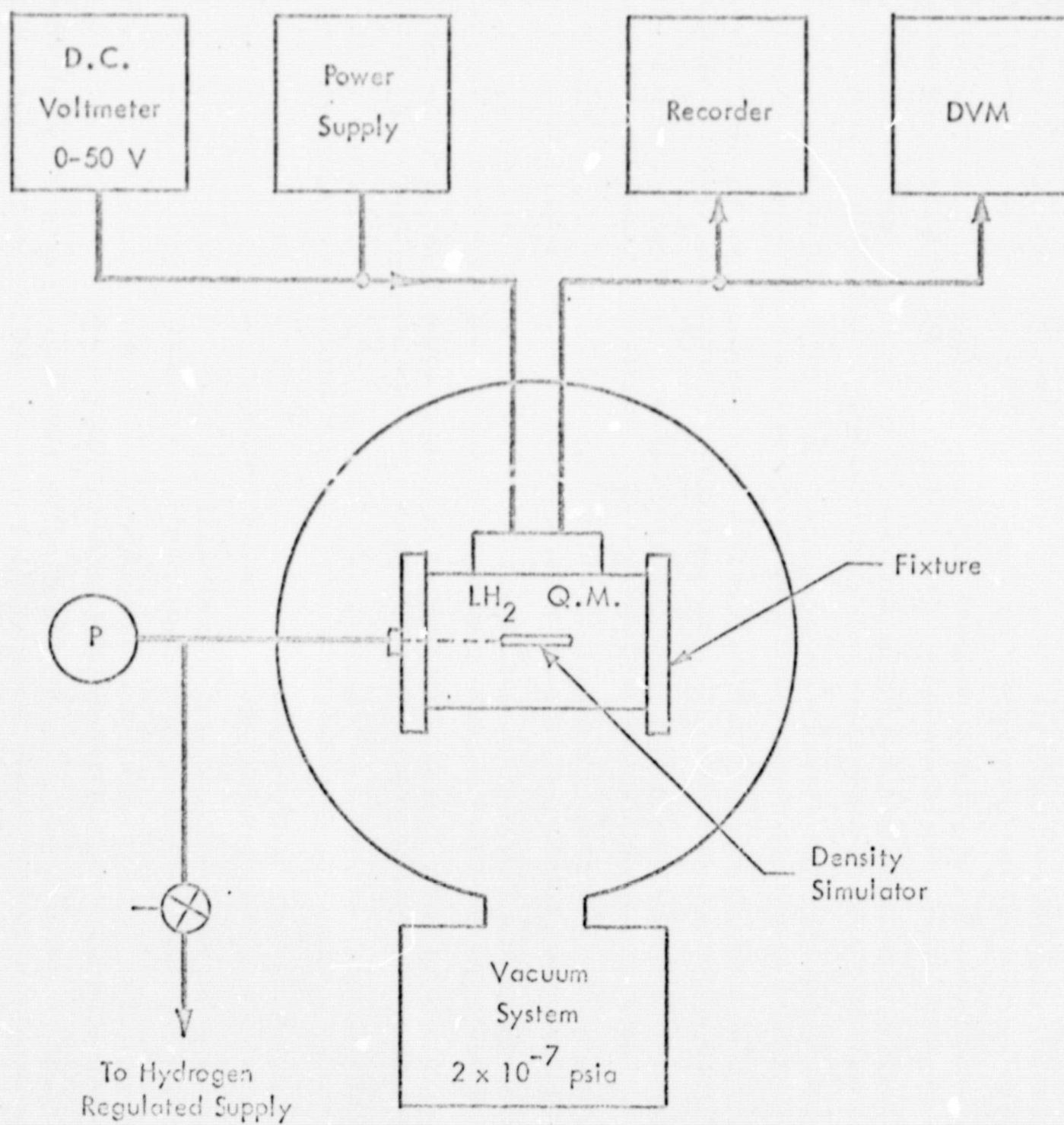


FIGURE 4 PRESSURE CYCLE TEST

- (2) External vent tube structure 2×10^{-7} psia (.01 microns of mercury) to ambient pressure.
- (b) Density - Special fixture. (Para. 3.2.2)
- 3.2.4.2 Quality Meter temperature requirements: Laboratory ambient.
- 3.2.4.3 Electronic equipment applications:
 - (a) Digital Voltmeter (Para. 3.2.1.5) - output measurements.
 - (b) D.C. Volimeter (Para. 3.2.1.6) - power supply monitor.
 - (c) Strip chart recorder (Para. 3.2.1.7) - output monitoring.
- 3.2.4.4 Environmental Test Procedure:
 - (a) Install cap seal fixture (Para. 3.2.3) and density simulator fixture (Para. 3.2.2).
 - (b) Install Quality Meter and connect as shown in Figure 4.
 - (c) Adjust D.C. Power Supply output to $28 \text{ V} \pm 3 \text{ V dc}$.
 - (d) Record ambient temperature and ambient pressure.
 - (e) After test equipment has stabilized, record the Quality Meter output for ambient internal and external pressure. Condition for 15 minutes minimum. Record data each 5 minutes.
 - (f) After the ambient pressure test, apply 55 ± 2 psia internal to vent tube in 5 or more steps at a rate pressure change not to exceed 2 psia/second. When 55 ± 2 psia is obtained, maintain pressure for a minimum of 30 minutes. Record pressure and Quality Meter output for each pressure step and each 5 minutes at 55 ± 2 psia.
 - (g) Reduce vent tube pressure at a rate not to exceed 8 psia/second. Record Quality Meter

- output at ambient pressure.
- (h) With vent tube internal pressure at ambient (line vented) start vacuum system (Para. 3.2.1.1)
 - (i) Take pressure and Quality Meter output data at 1000 microns of mercury and each decade lower or reading each 5 minutes, whichever is less, until an external pressure of 2×10^{-7} psia (.01 microns of mercury) is reached.
 - (j) At a pressure of 2×10^{-7} psia (.01 microns of mercury) let Quality Meter stabilize for 30 minutes. Record data each 5 minutes.
 - (k) After 30 minutes at an external pressure of 2×10^{-7} psia, apply internal pressure to vent tube of Quality Meter in 5 steps of pressure. Pressure rate change not to exceed 2 psia/second. Record Quality Meter output, and indicated pressures.
 - (l) When internal vent pressure is 55 ± 2 psia, let the Quality Meter stabilize for 30 minutes. Record all data each 5 minutes.
 - (m) After 30 minutes stabilization, reduce vent tube internal pressure from 55 ± 2 psia to ambient pressure at a rate not to exceed 8 psia/second.
 - (n) When vent tube internal pressure has reached ambient pressure, let the Quality Meter stabilize for 20 minutes. Record Quality Meter output and ambient pressure every 5 minutes.
 - (o) After 20 minutes, close off all vacuum valves and vent the pressure chamber to ambient pressure at an optional rate.
 - (p) After Quality Meter has reached ambient internal and external pressures, let Quality Meter stabilize for 30 minutes. Record ambient temperatures, pressure, and humidity. Record Quality Meter output every 5 minutes.

This completes the Pressure Cycle Test.

Date Started 1-23-67	Test Facility	Operator T.H. Dehkin
Date Completed 1-24-67	Test Item Aluminum Quality Meter	Engineer J.M. Erby
Normal Lab. Temp. 81°F	Type Of Test Pressure Cycle per paragraph 3.2.44.	
Humidity 34%	Mfg.	
Unit Number 5/w 001-P	Test Condition	

Time	Vent Tube Pressure External	Vent Tube Pressure Internal	Quality Meter Output Volts	Time	Vent Tube Pressure External	Vent Tube Pressure Internal	Quality Meter Output Volts
1-23-67 1042	Amb	Amb	1.33	1413	Amb	Amb	1.39
1046	Amb	Amb	1.34	1418	1000 Man	Amb	1.25
1051	Amb	Amb	1.34	1423	850 Man	Amb	1.25
1313	Amb	Amb	1.34	1428	800 Man	Amb	1.31
1318	Amb	Amb	1.34	1433	750 Man	Amb	1.32
1323	Amb	Amb	1.34	1438	650 Man	Amb	1.32
1328	Amb	Amb	1.34	1443	600 Man	Amb	1.31
1331	Amb	62.5" Hg	2.63	1448	550 Man	Amb	1.31
1334	Amb	80.6" Hg	3.35	1453	500 Man	Amb	1.31
1335	Amb	90.1" Hg	3.74	1458	500 Man	Amb	1.32
1336	Amb	100.0" Hg	4.12	1503	500 Man	Amb	1.32
1340	Amb	110.9" Hg	4.61	1508	470 Man	Amb	1.32
1345	Amb	112.0" Hg	4.60	1513	470 Man	Amb	1.32
1350	Amb	112.1" Hg	4.61	0842 1-24-67	.002 Man	Vented	1.33
1355	Amb	112.1" Hg	4.59	0846	.002 Man	Vented	1.33
1400	Amb	112.1" Hg	4.58	0851	.002 Man	Vented	1.33
1405	Amb	112.1" Hg	4.59	0856	.002 Man	Vented	1.33
1410	Amb	112.1" Hg	4.58	0901	.002 Man	Vented	1.33
				0906	.002 Man	Vented	1.33

Lab. Supervisor

Inspector

C. Whiting

Date Started	Test Facility	Operator
Date Completed	Test Item	Engineer
Normal Lab. Temp.	Type Of Test	
Humidity	Mfg.	
Unit Number	Test Condition	

Time	Vent Tube Pressure External	Vent Tube Pressure Internal	Quality Meter Output Volts	Time	Vent Tube Pressure External	Vent Tube Pressure Internal	Quality Meter Output Volts
0911	.002 P _m	Vented	1.33	1048	Vented	Vented	1.30
0912	.002 P _m	62.0" Hg	2.65	1053	Vented	Vented	1.30
0913	.002 P _m	80.4" Hg	3.40	1058	Vented	Vented	1.30
0914	.002 P _m	90.0" Hg	3.77	1103	Vented	Vented	1.30
0915	.002 P _m	100.0" Hg	4.15	1108	Vented	Vented	1.30
0917	.002 P _m	112.3" Hg	4.65				
0922	.002 P _m	112.3" Hg	4.65				
0927	.002 P _m	112.3" Hg	4.63				
0932	.002 P _m	112.3" Hg	4.62				
0937	.002 P _m	112.3" Hg	4.63				
0942	.002 P _m	112.3" Hg	4.63				
0947	.002 P _m	112.3" Hg	4.63				
0952	.002 P _m	Vented	1.33				
0957	.002 P _m	Vented	1.32				
1002	.002 P _m	Vented	1.32				
1007	.002 P _m	Vented	1.32				
1012	.002 P _m	Vented	1.32				
1058	Vented	Vented	1.32				
1043	Vented	Vented	1.31				

Lab. Supervisor _____
Inspector Whiting

3.3 Thermal Shock Test:

3.3.1 Instrumentation (as specified or equivalent) Figure 5A and 5B.

3.3.1.1 Temperature Environmental Chamber, American Instrument Co., Model 4-3356, Property # 611232.

- (a) Temperature Controller, Leeds & Northrup, Type G, (with a Copper Constantan Thermocouple), Property # N1285.
- (b) Temperature Monitor, Leeds & Northrup, Type G, Property # N1243.
- (c) Copper Constantan Thermocouples

Property # 510345-B Property # 510345-E
 Property # 510345-C Property # 510345-F
 Property # 510345-D Property # 510345-G

- (d) CO₂ System, LGNL, Property # N/A.

3.3.1.2 Ice Reference, LGNL, Property # N/A, Property # N/A.3.3.1.3 Temperature Environmental Chamber, American Instrument Co., Model 4-3356, Property # 611233.

- (a) Temperature Controller, Leeds & Northrup, Type G, (with a Copper Constantan Thermocouple), Property # N1265.
- (b) Temperature Monitor, Leeds & Northrup, Type G, Property # N1803.
- (c) Copper Constantan Thermocouples

Property # 510375-A Property # 510375-D
 Property # 510375-B Property # 510375-E
 Property # 510375-C Property # 510375-H

3.3.1.4 D.C. Power Supply, Hewlett-Packard, Model 726, Property # 616273.3.3.1.5 Digital Voltmeter, Digitec Model Z-200A, Property # 510152.3.3.1.6 D.C. Voltmeter, Property # 413131.3.3.1.7 Recorder, 2-channels, Sanborn Model 112-1100, Property # N1770.

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SHEET 18 OF 35

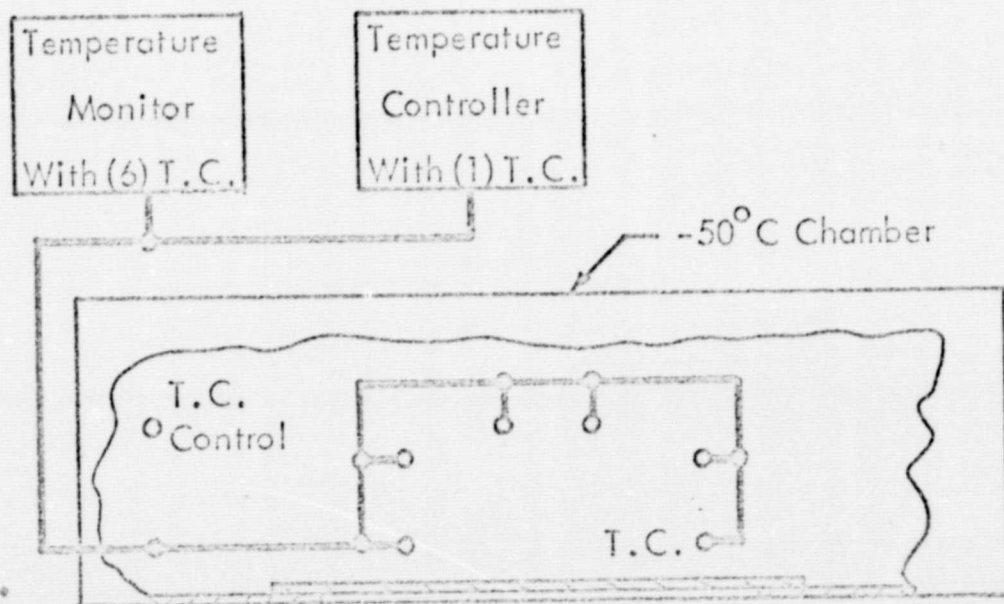
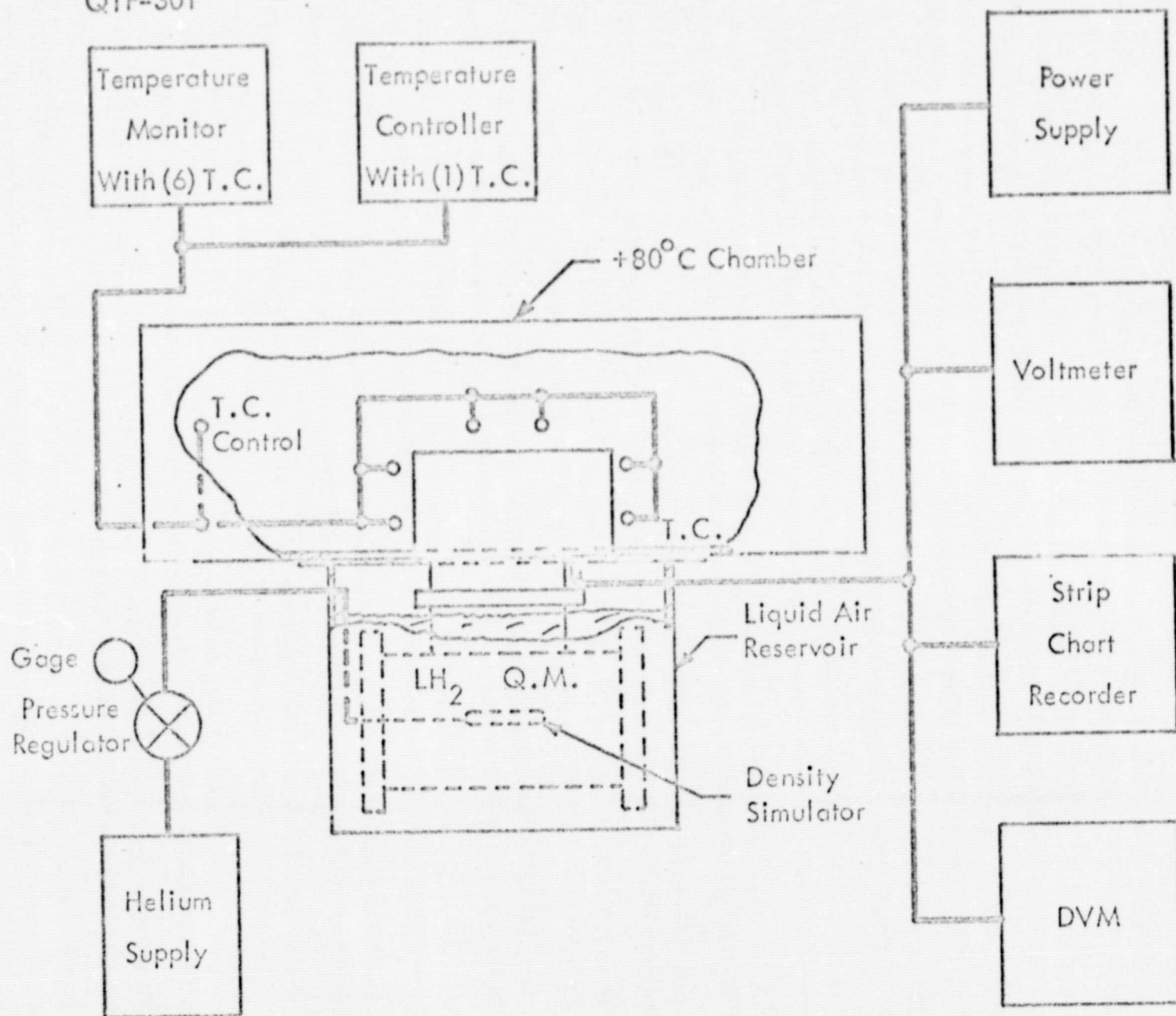


FIGURE 5 THERMAL SHOCK TEST

3.3.1.8 Pressure Regulator, Property # 59114.

3.3.2 Fixtures:

3.3.2.1 Density Simulator, Property # N6019812.

3.3.2.2 End Cap, Property # N6019808.

3.3.2.3 Liquid Air Reservoir, Property # N/A.

3.3.3 Thermal Shock Test:

The electronics compartment will be subjected to an environment of rapid temperature changes from -50°C to $+80^{\circ}\text{C}$. The vent tube section will be partially submerged in a bath of liquid air throughout the test. Each cycle consists of 4 temperature steps. Test item will be cycled 10 times. Test item will be operational during the thermal shock test. Deviations of more than 150 mV will be cause for rejection.

3.3.3.1 Quality Meter Hydrogen simulation required as follows:

- (a) Pressure - Convenient and constant pressure between 14 and 55 psia.
- (b) Density - Density simulator, Property # N6019812.

3.3.3.2 Electronics compartment temperature requirements:

- (a) $80^{\circ}\text{C} \pm 3^{\circ}\text{C}$ for 30 minutes. Step 1
- (b) Laboratory ambient for 15 minutes. Step 2
- (c) $-50^{\circ}\text{C} \pm 3^{\circ}\text{C}$ for 30 minutes. Step 3
- (d) Ambient for 15 minutes. Step 4

3.3.3.3 Electronic test equipment requirement and application.

- (a) Digital Voltmeter (Para. 3.3.1.5) - output measurements.
- (b) D. C. Voltmeter (Para. 3.3.1.6) - power supply monitor.
- (c) Strip Chart Recorder (Para. 3.3.1.7) - Quality Meter output monitor.
- (d) D. C. Power Supply (Para. 3.3.1.4) - Hewlett-Packard, Model 726, Property # G16273.

3.3.3.4 Environmental Test Procedure.

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ITEM - TEST DATA

SHEET 20 OF 55

Date Started 1-25-67	Test Facility Cycle (1)	Operator T.H. Debbins
Date Completed	Test Item ALUM. MODEL LH2 Q.M.	Engineer T.M. Trby
Normal Lab. Temp. 78°F	Type Of Test THERMAL SHOCK	
Humidity 31%	Mfg. PARA. 3.3	
Unit Number C01-P	Test Condition BAR. PRESS. 29.27" Hg INTERNAL PRESS. 82.1" Hg (81.6-82.7" Hg)	

Time	Step	Output	Time	Step	Output
START 0910	AMBIENT 3.3.3.4A	3.37	START 10129	COLD 3.3.3.4E	3.41
0915	"	3.37	10134	"	3.35
0920	"	3.36	10139	"	3.35
0925	"	3.37	10144	"	3.34
0930	"	3.37	10149	"	3.33
0935	"	3.35	10154	"	3.32
0940	"	3.32	10159	"	3.31
START 0942	HOT 3.3.3.4C	3.42			
0947	"	3.34			
0952	"	3.35			
0957	"	3.38			
1002	"	3.38			
1007	"	3.39			
1012	"	3.39			
START 1013	AMBIENT 3.3.3.4D	3.39			
1018	"	3.38			
1023	"	3.39			
1028	"	3.39			

Lab. Supervisor

Inspector

C. Whitling

Date Started 1-25-67	Test Facility CYCLE (3)	Operator J. J. Debbins
Date Completed	Test Item ALUM. MODEL 2H2 Q.M.	Engineer J. M. Irby
Normal Lab. Temp. 81°F	Type Of Test THERMAL SHOCK	
Humidity 34%	Mfg. PARA. 3.3	
Unit Number 001-P	Test Condition INTERNAL PRESS. ^{cap.} 82.0 "Hg	

Time	Step	Output	Time	Step	Output
START 12:34	AMBIENT 3.3.3.4 F	3.31	START 13:38	COLD 3.3.3.4 E	3.32
12:39	"	3.28	13:43	"	3.36
12:44	"	3.28	13:48	"	3.34
12:49	"	3.31	13:53	"	3.36
START 12:50	HOT 3.3.3.4 C	3.29	13:58	"	3.34
12:55	"	3.31	14:03	"	3.29
13:00	"	3.33	14:08	"	3.31
13:05	"	3.34			
13:10	"	3.36			
13:15	"	3.35			
13:20	"	3.36			
START 13:21	AMBIENT 3.3.3.4 D	3.34			
13:26	"	3.37			
13:31	"	3.38			
13:36	"	3.37			

Lab. Supervisor
Inspector C. M. H. J.

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ITEM -- TEST DATA

SHEET 20^D Of 55

Date Started 1-25-67	Test Facility CYCLE (4)	Operator J. H. Dobbins
Time Completed	Test Item ALUM. MODEL LH2 Q.M.	Engineer J. M. Irby
Normal Lab. Temp. 81°F	Type Of Test THERMAL SHOCK	
Humidity 34%	Mfg. PARA-3.3	
Unit Number 001-P	Test Condition INTERNAL PRESS. 82.0" Hg	

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Lab. Supervisor

Inspector

C. Whiting

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ITEM - TEST DATA

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Date Started 1-25-67	Test Facility CYCLE (5)	Operator J. H. Dobbins
Date Completed	Test Item ALUM. MODEL LH2 Q.M.	Engineer J. M. Irby
Normal Lab. Temp. 81°F	Type Of Test THERMAL SHOCK	
Humidity 39%	Mfg. PARA. 3.3	
Lot Number C31-P	Test Condition	

Time	Step	Output	Time	Step	Output
START 15:47	AMBIENT 23.34 F	3.29	START 16:50	COLD 3.33.4E	3.36
15:52	"	3.31	16:55	"	3.34
15:57	"	3.32	17:00	"	3.33
16:02	"	3.31	17:05	"	3.33
START 16:03	HOT 23.34 C	3.33	17:10	"	3.31
16:08	"	3.31	17:15	"	3.30
16:13	"	3.34	17:20	"	3.28
16:18	"	3.24			
16:23	"	3.34			
16:28	"	3.35			
16:33	"	3.34			
START 16:34	AMBIENT 23.34 D	3.31			
16:39	"	3.34			
16:44	"	3.25			
16:49	"	3.33			
16:54					

Inspector

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Lab. Supervisor _____
Inspector *E. J. L. King*

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ITEM - TEST DATA

SHEET 204 OF 55

Date Started 1-25-67	Test Facility CYCLE (8)	Operator J.H. Dobbins
Date Completed	Test Item ALUM. MODEL 2H2 Q.M.	Engineer J.M. Erby
Normal Lab. Temp. 80°F	Type Of Test THERMAL SHOCK	
Humidity 32%	Mfg. PARA. 3.3	
Unit Number 001-P	Test Condition	

Time	Step	Output	Time	Step	Output
START 20:29	AMBIENT 2.3.3.4F	3.30	START 21:32	COLD 3.3.3.4E	3.34
20:34	"	3.28	21:37	"	3.35
20:39	"	3.27	21:42	"	3.34
20:44	"	3.28	21:47	"	3.36
START 20:45	HOT 2.3.3.4C	3.27	21:52	"	3.32
20:50	"	3.30	21:57	"	3.31
20:55	"	3.36	22:02	"	3.29
21:00	"	3.36			
21:05	"	3.34			
21:10	"	3.36			
21:15	"	3.37			
START 21:16	AMBIENT 2.3.3.4D	3.31			
21:21	"	3.35			
21:26	"	3.35			
21:31	"	3.36			

 Lab. Supervisor
 Inspector

C. Whiting

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ITEM - TEST DATA

SHEET 20 OF 55

Date Started 1-25-67	Test Facility CYCLE (10)	Operator J.H. Dobbins
Date Completed 1-26-67	Test Item ALUM. MODEL LH2 QM	Engineer J.M. Dobbins
Normal Lab. Temp. 80°F	Type Of Test THERMAL SHOCK	
Humidity 32%	Mfg. PARA. 3.3	
Lot Number 001-P	Test Condition	

Time	Step	Output	Time	Step	Output
23:28	START AMBIENT 3.3.3.4F	3.30	00:41	START COLD 3.3.3.4F	3.34
23:43	"	3.30	00:46	"	3.37
23:49	"	3.31	00:51	"	3.34
23:53	"	3.32	00:56	"	3.34
23:57	START HOT 3.3.3.4C	3.30	01:01	"	3.32
23:59	"	3.32	01:06	"	3.29
00:04	"	3.33	01:11	"	3.29
00:09	"	3.36	01:12	START AMBIENT 3.3.3.4F	3.29
00:14	"	3.37	01:17	"	3.28
00:19	"	3.35	01:22	"	3.26
00:24	"	3.36	01:27	"	3.25
00:25	START AMBIENT 3.3.3.4D	3.35			
00:30	"	3.36		COMPLETED	
00:35	"	3.36		1-26-67	
00:40	"	3.34			

Lab. Supervisor

Inspector

C. Dobbins

- (a) Install Quality Meter vent tube in liquid air bath as shown in Figure 3. Turn on electronic equipment. After stabilization, monitor Quality Meter output each 5 minutes for 30 minutes.
- (b) Turn on both temperature environmental chambers.
- (c) After both environmental chambers have reached their selected temperatures and are stabilized install the electronics compartment in the $80^{\circ}\text{C} \pm 3^{\circ}\text{C}$ chamber.
- (d) After 30 minutes, remove the electronics compartment from the $80^{\circ}\text{C} \pm 3^{\circ}\text{C}$ chamber and store at ambient temperature.
- (e) After the electronics compartment has been at ambient temperature for 15 minutes, install the electronics compartment in the $-50^{\circ}\text{C} \pm 3^{\circ}\text{C}$ chamber.
- (f) After 30 minutes remove the electronics compartment from the $-50^{\circ}\text{C} \pm 3^{\circ}\text{C}$ chamber and store at ambient temperature.
- (g) After 15 minutes this will have completed one thermal shock cycle. Repeat these steps for a total of 10 cycles.

This completes the thermal shock test.

3.4 Humidity Test:

3.4.1 Instrumentation (as specified or equivalent) Figure 6.

3.4.1.1 Humidity Environment Chambers, Tenney Model A.
(modified for 100% humidity), Property # 510256.

3.4.1.2 Temperature Monitor, Leeds & Northrup, Type G,
with six (6) each Copper Constantan Thermocouples,
6 ft. minimum length. Leeds & Northrup Temperature
Monitor, Property # 510738.

Property # 510375-A

Property # 510375-B

Property # 510375-C

Property # 510375-D

Property # 510375-E

Property # 510375-H

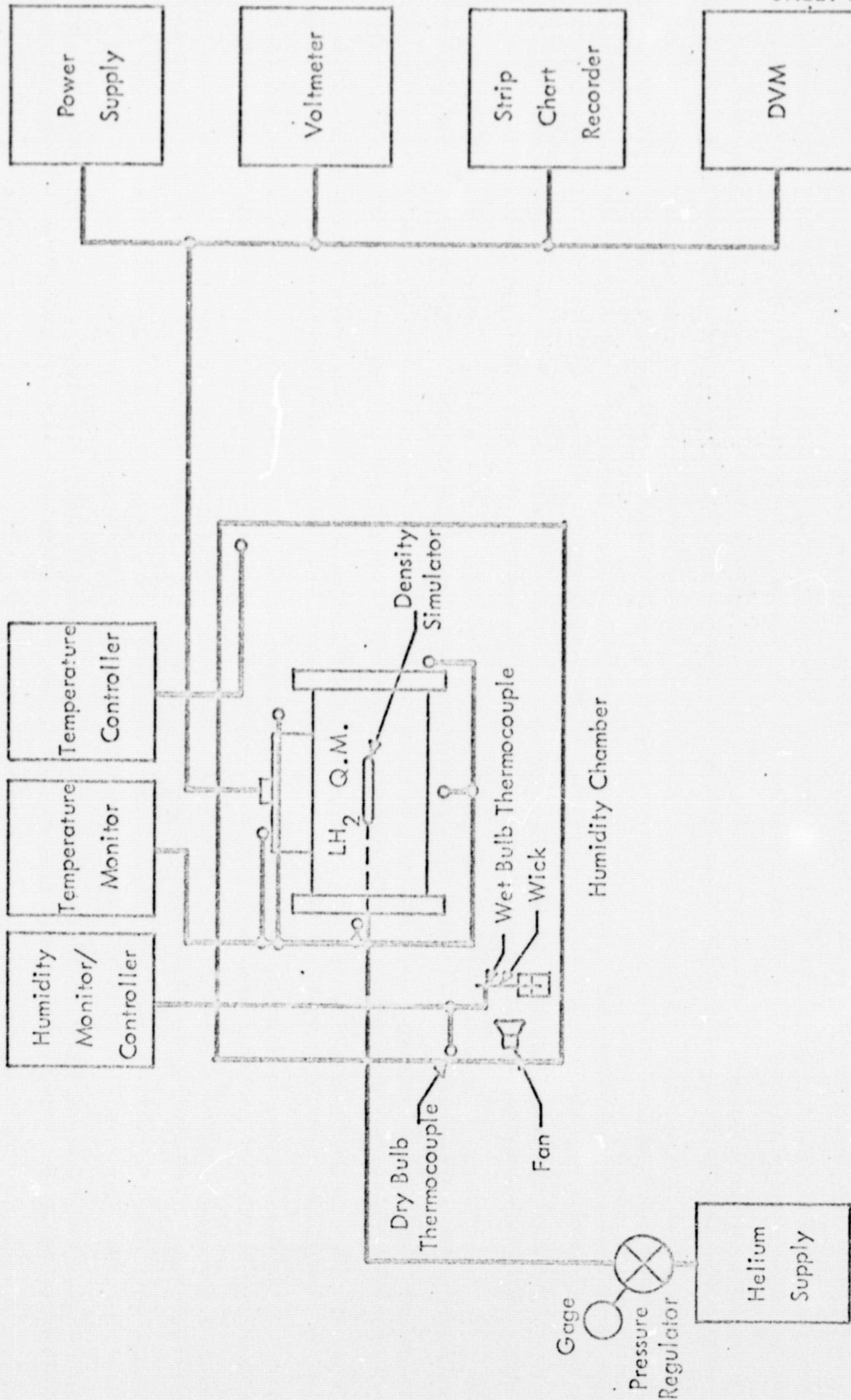


FIGURE 6 HUMIDITY TEST

- (a) Humidity Monitor, Leeds & Northrup, Type G, Property # 520573.
- (b) Copper Constantan Thermocouple wet bulb, Property # 513568.
- (c) Copper Constantan Thermocouple dry bulb, Property # 513969.
- 3.4.1.3 Ice Reference, LGNL, Property # N/A.
- 3.4.1.4 Power Supply, Hewlett-Packard, Model 726, Property # 616273.
- 3.4.1.5 Digital Voltmeter, Digited Model 2-200A, Property # 510152.
- 3.4.1.6 D. C. Voltmeter, 0-50 V, Mfg. _____, Type _____, Property # 510272.
- 3.4.1.7 Strip Chart Recorder, Sanborn Model 152-100A, Property # N770.
- 3.4.2 Fixture, density simulator, LGNL, Property # 019826.
- 3.4.3 Fixture, end cap seal, LGNL, Property # N6019808.
- 3.4.4 Humidity Test:

The LH₂ Quality Meter will be subjected to an environment of 98% - 100% humidity at 50°C temperature for a period of 4 hours. Quality Meter will be operational during test. Deviations of more than ± 150 mV shall be cause for rejection.

NOTE: Do not use data obtained in 3.4.4.1 (b) as base line data.

3.4.4.1 Pre-Test Requirements:

- (a) The humidity environmental equipment shall be calibrated to comply with Quality Assurance procedures.
- (b) Quality Meter shall be operated and monitored each 5 minutes for a period of 30 minutes.

3.4.4.2 Quality Meter Hydrogen simulation required as follows:

- (a) Pressure - Convenient and constant pressure between 14 and 55 psia.

- (b) Density - Special fixture (Para. 3.4.2)
- 3.4.4.3 Quality Meter temperature requirements as follows:
 - (a) Humidity test, $+50^{\circ}\text{C} \pm 3^{\circ}\text{C}$ for 4 hours.
- 3.4.4.4 Electronic test equipment requirements and application:
 - (a) Digital Voltmeter (Para. 3.4.1.5) - output measurement.
 - (b) D. C. Voltmeter (Para. 3.4.1.6) - power supply monitor.
 - (c) Strip Chart Recorder (Para. 3.4.1.7) - Quality Meter output monitor.
 - (d) D. C. Power Supply (Para. 3.4.1.4).
- 3.4.4.5 Environment Test Procedure:
 - (a) Install Quality Meter in humidity chamber as shown in Figure 6. Set power supply voltage to 28 VDC and monitor Quality Meter output with strip chart recorder and digital voltmeter.
 - (b) Set humidity chamber temperature control to $50^{\circ}\text{C} \pm 3^{\circ}\text{C}$.
 - (c) Set humidity control to 100%.
 - (d) When the temperature stabilizes at $50^{\circ}\text{C} \pm 3^{\circ}\text{C}$ with the relative humidity greater than 98%, readjust the vent tube pressure to obtain an output in the 50% to 100% quality range. Monitor this output for 4 hours at $50^{\circ}\text{C} \pm 3^{\circ}\text{C}$ and 98% - 100% relative humidity. Deviations of more than $\pm 150 \text{ mV}$ shall be cause for rejection.
 - (e) After 4 hours lower the temperature and relative humidity to laboratory ambient. Output deviations shall not be cause for rejection during this portion of test. (Detector temperature not constant).

This completes the humidity test.

3.5 Acceleration Test:

3.5.1 Instrumentation (as specified or equivalent) Figures 7A and 7B.

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ITEM - TEST DATA

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Started 1-26-67	Test Facility	Operator J.H. Dillis
Completed 1-26-67	Test Item ALUM. MODEL LH2 QM.	Engineer J.M. Icky
Lab. Temp. 79°F	Type Of Test HUMIDITY	
Humidity 34%	Mfg. PARA. 3.4	
Number 001-P	Test Condition INTERNAL PRESS. 82.0" Hg	

Time	Output	Time	Output
START AMBIENT 09:57	3.54	11:30	3.74
10:02	3.56	11:35	3.79
10:07	3.55	11:40	3.77
10:12	3.54	① 11:45	3.84
10:17	3.55	11:50	3.80
10:22	3.57	11:55	3.77
10:27	3.54	12:00	3.79
START HEAT & HUMIDITY 10:32	3.56	12:05	3.74
10:37	3.59	12:10	3.73
10:42	3.53	12:15	3.75
START TEST 10:45	3.56	12:20	3.77
10:50	3.56	12:25	3.83
10:55	3.65	12:30	3.80
11:00	3.70	12:35	3.75
11:05	3.76	12:40	3.73
11:10	3.72	② 12:45	3.70
11:15	3.78	12:50	3.69
11:20	3.76	12:55	3.65
11:25	3.82	13:00	3.66

Lab. Supervisor
Inspector C. Whiting

ITEM - TEST DATA

SHEET 25 OF 55

Started 1-26-67	Test Facility	Operator J. H. Dillins
Completed 1-26-67	Test Item ALUM. MODEL LHZ QM	Engineer J. M. Irby
Lab. Temp. 80°F	Type Of Test Humidity	
Humidity 34%	Mfg. PACR. 3.4	
Number 001-P	Test Condition	

Time	Output	Time	Output
13:05	3.72	14:40	3.64
13:10	3.70	(4) 14:45	3.62
13:15	3.72	14:50	3.62
13:20	3.72	14:55	3.60
13:25	3.68	15:00	3.62
13:30	3.64	COMPLETED	
13:35	3.70	1-26-67	
13:40	3.68		
13:45	3.66		
13:50	3.65		
13:55	3.68		
14:00	3.64		
14:05	3.71		
14:10	3.69		
14:15	3.65		
14:20	3.63		
14:25	3.64		
14:30	3.63		
14:35	3.63		

Lab. Supervisor
Inspector *Sanalbiting*

- 3.5.1.1 Accelerator, ^{H/A Counter} Genisco Model 521 A, Property # N2393. 611290
- 3.5.1.2 D. C. Power Supply, Hewlett-Packard, Model 726, Property # 616273.
- 3.5.1.3 Digital Voltmeter, Digitec Model Z-200A, Property # 510152.
- 3.5.1.4 D. C. Voltmeter, 0-50 V, Mfg Weston, Type 622, Property # N3531.
- 3.5.1.5 Strip Chart Recorder, Sanborn Model 152-1000, Property # N770.
- 3.5.1.6 Pressure Regulator, Property # 59105.
- 3.5.2 Fixtures, density, Property # 14019818.
- 3.5.3 Fixture, mounting, Property # 14019816.
- 3.5.4 Acceleration Test:

The LH₂ Quality Meter will be subjected to an environment of six (6) acceleration of 0-30 g's for 5 minute duration each. The specimen will be accelerated twice in each of its 3 axis. Quality Meter will have power supplied but not monitored for output during test. Deviation of more than ± 150 mV from pre-test output shall be cause for rejection.

3.5.4.1 Pre-Test Requirements:

- (a) The acceleration test machine shall be calibrated to comply with Quality Assurance procedures.
- (b) Quality Meter shall be operated and monitored each 5 minutes for a 30 minute period.

3.5.4.2 Quality Meter Hydrogen simulations required as follows:

- (a) Pressure - Convenient and constant pressure between 14 and 55 psia.
- (b) Density - Special fixture (Para. 3.5.2).

3.5.4.3 Environmental Test Procedure:

- (a) Each acceleration test will be conducted with $28V \pm 3V$ supplied to the test specimen as

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0-30 g's
Centrifuge

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Acceleration Monitor
Instrumentation & Control

Slip Rings

Voltmeter

Power
SupplyLH₂ Q. M.

Mounting Fixture

A

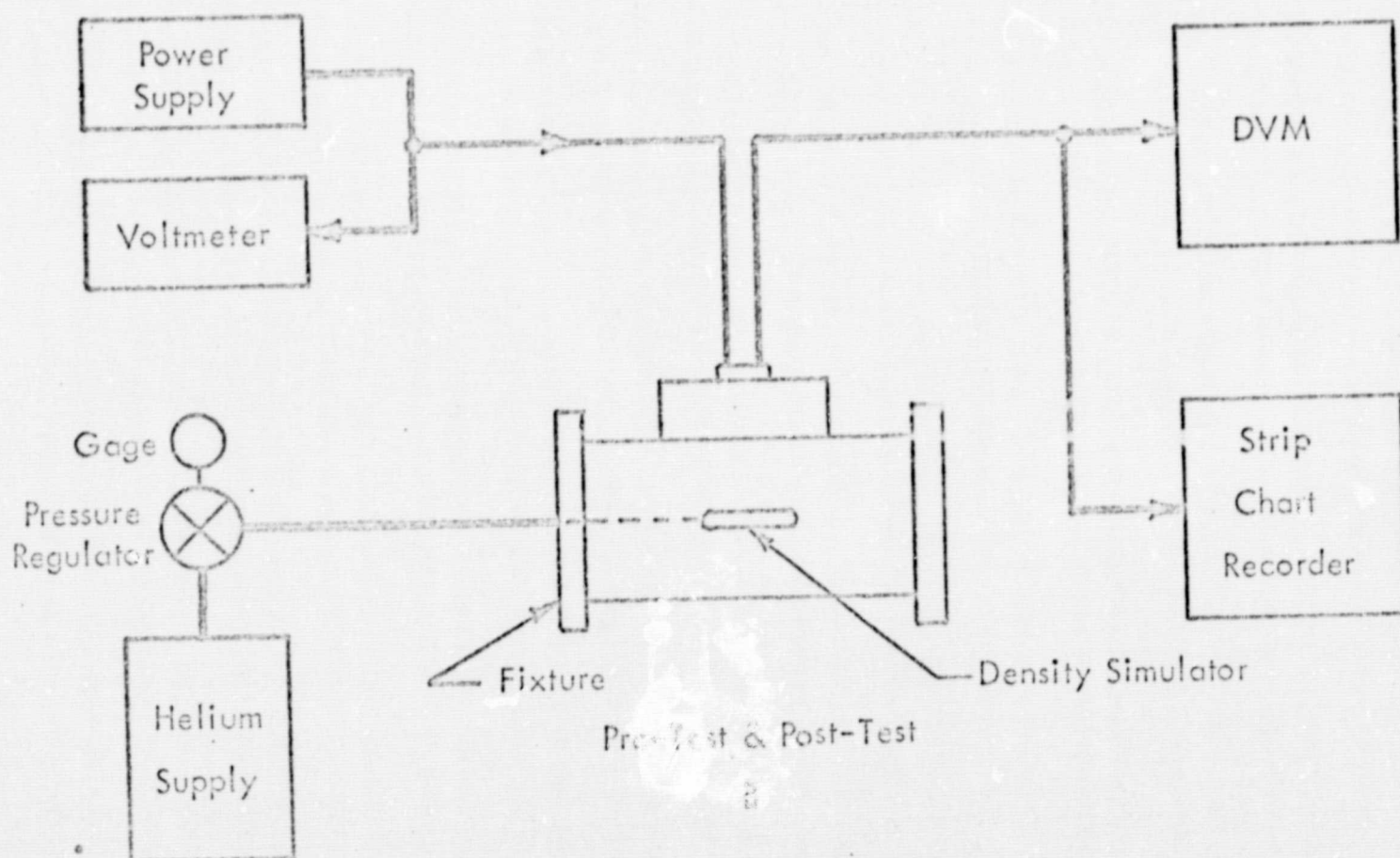


FIGURE 7 ACCELERATION TEST

shown in Figure 7A.

- (b) Install the specimen mounting fixture (Para. 3.5.3) on the accelerator.
- (c) Mount the test specimen on the mounting fixture in one of the two planes of the lateral axis. (For record purposes this will be known as the +X axis test) Accelerate for 5 minutes.
- (d) Remount the test specimen to the opposite plane of the lateral axis (-X axis). Accelerate for 5 minutes.
- (e) Remount the test specimen to one of the two planes of the vertical axis (For record purposes this will be known as the +Y axis) Accelerate for 5 minutes.
- (f) Remount the test specimen to the opposite plane of the vertical axis (-Y axis). Accelerate for 5 minutes.
- (g) Remount the test specimen to one of the two planes of the longitudinal axis (For record purposes this will be known as the +Z axis) Accelerate for 5 minutes.
- (h) Remount the test specimen to the opposite plane of the longitudinal axis (-Z axis). Accelerate for 5 minutes.
- (i) Remove the specimen from the accelerator and connect as shown in Figure 7B.
- (j) Monitor the specimen output each 5 minutes for a period of 20 minutes.

This completes the acceleration test.

3.6 Mechanical Shock

3.6.1 Instrumentation (as specified or equivalent), Figures 8A and 8B.

3.6.1.1 Shock Test Machine, AVCO Model SM010, Property #G13040.

- 3.6.1.2 D. C. Power Supply, Hewlett-Packard, Model 726, Property # 616273.
- 3.6.1.3 Digital Voltmeter, Digitec Model Z-200A, Property # 510122.
- 3.6.1.4 D. C. Voltmeter, 0-50 V, Mfg. Weston, Type 622, Property # N3231.
- 3.6.1.5 Strip Chart Recorder, Sanborn Model 152-1005, Property # N700.
- 3.6.1.6 Pressure Regulator, Property # 591025.
- 3.6.2 Fixture, density, Property # N4019808.
- 3.6.3 Fixture, mounting, Property # N4019816.
- 3.6.4 Mechanical Shock Test:

The LH2 Quality Meter will be subjected to an environment of 18 mechanical shocks of 0 to 100 g's for 8 millisecond duration. The specimen will be shock tested 6 times in each of 3 axis. Quality Meter will not be monitored during test. Deviations of more than ± 150 mV from pre-test output shall be cause for rejection.

3.6.4.1 Pre-Test Requirements:

- (a) The shock test machine shall be calibrated with a dummy specimen of the same weight as the test item. Calibration will be made in accordance with Quality Assurance procedures.
- (b) Quality Meter output shall be monitored every 5 minutes for 30 minutes.

3.6.4.2 Quality Meter Hydrogen simulation requirements:

- (a) Pressure - Convenient and constant pressure between 14 and 55 psia.
- (b) Density - Special fixture, (Para. 3.6.2).

3.6.4.3 Quality Meter temperature requirements:

- (a) Ambient

3.6.4.4 Electronic test equipment application:

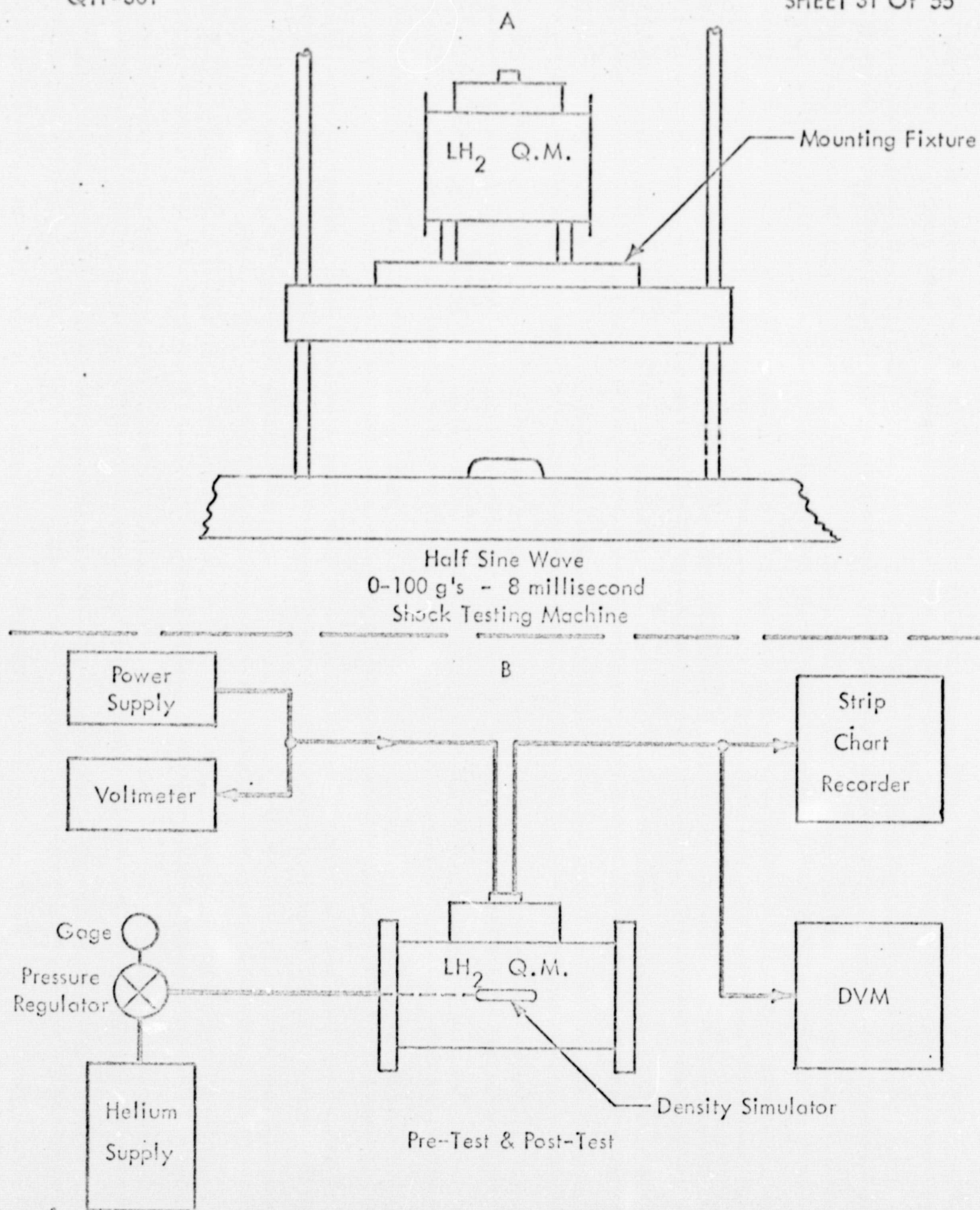


FIGURE 8 MECHANICAL SHOCK TEST

- (a) Digital Voltmeter (Para. 3.6.1.3) - output measurements.
- (b) D. C. Voltmeter (Para. 3.6.1.4) - power supply monitor.
- (c) Strip Chart Recorder (Para. 3.6.1.5) - output monitor.
- (d) D. C. Power Supply, (Para. 3.6.1.2) - 28V dc.

3.6.4.5 Environmental Test Procedure:

- (a) All shock tests will be made by raising the test specimen to the height of 26.32 inches and pushing machine test switch.
- (b) Mount the test specimen on the special test fixture (Para. 3.6.3) in one of the two planes of the lateral axis (For record purposes this will be known as the +X axis test). Shock test three (3) times.
- (c) Remount the test specimen to the opposite plane of the lateral axis (-X axis). Shock test three (3) times.
- (d) Remount the Test specimen to one of the two planes of the vertical axis (For record purposes this will be known as +Y axis). Shock test three (3) times.
- (e) Remount the test specimen to the opposite plane of the vertical axis (-Y axis). Shock test three (3) times.
- (f) Remount the test specimen to one of the two planes of the longitudinal axis (For record purposes this will be known as the +Z axis). Shock test three (3) times.
- (g) Remount the test specimen to the opposite plane of the longitudinal axis (-Z axis). Shock test three (3) times.

3.6.4.6 Post-Performance Test:

- (a) Connect Quality Meter as shown in Figure 8B.
- (b) Adjust D. C. Power Supply to $28V \pm 3V$ dc.
- (c) Let Quality Meter stabilize for 1 hour. Record output each 5 minutes.

This completes the mechanical shock test.

3.7 Vibration Test:

3.7.1 Instrumentation (as specified or equivalent), Figures 9A and 9B.

- 3.7.1.1 Vibration Console, MB Electronics Manufacturing Company, Model T 251, Property # 5101295.
- 3.7.1.2 Vibration Heat, MB Electronics Manufacturing Company, Model C 10D, Property # 510382.
- 3.7.1.3 Voltmeter, Ballantine 300 B (Vibration Level Monitor), Property # 510358.
- 3.7.1.4 Oscilloscope, Tektronix Model 502 (Cross-Talk Monitor), Property # 510729.
- 3.7.1.5 D. C. Power Supply, Endevco Model 2622 (Feedback amplifier), with Cathode Follower, Model 2208, Property # 52346.
- 3.7.1.6 Accelerometer, Endevco Model 22-15, Property # 510583.
- 3.7.1.7 Accelerometer, Endevco Model 22-15, Property # 510584.
- 3.7.1.8 Accelerometer, Endevco Model 22-15, Property # 510585.
- 3.7.1.9 D. C. Power Supply, Hewlett-Packard, Model 726, Property # 616273.
- 3.7.1.10 Digital Voltmeter, Digitec Model Z-200A, Property # 510152.

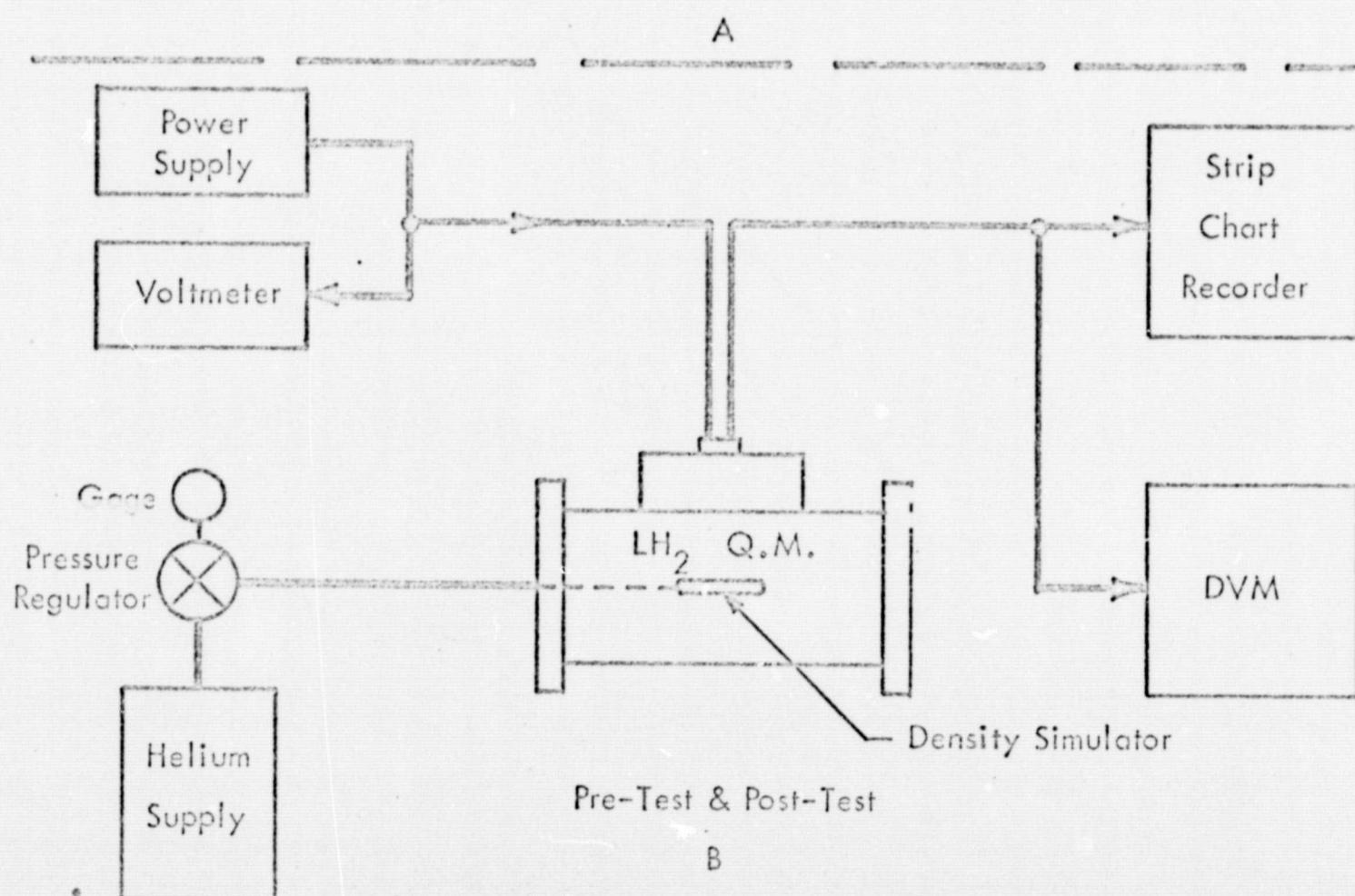
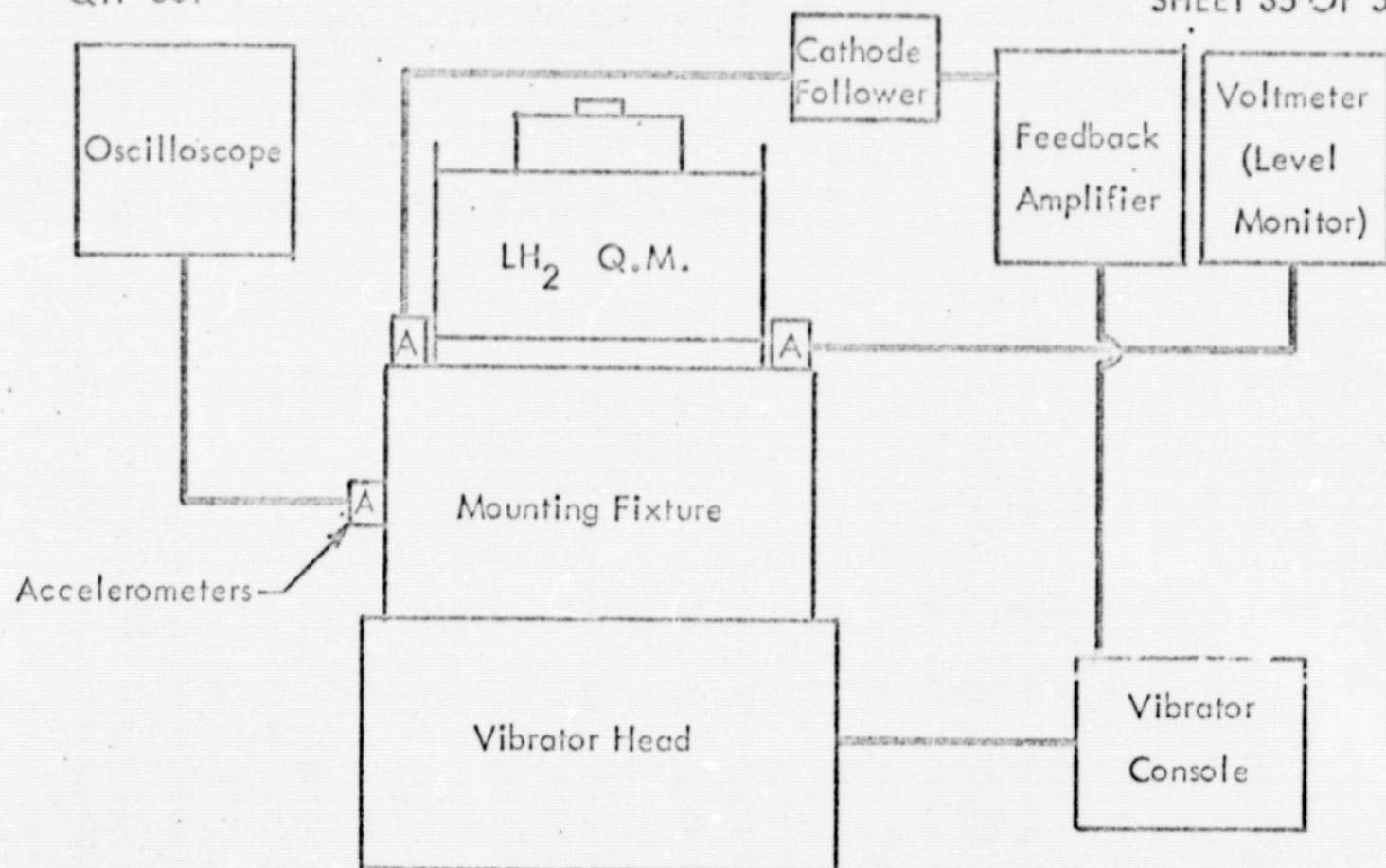


FIGURE 9 VIBRATION TEST

- 3.7.1.11 D. C. Voltmeter, 0-50 V, Mfg. Weston,
Type 622, Property # N3531.
- 3.7.1.12 Strip Chart Recorder, Sanborn Model A-2-1000,
Property # N700.
- 3.7.1.13 Pressure Regulator, Property # 59105.
- 3.7.2 Fixture, density simulator, LGNL, Property # N6019808.
- 3.7.3 Fixture, mounting, LGNL, Property # N6019816.
- 3.7.4 Vibration Test:

The LH₂ Quality Meter will be subjected to an environment of vibration as follows:

- (a) 5 to 65 hertz (Hz) at 0.04 inches D. A. displacement.
- (b) 65 to 110 Hz at 9.0 g's peak.
- (c) 110 to 200 Hz at 0.015 inches D. A. displacement.
- (d) 200 to 2000 Hz at 32 g's peak.

The frequency will be sweep logarithmically from low to high hertz's and back at the rate of one octave per minute. One complete cycle required. Specimen will have 28 V $\pm$ 3 V dc supplied but not monitored during vibration test. Deviations of more than $\pm$ 150 mV from pre-test output will be cause for rejection.

- 3.7.4.1 Quality Meter Hydrogen simulation required as follows:
 - (a) Pressure - Convenient and constant pressure between 14 and 55 psia.
 - (b) Density - Special fixture, (Para. 3.7.2).
- 3.7.4.2 Quality Meter temperature requirements:
 - (a) Ambient.
- 3.7.4.3 Electronic test equipment application as follows:
 - (a) Digital Voltmeter (Para. 3.7.1.10) - output measurements.

- (b) D. C. Voltmeter (Para. 3.7.1.11) - power supply monitor.
- (c) Strip Chart Recorder (Para. 3.7.1.12) - Quality Meter output monitor

3.7.4.4 Pre-Test Requirements:

- (a) Vibration testing equipment will be calibrated with a dummy specimen of equal weight as the Quality Meter. Calibration will be made in accordance with Quality Assurance procedures.
- (b) Specimen pre-test requirements as shown in Figure 9B.
- (c) Specimen will be monitored each 5 minutes for a period of 30 minutes.

3.7.4.5 Environmental Test Procedure:

- (a) Install specimen mounting fixture on the vibration head.
- (b) Mount the specimen on the mounting fixture in the lateral axis. (For record purposes this will be known as "X" axis.)
- (c) Set scanning speed at one (1) octave per minute.
- (d) Set power supply voltage to $28\text{ V} \pm 3\text{ V}$ dc.
- (e) For test environment of 5 hertz to 110 hertz at a constant "G" force of 9 and a displacement of 0.04 inches peak to peak set the following controls:
 - (1) Crossover control to 65 hertz.
 - (2) Acceleration to 9 g's.

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Date Started 5-17-67	Test Facility	Operator J. H. Dabbing
Date Completed 5-23-67	Test Item Aluminum Quality Meter	Engineer J. M. Erby
Normal Lab. Temp. 78°F	Type Of Test Vibration per paragraph 3.7.4	
Humidity 32%	Mfg.	
Unit Number S/N 001-P	Test Condition	

[illegible]

Lab. Supervisor
Inspector *C. Whiting*

- (3) Displacement to 0.04 inches peak to peak.
- (4) Scanning speed to one (1) octave per minute.
- (5) Set scanning limits, lower 5 hertz, upper 2000 hertz.
- (f) Start vibration and continue from 5 hertz to 110 hertz at one (1) octave per minute.
- (g) Stop vibration at 110 hertz. Set crossover control to 200 Hertz; set acceleration control to 32 g's; set displacement control to .015 inches D.A.. Restart vibration and continue vibrating from 110 hertz to 2000 hertz and from 2000 hertz to 110 hertz at the rate of one (1) octave per minute. Stop vibration at 110 hertz. Set crossover control to 65 hertz; set acceleration control to 9 g's; set displacement control to 0.04 inches D.A.. Restart vibration and continue vibrating from 110 hertz to 5 hertz at the rate of one (1) octave per minute.
- (h) Remount the specimen to its vertical axis (Y axis). Repeat same as lateral axis test (X axis).
- (i) Remount the specimen to its longitudinal axis (Z axis). Repeat same as lateral axis (X axis).

3.7.4.6 Post-Test:

- (a) Remove specimen and connect as shown in Figure 9B.
- (b) Monitor specimen each 5 minutes for a period of 30 minutes. Record data.

This completes the Vibration Test.

3.8 Electromagnetic Interference Test:

3.8.1 Instrumentation (as specified or equivalent).

3.8.1.1 D.C. Power Supply, Hewlett-Packard, Model 726, Property # 616273.

3.8.1.2 D.C. Voltmeter, 0-50 V, Mfg. Weston.

- Type 622, Property # N700.
- 3.8.1.3 Digital Voltmeter, Digitec Model Z-200A, Property # 510152.
- 3.8.1.4 Strip Chart Recorder, Sanborn Model 152-7005, Property # N770.
- 3.8.1.5 Ground Plane, Property # N/A.
- 3.8.1.6 Power Line Stabilizer, Property # N/A.
- 3.8.1.7 Screen Room, Property # N/A.
- 3.8.1.8 Test Sample Leads,
Property # NA, " Property # N/A.
- 3.8.1.9 Coax Lead, Double Shield, Property # N/A.
- 3.8.1.10 Interference Measuring Instruments:
- (a) Stoddart Model NM 20B, Radio Interference and Field Intensity Meter 0.15 - 25 Mc, Property # 510563.
 - (b) Stoddart Model NM 30A, Radio Interference and Field Intensity Meter 20 - 400 Mc, Property # 510564.
- 3.8.1.11 Audio Oscillator, Mfg. N/A, Type N/A, Property # 510536.
- 3.8.1.12 Audio Power Amplifier, Mfg. N/A, LGNL Property # 510537.
- 3.8.1.13 Isolation Transformer, Mfg. N/A, Type N/A, Property # N/A.
- 3.8.1.14 A.C. Voltmeter Broadband, Mfg. N/A, Type N/A, Property # 510569.
- 3.8.1.15 Radio-Frequency Signal Source, Property # 510128.
- 3.8.2 Fixture, Density, Property # N2019808
- 3.8.3 Electromagnetic Interference Test:

The LH₂ Quality Meter will be subjected to the following interference and susceptibility tests as prescribed in MIL16181D:

- (a) Conducted Interference - 0.15 - 25 Mc.
- (b) Radiated Interference - 0.15 - 400 Mc.

(c)* Conducted Susceptibility - 50 cps - 15,000 cps
and 0.15 - 400 Mc.

(d)* Radiated Susceptibility - 0.15 - 400 Mc.

3.8.3.1 Pre-Test Requirements:

All test equipment shall be calibrated to comply with Quality Assurance procedures.

3.8.3.2 Quality Meter Hydrogen simulation required:

(a) Pressure - Laboratory ambient.

(b) Density - Special fixture, (Para 3.8.2).

3.8.3.3 Quality Meter Output Loading:

(a) $100\text{ k}\Omega \pm 1\%$ resistive.

3.8.3.4 Suspect Interference Frequencies:

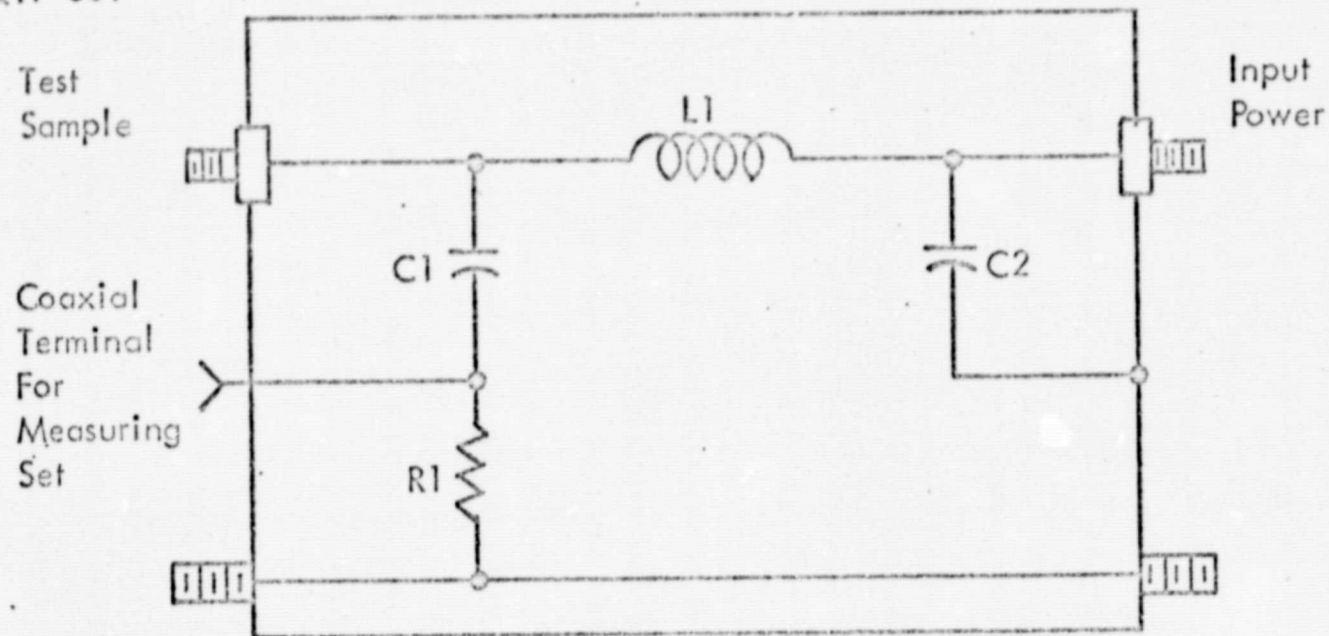
(a) 1.9 kcps and odd harmonics of 1.9 kcps.

3.8.3.5 Environmental Test Procedure:

(a) The specimen will be placed in an radio-frequency shielded room on a .01 inch thick copper ground plane greater than 12 feet square and 30 inches wide. The ground plane will be bonded to the shielded room at intervals of less than 3 feet and at both ends. The top surface of the electronics box will be located 4 inches $\pm 1/2$ inch from the edge of the ground plane.

Power input to the specimen will be applied through a power line stabilization network (Figure 10) bonded to the ground plane. The test sample leads to the stabilization network will be 24 inches ± 1 inch in length and so arranged that the distance between each lead and from each lead to ground will be 2 inches at all points more than 6 inches from the Quality Meter. The ambient interference level in the screen room will be measured with a sample specimen de-energized.

*Susceptibility measurements above 400 Mc are deleted due to the fact that the Quality Meter's electronic equipment is not capable of sensing frequencies greater than 100 Mc.



7. Resistor Data: $R1 = 1000 \text{ Ohm}$, 1 Watt Carbon
6. Capacitor Data: $C1 = .1\mu\text{F}$, 600 Volt dc, Bathtub
 $C2 = 1\mu\text{F}$, 600 Volt dc, Bathtub
5. Capacitors Shall Be Mounted On 1-Inch Insulating Blocks
4. Coil Data: $L1 = 5 \text{ Microhenries}$, 13 Turns Single Layer,
4 Inches Winding Length
3. Wire Data: Awg 6, 600 Volt, .310 Inch Dia. (OD)
2. Form Data: 5-1/4 Inches Length, 3 Inches Dia. (OD), .125 Inch
Wall Drill 3/8 Inch Hole 7/16 Inch From Each End
1. Enclosure Data: 14 Gauge (B & S) Aluminum Suggested Size
9-3/8 Inches x 4 Inches x 4 Inches

FIGURE 10 POWER LINE STABILIZATION NETWORK SCHEMATIC DIAGRAM

- (b) The specimen will be subjected to the radio interference tests in the frequency ranges specified by slowly scanning each octave and using the frequencies at which maximum interference or susceptibility occurs as test frequencies. A minimum of 3 measurements per octave will be made.

All measurements on the radio interference tests, unless otherwise noted, will be made with $28\text{ V} \pm 3\text{ V}$ dc applied to the dc input terminals through a line stabilization network.

- (c) Conducted interference measurements on the input dc power leads to the specimen will be made over a frequency range of 0.15 Mc to 25 Mc. The interference measuring instruments will be connected to the noise meter coaxial terminal on the line stabilization network. The connecting cable will be 50 ohm double-shielded coaxial cable, 6 feet long or less. Insertion losses will be neglected. Measurements will be made in accordance with Paragraph (b).

- (d) Radiated interference emitting from the specimen will be measured over a frequency range of 0.15 Mc to 400 Mc using the appropriate noise meters and antenna. A vertical rod antenna will be used for frequencies up to 25 Mc. The rod antenna will be placed so that the instrument panel or counterpoise is 6 inches below the level of the ground plane. The antenna will be located at the point where maximum interference indications are obtained when it is moved along a line parallel with the edge of the ground plane. The measuring distance from the specimens above 1 Mc will be 3 feet.

From 25 to 35 Mc, a resonant dipole antenna tuned to 35 Mc will be used for the radiated interference measurements. The dipole antenna will be positioned parallel with the front edge of the ground plane. Its height will be $12\text{ inches} \pm 1\text{ inch}$ above the level of the

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Date Started	Test Facility	Operator
Date Completed	Test Item	Engineer
Normal Lab. Temp.	Type Of Test <i>None (see Text)</i>	
Humidity	Mfg.	
Unit Number	Test Condition	

[illegible]

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Inspector

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ITEM - TEST DATA

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Date Started	Test Facility	Operator
Date Completed	Test Item	Engineer
Normal Lab. Temp.	Type Of Test	
Humidity	Mfg. <i>None (see Text)</i>	
Unit Number	Test Condition	

Frequency - Mc

Noise Voltage - mV

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ITEM - TEST DATA

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Date Started	Test Facility	Operator
Date Completed	Test Item	Engineer
Normal Lab. Temp.	Type Of Test <i>None (See Text)</i>	
Humidity	Mfg.	
Unit Number	Test Condition	

[illegible]

Lab. Supervisor
Inspector

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ITEM - TEST DATA

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Date Started	Test Facility	Operator
Date Completed	Test Item	Engineer
Normal Lab. Temp.	Type Of Test <i>None (see Text)</i>	
Humidity	Mfg.	
Unit Number	Test Condition	

[illegible]

Lab. Supervisor _____
Inspector _____

ground plane and its center adjacent to the geometrical center of the specimen under test. At least 12 inches clearance will be allowed between antenna extremities and the wall of the shielded room.

For frequencies above 35 Mc, the dipole antenna will be adjusted to the proper length so as to be tuned to the test frequencies. When the dimensions of the dipole antenna become smaller than the test layout, the antenna will be moved parallel to the edge of the ground plane to keep its sensitive elements adjacent to the point of maximum leakage. The radiated interference measurements will be performed in accordance with Paragraph (b). The noise meter coaxial terminal on the line stabilizing network will be terminated with a 50 ohm termination.

- (e) Conducted susceptibility of the specimen to radio-frequency will be tested by inserting a radio-frequency signal into the noise meter coaxial terminal of the line stabilization network. The signal level will be 100,000 μ V over a frequency range of 0.15 to 400 Mc.

The radio-frequency signal source to be used has an impedance of 50 ohms. A matching network suitable for use at the test frequencies will be used to obtain the proper source impedance. The specified voltage will be that which exists across the output terminals of the signal source when no load other than that necessary to meet the source impedance requirements is connected to the signal generator.

The conducted susceptibility test will be performed in accordance with Paragraph (b).

- (f) Conducted susceptibility of the specimens to audio frequency will be determined by applying an audio-frequency signal of 3 V rms over the frequency range of 50 to 15,000 cps to the

dc power leads of the specimen. The signal will be supplied by an audio-frequency signal generator and audio-frequency power amplifier of sufficient gain to furnish the specified level. An isolation transformer with the secondary in series with the positive dc lead to the specimen will be used to inject the audio-frequency signal. The transformer will carry all currents, including the dc when power is applied to the specimen, without saturation.

The output signal will be monitored for any malfunctions, degradation, or other effects from the introduced audio signal.

- (g) Susceptibility of the specimen to radio frequency radiation will be accomplished by similar procedures and stipulations of Paragraph (d), with the exception that radio-frequency signal sources will be used to drive the antenna. The frequency range will be 0.15 to 400 Mc, with a 100,000 μ V input signal measured at the antenna terminals.

The set-up for the 35 Mc tuned dipole antenna and the tuned dipole for frequencies above 35 Mc will be essentially the same. But for the rod antenna used with frequencies below 25 Mc, it will be necessary to have a 20 inch square counterpoise mounted on the antenna base. The counterpoise will be held at the proper level and bonded to the ground plane. Also proper termination at both ends of the 50 ohm cable connecting the rod antenna and signal generator will be necessary. Resistive pads will be used as required for the proper termination.

The specimen output will be monitored for any effects of the radio frequency fields.

This completes the Electromagnetic Interference Test.

3.9 LH₂ Calibration Check Test:

- 3.9.1 Instrumentation (as specified or equivalent) Figure 11.
- 3.9.1.1 D.C. Power Supply, Hewlett-Packard, Model 726, Property # G16273.
 - 3.9.1.2 D.C. Voltmeter, 0-50 V, Mfg. Weston, Type 622, Property # N3231.
 - 3.9.1.3 Digital Voltmeter, Digitec Model Z-200A, Property # 510152.
 - 3.9.1.4 Strip Chart Recorder, Sanborn Model 152-100A, Property # N770.
 - 3.9.1.5 Beta Gage Test Section, LGNL, Property # 520538.
 - 3.9.1.6 Preamplifier, Tennelec Model 100A, Property # N/A.
 - 3.9.1.7 D.C. Power Supply (Preamp. Filaments and B⁺), Property # 510459.
 - 3.9.1.8 D.C. Power Supply, Hewlett-Packard, Model 711A, Property # 510382.
 - 3.9.1.9 Linear Amplifier, ORTEC, Model 201, Property # N/A.
 - 3.9.1.10 One Mc Scale, RIDL, Model 210, Property # 510257.
 - 3.9.1.11 Gas Flow Measuring Orifice, LGNL, Property # G1520.
 - 3.9.1.12 Gas Flow Differential Pressure Transducer, ± 60 psid, Statham, Model N/A, Property # G1558.
 - 3.9.1.13 Pressure Transducer Voltage Divider, LGNL, Property # N/A.
 - 3.9.1.14 Liquid Flow Measuring Orifice, LGNL, Property # 510258.
 - 3.9.1.15 Liquid Flow Differential Pressure Transducer, $\pm$ psid, Statham, Model N/A, Property # G1543.
 - 3.9.1.16 Pressure Transducer Voltage Divider, LGNL, Property # N/A.
 - 3.9.1.17 Beta Gage Test Section Pressure Transducer, Statham,

Model N/A, Property # 510329.

3.9.1.18* Quality Meter Gaging Section, Pressure Transducer, Statham, Model N/A, Property # 510330.

3.9.1.19 Beta Gage Pressure Transducer Voltage Divider, LGNL, Property # N/A.

3.9.1.20 Quality Meter Pressure Transducer Voltage Divider, LGNL, Property # N/A.

3.9.1.21 Gas Flow Readout, Leeds & Northrup, Speedomax G, Property # 510128.

3.9.1.22 Liquid Flow Readout, Leeds & Northrup, Speedomax G, Property # 510129.

3.9.1.23 Beta Gage Pressure Readout, Leeds & Northrup, Speedomax G, Property # 510131.

3.9.1.24 Quality Meter Pressure Readout, Leeds & Northrup, Speedomax G, Property # 510132.

3.9.1.25 Liquid Hydrogen Test System, LGNL.

3.9.2 Calibration Check Test:

The Liquid Hydrogen Quality Meter will be placed inside an evacuated enclosure along with a beta gage calibration section. Liquid and gaseous hydrogen will be vented to the atmosphere through the beta gage and Quality Meter. The output of the Quality Meter will be monitored continuously. Beta counts will be taken at not less than ten different qualities between 50% and 100%. At each calibration point the Quality Meter output and pressure*, beta gage count and pressure and total hydrogen flow will be recorded. Hydrogen Quality will be calculated from the Quality Meter data and the beta gage data, and the Quality readings compared. Deviation of more than 5% Quality in the 50 - 100% quality range shall be cause for rejection.

*Quality Meter Gaging Section Pressure will be measured only on the first specimen tested. Since the quality readout is an integrated signal consisting of pressure and count rate, if pressure is known, then count rate can be established and compared to count rate in the beta gage calibration section. Any change in quality between the calibration section and Quality Meter due to pressure drop, flashing due to heat input, or any other variable between the two units would thereby be indicated.

Date Started 3-29-68	Test Facility L.H. Facility	Operator S.B. Moore
Date Completed 3-29-68	Test Item Aluminum Quality Meter	Engineer J.H. Nichols
Normal Lab. Temp. 75°F	Type Of Test Calibration check per paragraph 3.9.2	
Humidity 60%	Mfg.	
Unit Number 5/11 001-P	Test Condition	

Time	Run No.	Beta Gage Pressure psia	Quality Meter Pressure psia	LH ₂ Flow lbs/sec	GH ₂ Flow lbs/sec	Total Flow lbs/sec	Beta Gage Count per min.	Quality Meter Output (Volts)	Beta Gage Quality %	Quality Meter Quality %	Difference %
1000		40" Hg H ₂ Amb Temp	40" Hg H ₂ Amb Temp	~0.1	~0.1		799,708	5.58 Reg.	100	100	0
1030		26.7	26.7	~0.1	~0.1		87,020	2.48	48.4	50	1.6
1031		26.7	26.7				128,120	2.80	56.4	56	0.4
1032		26.7	26.7				158,390	3.14	62.6	63	0.4
1040		25.7	25.7				208,819	3.65	70.9	73	2.1
1041		25.7	25.7				213,070	3.70	72	74	2
1045		26.7	26.7				257,520	4.23	83.7	85	1.3
1047		25.7	25.7				274,446	4.55	86.8	91	4.2
1048		25.7	25.7				299,890	4.85	92.6	97	4.4
1049		25.7	25.7				293,520	4.73	91.4	94.6	3.2
1055		24.7	24.7				181,960	3.20	62.9	64	1.1
1056		24.7	24.7				184,270	3.29	63.8	66	2.2
1057		24.7	24.7				188,927	3.32	64.4	66.4	2
1058		24.7	24.7				137,880	2.92	57.2	58.4	1.2
		Vacuum 25°C in Lab.	Vacuum 25°C in Lab.				860,241	5.58 Reg.	100	100	0
		Test Button Amb. in	Quality meter					2.71			

Lab. Supervisor

Inspector J.F. Senger

3.9.3 Pre-Test Requirement:

Calibrate instrumentation to comply with Quality Assurance Procedures.

3.9.4 Calibration Check Procedure:

3.9.4.1 Install Quality Meter in Hydrogen vent line and connect to instrumentation as shown in Figure 11.

3.9.4.2 Close and evacuate the test tank. Apply 28 ± 3 V dc to Quality Meter. Turn on all electronic instrumentation to allow warm-up.

3.9.4.3 When the test tank pressure reaches approximately 30 microns of mercury, open Hydrogen control valves to allow liquid and gaseous Hydrogen flow. Adjust flow of liquid and gas to give a combined flow of .08 to .4 pounds mass per second.

3.9.4.4 Allow flow rates and beta gage pressure to stabilize for 30 seconds. Record output of Quality Meter for 1 minute and simultaneously obtain a 1 minute beta count from the beta gage. Record beta gage pressure. At the end of the 1 minute period, turn off all Hydrogen flow and calculate the Hydrogen quality from the beta gage data. Calculate the Hydrogen quality from output data of Quality Meter. Record the two qualities on the data sheet.

3.9.4.5 Repeat the procedure to obtain data at 10 different Hydrogen qualities between 50% and 100%.

This completes the LH_2 Calibration Check Test.

3.10 Inspection (Quality Assurance Provisions)

3.10.1 New Units- Quality Assurance shall assure the tests specified in this QTP are performed and that the equipment meets the requirements specified herein.

3.10.2 In the event rework is required, Article 7.0 of Quality Assurance Plan, NQD 5001, will be adhered to.

3.10.3 One copy of the completed QTP shall be shipped with the Quality Meter and one copy shall be placed in LGNL files.

3.10.4 Inspect for finish, workmanship, required identification, and

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dimensional conformance to reference drawings.

3.10.5 Verify that the Quality Meter weighs less than 15 pounds.

Part No. _____	Test Engineer <u>J. M. Trby</u>
Serial No. <u>001-P</u>	Operator <u>J. H. Dobbins</u>
Date <u>4-1-68</u>	Inspector <u>C. Whiting</u>