Department of consumer and corporate affairs / Ministère de la consommation et des corporations

STANDARDS BRANCH - DIRECTION DES NORMES

NOTICE OF APPROVAL

G - 62

OTTAWA February 24, 1970.

FOXBORO, MODEL 541
GAS FLOW COMPUTER

Apparatus

Static Pressure: (Ranges adjustable between indicated limits)	
Nickel Bellows	from 0-30 to 0-100 psig
Helical Elements, 316 stainless steel	from 0-100 to 0-700 psig
Helical Elements, 316 stainless steel	from 0-700 to 0-1,500 psig
Connection, piped to high or low pressure side	$\frac{1}{4}$" -28 tap
Differential Pressure:	
Capsule-type pressure element	fixed span, 0-100" W.C.
Cadmium-plated carbon steel D.P. element body material	Max. working pressure 1,500 psig
Connections, threaded, female	$\frac{1}{4}$" or $\frac{1}{2}$" NPT
Pneumatic Supply Pressure:	
Clean and dry air or gas	25 psig
For sustained operation below zero °F	30 psig
Air or gas consumption (balanced position)	0.75 SCFM
Connections	$\frac{1}{4}$" NPT
Numerical Readout:	
Integral non-reset counter	6 digit capacity
Max. full range count rate (based on mean barometric pressure of 14.4 psia)	67,500 counts per day
Electrical Pulse Output:	
Peak to peak value	3 volts
Frequency at full range count rate	600 Hz
Output wired to a phone jack terminal, accessible through instrument cover.	
Ambient Temperature Limits	-40°F to +180°F

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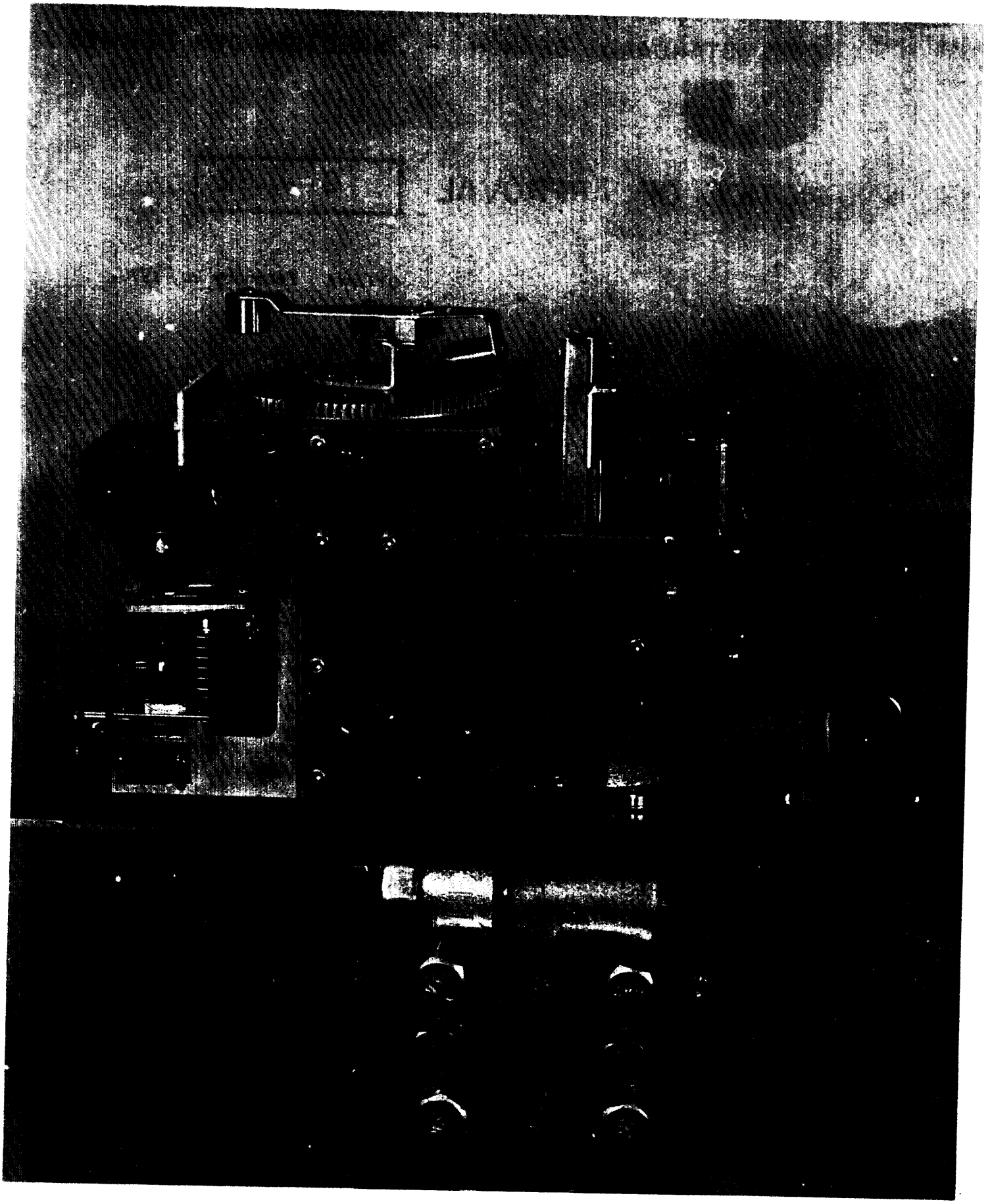

Foxboro Standard Performance Specifications

Ambient Temperature Effects:

A change of 50°F in ambient temperature may produce the following effects, in percent of full range.

1. "Differential Zero" Shift ±1.0%
   When the unit is operating at the maximum calibrated value of static pressure and a differential pressure value representing 20% of flow.

2. "Static Zero" Shift ±1.5%
   When the unit is operating at 100 inches of water differential and a static pressure value representing 20% of flow.

3. Computer Output Shift ±1.5%
   When operating at the maximum calibrated values of static and differential pressures.

Supply Pressure Effect

A change of 5 psi in the supply pressure may cause an error in the computer readout of ±1.0% of full range.

Computer Position Effect

A tilt of 5 degrees in any plane may cause an error in the computer readout of up to ±0.5% of full range when operating at the maximum calibrated values of static and differential pressures.

Description

The Model 541 Gas Flow Computer is a pneumatically operated instrument which performs the function of measurement, multiplication, square rooting and integration of differential and static pressures obtained from an orifice meter.

The differential pressure is sensed by a capsule element connected to the computer mechanism by a force bar. The static pressure is sensed by a pressure element linked to a pressure servomechanism. This servomechanism allows the use of measuring elements with adjustable span linkage for a wide variety of ranges.

A unique, turbine-type integrator mechanism, operating on the principle of a squared relationship between the rotational speed and centrifugal force, permits square-root extraction in the integrator, which, in turn, is geared to a rotary counter. The readings of this counter is proportional to the square root of the differential pressure times static pressure, i.e. $\sqrt{h_w p_f}$.

FOXBORO MODEL 541 GAS FLOW COMPUTER

A mechanical feedback link between the integrator mechanism and the computer stabilizes and improves the overall performance reliability.

Figures 1, 2 and 3 show the diagramatic and physical relationship of components in the flow computer. In operation, the differential pressure transmits a force through the force bar to the force arm which then tends to move toward the computer nozzle. The static pressure in the sensing element positions a flapper in the proximity of another nozzle. An adjustable span-lever assembly links the pressure element to the flapper. This nozzle output pressure is applied to the servo-bellows which, in turn, position the restraining yoke. The flexure arm follows position changes of the restraining yoke and thus causes changes in the relationship between the force arm and the computer nozzle. A deflection of the force arm causes a change in the relay output to the jet nozzle which drives the turbine wheel. The rotation of the turbine wheel provides the feedback force by means of the flexured counter-weight and the feedback rod, and also drives the mechanical counter, through a suitable gear train.

The rate of flow through an orifice meter is, in general, expressed by the formula

$$Q_h = C\sqrt{h_w p_f}$$

in accordance with A.G.A. Report No. 3 on Orifice Metering of Natural Gas.

During a period of 't' hours the volume of gas passed through the meter, at base conditions used in the evaluation of C, is given by

$$\text{Volume, cu. ft.} = t \times C\sqrt{h_w p_f} \qquad (1)$$

and this equation is adapted to utilize the data from the Model 541 Computer for the total gas flow computation, as follows:-

$$\text{Volume, cu. ft.} = C \times \text{Machine Constant} \times \text{Net Count} \qquad (2)$$

where:

(a) Machine Constant is selected from Table I for various values of maximum static pressures.

(b) Net Count is the difference between the two readings on the computer counter for a period of 't' hours during which the volume is to be computed.

The Machine Constant is defined by the following equation:

$$\text{Machine Constant} = \frac{\sqrt{h_w(\max) \times p_f(\max)}}{\text{counts / hr (max)}}$$

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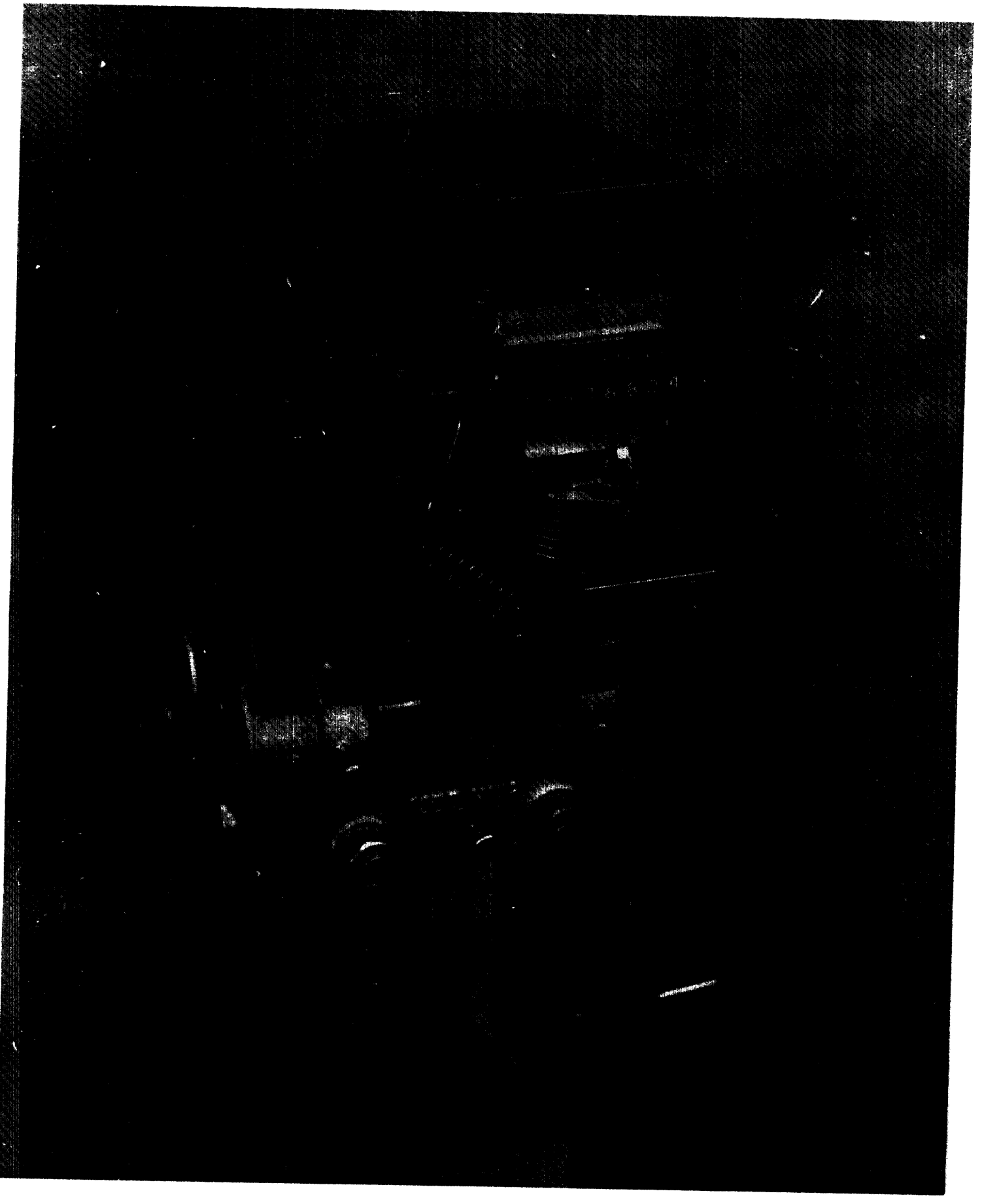

where:

$h_w(max)$ = maximum differential pressure, inches W.C.

$p_f(max)$ = maximum static pressure, psia,

counts/hr(max) = maximum hourly count rate based on available counter gear trains.

In the verification testing of this computer in the field, equations 1 and 2 may be used in establishing the accuracy of registration, as follows:

Apply to the operating computer constant values of the differential and static pressures. Measure these values by appropriate standards. During a period of 't' hours establish the "Net Count" which should not be smaller than 400. (For 80% of the max. flow this count value would be obtained in approx. 10 minutes). Assume a suitable value for C^1, say 1,000, and solve equation 1, which gives the true volume.

Using the established "Net Count" during the period 't' hours together with the data from Table I solve the equation 2 for the computer registered volume and calculate the accuracy in the usual manner. Allowable error is ±2% of full range value.

Tests should be made at approximately 80% and 40% of max. flow, using two different values of each parameter.

When the computer is operated on natural gas suitable piping must provide bleed discharge of gas to a safe release point.

Each computer shall carry a nameplate containing the information as to manufacturer's name, model designation, serial number, static and differential pressure ranges, full range count rate, applicable atmospheric pressure and maximum working pressure.

This Model 541 Computer is approved for billing purposes only when used in conjunction with approved temperature recorders, and when a satisfactory record is maintained to indicate the variations in the differential pressure or rate of flow through the meter against time.

Above requirements are made to ensure that sufficient information is available to establish the weighted average factor for the flowing gas temperature which is used in the evaluation of the orifice flow constant, C^1.

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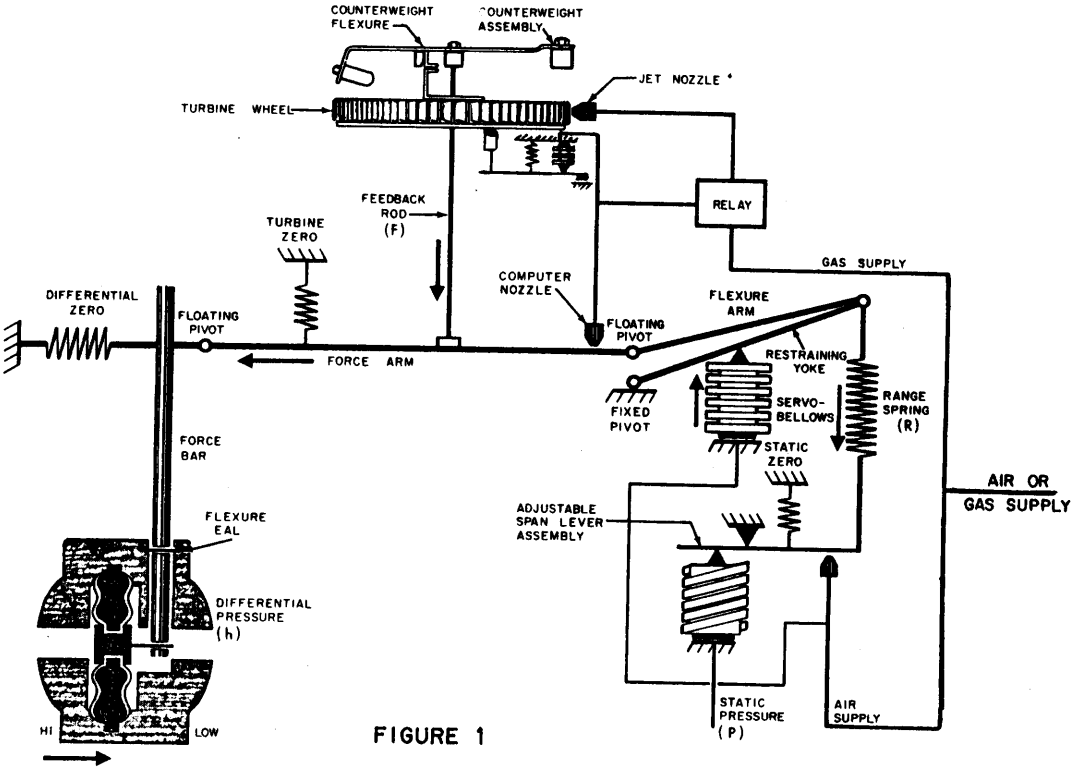

FIGURE 1

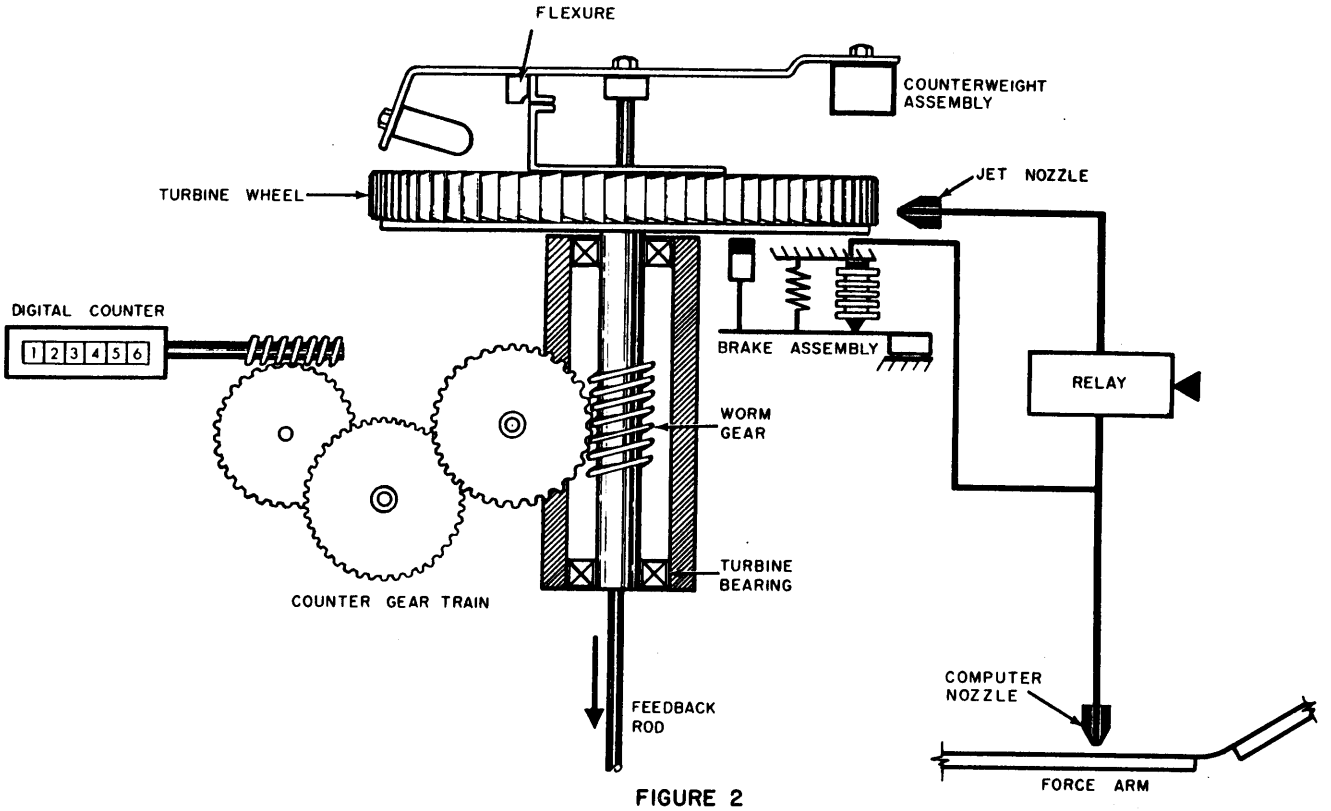

FIGURE 2

The selection of the weighted average supercompressibility factor, Fpv, should be based on a record of the flowing gas volumes, pressures and temperatures. If no continuous record is available, the variations in pressure and temperature normally existing in the orifice line must not introduce an error greater than ±0.5% in the selected Fpv factor.

Approval granted to:

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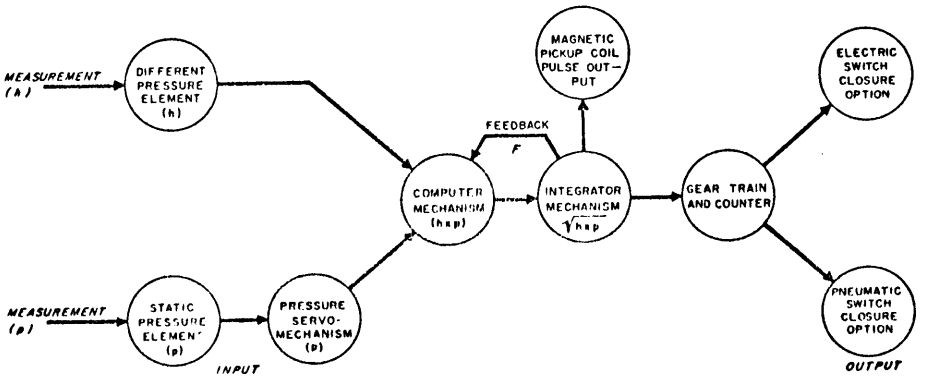

FIGURE 3

TABLE I
MACHINE CONSTANTS
(BASED ON 67,500 COUNTS/DAY)

STATIC PRESSURE MAX (PSIG)	MACHINE CONSTANT	STATIC PRESSURE MAX (PSIG)	MACHINE CONSTANT
30	.02369	275	.06049
40	.02622	300	.06304
50	.02853	325	.06551
55	.02962	350	.06787
60	.03067	375	.07016
65	.03168	400	.07238
70	.03266	425	.07453
75	.03362	450	.07662
80	.03454	475	.07866
85	.03545	500	.08064
90	.03633	550	.08447
95	.03719	600	.08813
100	.03803	650	.09165
110	.03966	700	.09504
120	.04122	750	.09830
130	.04272	800	.10147
140	.04418	850	.10454
150	.04559	900	.10752
160	.04696	950	.11042
170	.04828	1000	.11325
180	.04957	1050	.11600
190	.05083	1100	.11869
200	.05206	1150	.12132
210	.05326	1200	.12390
220	.05444	1250	.12643
230	.05559	1300	.12890
240	.05671	1350	.13134
250	.05781	1400	.13371
		1450	.13606
		1500	.13834