Texas Instruments calibration procedure / Procédure pour calibrer un « Texas instruments »

Mulligan, M. F.; Carvish, J.

Laboratory Memorandum (National Research Council Canada. Division of Mechanical Engineering. Engine Laboratory); no. LM-ENG-004, 1986-07

CONTROLLED
UNCLASSIFIED

CONTRÔLÉ
NON CLASSIFIÉ

Division of Mechanical Engineering Report

Rapport de la division de génie mécanique

1986 / 07

LM-ENG-004

TEXAS INSTRUMENTS CALIBRATION PROCEDURE

M.F. Mulligan and J. Carvish

Division of
Mechanical Engineering

Division de
génie mécanique

National Research Council Canada

Conseil national de recherches Canada

Canada

DIVISION OF MECHANICAL ENGINEERING PUBLICATIONS

DM **(Division of Mechanical Engineering Report)**
Scientific and technical information considered important, complete and a lasting contribution to existing knowledge.

TR **(Technical Report)**
Information less broad in scope but a substantial contribution to existing knowledge.

CTR **(Controlled/Classified Technical Report)**
A Technical Report with controlled distribution for national security, proprietary or other reasons.

LM **(Laboratory Memorandum)**
Preliminary or exploratory information with controlled distribution.

CAT **(Calibration Analysis and Test Report)**
Information on minor laboratory projects or services.

PUBLICATIONS DE LA DIVISION DE GÉNIE MÉCANIQUE

DM **(Rapport de la Division de génie mécanique)**
Informations scientifiques et techniques jugées importantes, complètes et susceptibles de contribuer de façon durable à l'avancement des connaissances courantes.

TR **(Rapport technique)**
Informations de moindre importance, mais pouvant contribuer substantiellement à l'avancement des connaissances actuelles.

CTR **(Rapport technique à diffusion contrôlée/classifiée)**
Rapport technique à diffusion contrôlée pour des raisons de sécurité nationale, de propriété intellectuelle et autres.

LM **(Mémoire de laboratoire)**
Informations préliminaires ou de nature exploratoire à diffusion contrôlée.

CAT **(Rapport d'étalonnage d'analyse et d'essai)**
Informations sur de petits projets ou des services de laboratoire.

TEXAS INSTRUMENTS CALIBRATION PROCEDURE

PROCÉDURE POUR CALIBRER UN "TEXAS INSTRUMENTS"

M.F. Mulligan, J. Carvish

Laboratory Memorandum — Mémoire de laboratoire

1986/07 — LM-ENG-004

Engine Laboratory
Laboratoire des Engins

ABSTRACT

This memorandum is intended to be used as a guide for calibrating a Texas Instruments, Model 157, Pressure Standard against a Bell and Howell Primary Pressure Standard.

Excerpts from the TI Operation and Maintenance manual have been included in Appendix B.

An actual calibration was used for demonstrating the procedure, which included electrical as well as mechanical adjustments. The calibration, ranging from 0 to 100 PSIG, indicates a maximum drift of 0.026% over three years, which is within the manufacturer's specification.

RÉSUMÉ

Le présent mémoire est un guide pour calibrer la pression d'étalonnage standard du "Texas Instruments" contre la pression d'étalonnage standard primaire de "Bell and Howell".

Des extraits du manuel "TI Operation and Maintenance" sont inclus dans l'appendice B.

Une calibration actuelle comprenant des ajustements électriques et mécaniques fut utilisée pour démontrer la procédure. La calibration variant de 0 à 100 PSIG, indique une déviation maximum de 0.026% pour une période de trois ans, ce qui est à l'intérieur de la spécification du fabriquant.

CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF APPENDICES

TEXAS INSTRUMENTS CALIBRATION PROCEDURE

1.0 INTRODUCTION

The purpose of the report is to facilitate the calibration of a Texas Instruments (TI), Model 157, Pressure Standard [Fig. 1] against a Bell and Howell Primary Pressure Standard [Fig. 2], which will also be referred to as a Dead Weight Tester (DWT). Although the Texas Instruments Operation and Maintenance Manual (Ref. 1) contained most of the information necessary for recalibrating the instrument, the organization of the manual was found to be difficult to follow. It was also discovered that an electrical problem existed with the device. This document will outline the procedure which was followed in actually calibrating a Texas Instrument Pressure Standard.

Relevant sections of the manual have been reordered in a logical sequence, and are included in Appendix B.

2.0 APPARATUS

The Texas Instrument Pressure Standard is a multi-range calibrator, capable of functioning as a pressure gauge or a pressure source. It incorporates a Bourdon capsule pressure sensor [Fig. 3], which is available for absolute or differential operation, in ranges from 5 to 200 PSI. Pressure is indicated as counts by a mechanical counter on the front panel. The instrument is also fitted with a meter, which will indicate any difference between the true pressure sensed by the capsule and that indicated on the mechanical counter.

The Bell and Howell Primary Standard is a precision pneumatic device that, through a number of piston, cylinder, and weight combinations allows pressures to be checked.

The calibration was carried out with reference to the Bell and Howell Primary Standard Operation Manual [Ref. 2] and the Bell and Howell Controller Operation Manual [Ref. 3]. No additional explanation is required as these manuals are well-organized and cover all the necessary steps clearly.

The standard was connected directly to the Bourdon capsule during the calibration. For the purpose of this calibration a 200 PSI Bourdon capsule was used limiting the maximum pressure to 100 PSI.

3.0 CALIBRATION PROCEDURE

The following gives the general procedure that was used to calibrate the TI. For detailed instructions refer to Appendix B, where excerpts from the manufacturer's Operation and Maintenance manual are included in a logical order.

Mechanical and electrical adjustments were made to the Texas Instruments before connecting the Bourdon capsule to the DWT. It was found that a noticeable friction existed while turning the fine adjust knob which was remedied by cleaning and relubricating the level gears on the fine adjust knob shaft. The Bourdon capsule temperature was adjusted to 49.0 ($\pm$ .5) degrees Celcius. Other electrical adjustments were made to set the DC amplifier offset, null amplifier offset and gain, panel meter full scale, and buffer offset and gain.

During the calibration, it was noticed that the lamp cap located on the gear block assembly [Fig. 4] was contacting the lamp circuit board causing unstable instrument operation. The lamp cap is an aluminum cover that shields the lamp circuit board.

Excessive vibration possibly caused by transporting the instrument may have made the cap contact the circuit board. This fault was corrected and the Bourdon capsule was then zeroed.

After connecting the Texas Instruments Pressure Standard to the Bell and Howell Primary Standard [Fig. 5] the calibration was performed with the TI set in manual mode. Weight, piston, and cylinder combinations of the DWT were chosen so as to cover the range of the instrument. The 1.5 to 50 PSI piston and cylinder combination suited the higher range (60 to 100 PSI). The higher range was more sensitive to contaminants at lower pressures and, therefore, was not used below 50 PSI. Improper operation of the DWT, which can be detected by a failure of the weights to rotate and/or bob freely, will produce errors in the results of the calibration.

4.0 RESULTS

The results, given in Table 1, show a maximum change of 0.026% from the original calibration. This drift is within the manufacturer's specifications, considering the time elapsed since the instruments calibration date of 1 August 1982.

5.0 CONCLUDING REMARKS

A) This report describes the calibration of a Texas Instruments Pressure Standard, using a Bell and Howell Primary Pressure Standard.

B) When operating the Bell and Howell Pressure Standard, use the 1.5 to 50 PSI piston and cylinder combination for the lower range (up to 50 PSI) and the 15 to 500 PSI combination for the higher range (from 60 to 100 PSI).

C) An important item, not mentioned in the TI Manual, is to check the position of the lamp cap to make certain that it does not contact the lamp circuit board.

D) The TI manual included most of the information for recalibrating the instrument, but it was found to be difficult to follow. The pertinent sections have been restructured and included in this report.

6.0 REFERENCES

1. TI Multi-Range Model 157/100 Pressure Standard Manual No. 2214217-9701, August 1980.

2. Bell and Howell type 6-201-0001 Operation and Maintenance Manual. Publication No.99114-880.

3. Calibration Pressure Controller Type 6-003-0002 Operation and Maintenance Manual. Publication No. 992310.

Figure 1. Multi-Range Model 157/100 Pressure Standard
(Model 157-01 Shown)

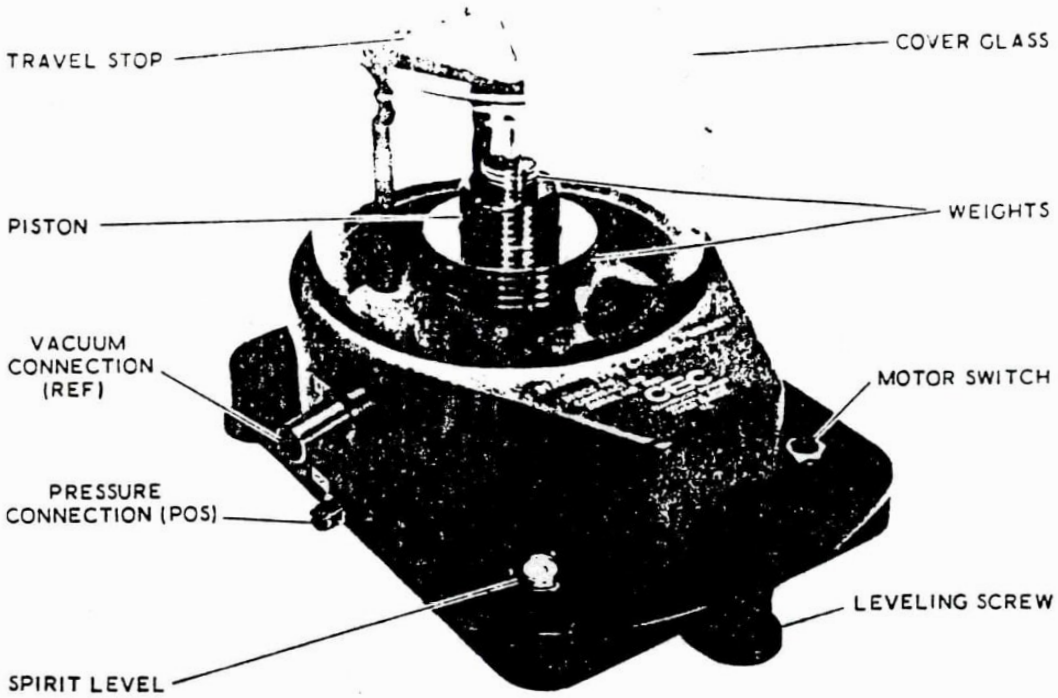


Figure 2: Primary Pressure Standard Type 6-201-0001

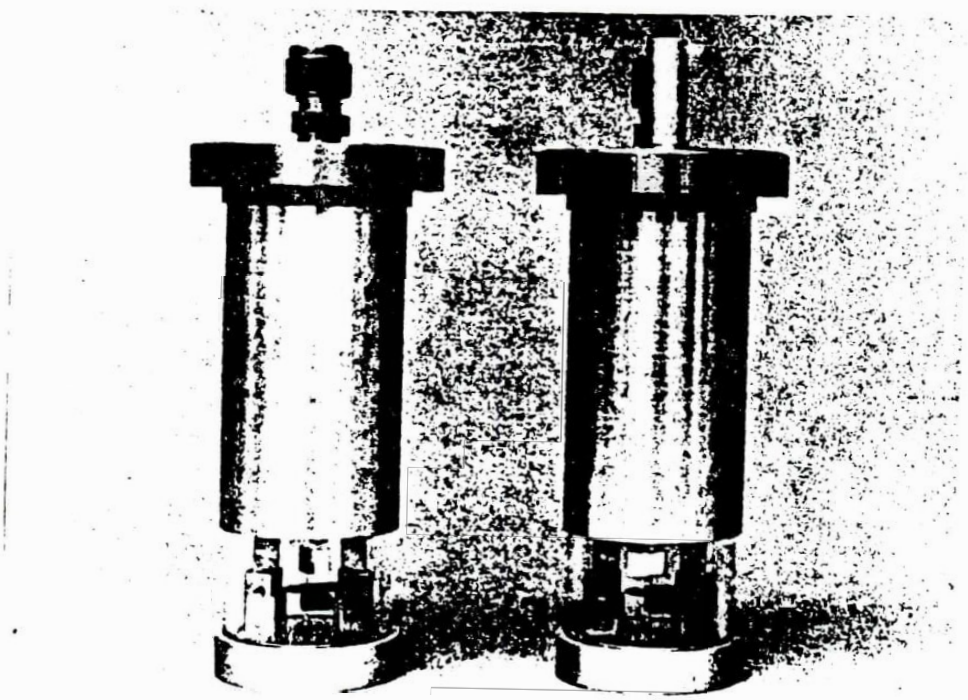
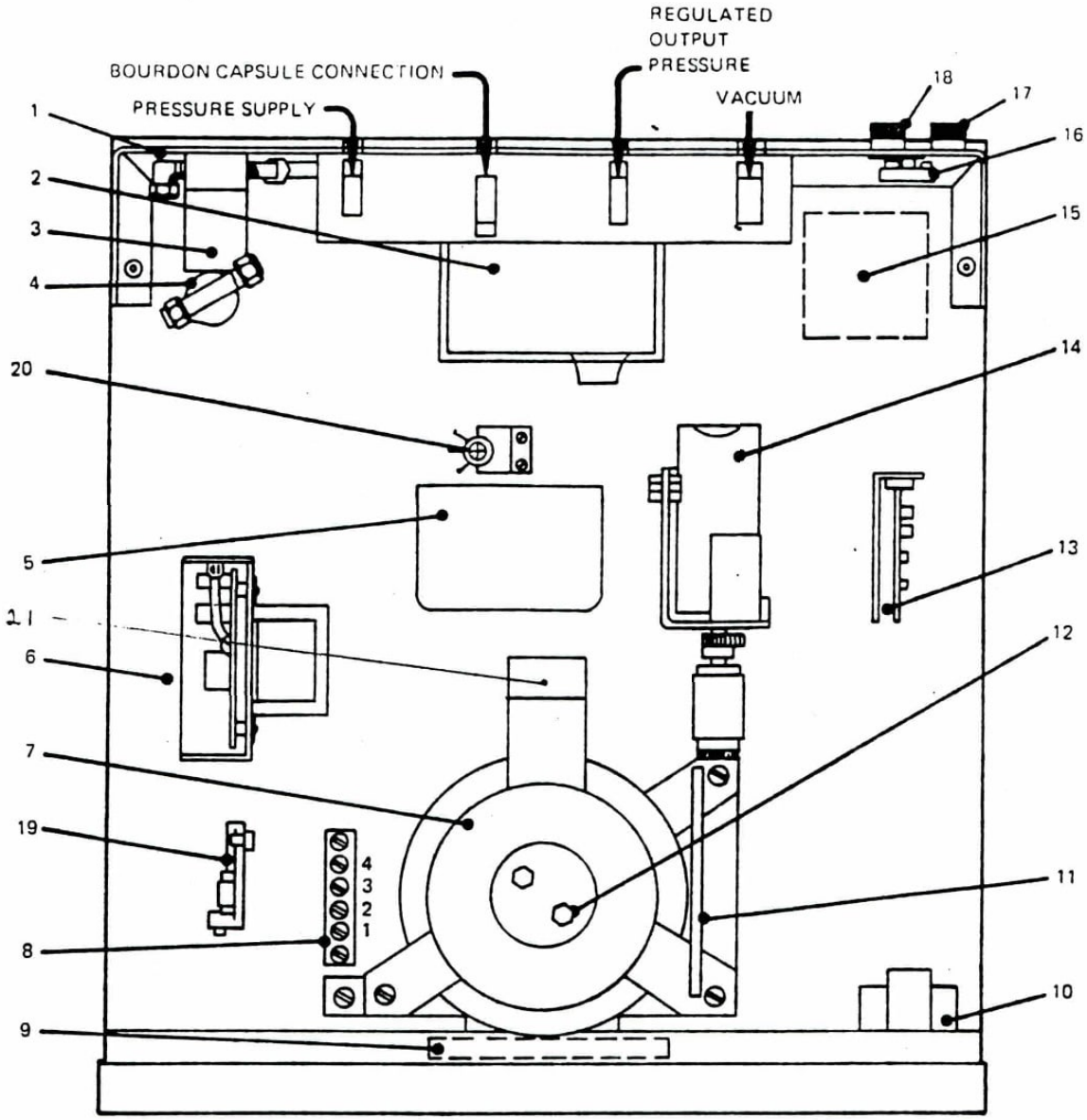


Figure 3: Bourdon Capsule



1 TERMINAL BOARD (TB2)
2 SERVO VALVE
3 INPUT SOLENOID
4 OUTPUT SOLENOID
5 ZENER SUPPLY
6 SERVO AMPLIFIER
7 GEAR BLOCK
8 TERMINAL BOARD (TB3)
9 METER (M1)
10 TRANSFORMER (T1)
11 CAPSULE TEMP CONTROL
12 BOURDON CAPSULE
13 AMPLIFIER-SERVO VALVE
14 SERVO GAGE MOTOR
15 STEP DOWN TRANSFORMER AS REQ'D
16 TERMINAL BOARD (TB1)
17 CONNECTOR (J1)
18 FUSES (F1 and F2)
19 NULL CIRCUIT
20 TRANSDUCER LAMP VOLTAGE ADJUST
21 LAMP CAP

Figure 4: Pressure Standard Parts Identification

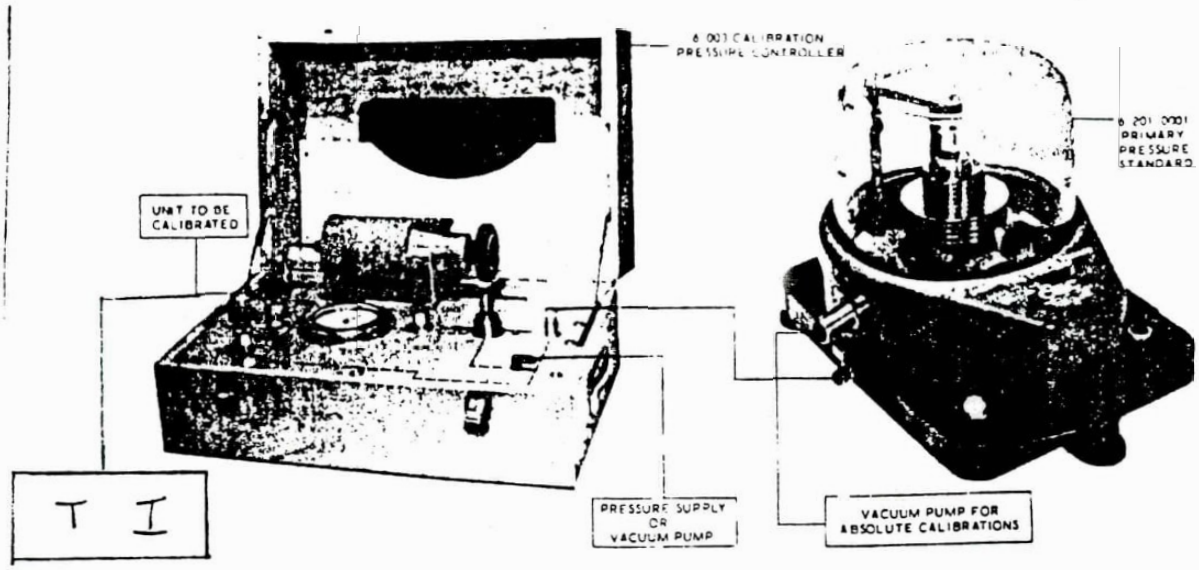


Figure 5: Primary Pressure Standard Calibration Set Up Using a Calibration Pressure Controller Type 6-003

D-22313

ENGINE LABORATORY
INSTRUMENT CALIBRATION

INSTRUMENT TYPE Calibration Unit **MAKE** Texas Instrument

N.R.C. MARKING **TYPE No.** 157-02-0001

RANGE 0 → 200 PSI **SERIAL No.** SN112

CALIBRATION REQUESTED BY

INSTRUMENT CALIBRATED BY M.F. Mulligan/ J. Carvish **DATE** 4 April 1985

SPECIAL INSTRUCTIONS **DEPT.** Mechanical Engineering

Unit contains Bourdon Capsule Type 801, #7951 0-200 PSI at 49.1°C.

CALIBRATION STANDARD - D.W.T. SN 4312

CALIBRATION BELL & HOWELL

NOTE CONDITIONS ETC.

		CHANGE FROM PREVIOUS CALIBRATION 01/08/82	
D.W.T. TRUE PSIG	**INDICATED COUNTS**	**COUNT DIFFERENCE**	**% COUNT DIFFERENCE**
10.0	10032	-1	.010
20.0	20056	-5	.025
30.0	30073	-13	.010
40.0	40082	-10	.025
50.0	50078	-13	.026
60.0	60077	-8	.013
70.0	70065	-10	.014
80.0	80045	-8	.010
90.0	90014	-16	.020
100.0	99974	-22	.020

TABLE 1 TEXAS INSTRUMENTS CALIBRATION RESULTS

APPENDIX A

EQUIPMENT LIST

1) Pressure Standard

   a. Texas Instruments Pressure Standard Model 157-02-0001 S.N. 112.

   b. Bourdon Quartz Capsule, Type 801, S.N. 7951 0 - 200 PSID.

2) Primary Pressure Standard

   a. Bell and Howell Primary Pressure Standard, Model 6-201-0001, S.N. 4312.

   b. Pressure Controller, Model 6-003-0002, S.N. 2232.

   c. Weight Set No. 6-002-0002.

   d. Piston and Cylinder Combination, 6-001-0003 15 - 500 PSI
   Piston #453
   Cylinder #554
   Accuracy .025% of reading.

   e. Piston and Cylinder Combination, 6-001-0002 15 - 50 PSI.
   Piston #162
   Cylinder #1777
   Accuracy .015% of reading.

APPENDIX B

CALIBRATION ADJUSTMENTS

The following sections extracted from the Texas Instruments Operation and Maintenance Manual have been reorganized and edited in order to facilitate their usage.

B.1 Gear Lubrication

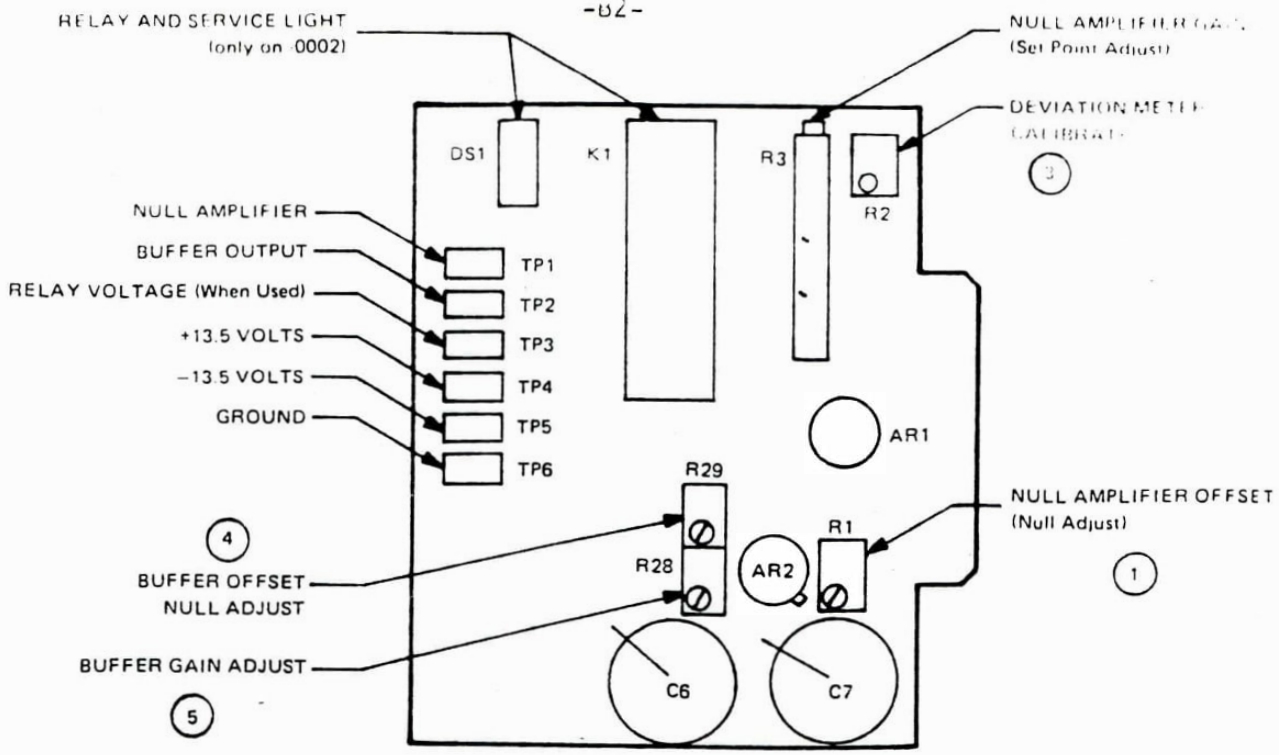
The bevel gears (control drive) are sparingly lubricated with Shell Darina Number 1 grease or equivalent. To relube, the front panel must be removed. Clean and relube only if friction is noted when the FINE ADJUST control is turned by hand.

CAUTION **Do not lubricate other gears. The worm and worm gear contain sufficient grease to last until a general overhaul is required. Spur gears accumulate particles of dirt when lubricated or oiled, which ruins these gears. When cleaning is required, brush the dirt out of the teeth with a clean, dry toothbrush.**

B.2 Capsule Temperature

Bourdon Capsule temperature is monitored by inserting a mercury thermometer into a hole located in the capsule body. Calibration temperature was measured by this method at 22°C to 25°C ambient temperature, with the instrument cover and capsule cover in place and after a minimum of two hours' stabilization time.

To reset the temperature, remove the instrument cover and observe the capsule temperature control; reference Figure 4, item 11. A capsule temperature control can be seen through the cover over the printed circuit assembly. This potentiometer is turned approximately one turn clockwise to increase the temperature approximately 1°C. Turn the potentiometer slightly, replace the cover on the instrument, and wait two hours for the capsule temperature to stabilize. Repeat this procedure until the potentiometer has been adjusted to the correct temperature.



ORDER OF ADJUSTMENT SHOWN BY CIRCLED NUMBERS.

Figure B1 Null-Indicator Circuit Board

B.3 Null Indicator Initial Adjustment

Set the function switch to OFF. After 30 to 45 seconds, note the deviation meter needle position. If not at null (zero), adjust the meter zero screw (which is located at the base of the needle on the face of the deviation meter) to achieve a null.

With the Bourdon Capsule installed, the instrument connected to power, and function switch in STANDBY, allow the temperature to stabilize a minimum of 30 minutes.

The Bourdon Capsule pressure should be unchanging at zero differential. For the differential Bourdon Capsule, open both ports to the atmosphere. Remove the instrument cover and shield the gearblock photocell assembly from a stray light with a cloth.

B.4 Null-Amplifier Offset-Null Adjustment

a. Switch the instrument to STANDBY mode.

b. Adjust R1 for a null reading on the front panel meter (center zero).

B.5 Null-Amplifier Gain Calibration

a. Switch the instrument to MANUAL GAGE AND EXTERNAL mode.

b. Null the deviation meter using the FINE ADJUST knob and note the counter reading.

c. Offset the counter plus or minus 10 counts multiplied by the counter gear ratio shown as "Gearing" on the calibration chart.

   Example:
   1:1 Gearing = 10 counts
   3:1 Gearing = 30 counts

d. Adjust R3 (Figure 5-1) for plus or minus 1.1 volts dc $\pm$10% between TP1 and ground (TP6).

e. Recheck the counter reading for a null on the front panel meter.

B.6 Meter Calibration

a. Offset the counter 20 counter divisions from null.

b. Adjust R2 for a 20-division deflection on the deviation indicator from center zero.

c. Offset the counter 20 counter divisions in the opposite direction from null.

d. Readjust R2 if needed to average the plus and minus error readings.

NOTE For a sensitivity setting other than a 1:1 ratio, adjust R2 as required. To exceed normal range, a different value for R4 may be employed.

B.7 Buffer Offset Null Adjustment

a. Switch the instrument to SERVO GAGE mode and adjust the gage gain and the gage damping for proper response of the servo gage per paragraph B.8.

B.8 Servo Gage and Control Adjustments

Servo gain and damping control is achieved by the adjustment of three recessed potentiometers on the front panel. These controls are labeled GAIN (GAGE), DAMP (GAGE), and GAIN (CONT). The potentiometers provide gain and damping control of the servo system when operated as a servo pressure gage (SERVO GAGE) or as a servo pressure controller (SERVO CONTROL).

Servo Gage

Servo gage gain and damping adjustments are outlined below.

a. Prepare to measure pressure. Apply a relatively constant pressure to the Bourdon Capsule. For example, leave the Bourdon Capsule port(s) open to the atmosphere.

b. Adjust the GAIN (GAGE) and DAMP (GAGE) potentiometers to midrange.

c. Jog the GAGE DRIVE switch several times and confirm that the reading on the counter is repeated within one count.

d. Check deadband by the deviation meter. A slight increase (clockwise) of the GAIN and decrease (counterclockwise) of the DAMP potentiometers should provide minimum deadband. The GAIN and DAMP potentiometers interact slightly; therefore, minor readjustment of these potentiometers may be required.

Servo Control

Servo control gain adjustment and performance is outlined below.

a. Proper adjustment of the GAIN potentiometer may be checked by the deviation meter.

b. Adjust the GAIN potentiometer to midrange.

c. Place the instrument in operation in SERVO CONTROL (as a pressure generator) at approximately 50 per cent of pressure span.

d. Momentarily activate the PRESSURE DRIVE switch; then permit the system to settle. The system should settle within 15 seconds.

e. Check deadband by the deviation meter. A slight increase (clockwise) of the GAIN control should provide minimum deadband. Repeat step d, activating pressure drive in the opposite direction. Adjust the gain control setting for minimum deadband. Using several different output pressures, adjust for the minimum gain that will permit the system to control pressure within specifications.

NOTE If steps d and e produce good repeatability but the deviation meter consistently shows offset from "0", allow the control pressure to stabilize and then change the function switch to SERVO GAGE. If the deviation meter is offset from "0", make the buffer offset null adjustment. If there is no offset when the function is SERVO GAGE, but offset occurs in SERVO CONTROL, remove the right-hand half of the instrument cover and adjust the potentiometer R11 located on the dc amplifier circuit card assembly.

B.9 Buffer Gain Adjustment

a. Switch the instrument to MANUAL GAGE mode.

b. With the FINE ADJUST knob, adjust the counter for a null on the deviation meter and note the counter reading.

c. Offset the counter 100 counts multiplied by the counter gear ratio shown as "Gearing" on the calibration chart.

Example:
1:1 Gearing = 100 counts
3:1 Gearing = 300 counts

d. Adjust R28 for 0.030 volt (±10% at the external jacks). (0.25 volt for one percent offset may be used.)

B.10 Pressure Zero

Pressure zero is a setting of the digital counter versus pressure at the Bourdon Capsule.

a. Apply equal pressure to the Bourdon Capsule pressure and reference ports, i.e., open both ports to the atmosphere.

b. Adjust the ZERO potentiometer (recessed) on the front panel to midrange.

c. Set the function switch to STANDBY ; then set the counter to 000000 by use of the GAGE DRIVE switch and the FINE ADJUST knob.

d. Place the LOCK button in the unlock position.

e. While the front surface of the FINE ADJUST knob is depressed, switch from the STANDBY to the SERVO GAGE mode. The FINE ADJUST knob will turn to a servo null. When the knob stops turning, release the FINE ADJUST knob.

NOTE If GAIN and DAMP adjustments are incorrect, a good servo null will not be obtained. See paragraph B.8 for the proper adjustment of these gage controls.

f. Final zero (000.000) may be obtained by adjusting the ZERO potentiometer on the front panel. Using a small screwdriver, adjust the ZERO potentiometer for a final zero. The GAGE should also indicate a zero-null in the MANUAL GAGE AND EXTERNAL mode.

g. Lock the LOCK button on the FINE ADJUST control.

h. Apply calibration pressures, per the pressure standard, recording the applied pressure and the counter reading of the gage being calibrated. The pressure standard may be a dead-weight tester, a mercury manometer or a secondary standard (such as another TI gage) of sufficient accuracy to correctly measure the applied pressure. The calibration pressure may be randomly specified pressure points or may be made in increments of five percent of full scale (recommended). When calibrations are made in even pressure increments, calculations may be easily made to determine if pressure applied and counter readings have no errors.

REPORT DOCUMENTATION PAGE/PAGE DE DOCUMENTATION DE RAPPORT

REPORT/RAPPORT	REPORT/RAPPORT
1a LM-ENG-004	1b
SECURITY CLASSIFICATION/ CLASSIFICATION DE SÉCURITÉ Unclassified 2	DISTRIBUTION/DIFFUSION ☒ Controlled/Contrôlé ☐ Unlimited/Illimité 3

TITLE/SUBTITLE/TITRE/SOUS-TITRE

Texas Instruments Calibration Procedure

4

AUTHOR(S)/AUTEUR(S)

M.F. Mulligan, J. Carvish

5

SERIES/SÉRIE

Internal Document

6

CORPORATE AUTHOR/PERFORMING AGENCY/AUTEUR D'ENTREPRISE/AGENCE D'EXÉCUTION

DME, NRC, Engine Laboratory

7

SPONSORING AGENCY/AGENCE DE SUBVENTION

8

DATE	FILE/DOSSIER	LAB. ORDER COMMANDE DU LAB.	PAGES	DIAGS	REFS
1986/97		22355	19	7	3
9	10	11	12a	12b	12c

NOTES

13

DESCRIPTORS(KEY WORDS)/MOTS-CLÉS

Calibration, Bell and Howell, Texas Instruments

14

SUMMARY/SOMMAIRE

The memorandum describes a calibration procedure performed on a Texas Instruments Pressure Standard.

15

ADDRESS/ADRESSE

D.M. Rudnitski
Section Head, Engine Laboratory
Division of Mechanical Engineering
National Research Council OTTAWA, Ont. K1A 0R6

16