WESTERN DIVISION

LTV RESEARCH CENTER

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NASA CR 101803

LTVR Project No. 08550

MOMENTUM SENSOR
(ELECTROSTATIC BALLISTIC PENDULUM
LABORATORY CALIBRATION UNIT)

LTV MODEL NO. D-11222

Final Report
July 1969
NASA Manned Spacecraft Center
Houston, Texas
Contract NAS 9-8870

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Anaheim, California

TABLE OF CONTENTS

I. INTRODUCTION

The electrostatic ballistic pendulum (EBP) impact momentum transducer has evolved over a series of contracts and subcontracts originating from the NASA/MSC to the LTVRC/WD. The transducer is designed to produce an electrical signal proportional to the momentum of the impacting particle.

Before emphasis is placed upon limitations, the positive results of this and previous programs should be noted.

a. A patent was awarded.

b. A unique sensing method resulted in useful measurement over 8 orders of magnitude in momentum.

c. Applications for space flights and a variety of laboratory experiments resulted.

d. Space experimentation feasibility was proven with thermal and vacuum performance.

e. A weight of under 20 grams for the package resulted.

f. Producibility of the sensor with detail drawings.

g. Internal or external self-calibration feature.

In the steps leading to the current design of the EBP sensors, constraints were imposed which limit the operational range. For example, the upper limit of momentum is restricted by strength of materials; the lower limit essentially by the mass of the impact plate. Since we are chiefly interested in space flight and laboratory microparticle detection, we will restrict further discussion to the lower threshold.

The EBP was designed as part of a composite experiment, primarily with the ability of accepting penetration layers of metallic foils on the impact plate. Additionally, the plate material was to be aluminum, and in a square configuration to permit stacking in an array.

The requirement of a separate impact plate has resulted in a current state-of-the-art lower limit of around 10^{-6} dyne-second (self-noise floor, or S/N = 1). These steps could be taken to further improve performance:

a. Lower plate mass.

b. Increase internal capacitance and resistance in EBP.

It is not believed that a great deal of increased sensitivity will result, i.e., less than an order of magnitude.

However, signal processing techniques may lead to improved sensitivity. Examples of real time signal processing are:

a. Use of match filter techniques at the system output.

b. Use of parallel processing amplifiers with summed outputs in place of the existing electronics. The output SNR improvement is a function of the number of amplifiers employed.

Additionally, for laboratory use several applicable techniques, including those that do not operate in real time, are available that may yield desirable SNR improvements.

II. MOMENTUM SENSOR PATENT

MOMENTUM TRANSDUCER

Filed Nov. 25, 1966

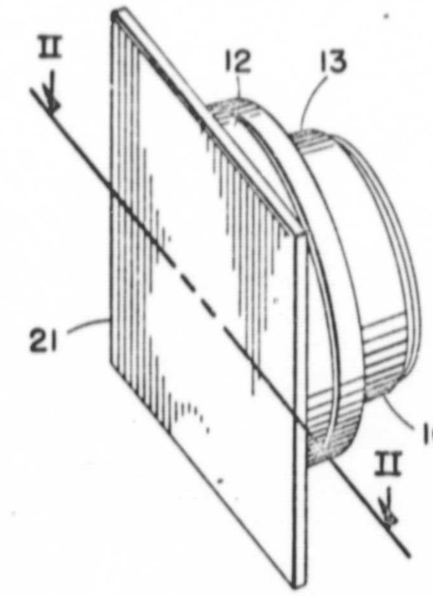

FIG 1

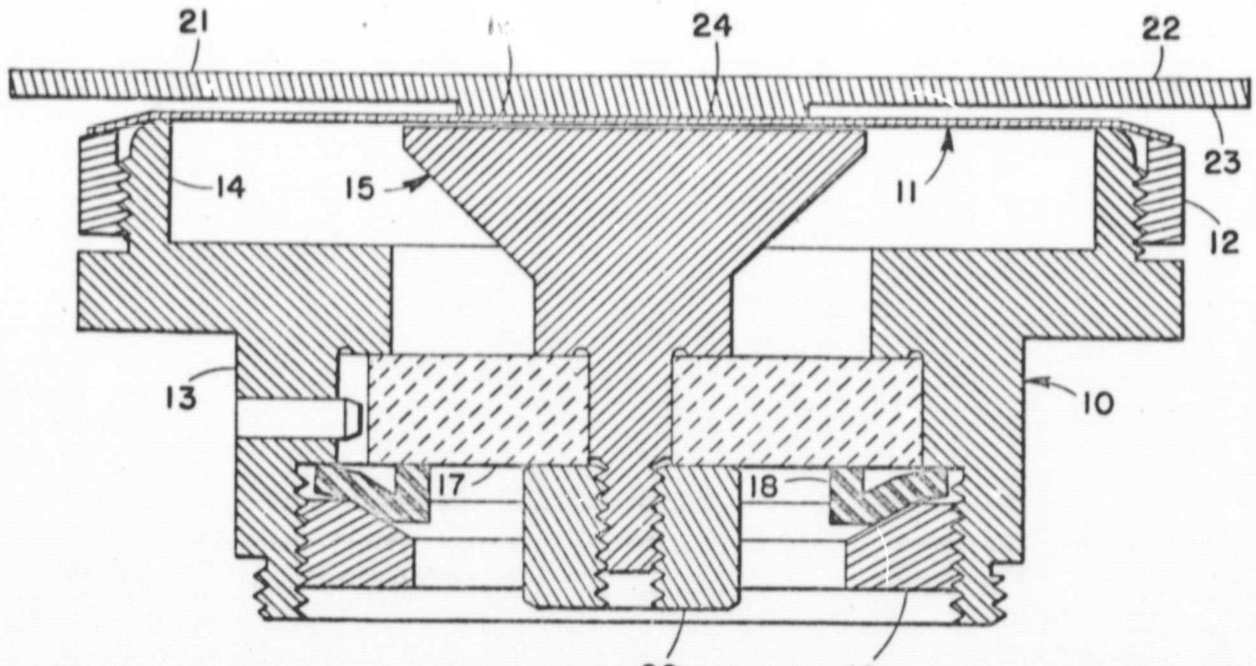

FIG 2

BOBBY R. BEAVERS
NORMAN J. MEYER

BY H.C. Goldwire
AGENT

United States Patent Office

3,418,546
Patented Dec. 24, 1968

1

2

3,418,546
MOMENTUM TRANSDUCER

Bobby R. Beavers, Garden Grove, and Norman J. Meyer, Costa Mesa, Calif., assignors, by mesne assignments, to Ling-Temco-Vought, Inc., Dallas, Tex., a corporation of Delaware

Filed Nov. 25, 1966, Ser. No. 597,036
8 Claims. (Cl. 317—246)

ABSTRACT OF THE DISCLOSURE

A capacitive momentum transducer is provided with a rigid plate supported resiliently from a central portion thereof and adjacent a conductive backplate. A conductive portion of the plate is adjacent but electrically isolated from the backplate such that capacitance is formed therebetween. Particles which impinge upon the plate cause a displacmeent of the plate toward the backplate such that a detectable variation of capacitance between the backplate and conductive portion occurs, the variation being proportional to the momentum of the particle regardless of its point of impingement.

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 U.S.C. 2457).

This invention relates to a momentum transducer and more particularly to such a transducer wherein momentum imparted to the transducer is detectable by a variation of an electrical capacitance thereof.

In accordance with the invention there is provided a structure having a backplate, a rigid mass element, and a suspension for supporting the rigid mass element adjacent the backplate, so that momentum imparted to the mass element is detectable by variation of the capacitance of the backplate and the mass element.

An apparatus which has previously been used to detect the impact of particles such as meteor particles is the condenser microphone. When a particle strikes the conductive membrane of the microphone, the membrane moves relative to a conductive plate, changing the capacitance between membrane and plate. The change in capacitance is converted by a circuit to an electrical signal indicating the impact of the particle. The signal does not, however, accurately indicate the momentum of each particle detected. A particle striking near the edge of the membrane where it is supported gives rise to a different membrane deflection and therefore a different electrical signal than one of the same momentum striking near the center of the membrane. The latter effect is largley due to the increased resistance of the membrane to motion at points away from its center. This difference in output signal due to different impact locations could be diminished by masking the membrane from impacts except near the center, but it is often undesirable to utilize so little of the area occupied by the instrument in the plane of particle impacts.

Accordingly, it is a major object of the invention to measure the momentum of impacting particles.

Another object is to measure the momentum of particles received in an area independent of where the particles impact within this area.

A further object of the invention is to provide a transducer for accurately measuring the momentum of particles received in all parts of a detecting area, which area utilizes most of the space occupied by the transducer in the plane of particle impacts.

Other objects and advantages will be apparent from the specification and claims and from the accompanying drawing illustrative of the invention.

FIGURE 1 is a pictorial view of a momentum transducer according to the invention.

FIGURE 2 is a vertical sectional view of the transducer of FIGURE 1, taken in the plane established by line II—II of FIGURE 1.

Referring now to the drawing, there will be described a preferred embodiment of the invention. The momentum transducer shown in FIGURES 1 and 2 is generally referred to by the reference numeral **10**. Transducer **10** has a circular, conductive membrane **11** attached to a threaded ring **12** at the periphery of the membrane, as by cementing. The membrane is preferably made of aluminum foil and approximately 0.0005 inch thick. Ring **12**, for example made of stainless steel, is threadedly engaged with a housing **13** of the same material. It often is preferable to make both the membrane **11** and ring **12** of the same materials, especially where a same rate of thermal expansion is an important factor. Housing **13**, which has a circular opening **14** therein, bears against the membrane **11** so that it supports the membrane at the periphery of opening **14**.

Mounted in fixed relation to housing **13** is backplate **15**, situated at the opening **14**. Backplate **15**, preferably made of stainless steel, has a plane, circular surface **16** concentric with the opening **14**. Because of its stainless steel construction, backplate **15**, including surface **16**, is electrically conductive. Supporting the backplate **15** and insulating it from housing **13** is an annular quartz insulator **17**. Washer **18** supports quartz insulator **17** and in turn is supported by an annular ring **19** threadedly engaged with housing **13**. Threaded section **20** secures backplate **15**, while making electrical contact thereto.

Transducer **10** has as a mass element a plate **21**. As shown by FIGURE 1 and FIGURE 2, plate **21** is basically in the shape of a rectangular solid with a square surface **22** larger than the opening **14**. Extending from surface **23**, opposite surface **22**, is a portion of plate **21** which is cylindrical in shape, having a plane, circular surface **24** centered relative to the surfaces **22** and **23** and parallel thereto. Plate **21** is preferably constructed of aluminum, or it may be of another metal, or a ceramic material, etc.: it need not be conductive.

Membrane **11** is rigidly attached to the cylindrical portion of plate **21**, as by cementing to the circular surface **24** thereof and thus, in the area of attachment, becomes a part of and forms a conductive surface on the mass element. The surface **24** is mounted concentric with the surface **16** of backplate **15**, and because of the suspension by membrane **11**, the surfaces are parallel. As shown in FIGURE 2, the diameter of surface **24** is smaller than that of surface **16**. Both surfaces are substantially smaller than the opening **14**. The surface **16** of backplate **15** is separated from the adjacent conducting surface by approximately 0.005 inch.

Electrical contact may be made with the capacitor of transducer **10** by conductively engaging the threads of section **20** for one lead and engaging the threads of the housing **13** for the other lead at a location outside the place where ring **19** is engaged. Of course, other arrangements are possible as long as one lead is electrically connected to the conductive surface **16** of backplate **15** and the other is connected to the conductive surface of membrane **11** opposite surface **24** on plate **21**.

In the operation of transducer **10**, particles, for example meteor particles, strike plate **21** traveling in the direction shown as downward in FIGURE 2. The momentum imparted to the plate **21** by a particle moves the plate toward backplate **15**, increasing the electrical capacitance between membrane **11** and backplate **15**. The change in capacitance is detected by a high impedance circuit connected to the electrical leads of transducer **10** to apply a polarizing voltage to the capacitor formed by the membrane **11** and backplate **15**. The polarizing voltage places a charge on the capacitor. When the capacitance is changed, the charge on the capacitor is prevented from quickly changing by the high impedance of the circuit connected to the transducer. Therefore, the voltage at the leads of the capacitor changes in proportion to the change in capacitance. The voltage change is amplified for recording and display. Since the foregoing circuit functions are required in the operation of a condenser microphone, a condenser microphone circuit may appropriately be the one connected to the leads of transducer **10** to detect the change in capacitance thereof.

For the transducer **10**, there is an accurate relationship between the voltage at its leads and the momentum of an impacting particle. The magnitude of the voltage generated per unit of received momentum (for example, in volts/dyne sec.) is given by S,

$$S=\frac{E_0}{2\pi d_0(kM)^{1/2}}$$

where

E_0 is the polarizing voltage applied,
d_0 is the separation of the capacitor plates at rest,
k is the spring constant of the suspending membrance **11**,
M is the mass of plate **21** and that part of membrane **11** overlying surface **24**.

Transducer **10** detects the momentum of an impacting particle regardless of where the particle strikes the surface **22** of plate **21**. It is the component of momentum in the direction perpendicular to surface **16** which the transducer detects, and a striking particle imparts to plate **21** a translational motion in that direction which does not depend on the point of impact, because plate **21** is a rigid body. This translational motion gives rise to the change in the capacitance of the parallel-plate capacitor formed by membrane **11** and backplate **15**, which change is detected by the external circuit as a measure of particle momentum. Additionally, if the particle strikes other than at the middle of the surface **22**, there is imparted to plate **21** an angular motion added to the translational motion. In its angular motion, the plate **21** will move toward surface **16** on one side of the center thereof and away from surface **16** on the other side. Such motion does not result in a change of capacitance, however, since an increased separation of the capacitor plates at, say, the left side of FIGURE 2, is offset by a decreased separation on the right side. Therefore, it is only the translational motion, which is independent of impact position, that produces an output signal.

The structural feature which gives rise to equal translational motion of plate **21** independent of impact position is its rigidity. The contrast between the response of such a mass element and that of a membrane is apparent. Moreover, it is partly the rigidity of plate **21** which eliminates a change in capacitance due to the angular motion of the plate; that is, the lower surface of plate **21** remains flat while in angular motion, making possible a displacement on one side which completely offsets a displacement on the other side. Further contributing to the elimination of capacitance changes from rotational motion is the symmetrical distribution of mass in plate **21**. The material of plate **21** is of uniform density, and the shape of the plate is symmetrical about the line perpendicular to circular surface **24** at its center. Therefore, the mass is distributed symmetrically about the line. Of course, the line also passes through the center of circular surface **16**, concentric with surface **24**. With such a distribution, if mass element plate **21** is symmetrically suspended by a resilient element, it will move in its angular motion about a line parallel to surfaces **22** and **24** and intersecting the previously described symmetry line. The symmetrical, resilient

suspension of plate **21** is provided by membrane **11** in exerting spring forces on the plate which are symmetrical about the described line of symmetry through the center of surfaces **24** and **16**. The angular motion resulting from the symmetrical suspension of plate **21** is the one desired wherein a change in capacitor plate separation on one side of the symmetry line is offset by an opposite change on the other side. Of course, to obtain no change in capacitance with such motion, the surfaces **24** and **16** should each be symmetrical about a common line, as in transducer **10**.

Thus, it is seen that transducer **10** provides for the measurement of particle momentum independent of the impact position on surface **22**. Moreover, the useful particle detecting area is not limited to a minor part of the area occupied by the transducer; rather, the useful area comprises the whole of surface **22**.

While only one embodiment of the invention, together with modifications thereof, has been described in detail herein and shown in the accompanying drawing, it will be evident that various further modifications are possible in the arrangement and construction of its components without departing from the scope of the invention.

We claim:

1. In a momentum transducer, the structure comprising:
- a conductive backplate;
- a rigid mass element having a conductive surface; and
- means for resiliently and pivotally suspending said mass element in relation to the backplate, from a central portion of said mass element and with said conductive surface disposed adjacent, electrically isolated from, and in spaced relation to said backplate, said mass element having a peripheral portion radially outside said central portion and spaced from said suspension means, whereby momentum imparted to said mass element is detectable by variation of the electrical capacitance of said backplate and said mass element.

2. The structure set forth in claim **1**, wherein said means for suspending is a means for suspending said mass element to move symmetrically relative to said backplate.

3. In a momentum transducer, the structure comprising:
- a backplate having a plane, electrically conductive surface;
- a rigid mass element having a central boss which has a plane, electrically conductive surface electrically isolated from the backplate conductive surface, said mass element having a peripheral portion radially outside said boss; and
- means attached to said boss at said conductive surface and spaced from said peripheral portion for symmetrically, resiliently, and pivotally suspending said mass element in relation to said backplate to position said conductive surface of said boss adjacent to and spaced from said surface of said backplate, thereby to form a momentum-variable capacitor.

4. The structure set forth in claim **3**, wherein said surface of said backplate is symmetrical about a point therein and the mass of said rigid mass element is distributed symmetrically about a line through said point, said line further being an axis of symmetry for the suspending forces exerted by said means, and wherein said surface of said backplate is parallel to said surface of said boss.

5. The structure set forth in claim **4**, further including a housing fixed relative to said backplate and having a circular opening therein, and wherein said suspending means includes a membrane supported by said housing at the periphery of said opening and symmetrically attached to said mass element.

6. The structure set forth in claim **5**, wherein said mass element has another plane surface parallel to said plane conductive surface thereof and larger than said circular opening.

7. In a momentum transducer, the structure comprising:

a mass element plate;

a housing having a circular opening therein smaller than the plate;

a conductive backplate fixed relative to said housing and situated at said opening; and

a conductive membrane supported by said housing at the periphery of said opening and attached to one side of said mass element plate at points removed from the perimeter of said plate to suspend said plate adjacent said backplate, whereby momentum imparted to said mass element plate is detectable by variation of the electrical capacitance of said membrane and said backplate.

8. A momentum transducer comprising:

a conductive backplate having a plane, circular surface;

a rigid, conductive mass element having a rectangular, solid portion with an outer surface and a cylindrical portion extending from the side of said rectangular solid portion opposite said outer surface, said cylindrical portion having a plane, circular surface parallel with and centered relative to said rectangular surface,

a housing fixed relative to said backplate and having a circular opening therein concentric with said circular surface of said backplate, and

a resilient, conductive membrane supported by said housing at the periphery of said opening, said membrane being symmetrically and rigidly attached to said cylindrical portion of said mass element to suspend said circular surface thereof adjacent to and parallel with said circular surface of said backplate, whereby momentum imparted to said mass element is detectable by variation of the electrical capacitance of said backplate and said membrane.

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3,307,407	3/1967	Berg	317—246 X

LEWIS H. MYERS, *Primary Examiner.*

ELLIOT GOLDBERG, *Assistant Examiner.*

U.S. Cl. X.R.

73—432

III. HANDLING, OPERATING AND STORAGE PROCEDURES MOMENTUM SENSOR D-11222

A. Handling

Care should be taken when handling the sensor, since by its very nature it is a delicate instrument. In particular, do not apply a torque or twisting force to the impact plate, or a force which tends to separate the impact plate from the sensor, although the sensor may be picked up by the impact plate without danger of physical damage.

Do not try to prevent the sensor from turning by holding the impact plate when tightening the mounting nut. Use a mounting hole of the proper diameter (4.04 $\pm$ .01 cm; 1.590 $\pm$ .004 in.) and the index pin (0.038 cm; 0.015 in. diameter on a 4.27 cm; 1.684 in. diameter bolt circle).

Do not over-tighten the mounting nut. It is sufficient to snug it down with a light finger grip on the wrench provided. A rubber cement may be used to prevent the nut from loosening during vibration testing.

B. Operating

The sensor may be checked for operation at atmospheric pressure by applying the proper voltages (see Schematic C-11282B) and tapping the test fixture with a finger while monitoring the output on an oscilloscope. <u>Do not leave the polarizing voltage on during pumpdown</u> to the operating pressure. There is a critical pressure range from approximately 500 torr to 10 torr where voltage breakdown can occur; such a breakdown will destroy some of the active devices in the electronics. It is therefore recommended that the sensor only be operated at atmopsheric pressure or at a pressure of 0.050 torr or less. It should be noted that due to air damping the characteristic ringing will be damped out at room pressure so that no quantitative tests can be performed.

It is essential that vibration isolation be provided in any test fixture where the sensor output is to be monitored. The axial acceleration sensitivity is approximately 100 v/g. Therefore if measurements are to be made in the 10^{-3} dyne-second momentum range, for example, the ambient vibration at 125-150 HZ should be on the order of 10^{-4} g. Note that the electronics will saturate at approximately 10^{-2} g.

C. Storage

Due to the fact that the diaphragm is 25 micron type 2024 aluminum alloy, it is recommended that for prolonged storage the sensors be placed in a desiccator. This is particularly true when the location is near the ocean where corrosion is more severe. No other special storage procedures are required.

IV. LIST OF TEST EQUIPMENT
FOR
MOMENTUM SENSOR
D-11222 (REF. NAS 9-8870
(See Block Diagram B-11314)

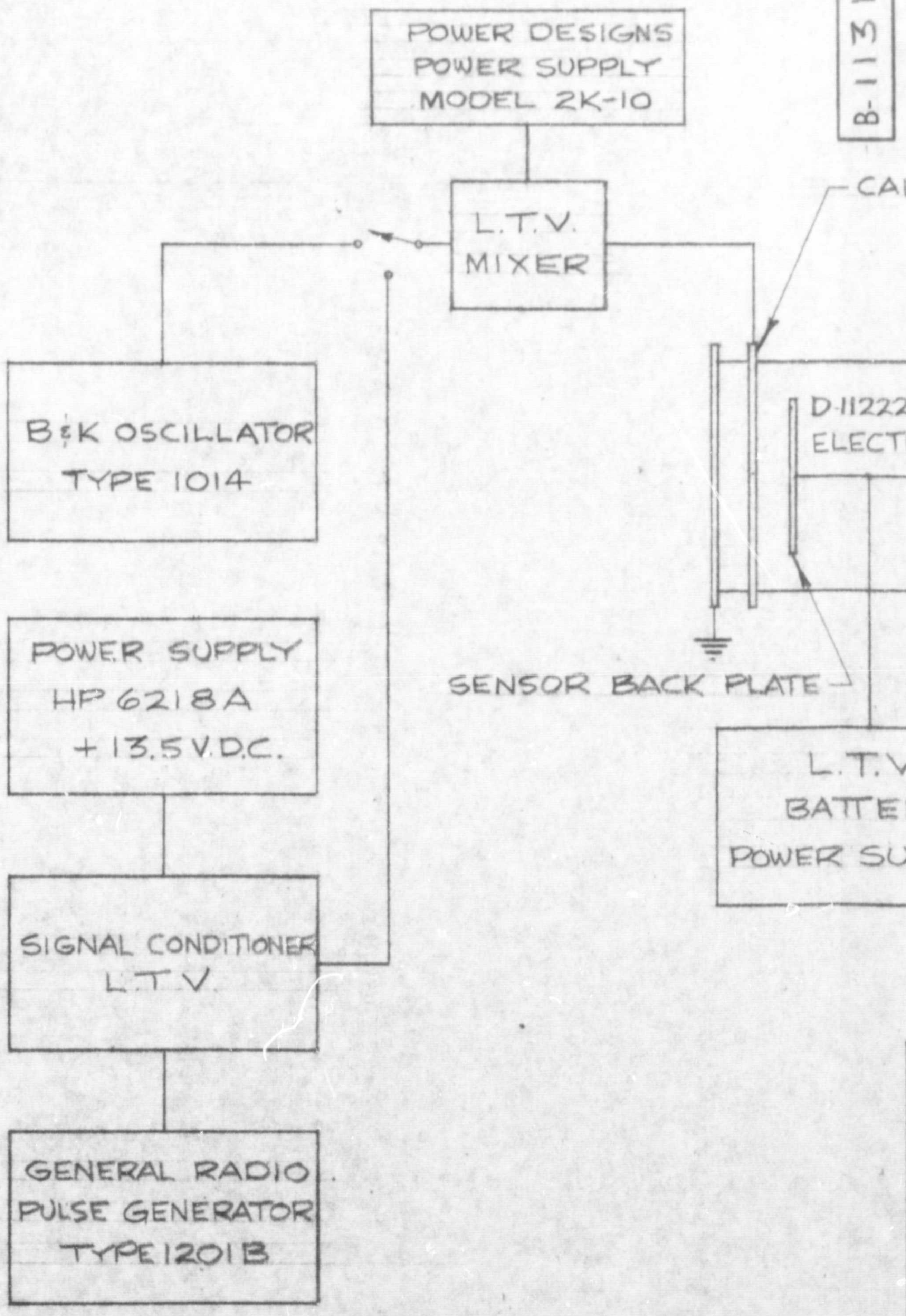
1. 1 ea. Tektronix Type Storage Scope, Model 549
2. 1 ea. Power Designs Power Supply, Model 2K-10
3. 2 ea. Hewlett Packard Power Supply, 6218A
4. 1 ea. General Radio Pulse Generator, Type 1217-B
5. 1 ea. Bruel & Kjaer Oscillator, Type 1014
6. 1 ea. L.T.V. Mixer Box (See L.T.V. Sch. C-11282B)
7. 1 ea. L.T.V. Signal Conditioner (See Conditioning Circuit Fig.-11, 9-13-68)
8. 1 ea. L.T.V. High Voltage Battery Power Supply
9. 1 ea. Systron Donner Counter, 1037

V. TEST EQUIPMENT BLOCK DIAGRAM

(B-11314)

Foldout Frame-1

B-11314



NOTES: UNLESS OTHERWISE SPECIFIED

Foldout Frame-2

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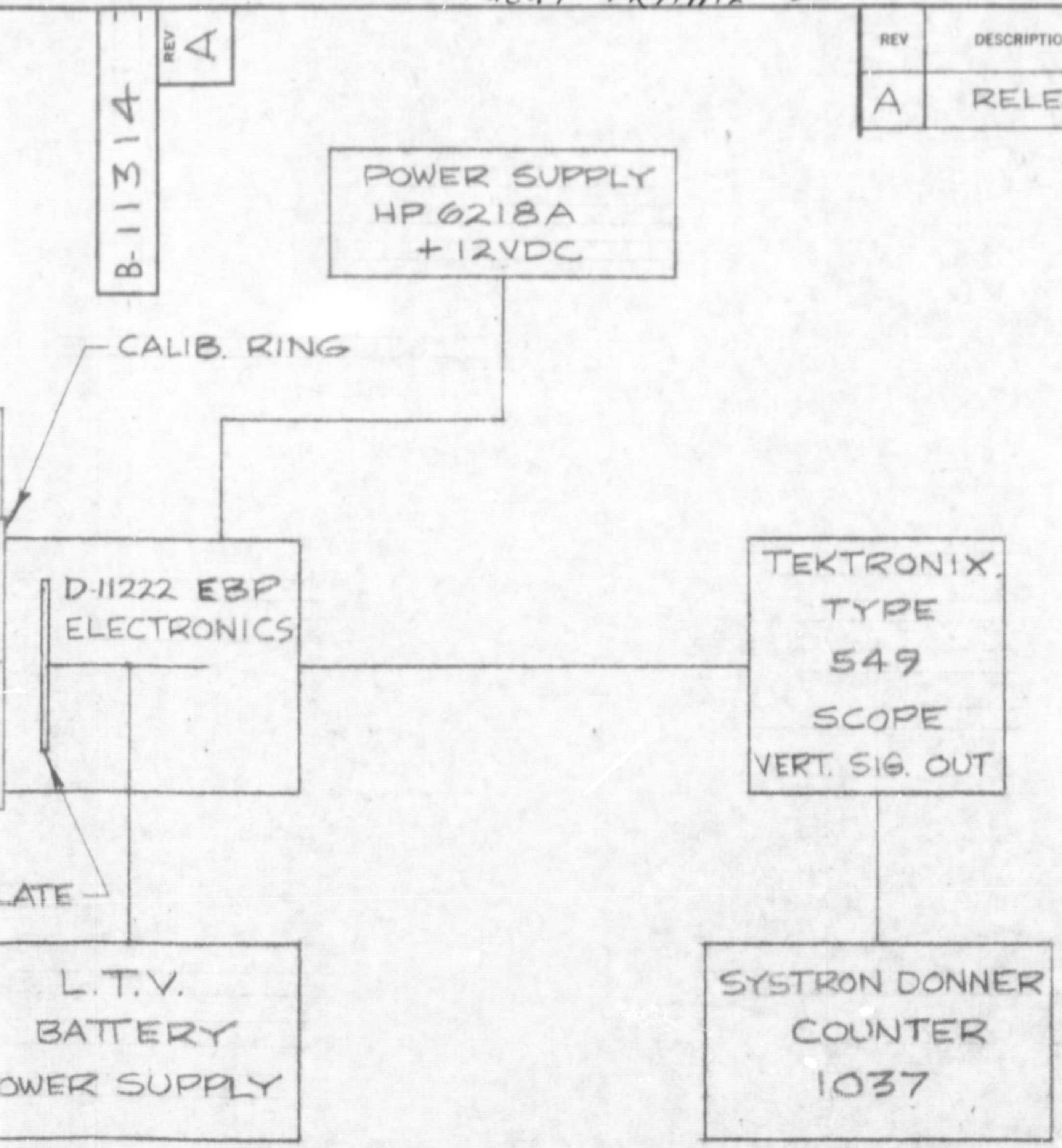

ITEM	REQ'D	PART NO.	DESCRIPTION

FINISH | MATERIAL | TOLERANCES UNLESS OTHERWISE SPECIFIED
3 PLACE DECIMALS ± .010 ANGULAR ± 0° 30'
2 PLACE DECIMALS ± .03

DRAWN W.H. White DATE 7/8/69
CHECKED DATE
APPROV DATE
APPROV DATE

TITLE
D11222 SENSOR
TEST BLOCK CIRCUIT
DIAGRAM

SCALE NONE | DATE 7/8/69
DWG NO B-11314 | REV A

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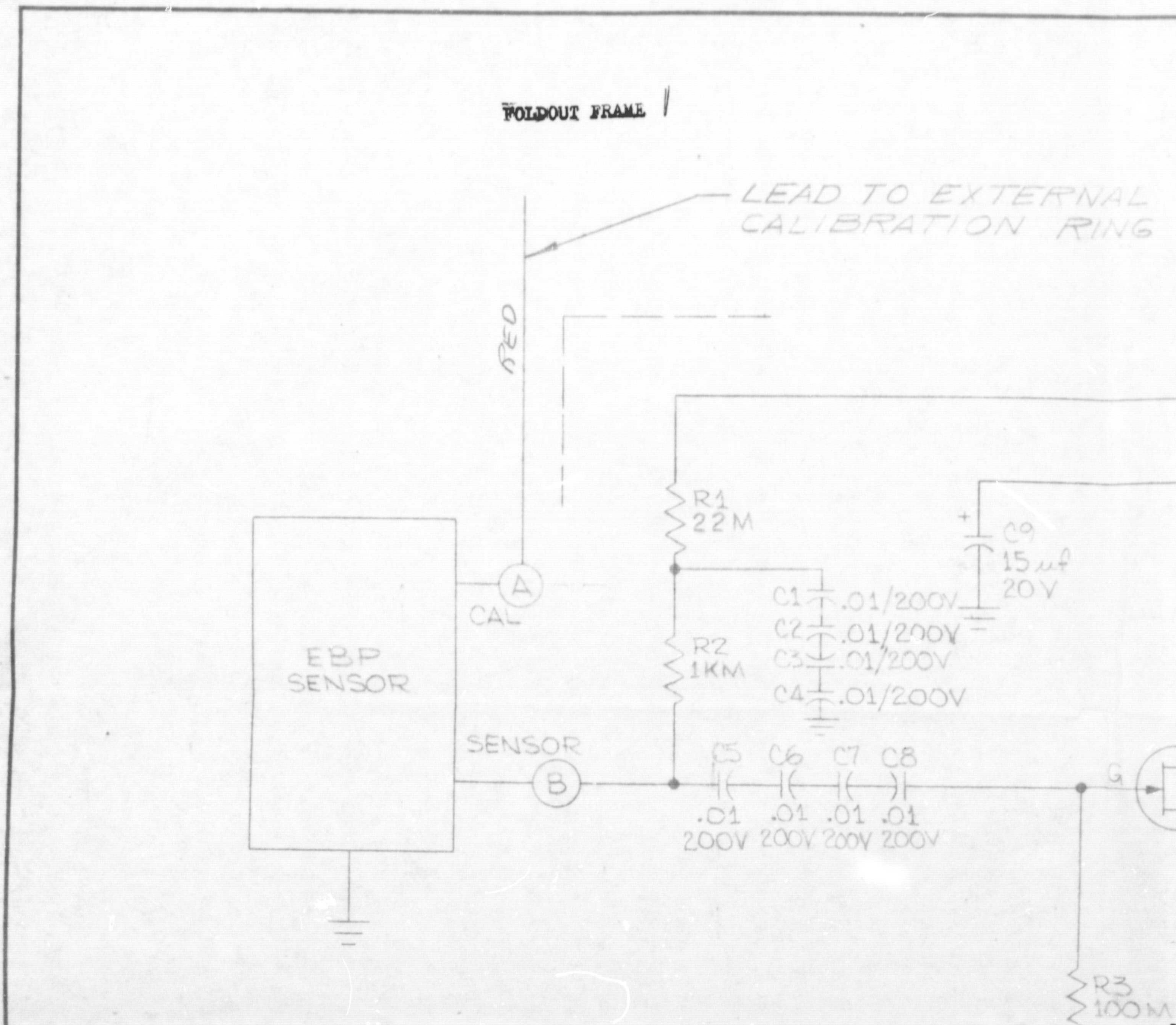
WESTERN DIVISION
LING-TEMCO-VOUGHT, INC.
1859 SOUTH MANCHESTER AVENUE • ANAHEIM, CALIFORNIA

USED ON

VI. MOMENTUM SENSOR SCHEMATIC

(C-11282)

FOLDOUT FRAME 1



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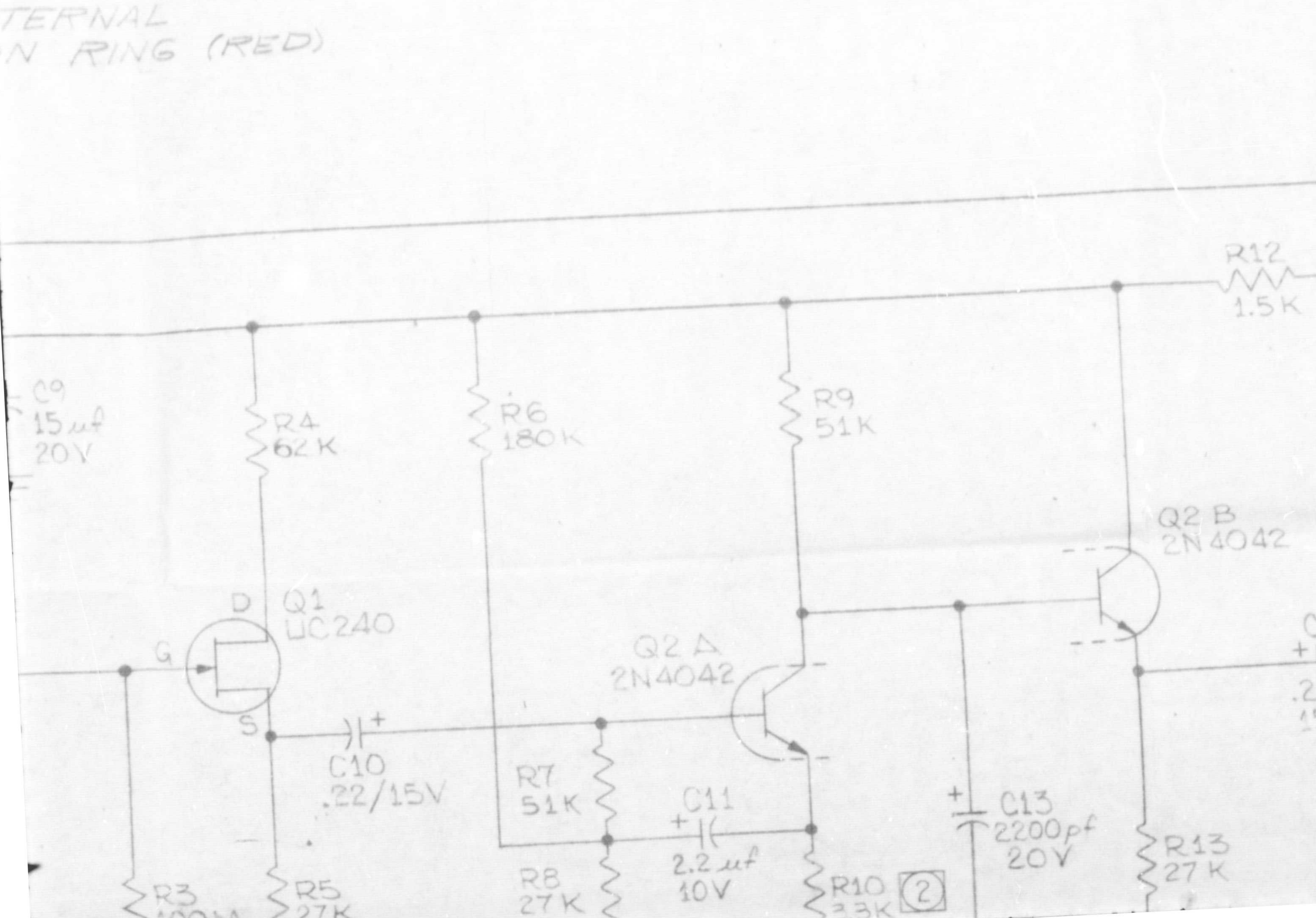
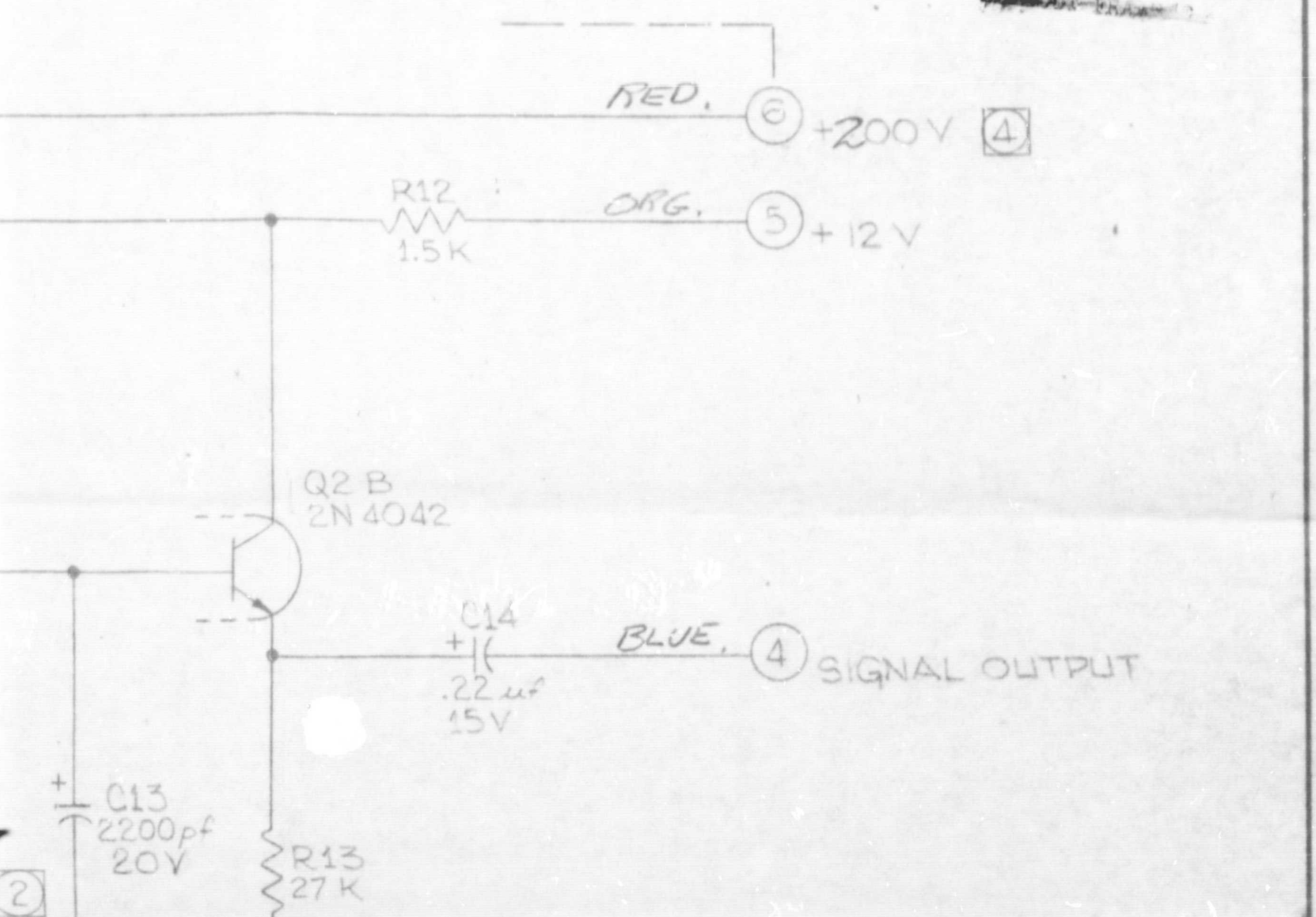
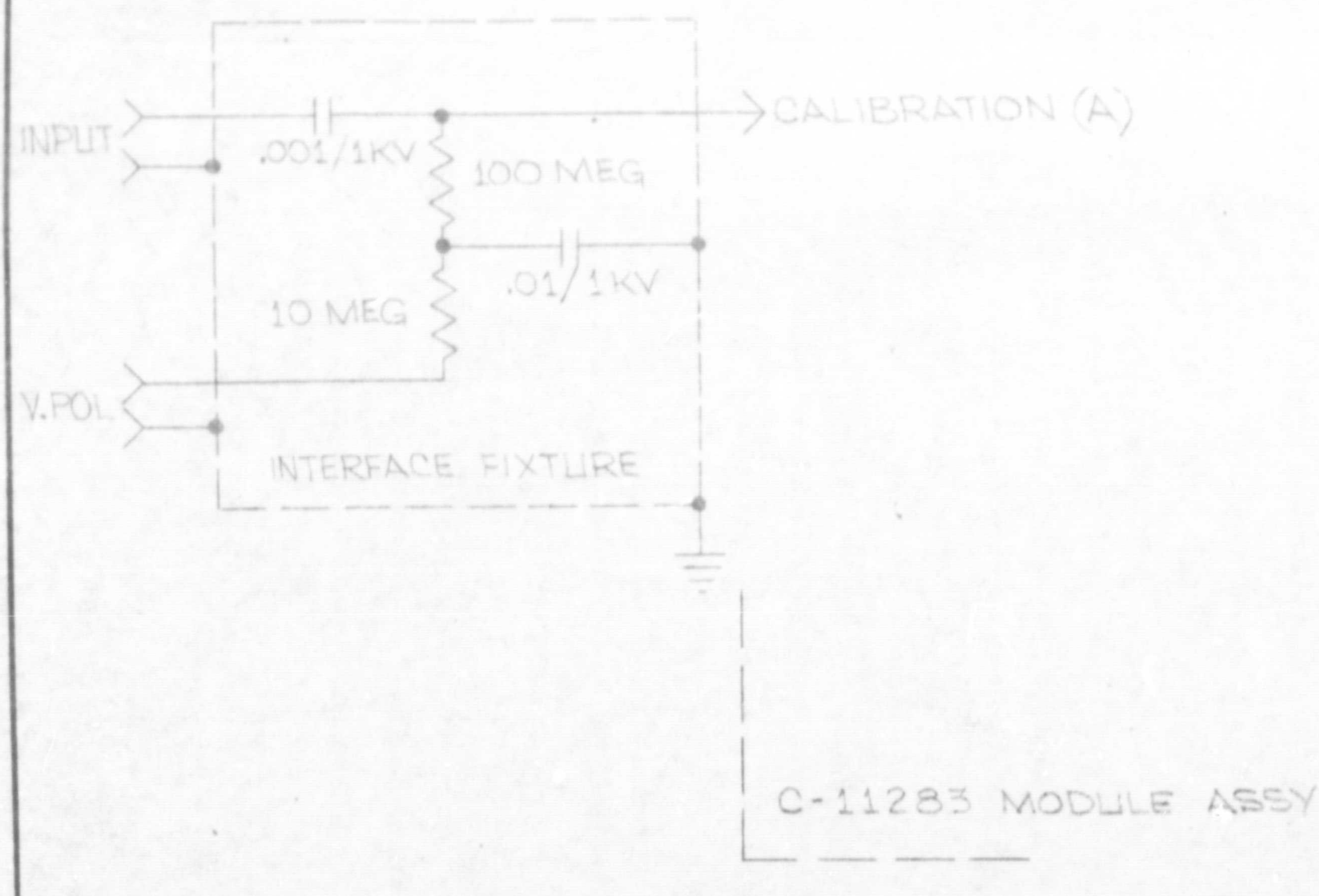


REV	DESCRIPTION OF CHANGE	DRAWN BY	APPROV	DATE
A	RELEASE	K.H.	FEJ	5/20/69
B	200 V POLARIZATION WAS 700 (AND CAL LEAD NOTE)	FEJ	FEJ	7/7/69
C	ADD COLOR CODE	FEJ	FEJ	7/8/69

FOLDOUT FRAME 3





FOLDOUT FRAME 4

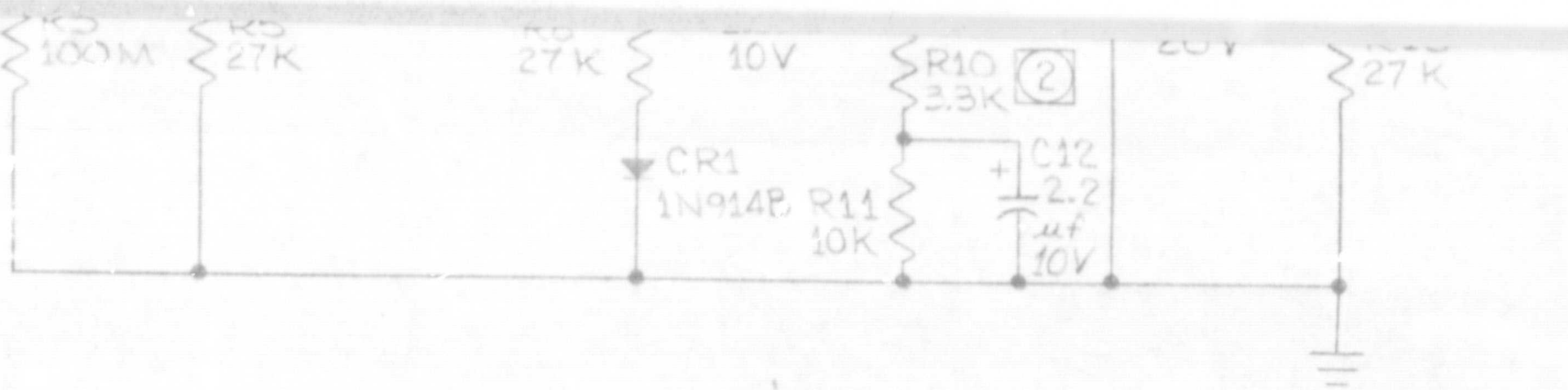
4. WITH THE SENSOR ATTACHED, THE POLARIZING VOLTAGE SHOULD NEVER EXCEED +50V IN AIR

3. REFERENCE PARTS LIST LTVL-1000

2. VALUE MAY BE SELECTED DURING FINAL TEST, NOMINAL VALUE INDICATED.

1. ALL RESISTORS - OHMS ± 5%, 1/8 W

NOTES: UNLESS OTHERWISE SPECIFIED



FOLDOUT FRAME 5

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FINISH			MATERIAL
DRAWN K.E. HAGNESS	DATE 5-13-69		TITLE
CHECKED	DATE 5-16-69		
APPROV	DATE 16 MAY 69		
APPROV	DATE		

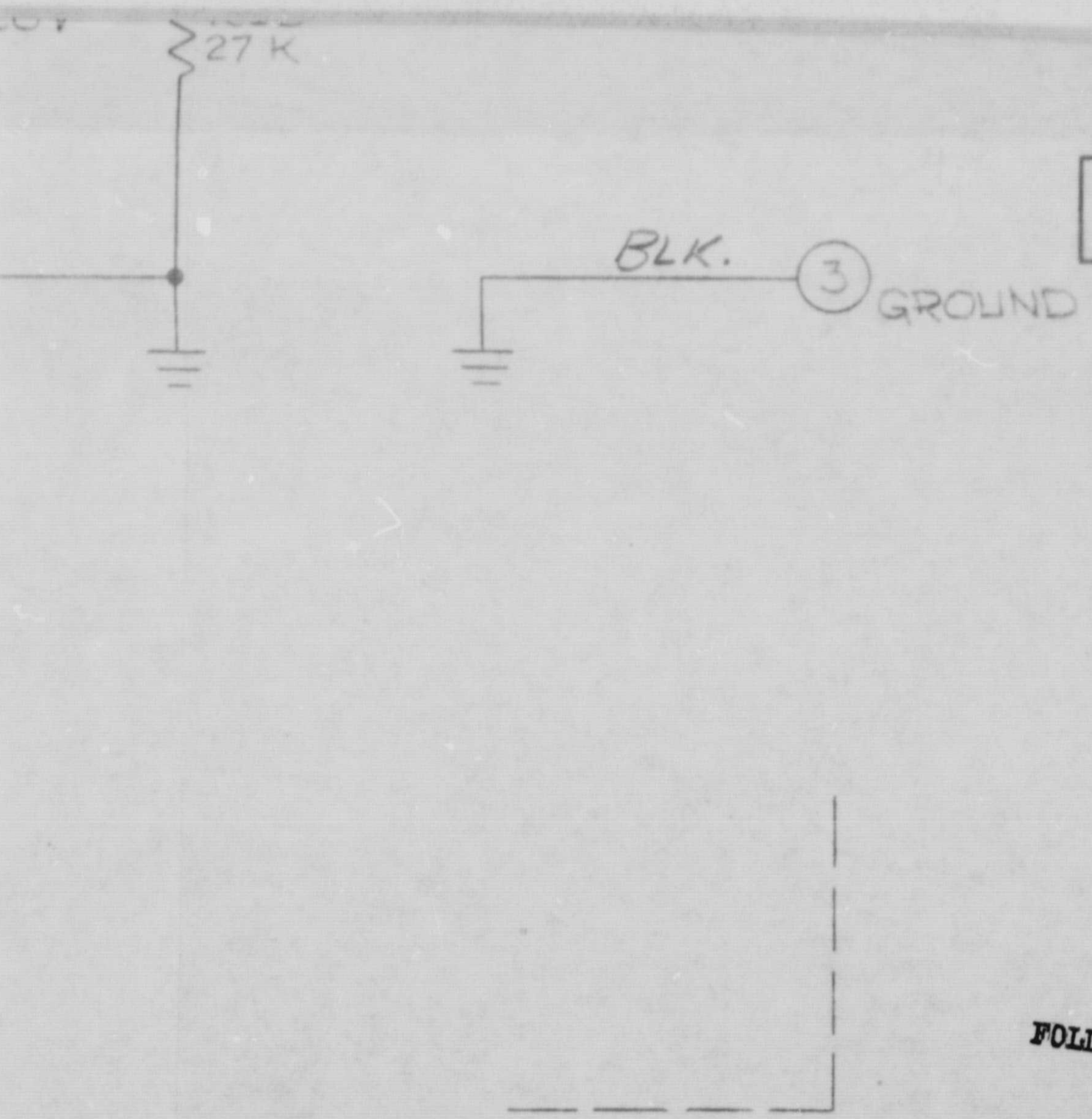
C-11283

USED ON

LTV RESEARCH
WESTERN D
LING-TEMCO
1859 SOUTH MANCHEST

C-11282

REV C



FOLDOUT FRAME 6

	PART NO.	DESCRIPTION	
		MATERIAL	TOLERANCES UNLESS OTHERWISE SPECIFIED 3 PLACE DECIMALS ± .010 ANGULAR ± 0° 30' 2 PLACE DECIMALS ± .03

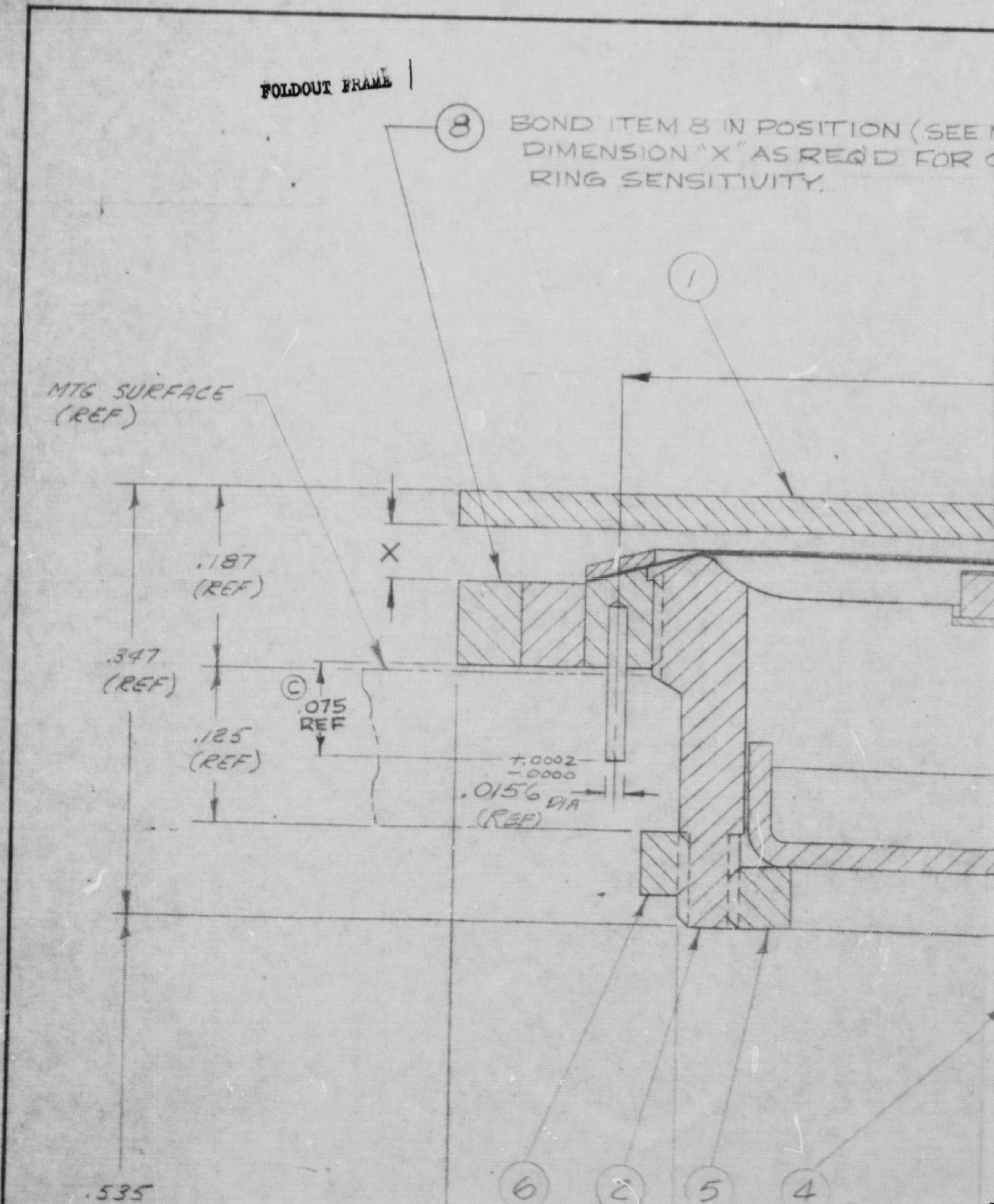
NESS DATE 5-13-69	TITLE
DATE 5-16-69	SCHEMATIC
DATE 16 MAY 69	EBP SENSOR
DATE	(LAB MODEL)

RESEARCH CENTER WESTERN DIVISION LING-TEMCO-VOUGHT, INC. 3332 SOUTH MANCHESTER AVENUE • ANAHEIM, CALIFORNIA	SCALE ———	DATE 5-13-69
	DWG NO C-11282	REV C

VII. MOMENTUM SENSOR ASSEMBLY

(D-11222)

FOLDOUT FRAME



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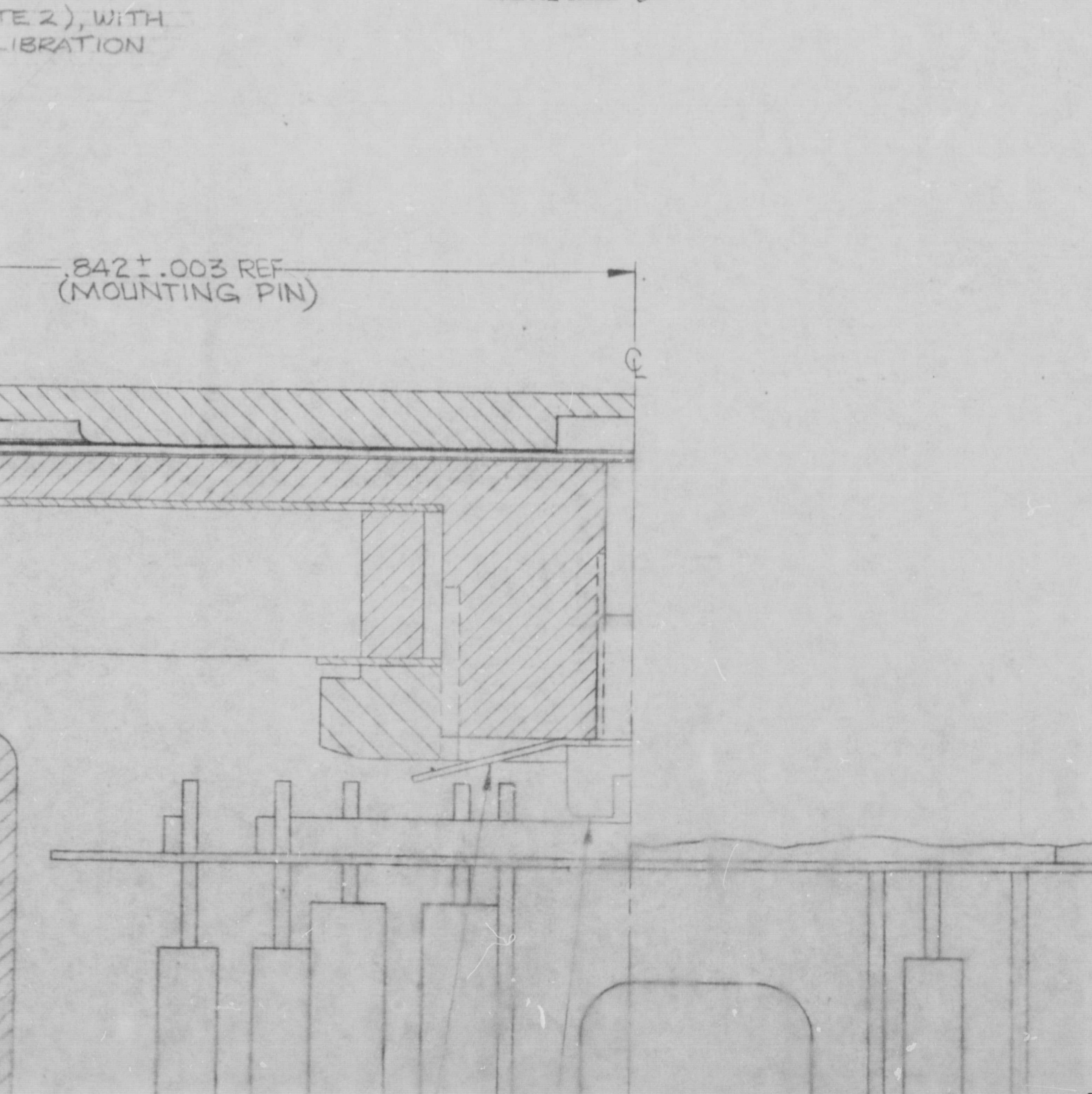

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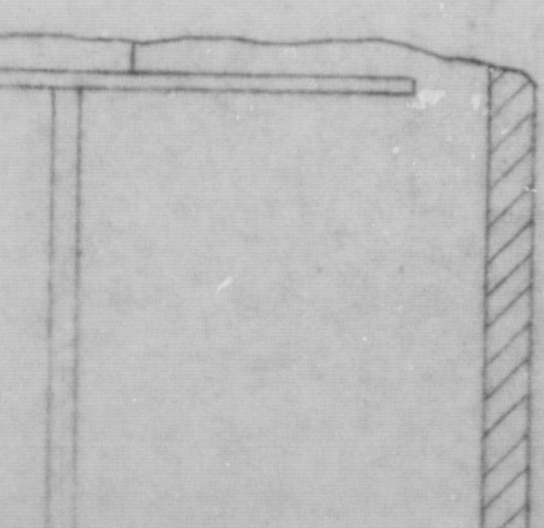


FOLDOUT FRAME 4

REV	DESCRIPTION OF CHANGE	DRAWN BY	APPROV	DATE
A	RELEASE	JM	FEJ	6/20/69
B	REVISED DIA OF ITEM 2	K.H.	FEJ	6/26/69
C	ADD. ".075 REF" DIM & REV. PICTURE OF ITEM 1 ADD. NOTE 2 & ITEM 8	W.W.	FEJ	7/14/69

2. BONDING PROCEDURE:

a.) USE ADHESIVE, ITEM 4, MIXED AS FOLLOWS:

NARMCO 7343 = 10.0 GRAMS

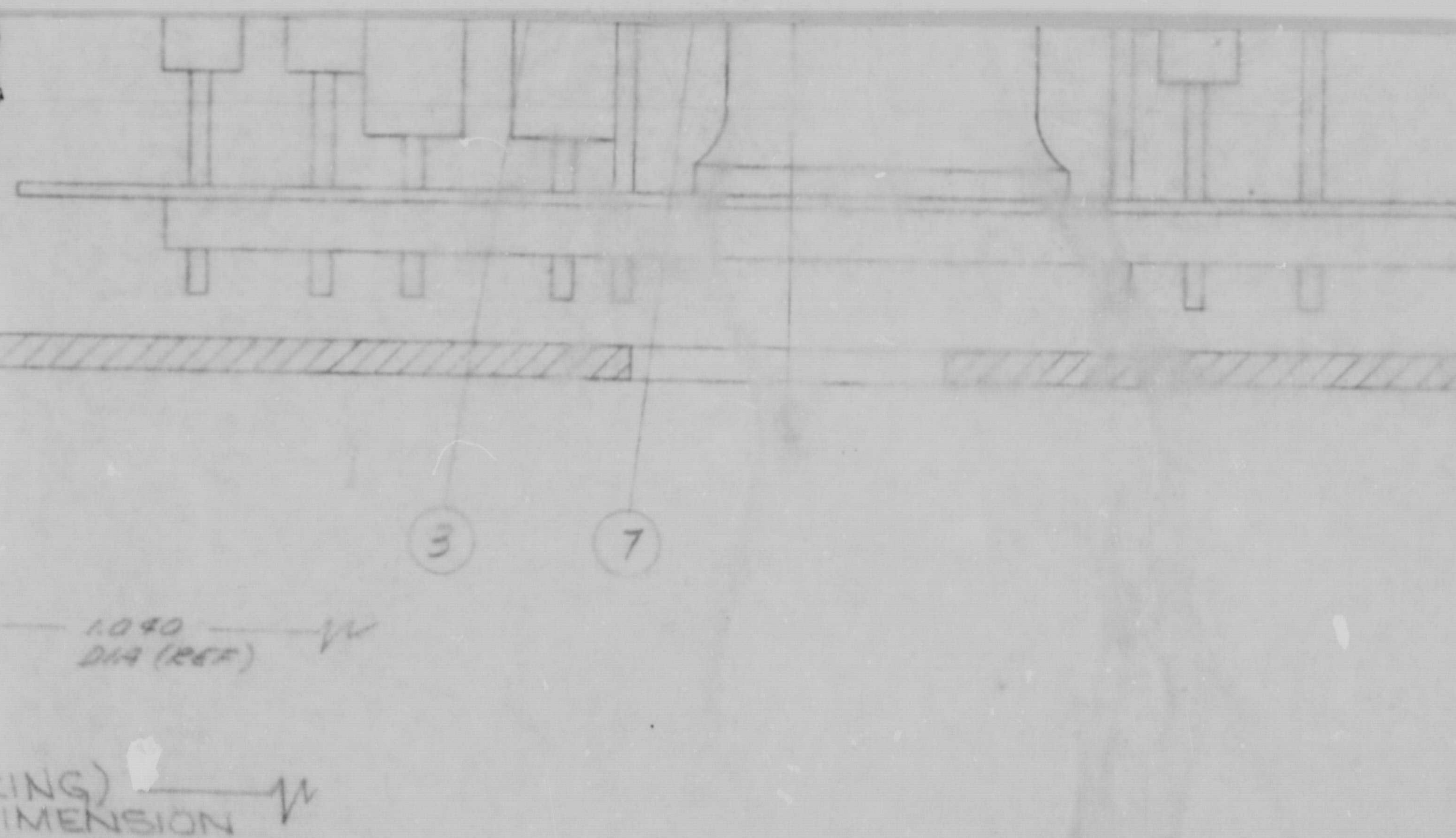
NARMCO 7139 = 1.1 GRAMS

NOTE: THE MIXING ACCURACY OF THESE COMPONE
SUCH THAT THE WEIGHT RATIO OF 7139 TO 7

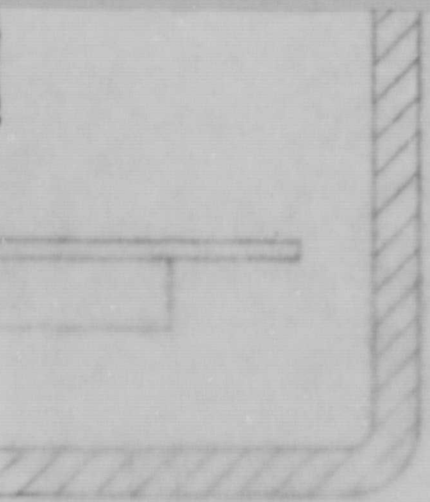
b.) PLACE ENTIRE ASSY IN PREHEATED OVEN AT 210° ± 5°F
+5 MIN −0 MIN. TURN OFF OVEN & ALLOW TEMPERATUR
TO 95°F OR LESS BEFORE REMOVING ASSY.

1. FOR SCHEMATIC SEE DWG C-11282

NOTES: UNLESS OTHERWISE SPECIFIED



SHALL BE
IS 0.11±0.0022
3HOURS
O RETURN



ⓒ	8
	7
	6
	5
	4
	3
	2
	1
	ITEM

FINISH

DRAWN

CHECKED

APPROV

APPROV

FOLDOUT FRAME 7

D-11222

REV C

(C)	8	1	B-11322	CALIB. ELECTRODE & INSULATOR ASSY
	7	1	B-11221	SCREW, CONTACT
	6	1	B-10922	MOUNTING NUT
	5	1	B-10923	NUT, MOUNTING, ELEC. ASSY.
	4	1	C-11287	ELECTRONIC ASSY
	3	1	B-10951	LUG
	2	1	D-11281	HOUSING & BACKPLATE ASSY
	1	1	C-11218	IMPACT PLATE ASSY
	ITEM	REQ'D	PART NO.	DESCRIPTION

FINISH

MATERIAL

TOLERANCES UNLESS OTHERWISE SPECIFIED
3 PLACE DECIMALS ± .010 ANGULAR ± 0° 30'
2 PLACE DECIMALS ± .03

DRAWN [signature] DATE 2-24-69
CHECKED FEJ DATE 5/20/69
APPROV FEJ DATE 5/20/69
APPROV DATE

TITLE SENSOR, MOMENTUM, EBP (LAB MODEL) COMPLETE

SCALE 10/1 DATE 2-24-69

LTV RESEARCH CENTER
WESTERN DIVISION
LING-TEMCO-VOUGHT, INC.
1859 SOUTH MANCHESTER AVENUE • ANAHEIM, CALIFORNIA

DWG NO D-11222 REV C

ECT

ON

VIII.

CALIBRATION DATA

MOMENTUM SENSOR (ELECTROSTATIC

BALLISTIC PENDULUM) LTV MODEL D-11222

REF CONTRACT NAS 9-8870 AS AMENDED

5/20/69, LTV PROJECT 08550

1. Serial No. 1

2. Date of Calibration: 7/3/69

3. Calibration Pressure: 30 - 40 Micron Hg

4. Applicable Sensor Drawing: D-11222B

5. Applicable Sensor Schematic: C-11282B

6. Bead Drop Calibration

   6.1 Sensor Output Voltage (first positive peak) : 0.15 Volts

   6.2 Input Momentum: .00665 dyne seconds ($\pm$5%)

   6.3 Resulting Sensitivity volts/dyne second 22.54

7. Calibration Ring inputs (using "interface fixture" as shown on C-11282B) Square pulse+9 volts amplitude, 300 microseconds duration (at "input") with 500 volts polarization:

   7.1 Sensor Output, first positive peak: 0.006 volts

   7.2 Sensor Output, first negative peak: 0.009 volts

8. Observed Natural Frequency of Sensor with Sinusoidal Drive on Calibration Ring: 125 Hz

9. Nominal laboratory conditions of test: 70-80^{O}F., 25-50% relative humidity

VIII.

CALIBRATION DATA

MOMENTUM SENSOR (ELECTROSTATIC BALLISTIC PENDULUM) LTV MODEL D-11222 REF CONTRACT NAS 9-8870 AS AMENDED 5/20/69, LTV PROJECT 08550

1. Serial No. 2
2. Date of Calibration: 7/3/69
3. Calibration Pressure: 30 - 40 Micron Hg
4. Applicable Sensor Drawing: D-11222B
5. Applicable Sensor Schematic: C-11282B
6. Bead Drop Calibration

   6.1 Sensor Output Voltage (first positive peak): 0.18 Volts

   6.2 Input Momentum: .00665 dyne seconds ($\pm$5%)

   6.3 Resulting Sensitivity volts/dyne second 27.1

7. Calibration Ring inputs (using "interface fixture" as shown on C-11282B) Square pulse+9 volts amplitude, 300 microseconds duration (at "input") with 500 volts polarization:

   7.1 Sensor Output, first positive peak: 0.012 volts

   7.2 Sensor Output, first negative peak: 0.017 volts

8. Observed Natural Frequency of Sensor with Sinusoidal Drive on Calibration Ring: 141 Hz
9. Nominal laboratory conditions of test: 70-80°F., 25-50% relative humidity

IX. FORM DD-250

X. CERTIFICATIONS

A. CONDITIONS

The LTV Research Center, Western Division hereby certifies that:

1. The delivered items conform to the Contractor's current standards of performance and quality for items of the specified designation.

2. Traceability records or documentation can be furnished assuring that new materials have been used.

B. CERTIFICATION OF CONFORMANCE

The LTV Research Center, Western Division hereby certifies that the test reports for Item 3.1 are on file and available for examination.

John K. Hilliard

John K. Hilliard
Director