

# NASA Technical Memorandum 101650

## PORTABLE DIGITAL PRESSURE INDICATOR FOR CALIBRATING MAGNETIC TAPE RECORDERS

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(NASA-TM-101650) PORTABLE DIGITAL PRESSURE  
INDICATOR FOR CALIBRATING MAGNETIC TAPE  
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## INTRODUCTION

A portable Digital Pressure Indicator (DPI) was designed and developed at NASA's Langley Research Center to reduce maintenance time required for the calibration of the pressure system in digital magnetic tape recorders.

High-speed magnetic tape recorders require air pressures from 0 to 20 pounds per square inch gage (psig) and vacuum of 30 inches of water to assure peak recorder operation. The errors in the previous system, e.g., scale resolution, parallax, and mechanical friction have been eliminated by the DPI which provides a digital panel readout and has a resolution of 0.1 psig. Both pressure and vacuum can be attached to the instrument simultaneously and displayed on the digital panel readout by means of a pressure and vacuum selector switch.

## DIGITAL PRESSURE INDICATOR

The digital pressure indicator (DPI) was designed to aid technicians in the calibration and setup of magnetic tape recorders. In high-speed magnetic tape recorders, air pressure is used to produce an air cushion across fixed tape guides to reduce tape-to-guide friction and reduce guide wear. Vacuum is used to hold a loop of tape in the tape buffer chambers and to allow the recorder to achieve the fast start/stop tape movements required in high-speed recording. Former calibration procedures required the technician to use multiple analog pressure/vacuum gages and, at times, guess at the lower readings due to the limited gage resolution. The DPI has a measurement uncertainty of  $\pm 1\%$  over its entire range of 0-20 psig. The DPI (fig. 1) consists of pressure and vacuum sensors, operational amplifiers with associated adjustment circuitry, pressure and vacuum display select switch, and a 4 1/2 digit digital display.

## PRESSURE SENSOR

The pressure sensor (fig. 2) of the DPI is a Micro-Craft Model 142PC-0-30G with a range of 0-20 psig. This sensor is a solid state piezoresistive device which has the four resistive elements forming a Wheatstone bridge etched onto a silicon wafer diaphragm. Voltage excitation for the bridge is 15 Vdc and will produce an output proportional to sensor input pressure.

## VACUUM SENSOR

The vacuum sensor (fig. 2) is a Micro-Craft Model 161-PC-01D with a range of 0-30" H<sub>2</sub>O. Internal construction and components are identical to the pressure sensor. The difference comes in application of the sensors. The 161-PC is custom built to be more sensitive over the range of 0 to 30" H<sub>2</sub>O.

## SIGNAL SENSING/SCALING ELECTRONICS

Dual AD540KH differential operational amplifiers provide sensor output signal conditioning and scaling. The scaling circuit (fig. 3) permits independent adjustment of the amplifier null and sensitivity. The first op-amp stages U1 and U3 accept the transducer output signal and sum it with a variable voltage offset provided by the pressure and vacuum zero adjust potentiometer. The zero adjustment is used to obtain zero voltage at the output of U1 and U3 to correspond to zero pressure applied to the sensor. This zero adjustment of the sensor's zero output simplifies the operator's task by electrically eliminating readout offset errors caused by resistive differences in the bridge elements of the sensor. In the second stage of the scaling circuit, U2 and U4, an AD540KH and associated circuitry provide signal gain and full scale adjustment of the sensor output signal. Operational amplifiers U1 through U4 electrically shift the zero and full scale operating parameters of the sensor to produce an output voltage proportional to applied pressure (fig. 3). The DPI digital readout displays air pressure in pounds per square inch (psig) and vacuum in inches of water (H<sub>2</sub>O).

## READOUT

The readout for the DPI is a low cost 4-1/2 digit Datel DM-4100L digital panel meter powered by a built-in 5-volt power supply. The display contains segmented light emitting diodes that are 0.56 inches in height for easy viewing. The panel meter has been modified to better suit this particular application. The modifications include fixing the decimal point to two places and disabling the circuit for the least significant hundredth digit. Disabling the hundredths of a psi digit eliminates the meaningless flickering of this digit and avoids possible operator confusion.

The combination of a resistive attenuator on the input of the panel meter and a fixed decimal point on the LED readout allows measurements to be read directly in psi or inches of water respectively.

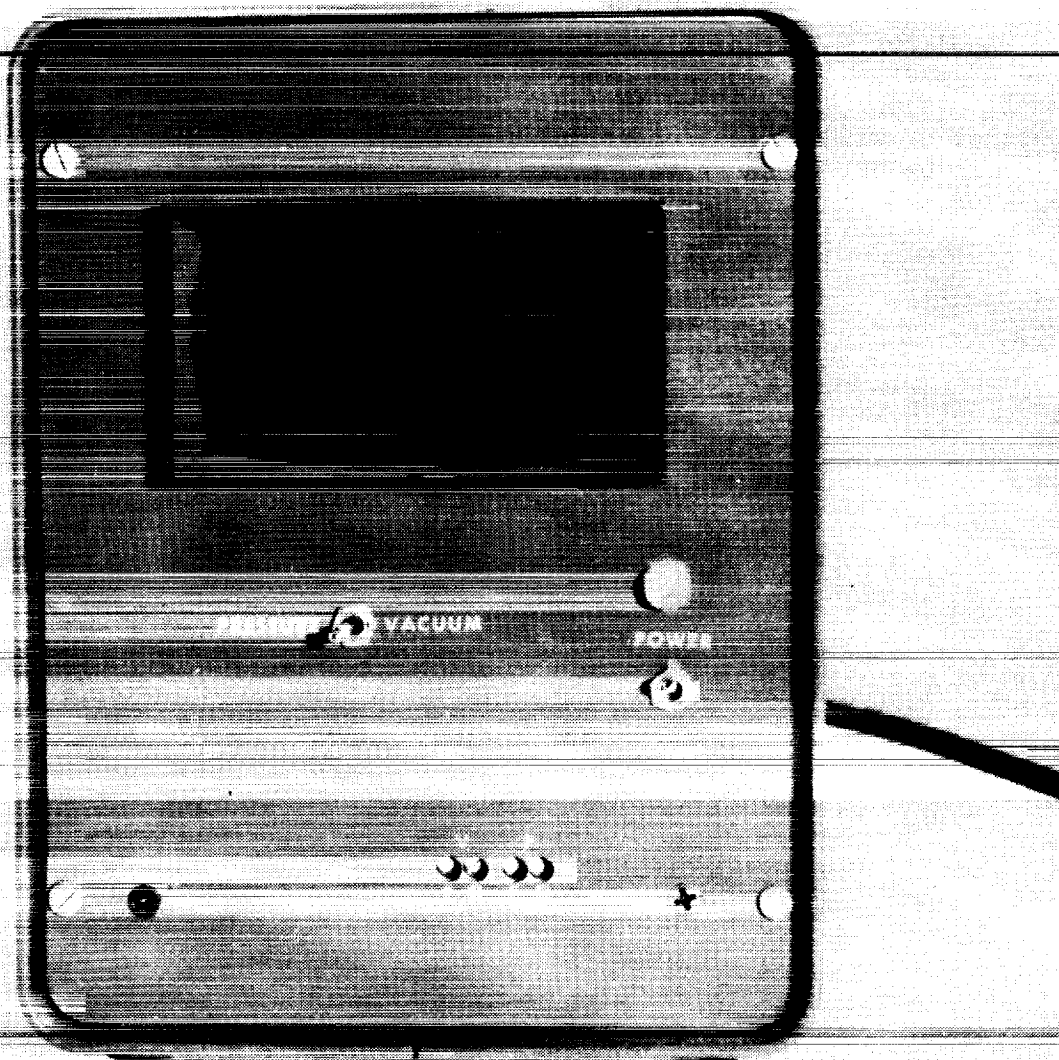
## TRANSDUCER CALIBRATION

Figures 4 and 5 show the calibration of the DPI sensors against a quartz pressure standard traceable to the National Institute of Standards and

Technology (NIST). The 20 psig transducer showed a maximum deviation of 0.5% and the 30-inch H<sub>2</sub>O transducer showed a 0.3% full scale deviation.

#### SUMMARY

This paper describes the design of a portable Digital Pressure Indicator (DPI) to be used for calibrating the pressure systems on Langley's magnetic tape recorders. High-speed magnetic tape recorders require pressure (0 to 20 psig) for providing an air cushion across the tape guides and a slight vacuum (30" H<sub>2</sub>O) for maintaining the proper number of tape loops in the advance and feed chamber. The DPI is a hand-held device that can be quickly coupled to a magnetic tape recorder and includes a two-position switch for selecting either pressure or vacuum measurement modes to be displayed digitally in engineering units. The DPI is currently in use in Langley's Analysis and Computation Division.



**FIGURE 1. DIGITAL PRESSURE INDICATOR UNIT**

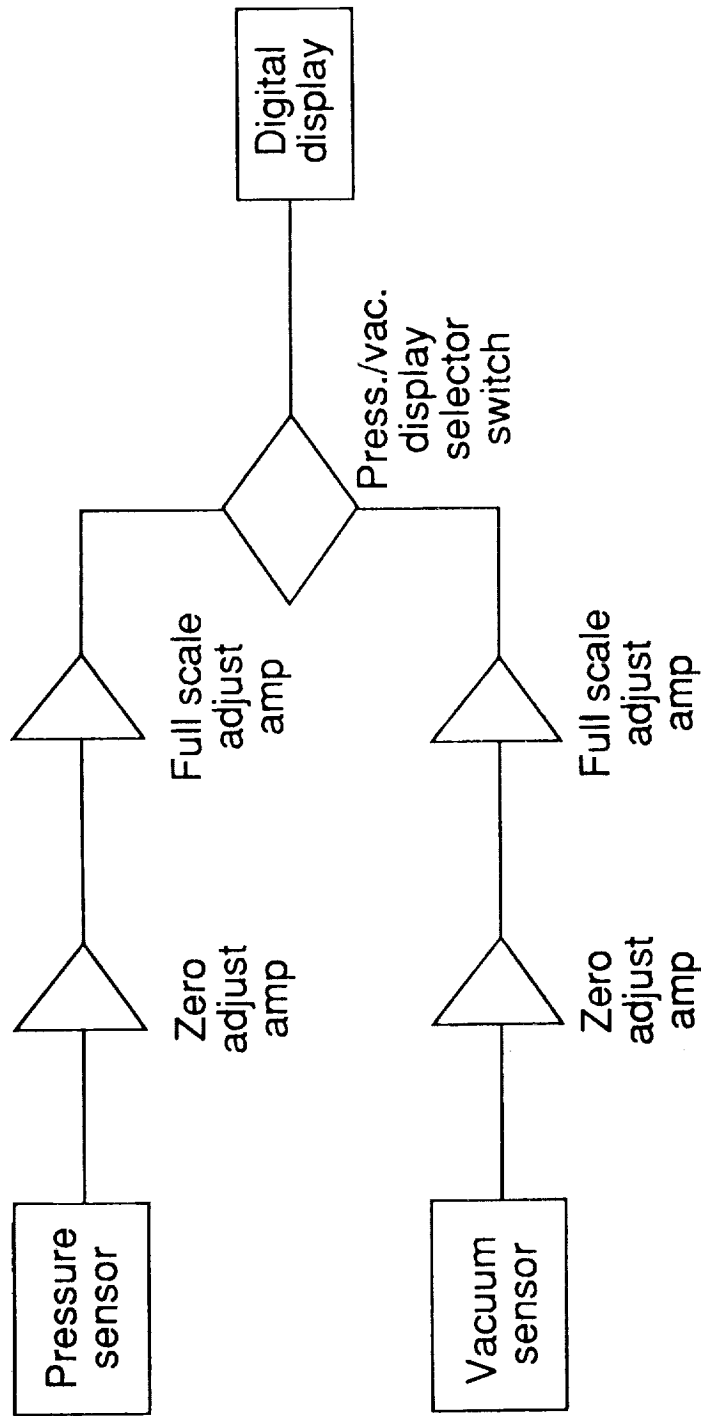
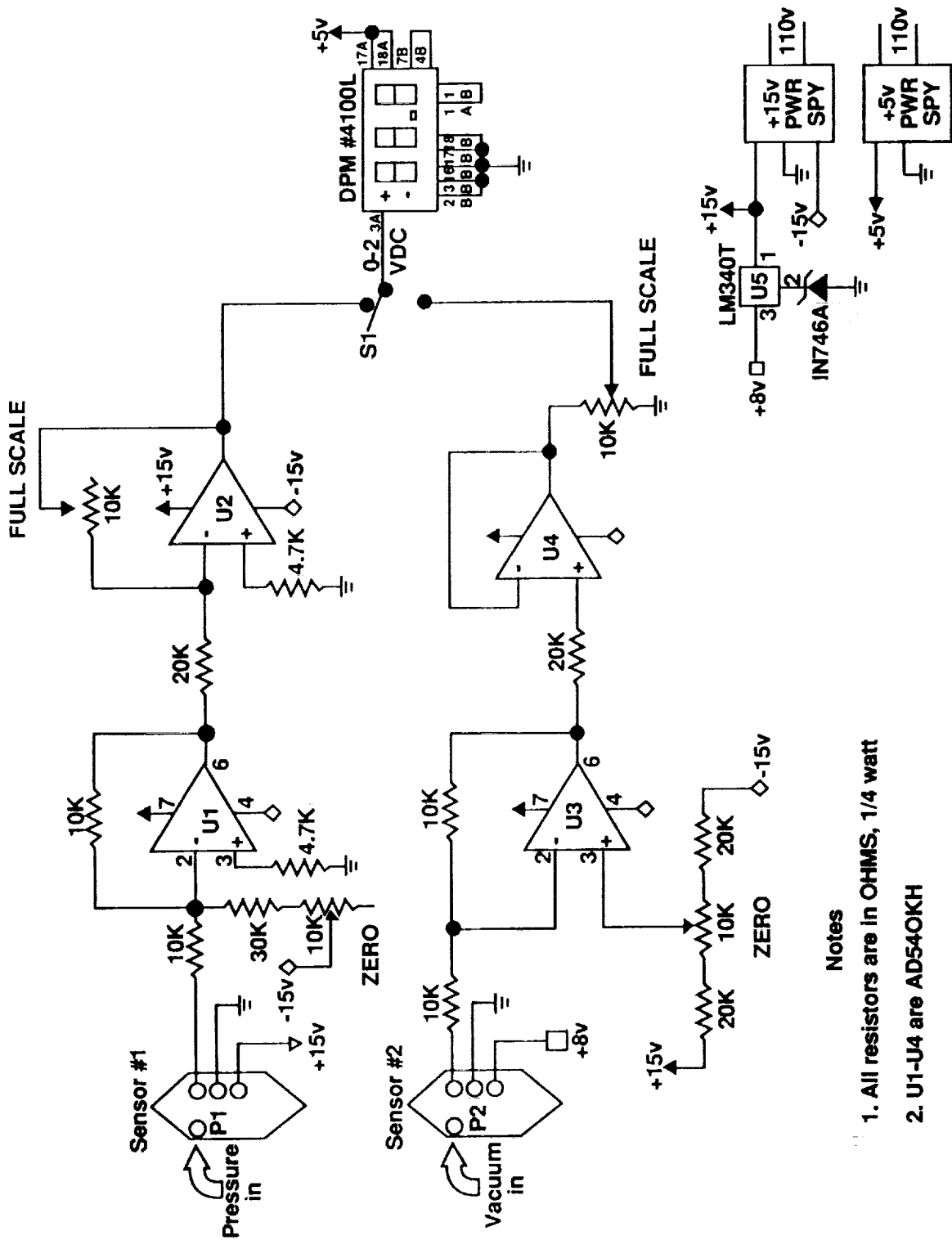


Figure 2. Flow diagram of digital pressure indicator



- Notes
1. All resistors are in OHMS, 1/4 watt
  2. U1-U4 are AD540KH

Figure 3. Schematic of digital pressure indicator



# STATIC CALIBRATION OF PRESSURE INDICATOR

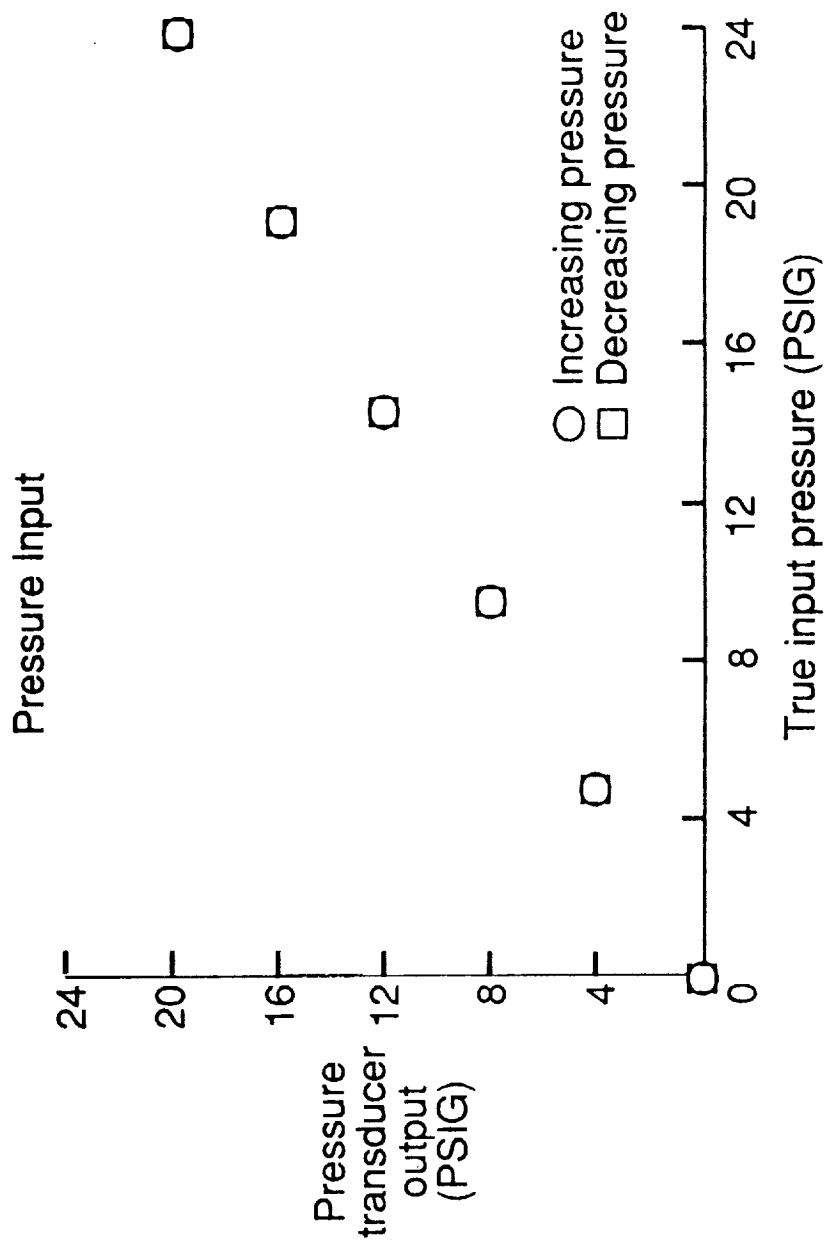


Figure 4. Calibration of 20 PSIG transducer

## STATIC CALIBRATION OF PRESSURE INDICATOR

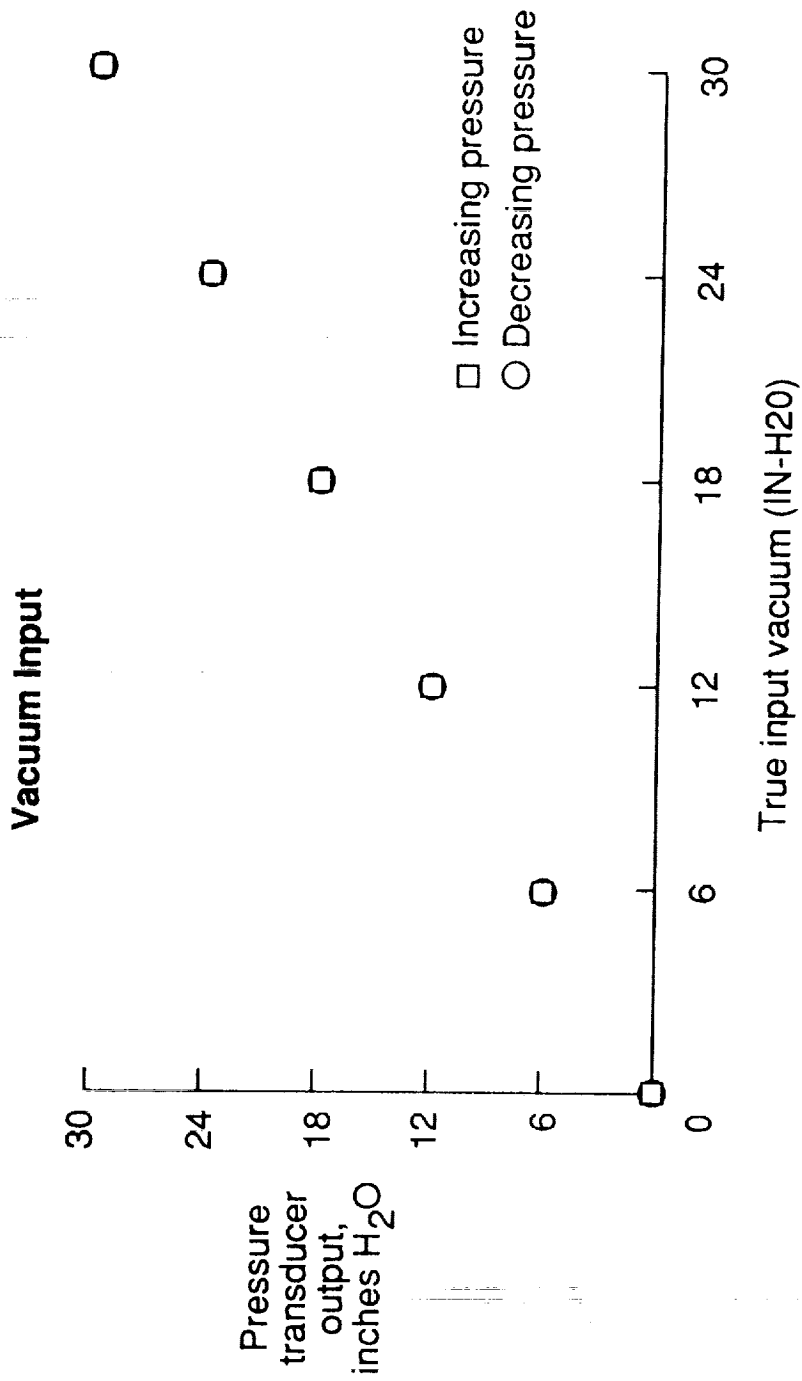


Figure 5. Calibration of 30-inch H<sub>2</sub>O transducer



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