Liquid-hydrogen-control-system modifications

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ABSTRACT: By late 1987, the Los Alamos Neutron Scattering Center (LANSCE) liquid-hydrogen-control-system electronics had evolved to a functionally adequate stage, but occasionally showed signs that rebuilding was needed. The rebuild offered opportunity to redesign the external features of the system, which are described in this paper along with some technical features.

The LANSCE liquid-hydrogen control system had grown during the years and reached a stage, by late 1987, where major revisions were needed. A main feature of the rebuild was the ergonomic aspects of the front control panel. The design changes that were implemented with considerable success were as follows.

1. All push-button controls are now lighted in red or green. The normal state-of-the-function is indicated by green illumination in the upper half of the square button, with the illuminated legend indicating status (e.g., "open"). Thus, when all valves, etc., are in their normal state, the control panel shows only green across the tops of all the buttons (see Fig. 1).

2. If any function is in an abnormal state, a red light within a schematic of the system is illuminated (see Fig. 2).

3. Any transient condition that can lead to a safety dump of the liquid hydrogen is latched in an indicator panel until reset (Fig. 2).

The consequences of these changes have exceeded our expectations. System troubleshooting is almost "at a glance". The ability of new personnel to learn the system has been enhanced, and the solid construction has increased reliability.

Most of the subsystems in the hydrogen control system provide for remote readout—the exception being the thermocouple vacuum gauges. Because of poor history with electromechanical gauges, it was decided to build an all electronic vacuum gauge to meet our needs. Two designs were made: one for the four-wire thermocouple gauge, such as the Varian series; and one for three-wire gauges as provided by Hastings.

A thermocouple vacuum gauge applies a heating current to a fine wire exposed to the vacuum to be measured. A thermocouple attached to the heated wire records the temperature of the wire, which rises as vacuum improves (less convective cooling). In an electromechanical gauge, the thermocouple directly drives a meter. The meter scale is marked off to account for the peculiar calibration curve of the gauge. Typical

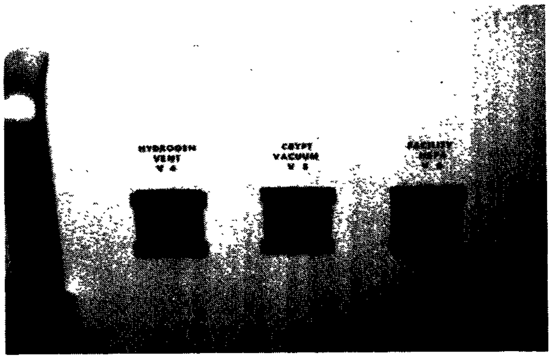

Fig. 1 Control switches.

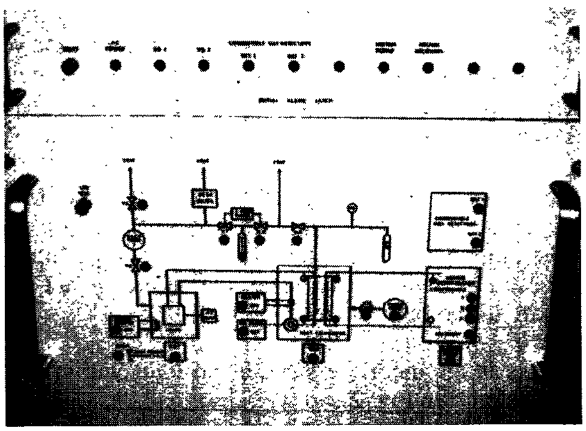

Fig. 2 Alarm hatch panel and status panel.

constants for a three-wire Hastings tube are 20 ma heater current and 10 mv (300° C) thermocouple output. The principal problem in an electronic gauge is matching a non-linear circuit to the calibration curve of the tube used. We accomplished this by using a linear amplifier with two break points to achieve a 0 to 1999 micron vacuum range. The amplifier circuit is shown in Fig. 3 and, once adjusted, conformance with a McLeod gauge is shown in Fig. 4.

In addition to the above, the corrected output is applied to a voltage-to-current converter making three separate outputs available that convert 0 to 2000 microns to 0 to 1 ma of output with approximately 7 volts of compliance.

The entire revised system has all critical functions (defined as those functions that can lead to venting of the liquid hydrogen due to safety) operating on two sealed gel-cell batteries. In the event of a power failure, all systems will stay alive for more than an hour. Note that when the helium compressors associated with the hydrogen refrigerator go off because of power loss, the system warms and must be vented in six minutes to avoid possible excess pressure.

The revised hydrogen control system has been very successful in attaining its objectives. Corrective actions are more rapidly determined and down time caused by control-system failure appears to be a thing of the past.

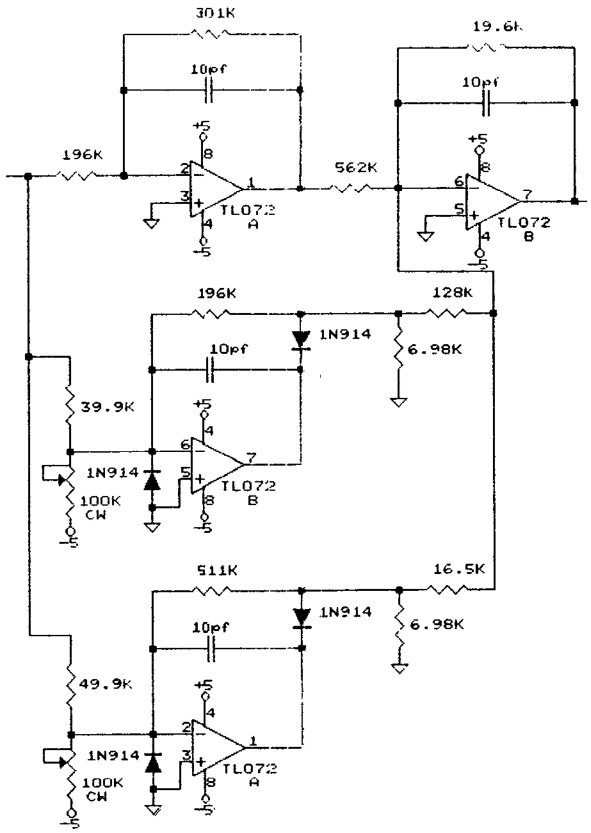

Fig. 3 Amplifier with break points.

Acknowledgements

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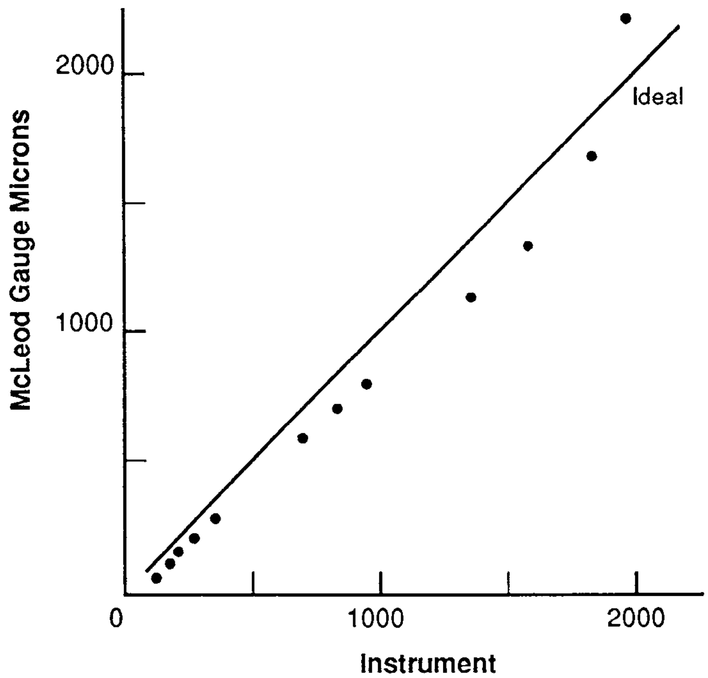

Fig. 4 Measured response after first adjustment.