PRESSURE TRANSFORMER

Problem: In order to measure the pressure accurately in a rocket motor, a pressure transducer is required. However, the cost can be prohibitive (upward of 500$). A low cost unit was recently obtained for $35, but could measure pressures only to a maximum of 700 kPa.(100 psi), whereas the rocket chamber pressures are in the order of 10,000 kPa.(1500 psi). Can this unit be utilized in some manner?

Solution: A pressure transformer is a device that transforms the input pressure to another level, by a fixed ratio. In this case, a ratio of 14,000/700= 20 is required to allow a maximum pressure of 14,000 kPa. (2000 psi) to be measured.

The device works on the principle of the equilibrium of forces acting on a double ended piston. Since Force(F) = pressure (P)X Area(A), by varying the area of the piston ends by a given ratio, the pressure required to maintain equilibrium is modified by this factor, as shown below:

$$P_i A = P_i f A \frac{1}{f}$$

where f is the pressure modification factor

or

$$\frac{P_o}{P_i} = \frac{P_i f}{P_i} = f$$

Construction: In order to reduce oscillation resulting from compressibility of the working fluid, hydraulic fluid is used in the low pressure chamber(or sealed chamber). As well, this reduces the effects associated with displacement of the moving components in the system. In addition, response time is improved.

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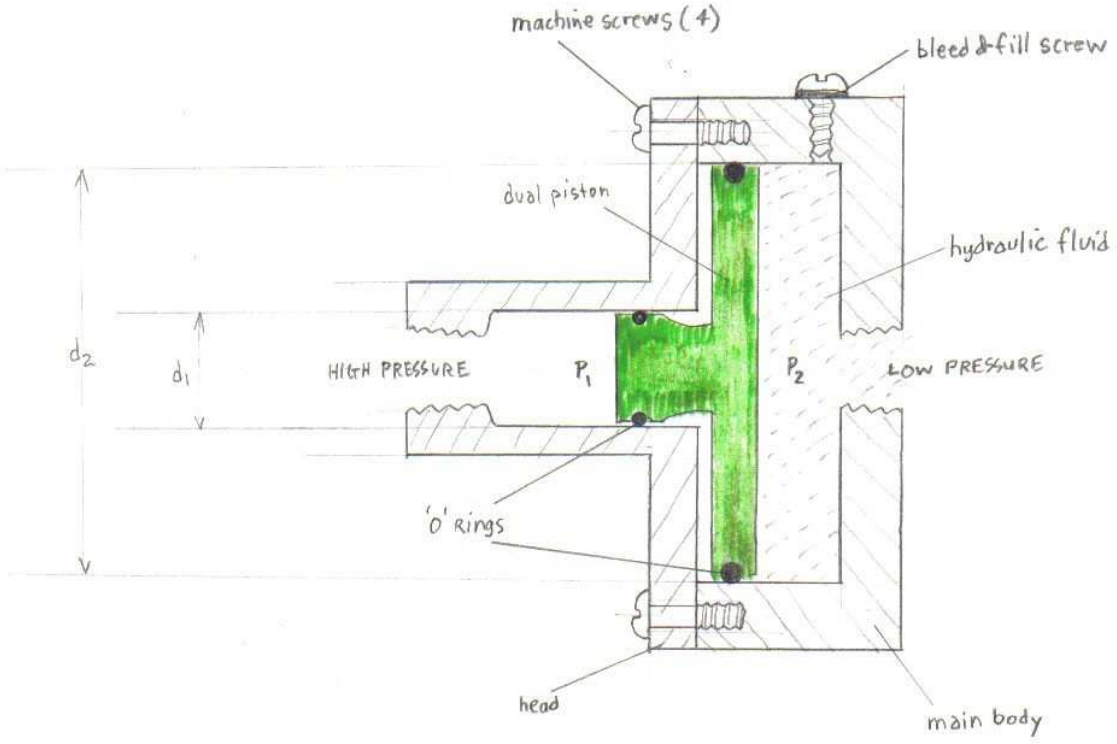
The entire device is constructed from machined bar aluminum. The piston is sealed at both ends with 'o' rings, fitting snugly in the respective polished cylinders.

The hydraulic fluid is filled and bled through a threaded hole at the top of the low pressure housing. This is then sealed with a machine screw fitted with a fibre washer.

The low and high pressure housings are separate units held together by four machine screws.



Pressure Ratio: **20.5:1**

Piston Area ratio: **20.5:1**

Piston Diameter Ratio: **4.52:1**

CALIBRATION DATA FOR 20:1 PRESSURE TRANSFORMER

Test date: Feb. 2, 1985

Definitions:

P_H - transformer high pressure reading.

P_L - transformer low pressure reading.

$f_{\updownarrow}$ - transformation factor, where arrow indicates if pressure is increasing or decreasing at time of reading.

dev - maximum deviation of pressure reading from the average, where the average is defined as

$$\frac{P_H + P_L}{2}$$

$\bar{f}$ - The average transformation factor.

P_H*(kPa)	$P_{L\uparrow}$**(kPa)	$f_{\uparrow}$	$P_{L\downarrow}$(kPa)	$f_{\downarrow}$	$\bar{f}$	dev %
2000	93.1	21.5	109	18.3	19.9	8.0
3000	134	22.4	155	19.4	20.9	7.2
4000	179	22.3	199	20.1	21.2	5.2
5000	227	22.0	235	21.3	21.7	1.4
6000	270	22.2	283	21.2	21.7	2.3
7000	316	22.2	330	21.2	21.7	2.3
8000	364	22.0	371	21.6	21.8	0.9
9000	410	22.0	420	21.4	21.7	1.4
10,000	458	21.8	465	21.5	21.7	1.4
11,000	510	21.6	503	21.9	21.7	0.9
12,000	558	21.5	---	---	21.5	---

* measured with 0-2000 psi CANFLO™ gauge.

** measured with 0-80 psi USG™ gauge.

Pressure Transducer Calibration Test- resistance as a function of pressure.

test date: March 3, 1985

Detail- In order to calibrate the pressure transducer to obtain a transfer function of its pressure-resistance curve, a setup was used to steadily increase (or decrease) the pressure acting on the device while readings were recorded. In the following table, the arrows indicate whether the pressure was inceeasing or deкreasing at the time of testing.

Pressure (psi)	R↑ (Ω)	R↓ (Ω)	R↑ (Ω)	R↓ (Ω)	test of 05-03-85 R↑ (Ω)	R↓ (Ω)
0	1	3	1	3	1	—
10	9	34	8	44	8	44
20	56	93	56	92	56	93
30	104	151	115	151	103	151
40	152	187	154	189	151	188
50	199	225	199	224	194	226
60	235	260	237	260	234	263
70	272	302	275	310	270	296
80	322	330	321	331	320	342

Tested with USG gauge, 0-80 psi (true pressure)

- To be fitted to a second order curve.

PRESSURE TRANSFORMER COMPONENT DIMENSIONS (centimetres)