BOURNS

BOURNS, INC.

TECHNICAL REPORT

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APPENDIX

N66-37359

1.0 ABSTRACT

This is the final report after the conclusion of Contract No. NAS 8-20501. The contract was let for Phases I and II in the development of a Calibratable Pressure Switch designated Model 471 by Bourns, Inc. The original duration of the contract was to be ten months; however, a two month extension was granted beginning May 1 and running through June 30, 1966, when all effort on the project was terminated except for the writing of this report. Only one of the three example units intended under Phase II was carried to the point of obtaining operational data. This one unit is considered indicative of the performance capabilities of the Model 471, and the test data obtained indicated that the design falls short of the controlling specification MSFC Drawing No. 20M32021 requirements in both the temperature and vibration performance categories.

Author

2.0 SUMMARY OF PHASES I AND II

The purpose of Phase I as defined by the contract was to correlate theoretical and empirical information relevant to the design concept chosen to meet the requirements of the calibratable pressure switch under MSFC Specification 20M32021. Principal among the requirements are operation between -420°F and +165°F and during 30.0 g peak sinusoidal vibration between 38 and 2000 cps. Under Phase II the information gained during this theoretical and empirical study was to be used in the design and manufacture of three example units of the new instrument design.

2.1 Phase I - Correlation between Theoretical and Empirical Information

The "snapbeam" module is both the heart and the peculiarity of the Bourns Model 471. This component consists of a flat spring clamped securely at each end and having an active length of .50 inches between clamps. When mounted in the snapbeam module the flat spring is squeezed endwise between horizontal end clamps so as to cause a .020 to .030 inch bow. To obtain a frictionless coupling between the snapbeam component and the rest of the linkage, a .012 inch diameter stainless steel wire is affixed to the approximate center of the active length of the flat spring. Figure 1 gives the tension force profiles of three characteristic snapbeam modules fabricated during the latter months of the contract. Refer to the fold-out size layout on the last page of the report for the relative location of the snapbeam module and the other components of the Model 471 instrument linkage.

In Figure 2, a summation of the snapbeam force profile and the remaining linear springs of the linkage is plotted on coordinants of input force vs. linkage displacement. For the purposes of this chart, input force may be conceived of in either kilograms or PSI of input pressure. The conversion between these two was found to be 300 grams per PSI of pressure. In understanding the snap function of the M-471, the negative slope of segment AB is the significant portion of the chart. The vertical displacement between points B and C represents the force available for actuating the switch module which contains the electrical switching contacts of the instrument.

FIGURE I

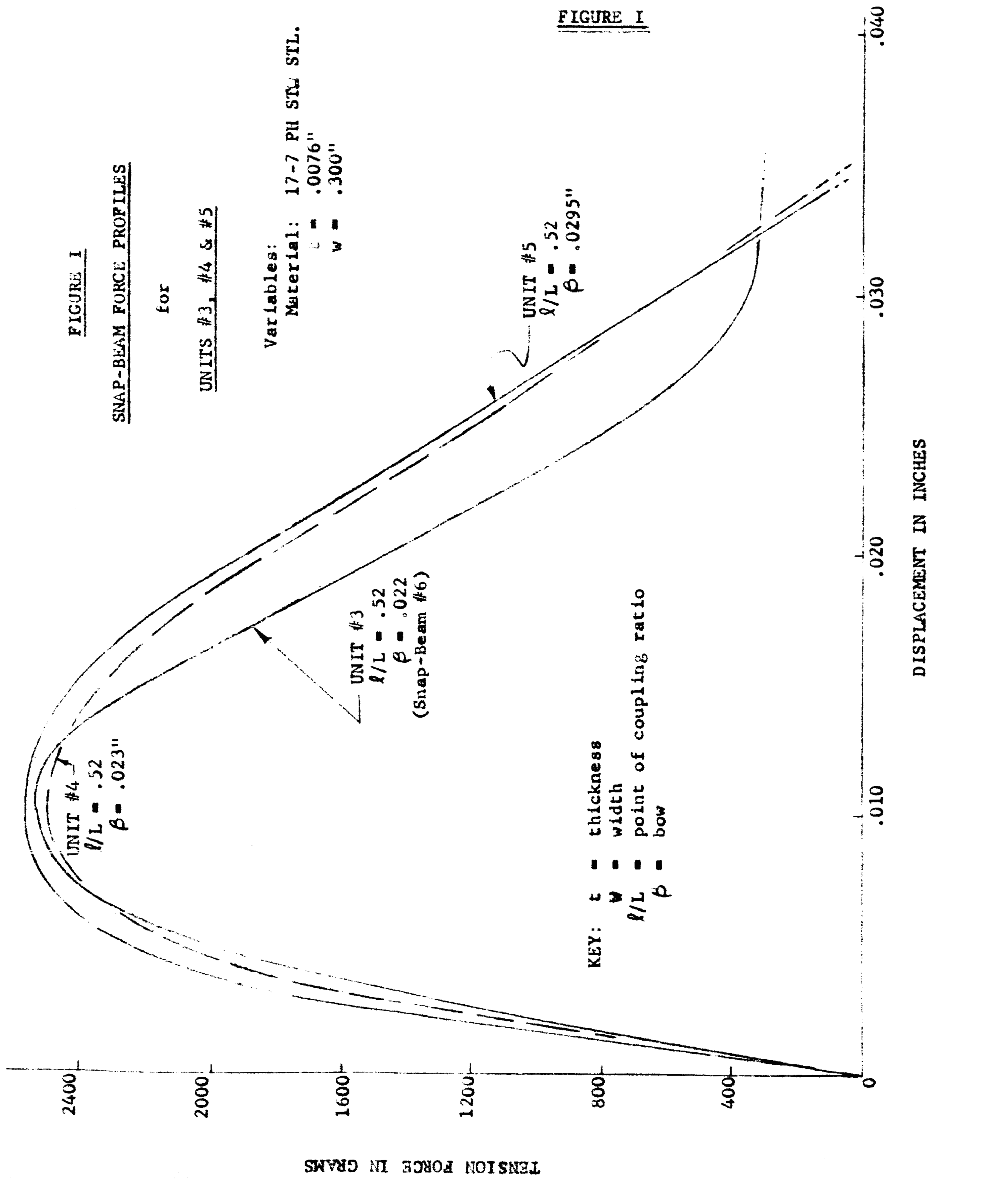
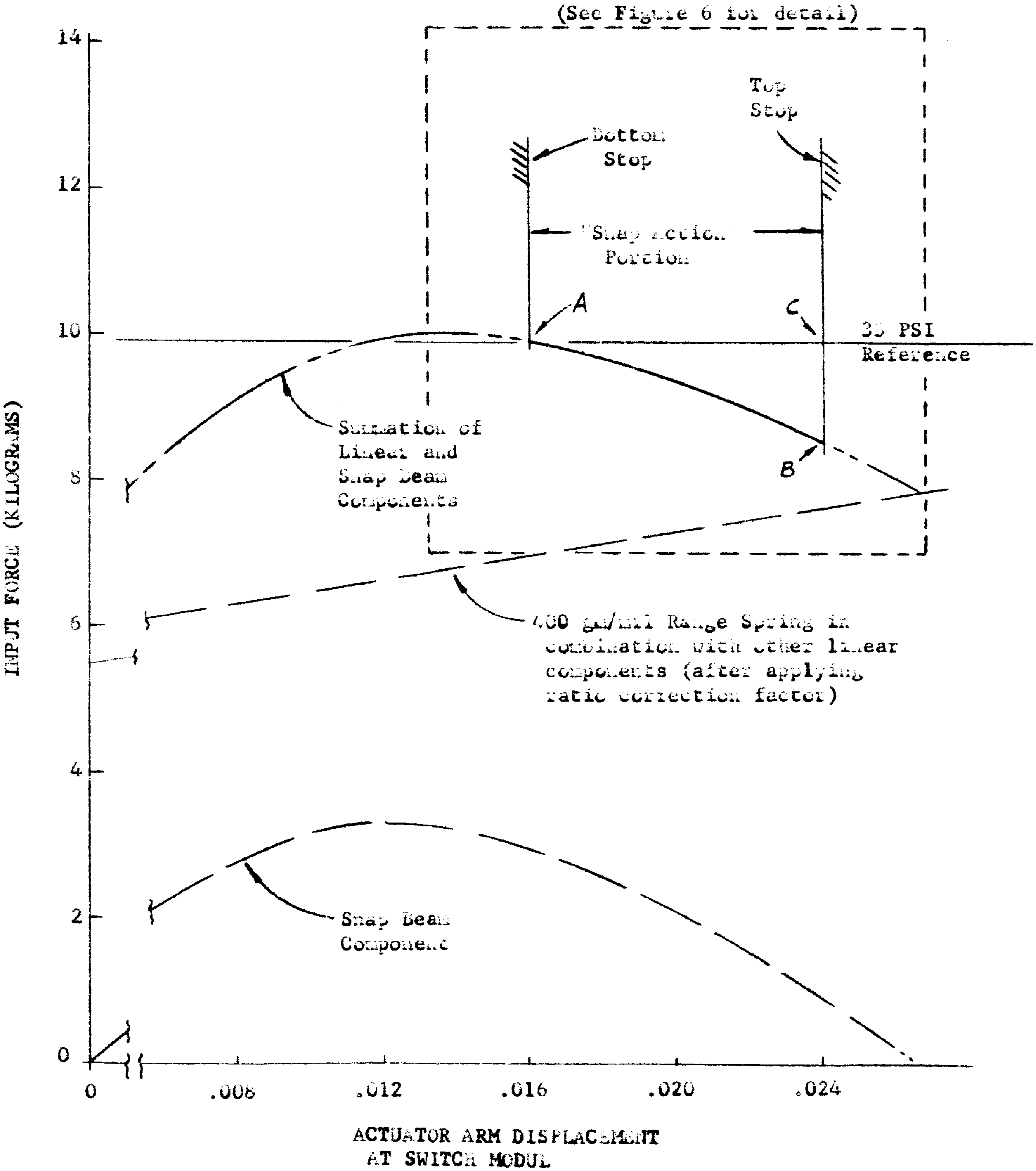


FIGURE I
SNAP-BEAM FORCE PROFILES
for
UNITS #3, #4 & #5
Variables:
Material: 17-7 PH STL STL.
t = .0076"
w = .300"
UNIT #5
ℓ/L = .52
β = .0295"
UNIT #3
ℓ/L = .52
β = .022
(Snap-Beam #6)
UNIT #4
ℓ/L = .52
β = .023"
KEY: t = thickness
w = width
ℓ/L = point of coupling ratio
β = bow
DISPLACEMENT IN INCHES
0
.010
.020
.030
.040
TENSION FORCE IN GRAMS
400
800
1200
1600
2000
2400

Figure II

Model 471
Operating Force Diagram
(Theoretical)



With the input pressure held constant at 33 PSI, motion along the segment between points A and B represents greater and greater force available to do the useful work of switch module operation.

In order to verify the analysis of Figure 2, two units of a pre-prototype version of the design were assembled to test the snap action concept and to obtain empirical information on the spring system involved. One of these pre-prototype designs is pictured in Figure 3.

The calculations required for Figure 2 result in an analytic value of 1300 grams for the .008 inch snap action noted on the Figure. This compares with an empirical value of 1050 grams obtained from measurements taken on the pre-prototype design of Figure 3. This is a variation of 19.2%, based on the analytical value as being the more accurate. Although a descrepancy of 19.2% seems rather excessive, this variance is currently assumed to result from inaccuracies in the measurements taken from the empirical model.

2.2 Phase II - Building of Prototypes

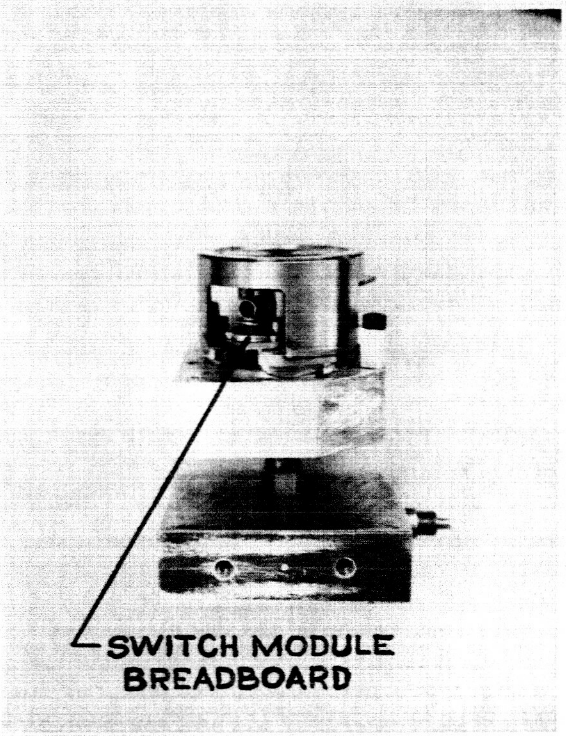
During February, 1966, the pre-prototype version of the design was revised and brought up to date to incorporate the experience gained with the pre-prototype units. Between March and June, 1590 man-hours were expended toward the production of the three prototypes of Phase II. 506 of this total were Machine Shop hours for parts production, and 1084 were technician hours for assembly. Subtracting rework and experimental time from these figures, the appropriate figures would be approximately 400 hours total for parts fabrication and 542 hours for assembly. These totals equate to approximate per unit figures of 130 hours for parts production and 180 hours for assembly. These are necessarily rough approximations because of the abundance of rework effort, particularly in the assembly category, and the fact that only one of the three prototype units can be said to have been carried close to completion, the other two units remaining only about 25% complete as of the termination date of the contract.

Drawing No. 2004711000, the final Outline Drawing of the Model 471, is ~~included on Page iii of the Appendix. The fold-out drawing on the last page~~ of this report is the final up-dated design layout as of the termination date.

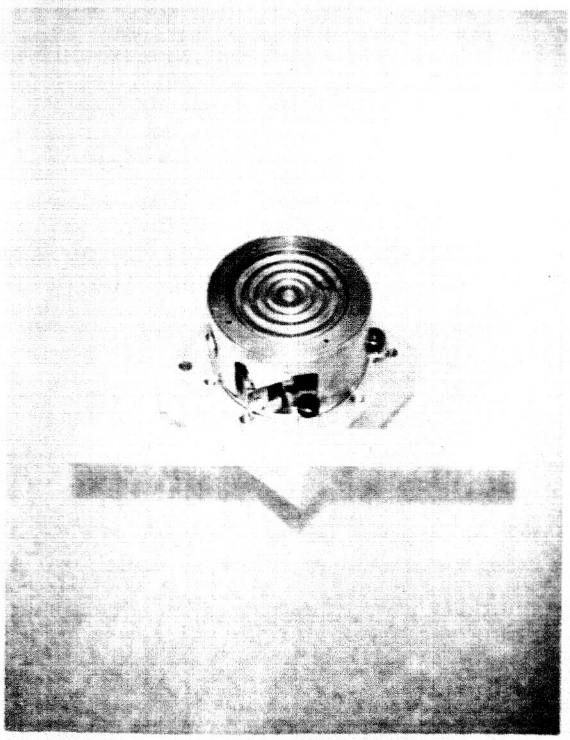
2.2.1 Activity During Final Month of Contract (June): Progress in the assembly of the three prototypes was satisfactory up to June 10. Prototype #3 was brought to the point of dynamic balancing and Prototypes #4 and #5 were both operative after establishing the overpressure heredity of the system and calips port diaphragms. After the 10th, little progress was made on either Prototype #3 or #4, with #3 falling out of calibration during the dynamic balancing procedure, and Unit #4 developing a faulty snapbeam module. As of June 15, Prototype #5 had been carried through the dynamic balancing and vacuum sealing operations with apparent success.

FIGURE III

PROTOTYPE PRESSURE SWITCH MOUNTED ON PRESSURE CALIBRATION FIXTURE



a) View Showing Breadboard of Switch Module thru Adjustment Window in the Range Spring Support Shell



b) Top View of Prototype Pressure Switch

On the 15th, -320°F performance was obtained from Prototype Unit #5 (see below). However, following this temperature performance test a serious leak was found to have developed in the system diaphragm of the unit. Because of the difficulty of correcting this type leak, Prototype #5 was set aside and has been left in substantially the condition it existed as of the 15th June. During the remainder of the month, one difficulty after another prevented the completion of Prototype Units #3 and #4 and these two units now stand approximately 25% complete, having at various points in time been carried forward to approximately the 80% complete condition.

2.3 Performance Data from Prototype #5

The performance data given below was taken from Prototype #5 and is considered valid as far as it goes, except that the final readings taken after the -320°F soak show considerable influence due to the leak mentioned above.

2.3.1 -320°F Performance: Comparative data taken through the system and the calips ports are given in Table I. In all cases the comparison between the system and calips operation is valid. Also the differential pressure between actuation and deactuation is valid in all cases. The 0.71 PSI shift between the original and the final calibrations of this instrument are believed to result from the leak mentioned above in Paragraph 2.2.1. The maximum pressure differential observed in the system port was 2.27 PSI at -320°F, compared to the specification limit of 1.5 PSI max.

TABLE I

-320°F Performance of Prototype Unit #3

Temperature	System Port			Calips Port		
	P_A	P_D	ΔP	P_A	P_D	ΔP
	(PSIA)	(PSIA)	(PSI)	(PSIA)	(PSIA)	(PSI)
Room (initial)	34.04	33.02	1.02	33.90	32.90	1.0
	34.04	33.02	1.02	33.91	32.92	.9
	34.05	33.02	1.03	33.90	32.92	.8
-320°F	34.40	32.13	2.27	34.12	32.32	1.80
	34.09	32.16	1.93	34.11	32.32	1.79
	34.08	32.19	1.89	34.10	32.32	1.78
Room (final)	34.75	33.85	0.90	34.60	33.75	0.85
	34.75	33.85	0.90	34.60	33.75	0.85
	34.75	33.85	0.90	34.60	33.75	0.85

Key: P_A = Actuation Pressure
P_D = Deactuation Pressure
ΔP = Actuation/Deactuation Pressure Differential

2.3.2 Vibration Performance of Prototype Unit #5: A record tape was taken according to the procedure of MSFC No. 20M32021, Para. 4.3.4.5 Vibration; however, only 10 g and 20 g peak sinusoidal levels were applied instead of the 30 g peak specified. Only the sensitive axis was tested.

Switch continuity was sound at both g-levels within 0.3 PSI of the critical actuation and deactuation pressures, except at approximately 1000,1150, and 1550-2000 cps. At these resonant frequencies, both multiple contact transfers and opens were observed.

3.0 CONCLUSION

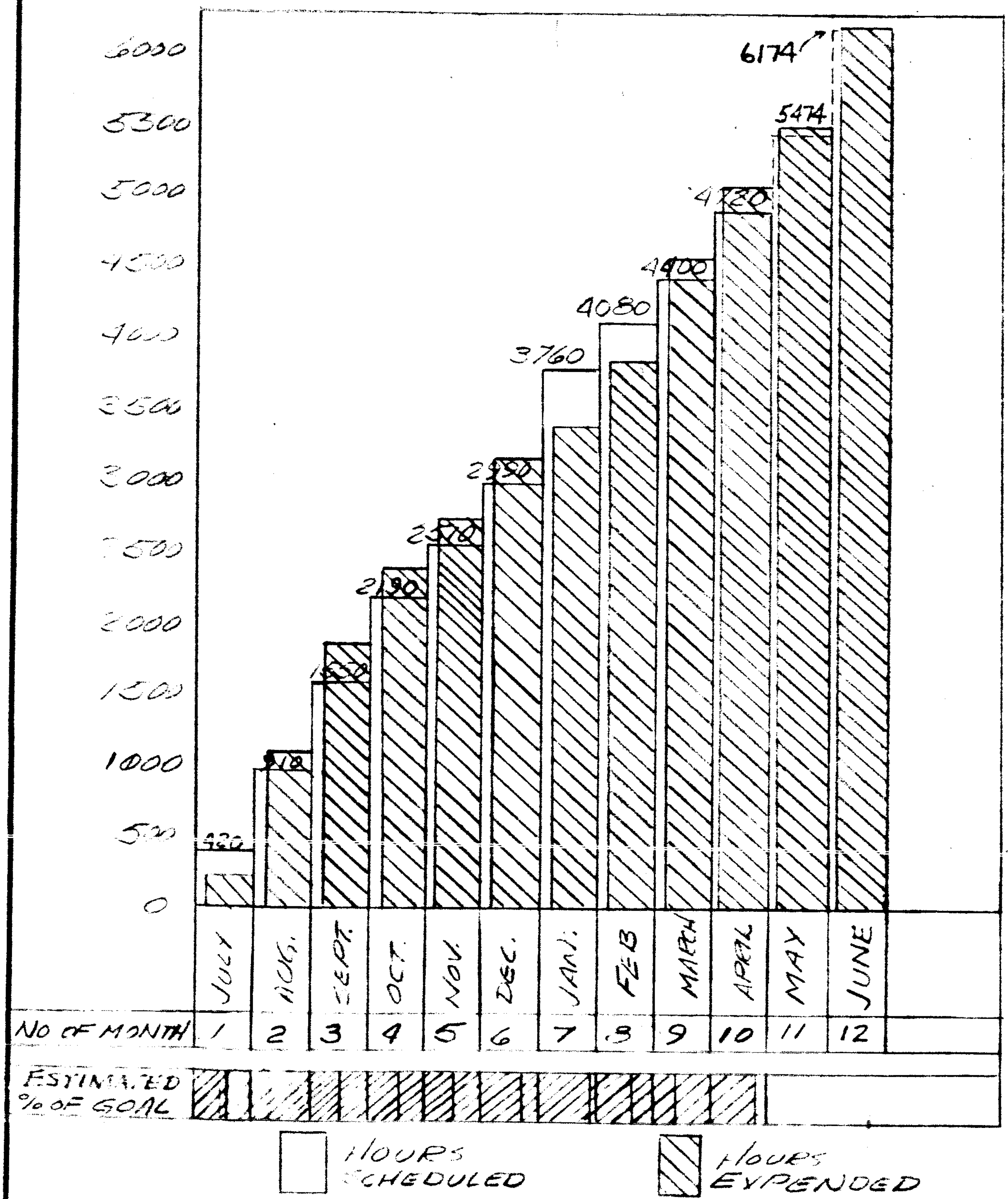
At the completion of Phase II, the Bourns Model 471 falls short of the MSFC No. 20M32021 requirement in the major performance categories of operational temperature and vibration. Although the instrument is operative between -320°F and room temperatures, the actuation/deactuation pressure differential is approximately 20% over the maximum allowed value. The instrument cannot be considered operative during vibration specified in Paragraph 4.3.4.5 of MSFC No. 20M32021.

A P P E N D I X

DAILY ACTIVITY LOG

Date	Activity
6-1-66	Reworked switch module to match requirements of Prototype Unit #3.
6-2-66	Ran the Leak Check on Base Assemblies (isolation diaphragm) for Units #4 and #5.
6-6-66	Obtained Calips Port performance on Units #4 and #5.
6-7-66	Change flex pivots on Unit #5 from .0115 to .0087" thickness to allow increased stiffness in the Be-Cu range diaphragm.
6-8-66	Experienced leaks in the PT06-CE-12-3P type electrical connectors and decided to substitute PTIH-8-4P type connectors on hand.
6-9-66	Attempted dynamic balancing for Unit #3.
6-10-66	Unit #3 out of calibration after previous day's vibration.
6-14-66	Obtained successful operation with Unit #5 and performed dynamic balance procedure. Baked unit in vacuum oven at 230°F for 8 hours.
6-15-66	Vacuum sealed Unit #5 and demonstrated -320°F operation for visiting NASA personnel.
6-16-66	Discovered leak in Unit #5.
6-20-66	Reworked switch module for Unit #4 but failed to obtain good snap action.
6-23-66	Changed range spring on Unit #4.
6-24-66	Snapbeam of Unit #4 discovered cracked due to defective spot welds.
6-27-66	Mounted new snapbeam for Unit #4 and began reassembly.
6-30-66	Obtained 20 g peak sinusoidal vibration data from Unit #5.

BOURNS, Inc. ENGINEERING DEPT. RIVERSIDE, CALIF.	ACTUAL & PROJECTED MAN HOURS TO COMP.	PAGE ii OF BY KMC CHKD DATE 6/30/66



2004711000

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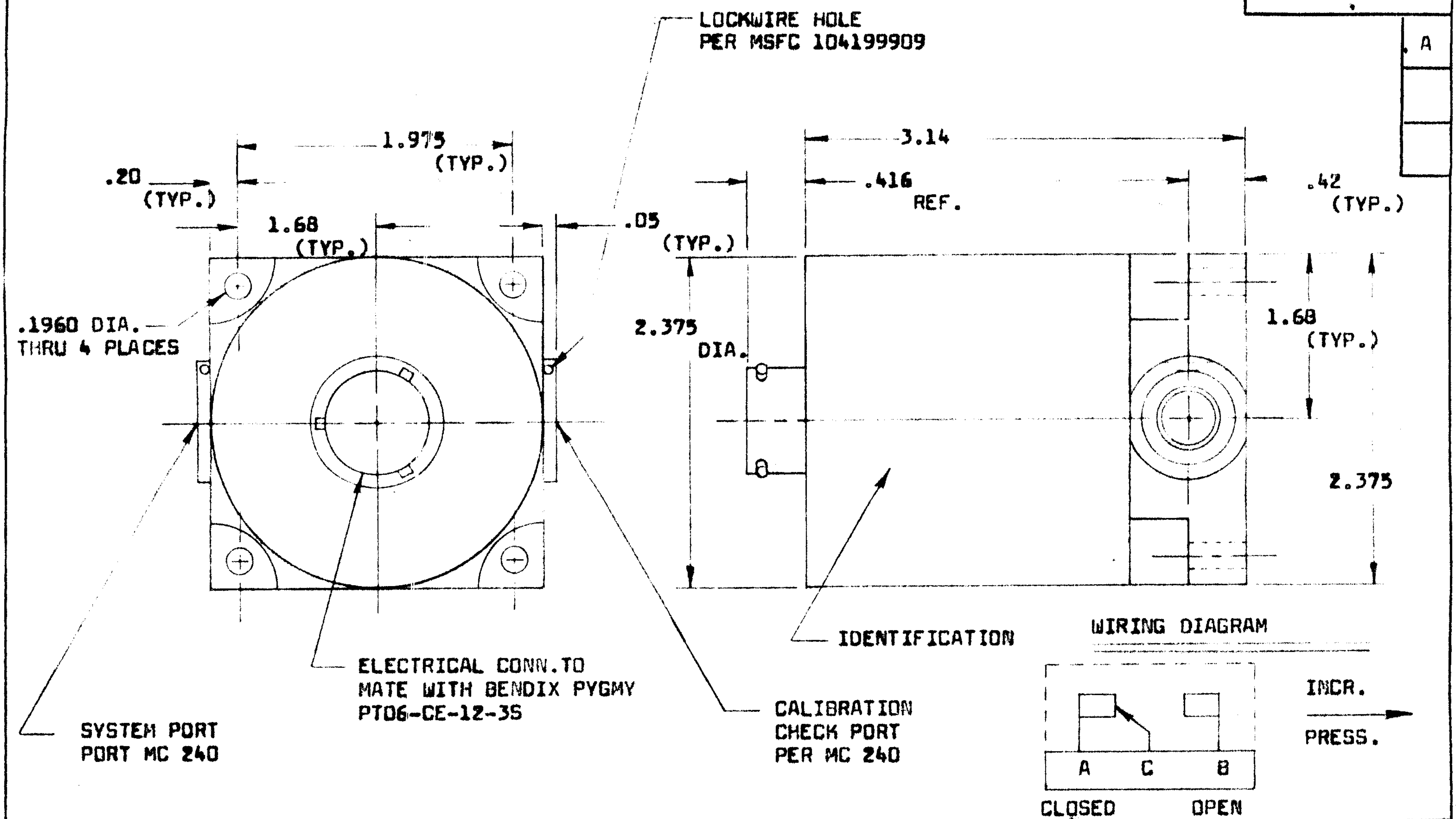


CHG. LETTER	E. O. NO.	DETAILS	MADE BY	DATE	CHECKED BY	DATE
A		REL. FOR S/O 75112-02	-	-	-	-

MATERIAL -

SPEC. -

NOTES, EXCEPT AS SPECIFIED

1. DIMENSIONS IN INCHES.
2. TOLERANCES: .XXX ±.005, .XX ±.015; HOLE TOLERANCES: UP to .040 ±.001, .041 to .130 ±.002, .131 to .375 ±.003, .376 UP ±.005
3. SURFACES SHALL BE FLAT WITHIN ±.001 IN./IN.
4. DIAMETERS WITH SAME ℄ SHALL BE CONCENTRIC WITHIN .005 TIR.
5. DEBURR EDGES .005 MAX.
6. SURFACE ROUGHNESS 63
7. ANGLE TOLERANCE: ±½°

SCALE: 1" = 1"	INITIALS	DATE
DRAWN BY	[illegible]	4/27/66
TOLERANCES CHECKED BY		
APPROVED BY	WMC	4/28/66

BOURNS, Inc.

RIVERSIDE CALIFORNIA —— AMES, IOWA

FORM NO. 1332 A

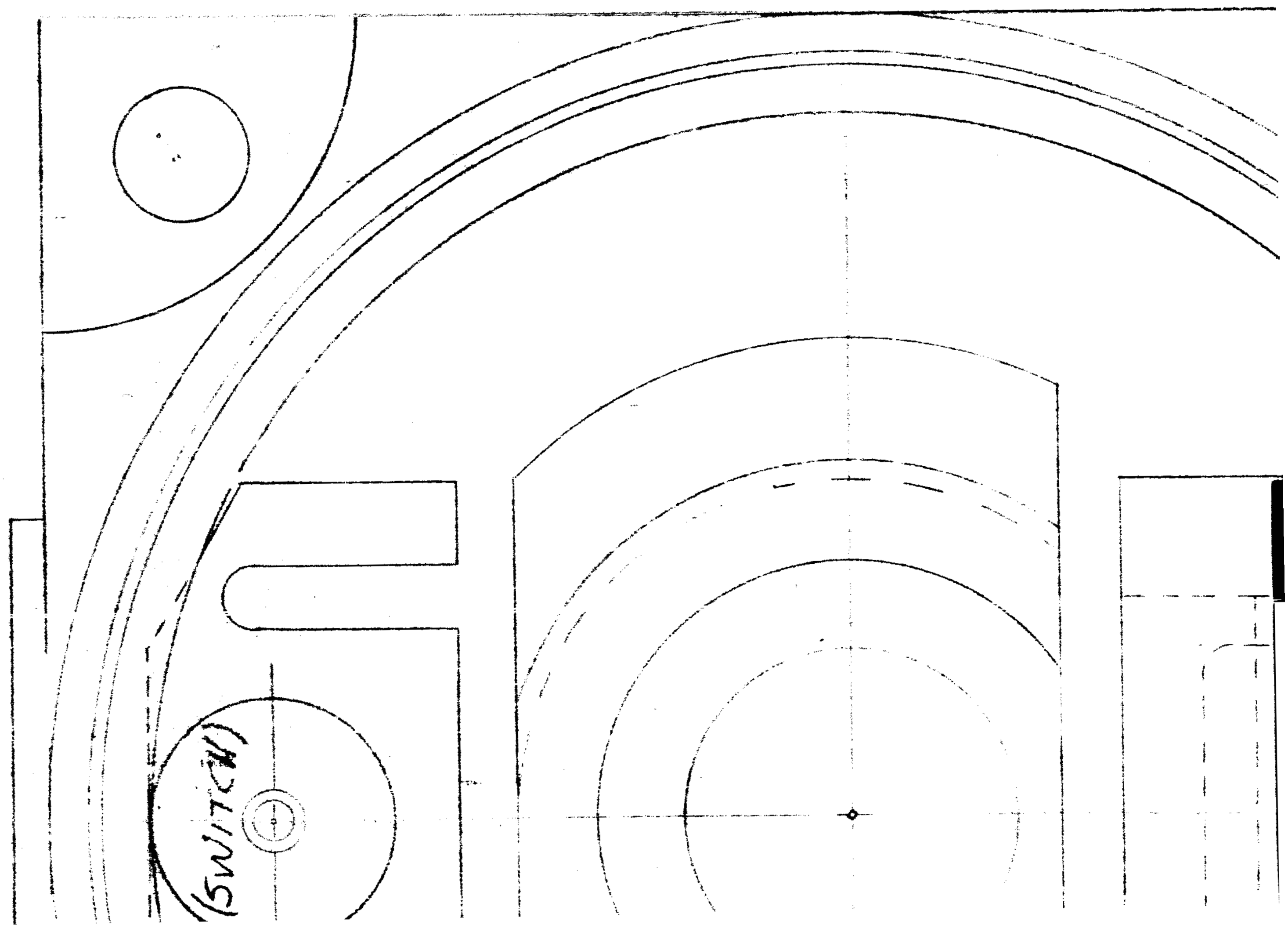
ABSOLUTE PRESSURE SWITCH

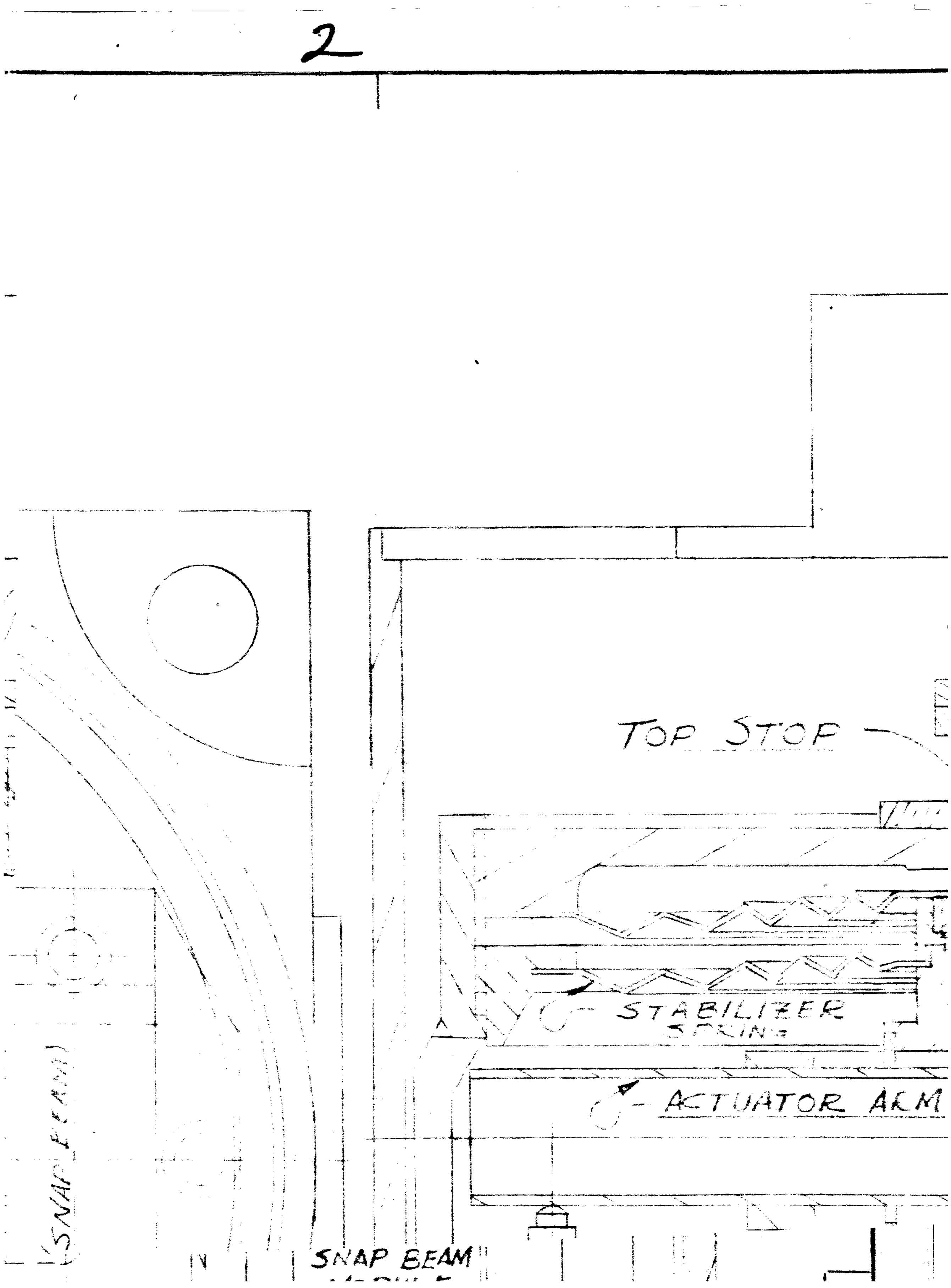
CALIBRATABLE

MODEL 471

DIETERICH-POST CLEARPRINT 1000H

1




2
TOP STOP
STABILIZER
ACTUATOR ARM
SNAP BEAM

DRAWING NO. ONLY

PAGE iv

REPORT N-471-12

A
B
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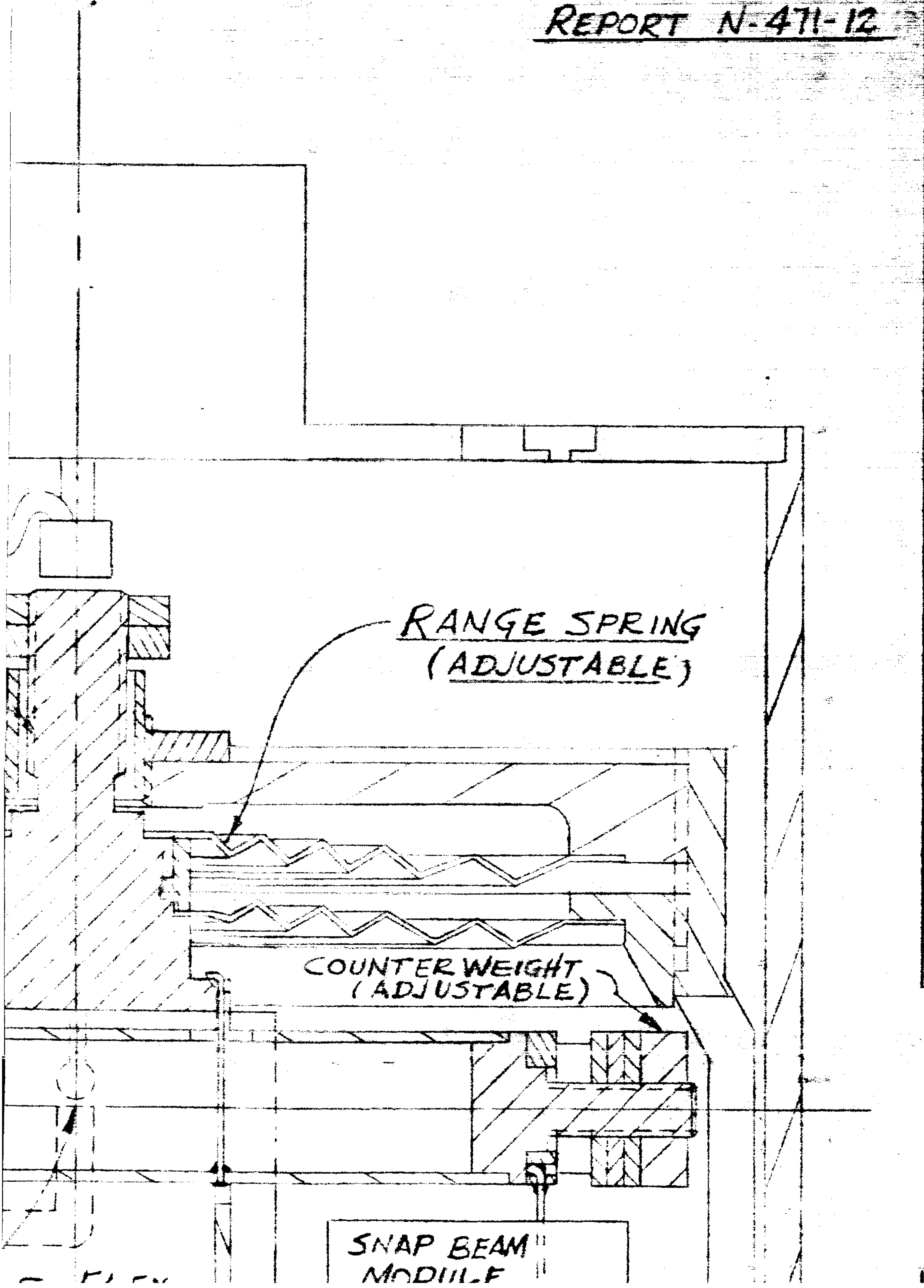

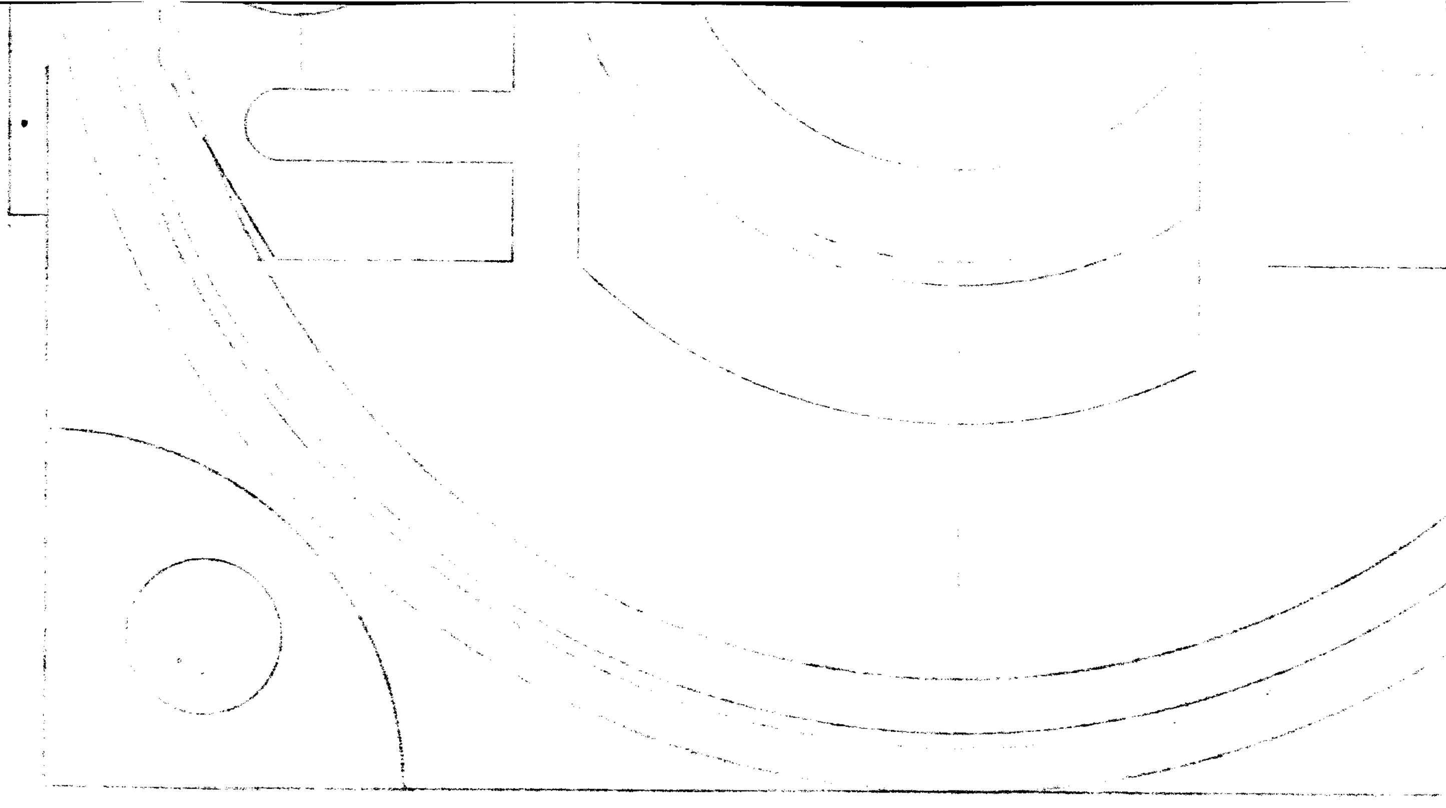

HORIZONTAL SECTION

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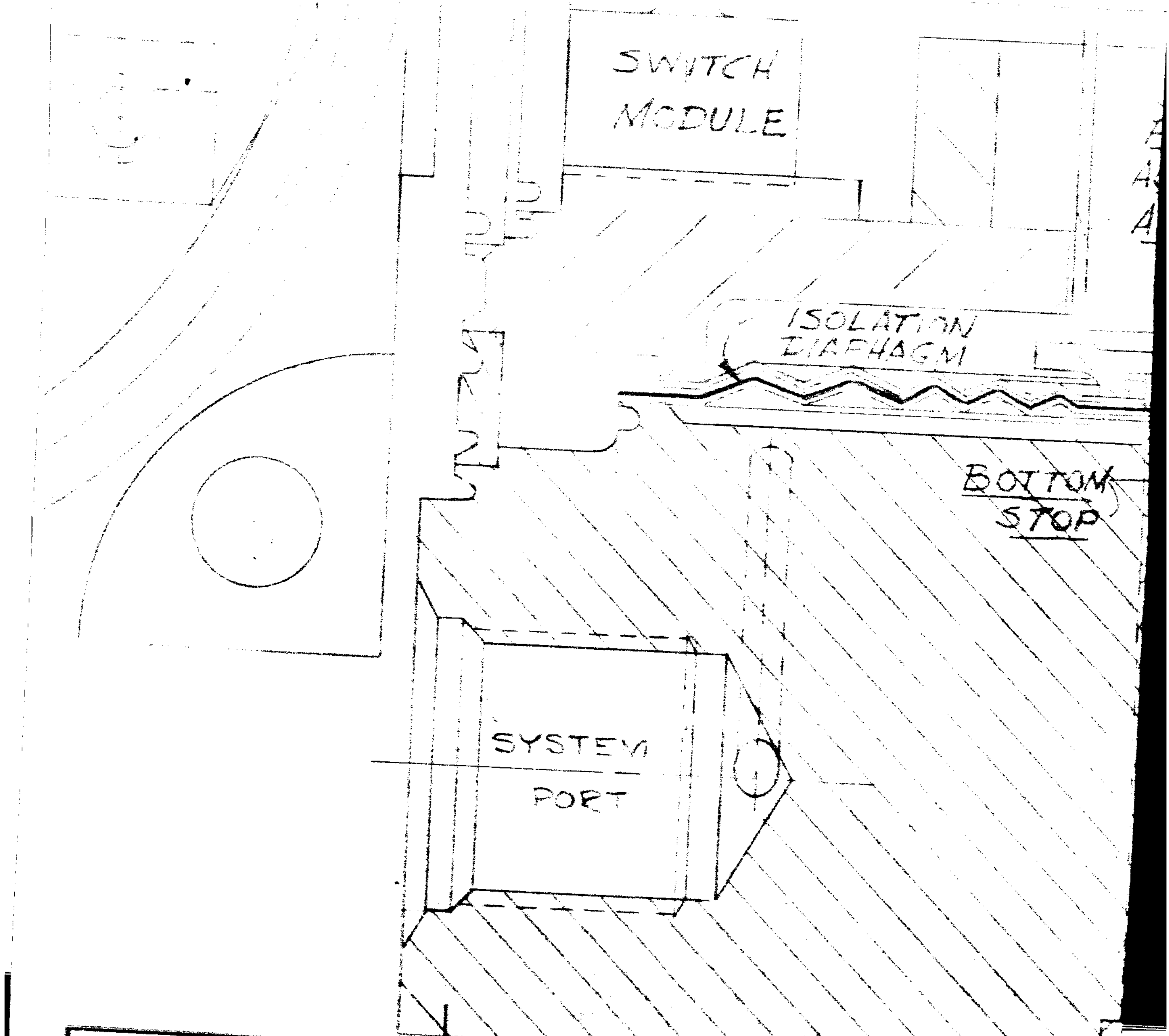


MATERIAL:

COND.

HEAT TREAT

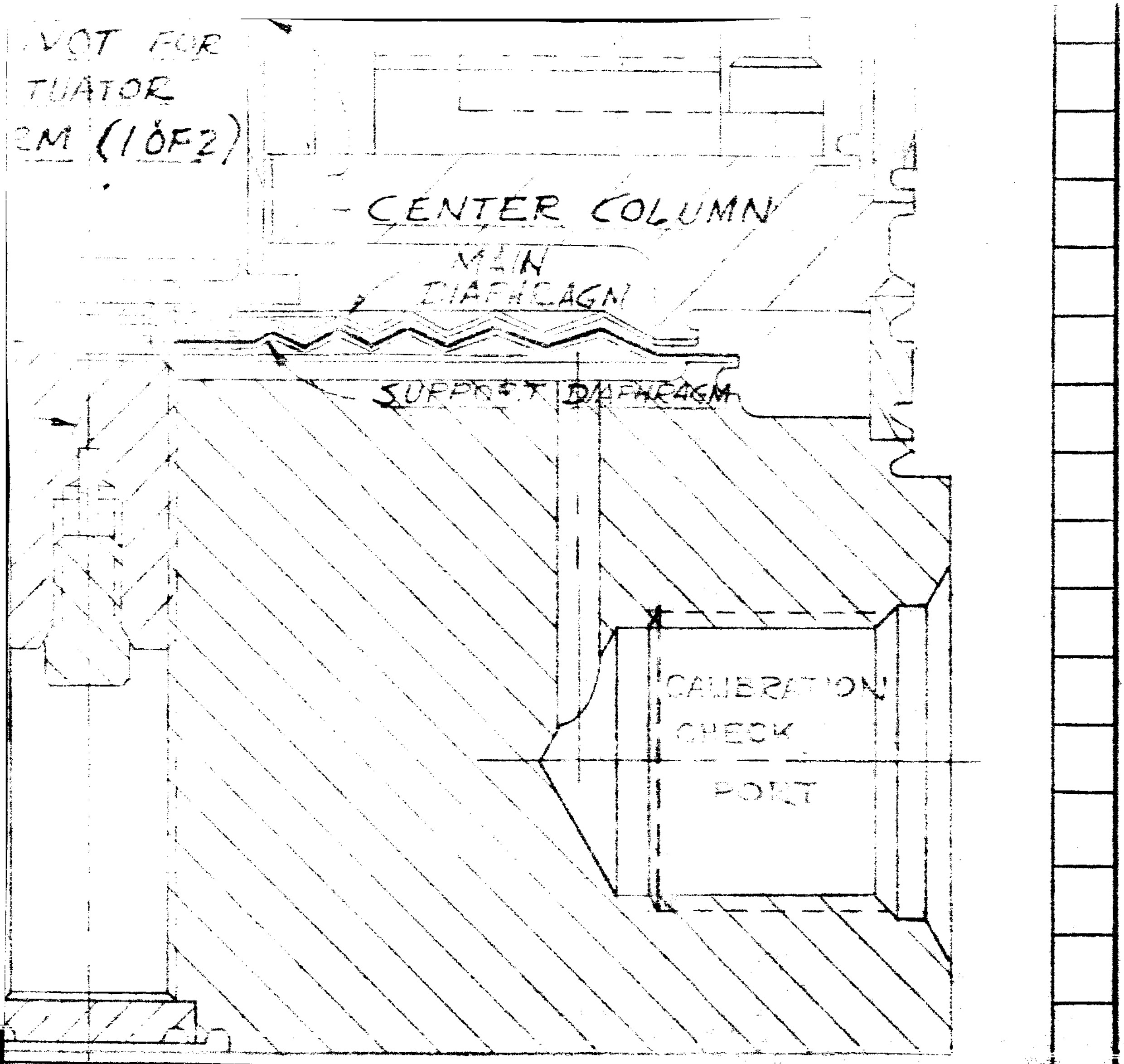
DATE

NOTES, EXCEPT AS SPECIFIED

1. DIMENSIONS IN INCHES.
2. TOLERANCES:

.XXX	±.005	HOLE TOLERANCES:		
.XX	±.015	UP to .040	±.001	.131
		.041 to .130	±.002	.376

3. SURFACES SHALL BE FLAT WITHIN ±.001 IN./IN.
4. DIAMETERS WITH SAME ℄ SHALL BE CONCENTRIC
5. DEBURR EDGES .005 MAX.
6. SURFACE ROUGHNESS 63
7. ANGLE TOLERA
8. INSIDE RADIUS



o .375 ± .003 UP ± .005 WITHIN .005 TIR. NCE: ± ½° .005 MAX.	SCALE: 4 X			BOURNS, Inc. RIVERSIDE, CALIFORNIA —— AMES, IOWA BOURNS FORM NO. 832C
		INITIALS	DATE	
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	TOLERANCES CHECKED BY			LAYOUT MODEL 471
	APPROVED BY	[signature]	2-25-66	