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Instruments

AEC Research and Development Report

A LEVEL INDICATOR FOR LIQUEFIED GASES

by

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Applied Physics Division

March 1960

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INSTRUMENTS
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ABSTRACT

A capacitance instrument is described that indicates the level of liquefied gas in a closed container. The instrument has been used to indicate and control the level of liquid nitrogen, hydrogen, and methane.

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A LEVEL INDICATOR FOR LIQUEFIED GASES

INTRODUCTION

The operation of a laboratory process in which liquefied gases were contained within insulated metal cylinders required an instrument that would indicate and control the level of such a liquid. The temperature of operation was at times within a few degrees of absolute zero. Most buoyancy or float-type detectors are inoperative at such low temperatures. A capacitance probe that has no moving parts and does not introduce appreciable heat leaks in the system appeared to be a good way to make such a measurement.

SUMMARY

A dual-channel instrument was designed to indicate remotely the level of liquid hydrogen, nitrogen, or methane in a closed container. The sensing probe was a cylindrical capacitor with one end dipping into the liquid surface. The capacitance of the probe is a linear function of the height of the liquid. A continuously balanced bridge was used to measure the capacitance and thereby the level of the liquefied gas. The addition of a cam-actuated switch on the servo-actuated indicator provided a means to control the liquid level during process operations.

DISCUSSION

In the use of liquefied gases in laboratory processes, the need often arises for a means of measuring and controlling, from a remote position, the level of these liquids within closed vessels. A versatile instrument was needed that could be used in various types of vessels and with liquefied hydrogen, nitrogen, or methane.

A common type of liquid level probe depends on the cooling of a resistance coil mounted so that one end dips into the liquid. Such a simple device, which can easily be made from commercial resistance thermometers, was not sufficiently accurate with liquefied gases because of the absence of any significant temperature differential in the wire at the liquid-vapor interface.

A successful instrument was made with a capacitance gage. It had no moving parts and did not introduce heat into the liquefied gas. Such an instrument may be used to indicate and control the level of a liquefied gas in a closed vessel. The indicator of a dual-channel instrument of this type is shown in Figure 1.

The instrument consists of the sensing probe and the indicator-control mechanism. The sensing probe is a cylindrical capacitor that forms one element of an AC bridge circuit. The bridge output operates the indicator-control mechanism.

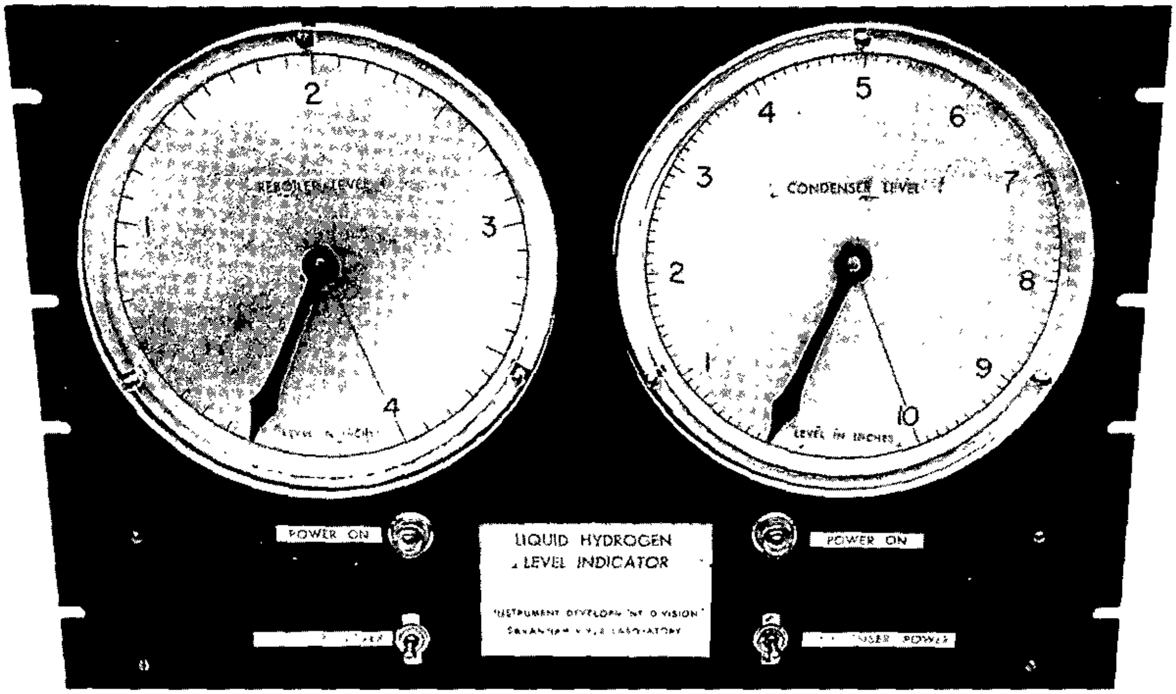

FIG. 1 DUAL-CHANNEL LIQUID HYDROGEN LEVEL INDICATOR

The sensing probe capacitor assembly is shown in Figure 2a. The capacitor consists of three concentric stainless steel tubes, as shown in Figure 2b. "Teflon"-insulated spacers were used between the tubes. The outer tube acts as a shield; the two inner tubes form the active capacitive element. A number of holes were placed in the outer tube and in the "Teflon" spacers to allow the liquefied gas to rise freely between the tubes. The change in capacitance is due to the difference in the dielectric constants of the liquid and the vapor. The capacitance of the sensing element is a linear function of the height of the liquid column. The probes were coated with an insulating varnish to lessen any danger of an electric spark in the probe when they were used with liquid hydrogen. As an additional precaution, the voltage is kept low. The tabs shown on the outer tube were used to weld the probe inside a stainless steel vessel. Moisture collecting in the probe was no problem since the process system was sealed off from the atmosphere. Probes of various size have been installed. Their dimensions range from 2-1/2 inches long and 3/8 inch in diameter to 12 inches long and 3/4 inch in diameter.

The measuring circuit is essentially the same as one described by Williams and Maxwell[1]. The block diagram of one channel of the instrument is shown in Figure 3.

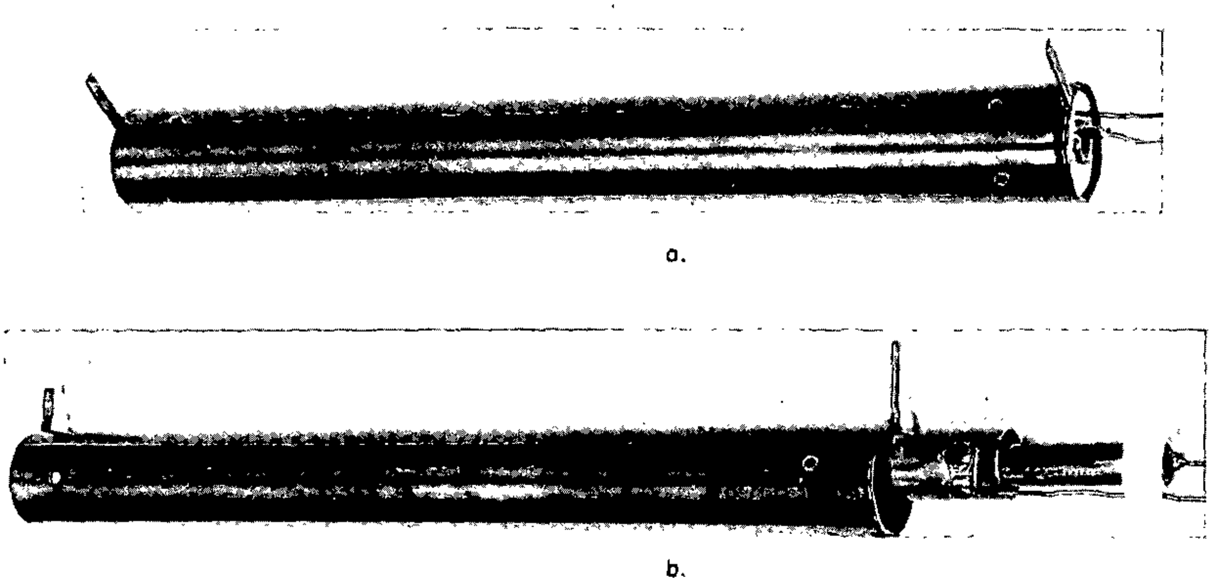

FIG 2 CAPACITANCE PROBE

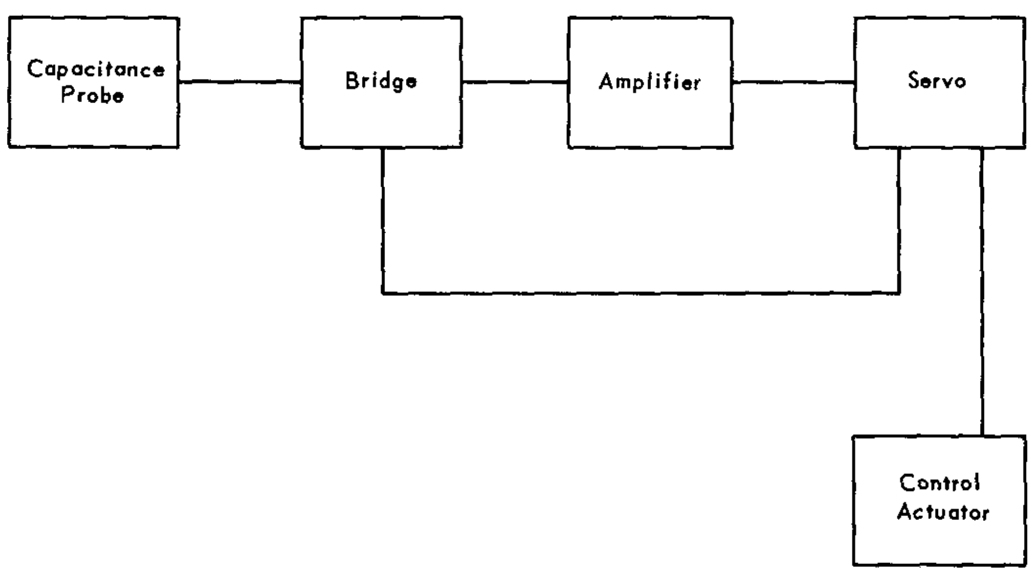

FIG. 3 BLOCK DIAGRAM OF LIQUID LEVEL INDICATOR

The capacitance bridge circuit is shown in Figure 4. The lead to the center element of the probe capacitor was left unshielded since it had a high signal level and a low impedance to ground. The high impedance lead from the middle element is a coaxial cable with the shield connected to the outer element. The capacitor, C_1, compensates the bridge for any stray capacitances. The correct value of this capacitor depends upon the particular installation involved. A typical value is 0.5 microfarad.

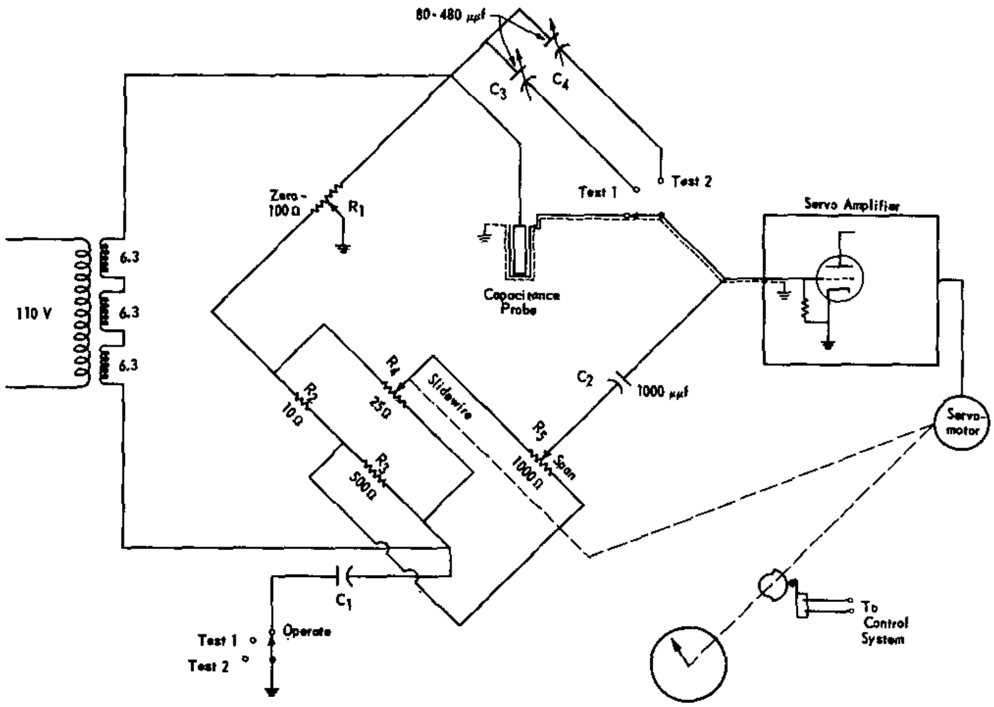

FIG. 4 SCHEMATIC DIAGRAM OF CAPACITANCE BRIDGE

The zero adjustment, R_1, is a 100-ohm, 10-turn potentiometer to permit a fine initial adjustment over a wide range of probe sizes.

Two test levels are provided by substituting capacitors C_3 and C_4 for the active probe. This facility allows the operator to confirm the calibration of the instrument.

The reference capacitor, C_2, must be of a good quality not subject to drift.

The span adjustment, R_5, is a 1000-ohm, 10-turn potentiometer. To prevent the bridge from becoming unstable a lower limit of span adjustment is provided by R_2 and R_3.

The bridge output is fed to a conventional phase-sensitive amplifier. The amplifier output is used to energize a two-phase motor geared to the slidewire that restores the bridge balance.

The slidewire, R_4, is a 25-ohm, 10-turn potentiometer that is geared mechanically to the servomotor. A change in the capacitance of the probe will unbalance the bridge. The balance position of R_4, which is proportional to the liquid level, is displayed on a circular scale 8 inches in diameter (Figure 1).

Four liquid level systems have been installed, two of which were of the dual-channel design. Three of the instruments operated satisfactorily; however, difficulty was experienced in the fourth due to cross-talk in the probe leads. This installation required exceptionally long leads in close proximity.

A cam-operated switch was geared to the slidewire in one of the dual-channel instruments to control the level of liquefied methane and nitrogen. The level variation was approximately 6% for methane and 12% for nitrogen. This variation could have been reduced by adding capacity to the liquefied gas supply system but no closer control was required for the specific application.

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