CONTRACT NO. NAS8-24273

FINAL REPORT

LOW-POWER ENCODER SYSTEM USING ELECTRON BEAM DERIVED FROM A COLD SOURCE

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April 27, 1970

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SECTION 1.

Scope of Work

Develop one working model of an encoder system utilizing electron beams derived from a cold source. The primary goal of this task was to develop a system which consumes a minimum of power.

1. Encoder Specifications:

   Type: Cyclic binary

   Resolution 2^{13}

   Interrogation: Electron Beam (in lieu of normal light-optics)

2. Other research and development considerations to accomplish primary objectives:

   a. Methods of increasing scan rate.

   b. Develop an electron emission from metal junctions.

   c. Techniques for regulating and controlling electron emissions.

   d. Possibility of extending this encoding technique to resolutions greater than 2^{13}.

   e. Detection of electrons by reflection or transmission through encoder disc.

   f. Electron multipliers as transmitters and detectors.

   g. Reliability of the electron beam encoding with a cold source.

SECTION 2

Assessment of Work

A breadboarded 2^{13} encoder system utilizing a cold source of electrons and designed with the best efforts of the investigators to adhere to the goal of minimum power consumption was developed. However, as reported earlier, sustained operation of a cold source in the developed system was not achieved. Emission levels of the cold electron sources were increased approximately one order of magnitude during the course of the development effort. Operational lifetime tests of the improved electron sources were conducted and source lifetimes in excess of 500 hours were achieved. However, placement of identical sources in the confines of the electron optics assembly resulted in early failure.

Preliminary system calibrations and tests were performed utilizing a thermionic (hot) source of electrons in the electron gun. Operating in this manner, all essential system functions were performed. These included:

a) electron beam focusing to a spot size comparable to one bit of 2^{13} code,

b) electrostatically deflecting the beam radially across the code track array,

c) demonstrating that the electron beam could resolve the minimum radial dimension of the code pattern during beam sweep,

d) sensing the current induced in the chromium code disc. (Initially, a very high binary "zero" current level was encountered. Secondary electron emission was later identified as the cause of this problem.

An appropriately voltage-biased plate placed near the code pattern collected the secondary electrons and a good ratio of binary one to binary zero current level was then obtained.),

e) amplifying the low-level current with a low-power amplifier to a high-level voltage having a good signal-to-noise characteristics,

f) using the preamplifier output signal to activate programming one-shots, sample-and-hold circuits, and decision-making circuits necessary to the digitization process,

g) converting the digitized serial cyclic binary code word to a parallel word,

h) displaying the parallel code word with a bank of 13 light sources.

In addition to the above described achievements, the feasibility of the developed system concepts was further demonstrated momentarily while using a cold source of electrons. Photograph #1 depicts the preamplifier output obtained while using a cold source of electrons. Critical focusing had not been attempted when this photo was taken but timing pulses are clearly distinguishable from code pulses. Signal-to-noise characteristics indicate a potentially usable signal. The peak amplitude of the signal obtained with a cold source was approximately one-tenth that achieved while using a hot source.

The primary goal of the contract effort was to develop an encoder system which consumes a minimum of power. This criterion was one of the prime factors in the selection of a serial mode of interrogation. At the present state of the art, the single source of electrons and beam sweeping circuit required for a serial readout system consumes substantially less power than the 13 sources required by a parallel system.

As indicated elsewhere, other factors contributing to this choice were a) better reliability probabilities due to fewer components were possible with a serial mode, and b) sources matched in emission level, or at least individually adjustable, would have been required if a parallel mode had been selected.

Minimizing the power of the electron source was approached by attemptingto improve its efficiency. Changes in source geometry and processing techniques resulted in approximately X10 improvement in signal obtained at the preamplifier output for the same source power input. Total electron emission was increased well in excess of time 10, but the higher emission was accomplished in part by increasing the total emission angle, i.e., the emission was less collimated.

Lower power consumption in the electronics system was achieved by the use of:

a) low-power operational amplifier μA735,

b) specially-designed low-standby power one-shots in logical programming and timing functions,

c) cos-mos integrated circuit logic for serial-in, parallel-out shift registers and parallel-output storage registers.

Given below is a tabulation of power consumed by various portions of the encoder system. These figures are based on system operation during continuous self-interrogation at the rate of 500 times per second. It should be noted that the electron source can be rapidly switched on and off. Therefore, for applications requiring infrequent interrogation upon command, the source-and-sweep circuit could be switched on prior to each interrogation cycle. Also note that if serial code output were desired, the power indicated in Items 3 and 4 would be eliminated.

Power Apportionments

	System Element	Power
1.	Preamplifiers (two)	8 milliwatts
2.	Programming logic and circuits through serial output	1.4 milliwatts
3.	Interrogation Oscillator (Clock)	1.6 milliwatts
4.	Serial-to-Parallel Register & Output Storage	.65 milliwatts
5.	Sweep Circuit	13.0 milliwatts
6.	Electron Source Bias	300.0 milliwatts
7.	Electron Gun Bias	30.0 milliwatts

Scan Rate

Potentially faster scan rates were initially attained by the design choice to use the metalized code wheel as an electron detector in lieu of multiple channel multipliers. Time response delays due to such electron detectors were thus eliminated by eliminating the detectors.

Secondly, electron current sensed at disc was amplified in a current-to-voltage amplifier rather than by a more conventional electrometer-type amplifier having high input impedance.

A high-gain operational amplifier with negative feedback exhibits a "virtual ground" characteristic at its inverting input terminal. By providing a conductive path from the metalized code disc, through slip rings to the inverting input of such an amplifier, stray capacitance associated with the disc tends to be "shorted out" by the amplifier input, i.e., the system time constant is greatly reduced.

The output voltage of the amplifier is approximately given by:

$$V_{OUT} \doteq R_F I_D$$

R_F is the feedback resistor and I_D is the current sensed at the disc.

The time response of the system (τ) is approximately given by

$$\tau \doteq \frac{R_F C_S}{K+1}$$

C_S is the stray capacitance and K is the open-loop gain of the amplifier.

This equation assumes that the amplifier itself is not a frequency-limiting factor.

In general, a low-power system tends to be slow.

Based on the desire to achieve a) low-standby power consumption, b) fast-slewing rate, c) high open loop gain, d) low noise, the Fairchild µA735 operational amplifier was selected for use as the current-to-voltage preamplifier.

Scan rate was also found to be a function of code pattern geometry. In general, for a given number of code rings and timing rings, the optimum scan rate occurs when the minimum radial dimension among all of the radial elements is a maximum.

In terms of signal produced, this means simply that time response requirements are minimized when the minimum pulse width of all possible pulses occurring is a maximum.

This indicates a) the desirability of making each radial element of the pattern have the same dimension, and b) the desirability of a large track array (the dimension from the inner edge of the inner track to the outer edge of the outer track). However, a large track array requires a large electron beam traverse.

Electron Emission

Improved electron emission levels were achieved during the development effort. A discussion of this work is contained in the attached report written by the Graduate Institute of Technology.

Regulating and Controlling Electron Emission

The primary purpose of regulating electron emission in the encoder system is to achieve a signal which can be reliably digitized into discrete binary one or zero levels. Most forms of supply regulation waste power. Therefore, the design approach followed was to seek a system which could function reliably in the presence of supply variations and beam sweep rate variations. A code pattern was conceived which has clear (non-metallic) rings interlaced with the code track rings and which provides a conductive path from any portion of the code pattern to a contact point or any inner radius.

Timing rings provided the means of activating circuits which could a) provide time location identification of each code ring pulse, and b) sample the current level of a binary one condition immediately prior to sampling the current level of each code ring. If the code ring current sample exceeded one-half of the reference-level current sample, a binary-one state was identified by the circuit. If it were less, a binary zero was identified. One-shot pulse widths and beam sweep excursion tolerances were greatly relaxed by this approach.

Resolutions Greater than 2^{13}

Theoretical resolution limits are directly related to wavelength in both optical systems and electron-optical systems. Due to the extremely short effective wavelengths obtainable with electron-beam readout systems, all indications are that resolutions far beyond those obtained by optical techniques are therefore possible, (e.g. greater than 2^{19}).

However, adequate electron emission can be a much more restrictive limitation than the theoretical resolution limit. An electron optics system which can focus an electron beam to a very small size is also one which presents a very small entrance angle to electrons leaving the source, i.e., small beam or spot size indicates small signal size. One means of increasing emission would be to increase the power input. This approach is limited by heat dissipation capabilities but a switched source method would permit greater peak input power with less heating. Indirectly this would extend resolution limits. By similar reasoning, improvements in electron source efficiency through the use of other materials or other source geometries would permit the use of electron systems capable of focusing to a smaller spot size.

Detection of Electrons by Reflection or Transmission through Encoder Disc

Transmission mode readout utilizing techniques available to the investigators would have limited the investigation to a system having less than 2^{13} resolution. For this reason and because a perforated disc would have had to be very thin, other alternatives were pursued. Reflection mode readout which consisted of collecting electrons reflected from a ground code pattern was attempted during early experimental work with moderate success.

Electron Multipliers

As previously indicated, electron multipliers were not utilized. Power reduction, faster scan rate and better reliability were factors in this selection.

Reliability of Electron Beam Encoding

At present the weak link in overall system reliability is the electron source. Since source failures occurred in the electron optics gun but notin life-test stations, it seems reasonable to speculate that this type of failure could ultimately be eliminated. According to the Graduate Institute, the mechanism of electron emission does not appear to be one in which the source is used up.

Emission levels attained during this effort appear to be usable for encoder systems in the 2^{13} class. Higher emission levels would perhaps be necessary for a 2^{13} system in a noisy environment.

Secondary electrons produced by the chromium were collected by a slotted metal plate placed near the code disc. Operation in the manner yielded very satisfactory results over the short span of this effort.

However, changes in secondary emission characteristics might occur over long periods of time. If so, system operation might deteriorate.

Electron beams are deflected by magnetic fields (e.g., the earth field). For mobile systems, magnetic shielding would be necessary to avoid "zero shift" angular error.

SECTION 3

System Description

Drawing C906-854 specifies the final form of the code disc pattern. This pattern is formed by selectively etching the .07 micron chromium coating deposited on a flat glass plate. Enclosed areas of the pattern are bare glass; background areas are chromium. The 13 Gray tracks comprise the cyclic code which uniquely identifies 2^{13} (8192) angular positions. Associated with each code track is a pair of timing ring tracks. Note that the timing rings overlap but do not touch. This aspect of the pattern permits the entire chromium pattern to be conductively connected, i.e., there is a conductive path from any portion of the pattern to any other portion.

A copper ring (CX-450) positioned under the disc clamp (B905-4708) is used to provide electrical contact with the innermost radius of the code pattern. The copper ring is connected through a slip-ring assembly to the external circuitry.

One source of electrons is used per system. Electrons emitted by the source are electrostatically focused to a small spot (≈.001") in the plane of the code pattern. A sawtooth-shaped voltage wave applied to deflection plates sweeps the focused spot of electrons from an inner radius position to an outer radius position. When the focused electron beam impinges upon a chromium portion of the code pattern, secondary electrons are emitted by the pattern and collected by a slotted elecrode plate positioned near the disc. The net flow of electrons out of the code pattern to the plate electrode is exhibited as conventional (+)

current flow into the external electronics.

As the electron beam proceeds on its traverse from inner to outer radius, it first encounters either timing ring A_1 or timing ring B_1. In either case, the motion of the beam from the conductive background area of the pattern to the bare glass area of the timing ring produces a negative (-) going change in current sensed by the circuitry. After amplification this step change initiates two basic actions. The first is the activation of timing one shots which control the subsequent sampling of amplifier output voltage during the time the electron beam impinges the chromium background area (reference zone) located between timing rings A_1 or B_1 and the first Gray-code track. The storage of this voltage level in a sample-and-hold circuit provides a measure of electron emission level. The second action is the activation of one shots which control the comparison of amplifier output with one-half of the previously sampled reference zone level.

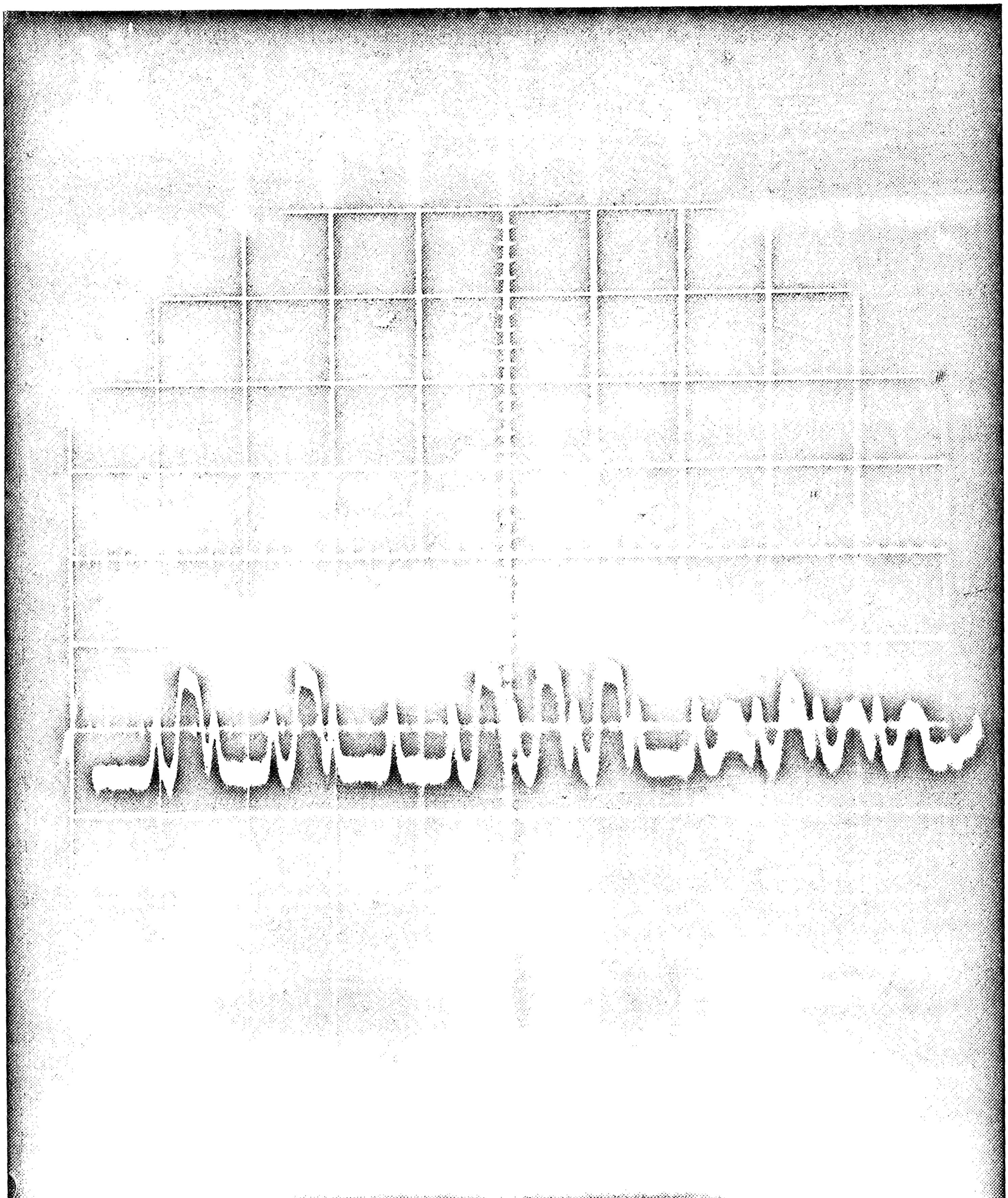
If the voltage produced by the electron beam in crossing a code track is greater than one-half of the "stored" voltage reference level, a binary-one condition exists. If this voltage is less than the reference level, a binary-zero condition exists. A differential comparator amplifier is used to make these binary-level decisions. The output of the comparator is therefore a serial code.

Circuit Description

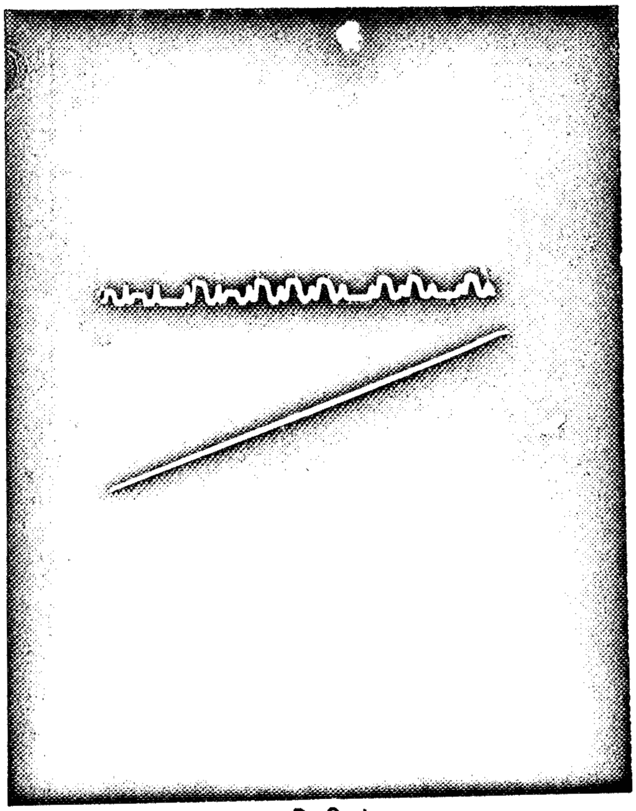
A free-running clock circuit consisting of Q_1 and Q_2 (see X-403) in a multivibrator circuit provides the basic timing for the entire circuit. Referring to the timing diagram, Figure 1, the clock period is approximately 2 ms. The clock drives a reset one-shot consisting of Q_3, Q_4, Q_{20} and Q_{21}. This one-shot provides a narrow (approximately 10 μsec) pulse which resets the storage and shift flip-flops before any operation. This one-shot also resets the sweep saw-tooth. The sweep is generated by Q_{39}, Q_{40} and Q_{41}. It basically is a resettable constant current generator driving a capacitor. A typical saw-tooth sweep is shown in Photograph P-2 and P-3 where code timing and reference levels are shown also. Note that the LSB occurs at the far right-hand side of the photographs. As previously discussed, one or two timing pulses may occur from the disc scan process. These timing pulses after amplification are fed to a squaring circuit (Q_{34}, Q_{35}, Q_{36}, see output in P-4), then to a code sample "A" one-shot. The trailing edge of "A" triggers the "A1" one-shot which in turn samples the code level via Q_{37}, a series FET switch. The "A2" one-shot (triggered also by "A") is used to shift digitized data in the serial-to-parallel shift register (T_0 through T_{13}). The reference level is sampled in like fashion on one-shots "B" and "B1" (see Figure 1).

The sampling of analog reference levels are obtained by another series FET switch Q_{38}. A differential comparator operational amplifier then compares one-half of the reference level with the code level. A level greater than this level is a binary one while one less is a binary zero. The data is thus digitized as shown in Photograph P-5. These are sequentially shifted into T_0 through T_{13}. Parallel outputs are obtained when a preset reference ONE, initially introduced into T_0, is shifted into T_{13}. The binary outputs are available on lines 1 through 13 and drive a lamp display for the users convenience.

The one-shots used in this circuit deserve some mention, since they must conserve power and must be of relatively fast rise and fall times. Normally these two factors are incompatible; here, however, special design makes both possible. The transistors selected are of a complimentary NPN-PNP pair and are so arranged that only one (in a collector leg) is on at a time. Thus in DX-403, Q_4 and Q_{20} are normally on while Q_{21} and Q_3 are off, for instance. One-shot firing reverses on-off order and the output terminal is thus connected to either -10 volts or ground --- either case of which is very low driving impedance. This feature allows charging any associated capacitance quickly with little power. The only steady power drawn is in the base biasing resistors. This power is minimized by large value resistors.



P-1
Preamplifier Output Using Cold Source



P-2 ↑
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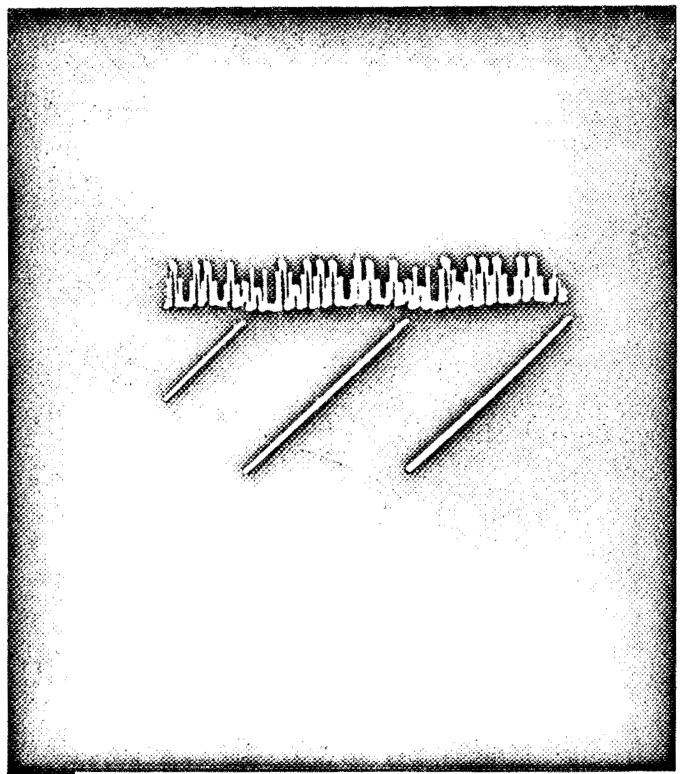

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P-4 ↓
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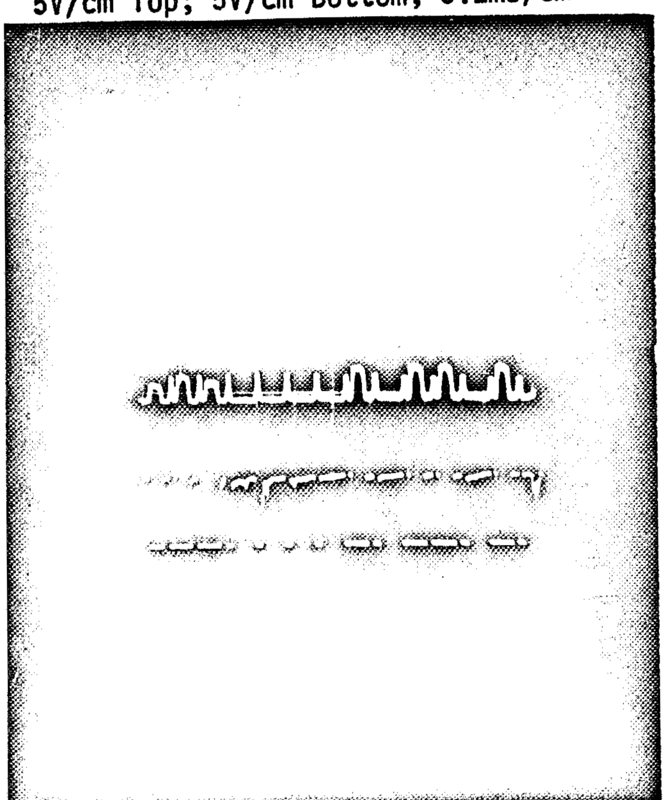

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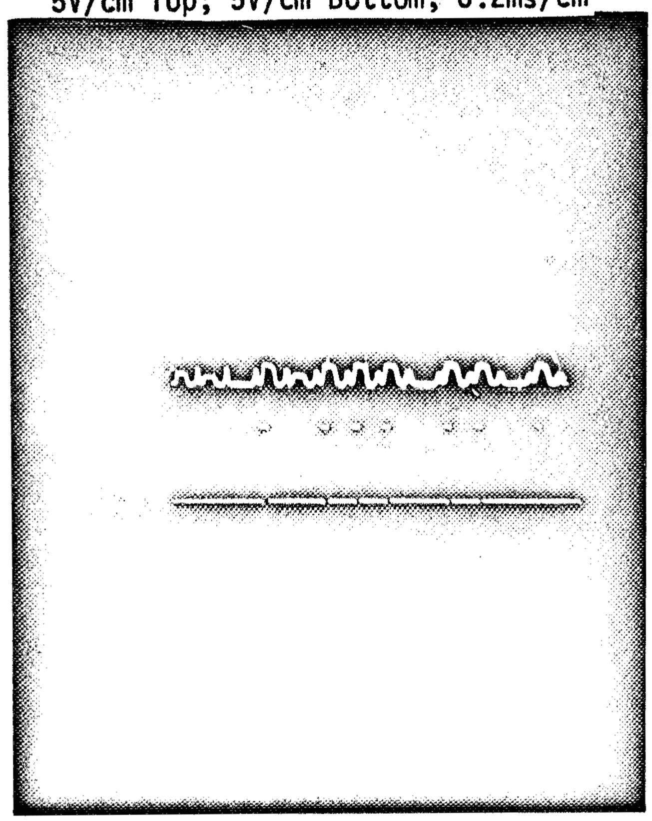
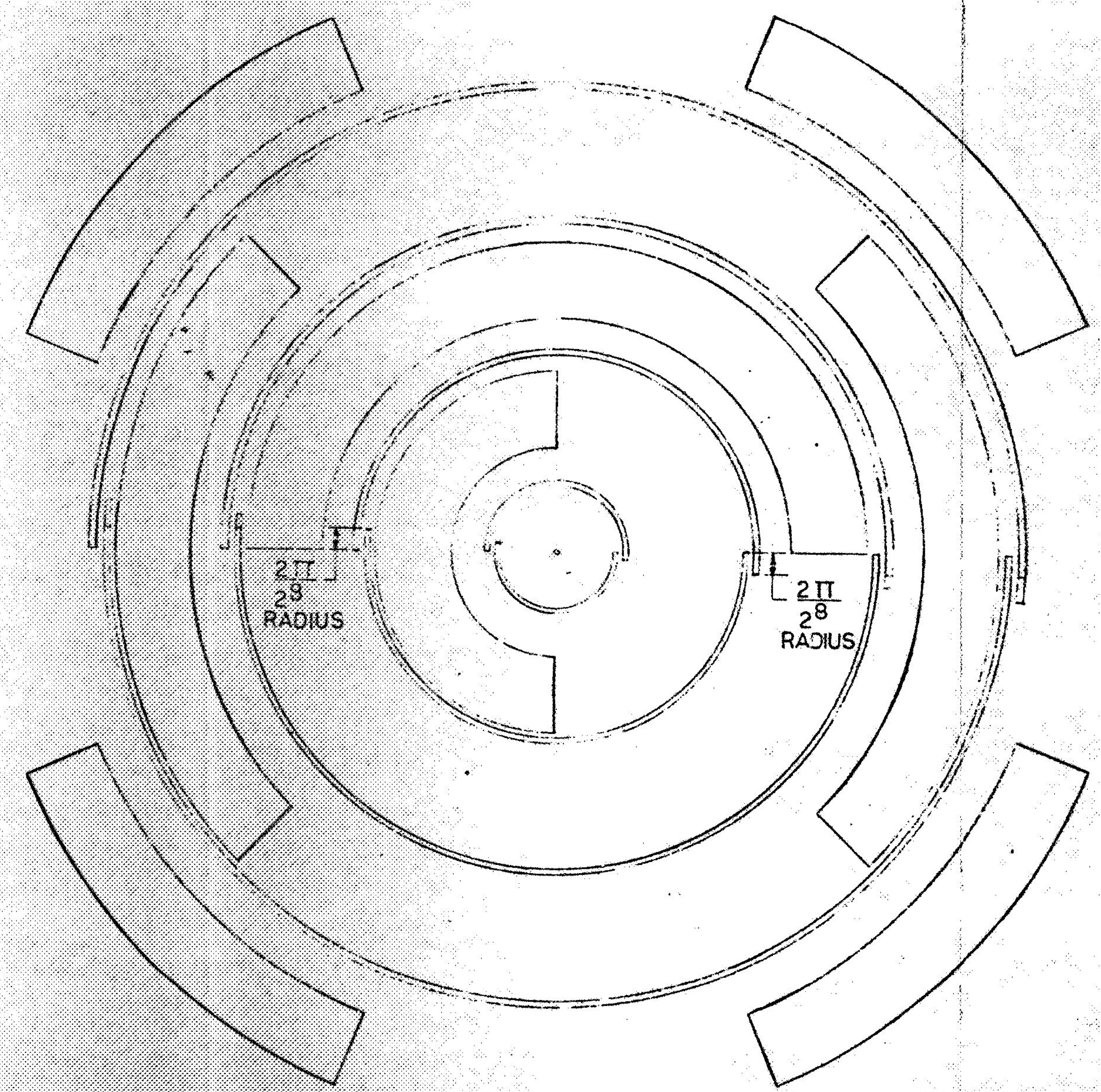


TRACK	DESCRIPTION	PAD ∠ LENGTH	RADIUS TO ℄
40	13 GRAY	.025	1.687
39	TIMING B13	.005	1.658
38	TIMING A13	.005	1.651
37	12 GRAY	.025	1.626
36	TIMING B12	.005	1.597
35	TIMING A12	.005	1.590
34	11 GRAY	.025	1.565
33	TIMING B11	.005	1.536
32	TIMING A11	.005	1.529
31	10 GRAY	.025	1.504
30	TIMING B10	.005	1.475
29	TIMING A10	.005	1.468
28	9 GRAY	.025	1.443
27	TIMING B 9	.005	1.414
26	TIMING A 9	.005	1.407
25	8 GRAY	.025	1.382
24	TIMING B 8	.005	1.353
23	TIMING A 8	.005	1.346
22	7 GRAY	.025	1.321
21	TIMING B7	.005	1.292
20	TIMING A7	.005	1.285
19	6 GRAY	.025	1.260
18	TIMING B6	.005	1.231
17	TIMING A6	.005	1.224
16	5 GRAY	.025	1.199
15	TIMING B5	.005	1.170
14	TIMING A5	.005	1.163
13	4 GRAY	.025	1.138
12	TIMING B4	.005	1.109
11	TIMING A4	.005	1.102
10	3 GRAY	.025	1.077
9	TIMING B3	.005	1.049
8	TIMING A3	.005	1.041
7	2 GRAY	.025	1.016
6	TIMING B2	.005	.987
5	TIMING A2	.005	.980
4	1 GRAY	.025	.955
3	TIMING B1	.005	.926
2	TIMING A1	.005	.919
1	CLEAR	.025	.500



VIEW OF EMULSION SIDE
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CENTER HOLE DIA. 1.00
EMULSION TRIM DIA. NONE
MATERIAL: METAL CLAD-II

APR 27 1970

REVISIONS

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:
ANGLES ± ½°
FRACTIONS ±
2 PLACE DECIMALS ±
3 PLACE DECIMALS ± .005

DWN. WWW
DATE 10- -69
CH'D.
APP'D.
APP'D.
FINISH

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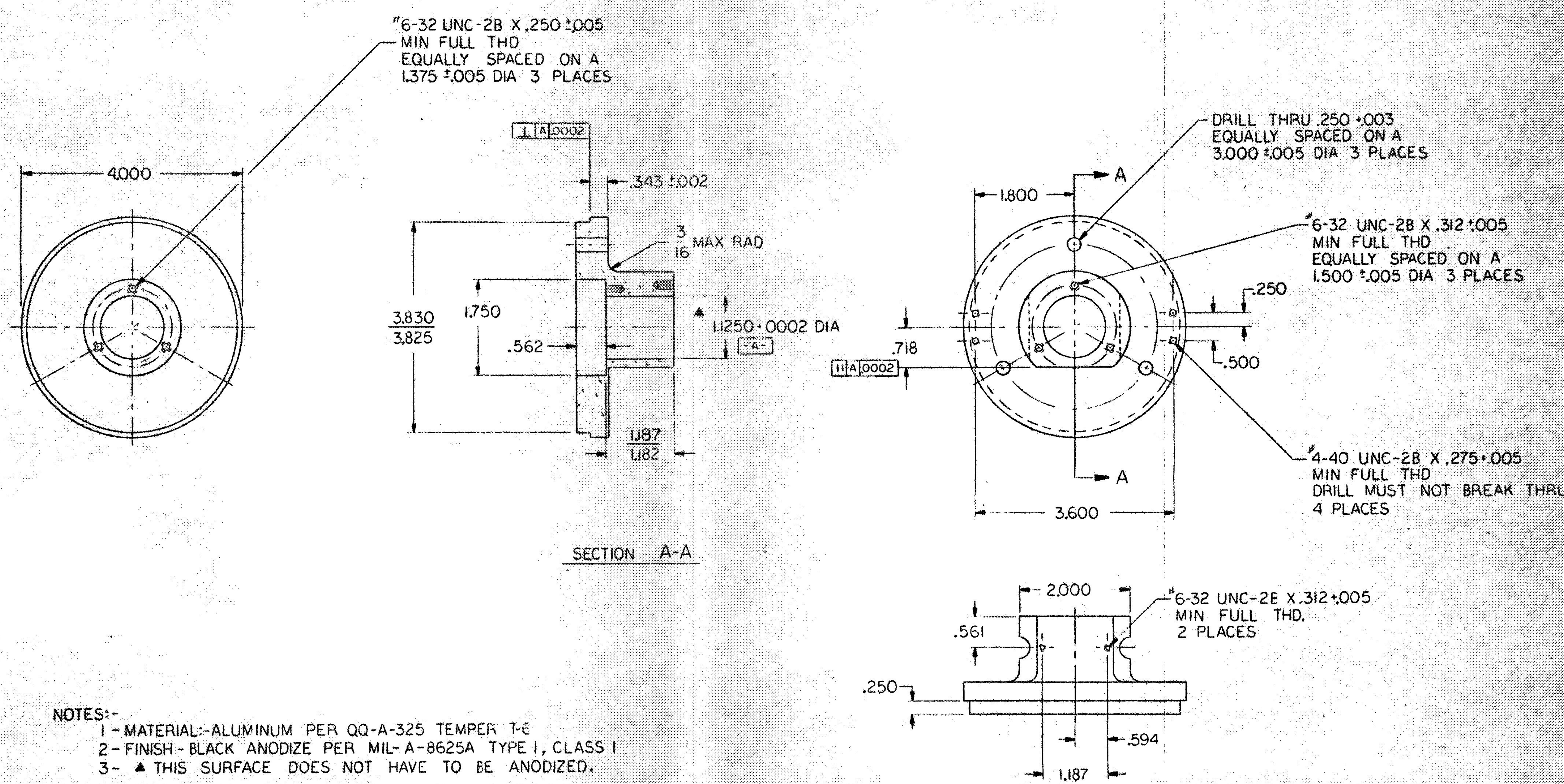
REQ. | NEXT ASSEMBLY

BALDWIN ELECTRONICS, INC.
LITTLE ROCK, ARKANSAS

C 906-854 REV.



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3 - ▲ THIS SURFACE DOES NOT HAVE TO BE ANODIZED.

APR 28 1970

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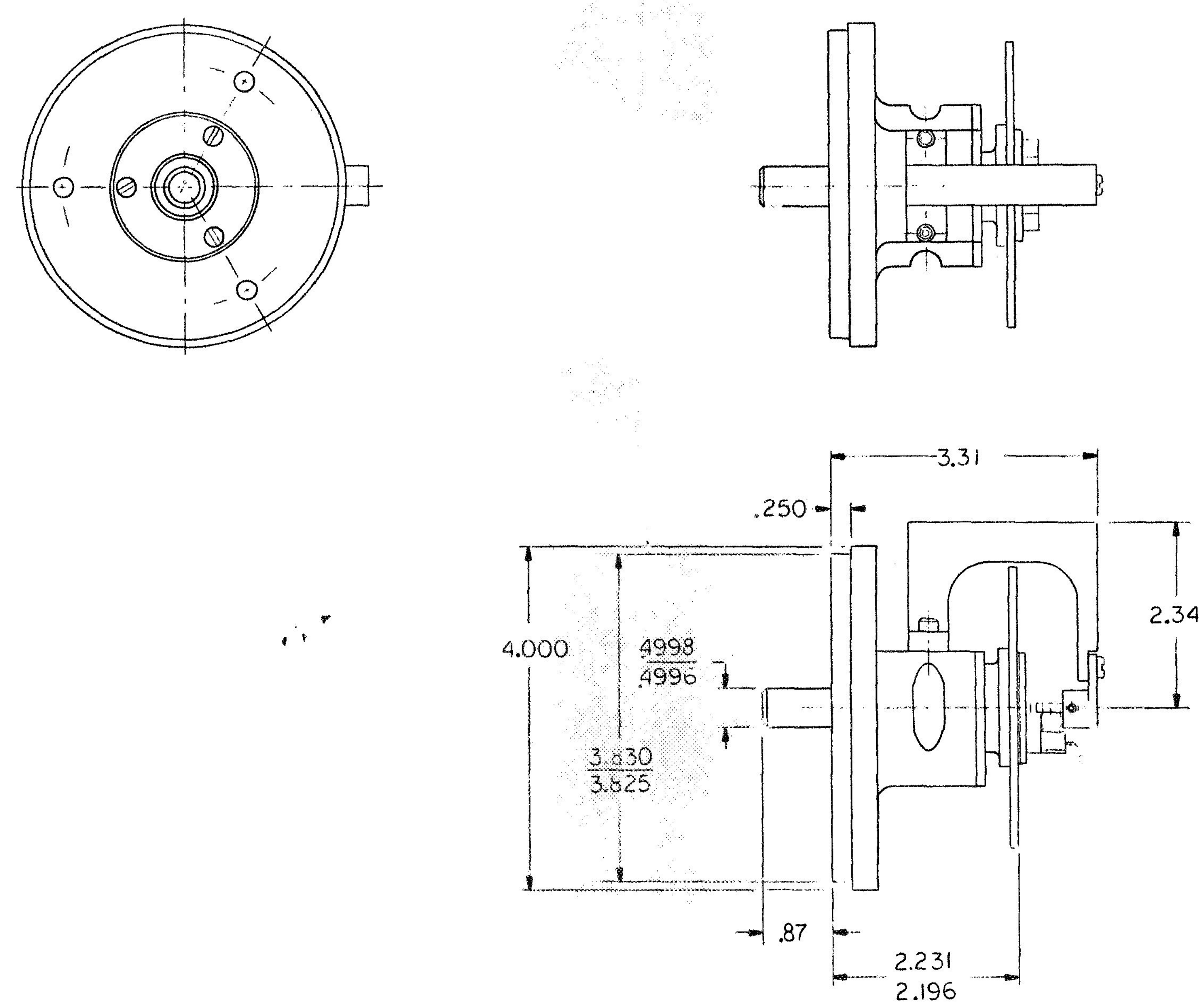
REVISIONS



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UNLESS OTHERWISE SPECIFIED TOLERANCES ARE: ANGLES ± ½° FRACTIONS ± 2 PLACE DECIMALS ± 3 PLACE DECIMALS ± .005	ALL DRAWINGS AND SPECIFICATIONS ARE AND REMAIN THE PROPERTY OF BALDWIN ELECTRONICS. ALL SPECIFICATIONS ARE CONFIDENTIAL AND ARE NOT TO BE DISCLOSED TO ANY PERSONS OTHER THAN THOSE TO WHOM THEY ARE SENT. NO DRAWINGS, SPECIFICATIONS OR OTHER DATA BELONGING TO BALDWIN ELECTRONICS WHICH MAY BE FURNISHED TO MANUFACTURERS OR OTHERS FOR ANY PURPOSE ARE TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.
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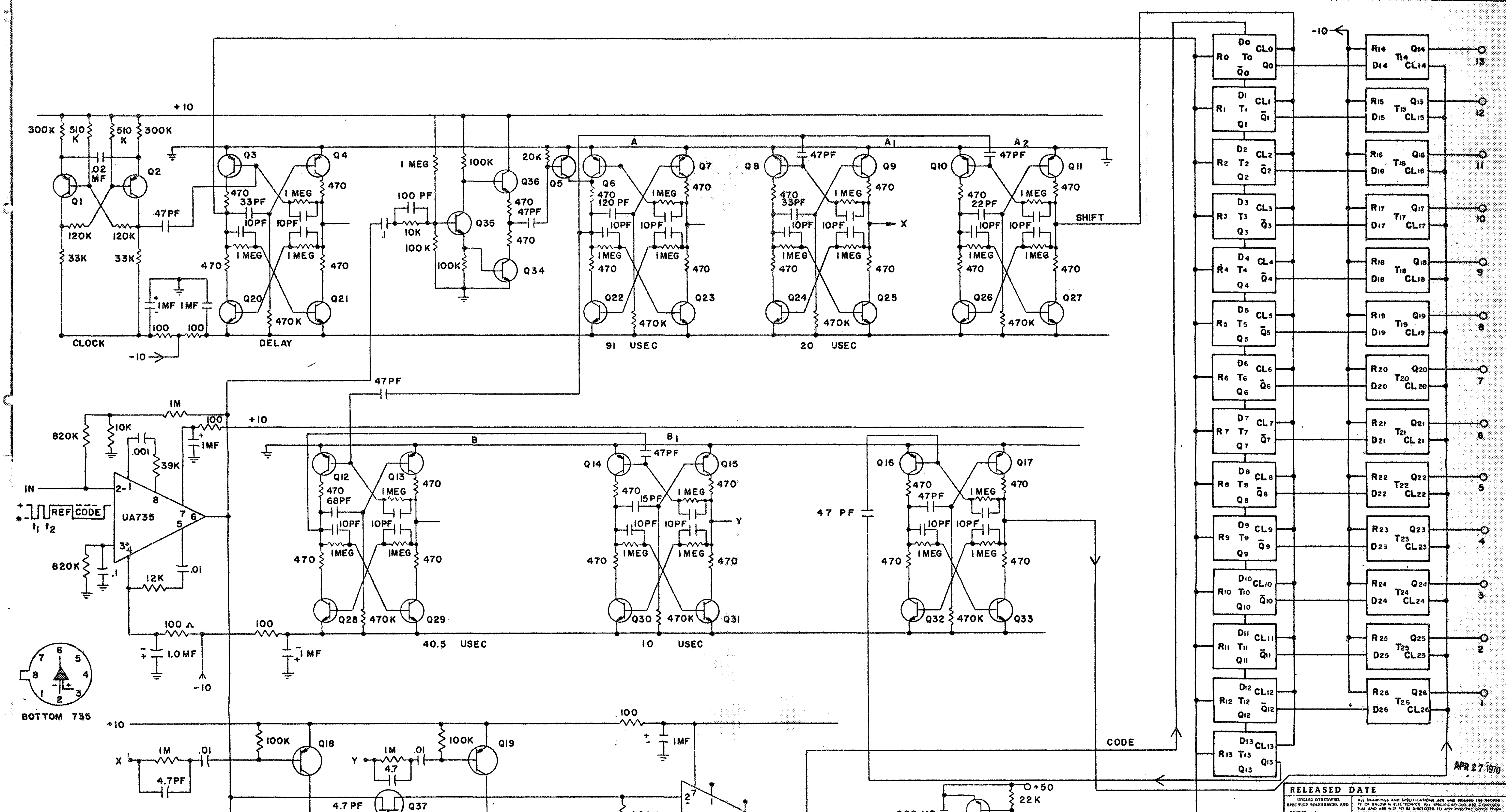


NOTE
1-Q1 THRU Q19 - 2N3527
2-Q20 THRU Q36 - 2N2432
3-T0 THRU T26 - CD4003D (RCA)

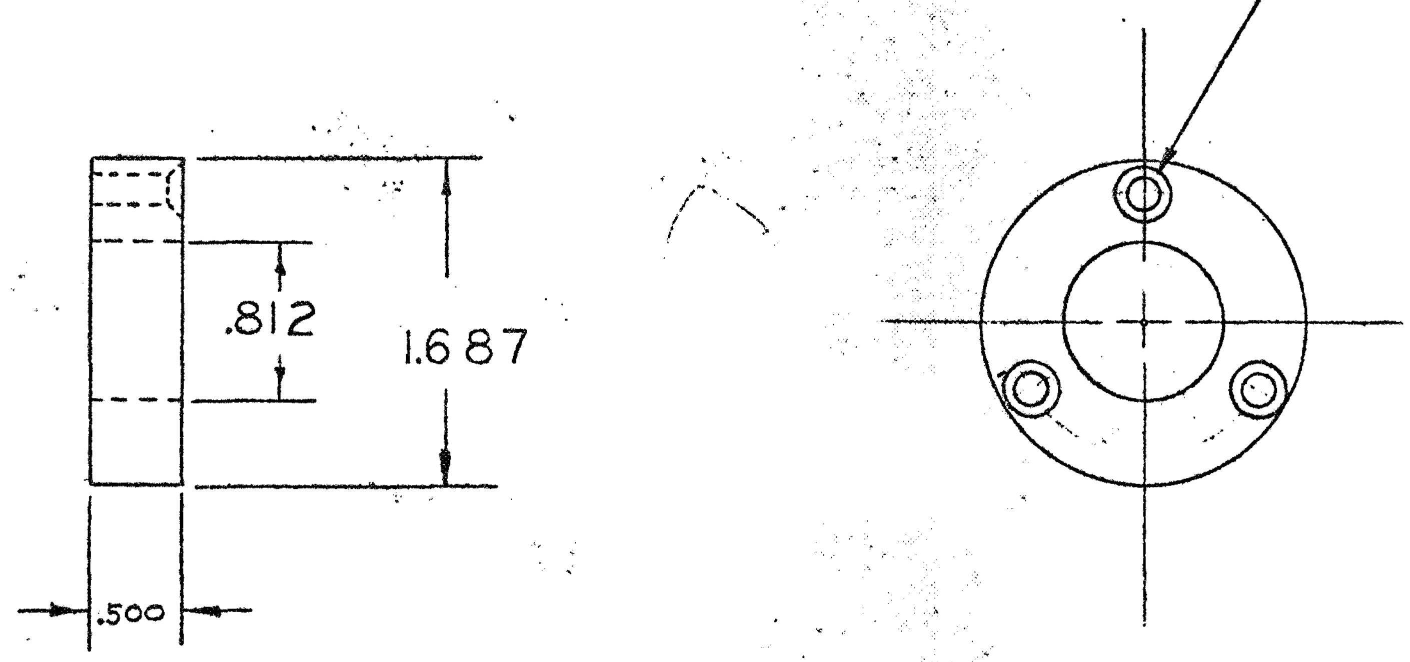
RELEASED DATE

DWN MOORE
DATE 1-7-70
CHD G. Mills
APPD.
APPD.
FINISH

PART NAME ELECTRON BEAM ENCODER
CIRCUIT DIAGRAM

BALDWIN ELECTRONICS, INC.
LITTLE ROCK, ARKANSAS

D X-403



NOTES: 1. MAT'L - ALU PER QQ-A-327b
TEMPER T-6

2. FINISH - BLACK ANODIZE PER
MIL-A-8625 A TYPE II, CLASS I

APR 22 1970

RECORD OF CHANGE

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE: ANGLES ± ½° DECIMAL ± .005 FRACTIONAL ± .015	ALL DRAWINGS AND SPECIFICATIONS ARE AND REMAIN THE PROPERTY OF A R & T ELECTRONICS AND MUST BE RETURNED TO IT. ALL SPECIFICATIONS ARE CONFIDENTIAL AND ARE NOT TO BE DISCLOSED TO ANY PERSONS OTHER THAN THOSE TO WHOM THEY ARE SENT. NO DRAWINGS, SPECIFICATIONS OR OTHER DATA BELONGING TO A R & T ELECTRONICS WHICH MAY BE FURNISHED TO MANUFACTURERS OR OTHERS FOR ANY PURPOSE ARE TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.
PRINT ISSUE	
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RELEASED
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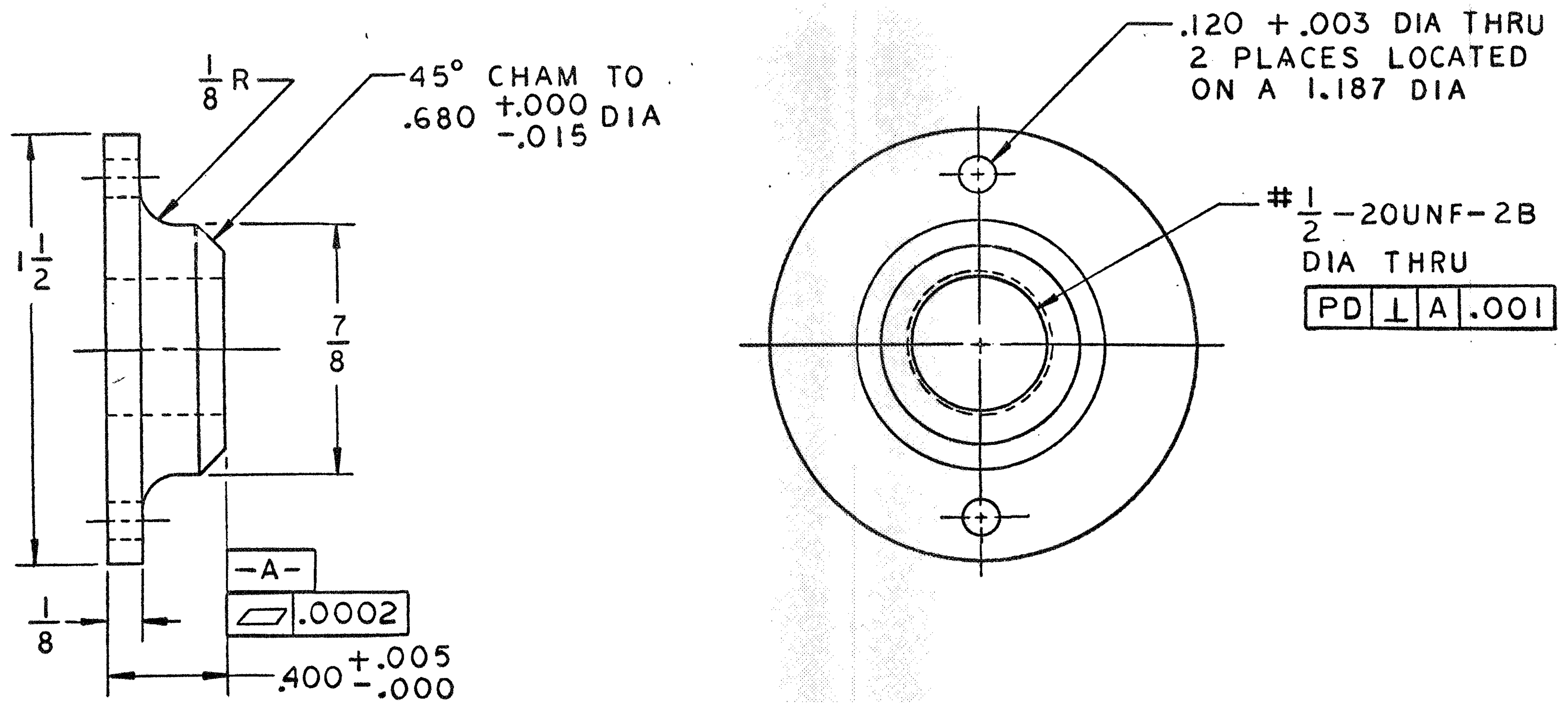

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FINISH NUMBER 5.4.2

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DATE 8-1-68

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	REVISIONS	

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3 PLACE DECIMALS ± .005

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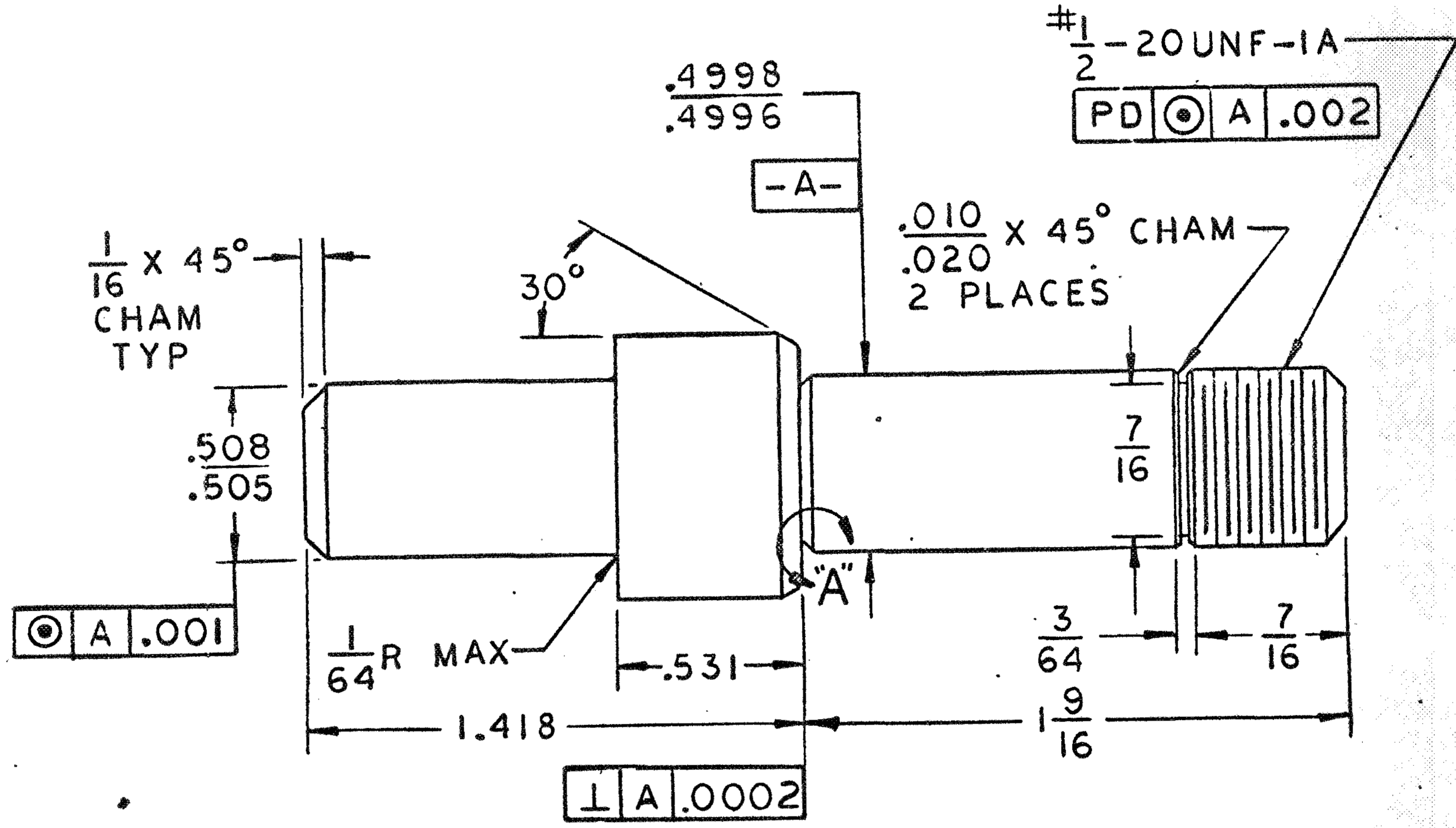

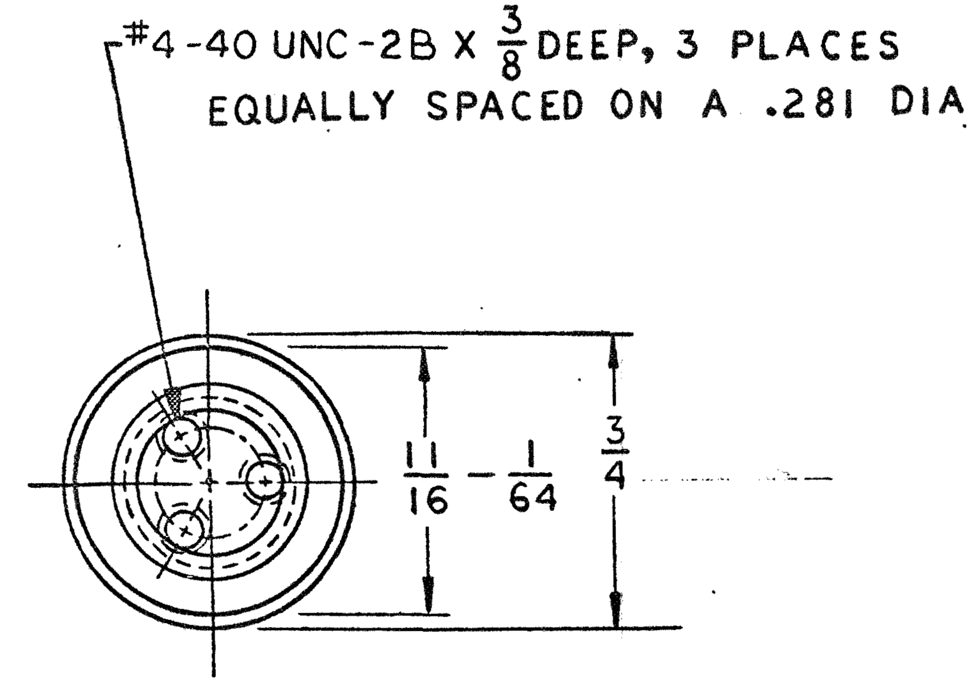

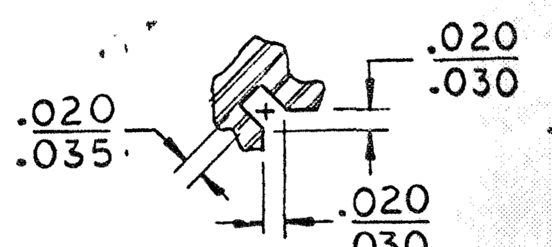

DETAIL A
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GRINDING RELIEF
CONFIGURATION
VENDOR'S OPTION

NOTES:
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2. ALT MATL: CRES BAR TYPE 303 PER QQ-S-763 CLASS 303 COND A
3. FINISH: PASSIVATE PER MIL-STD-171 (ORD) FINISH NO. 5.4.1

APR 22 1970

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G	REDRAWN PER E-1413	6 21 68		SKB

REVISIONS

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:
ANGLES ± ½°
FRACTIONS ±.015
2 PLACE DECIMALS ±
3 PLACE DECIMALS ± .005

DWN. BREWER
DATE 6-21-68
CH'D. HWR
APP'D. G. Hill
APP'D.
FINISH NOTE 3

PART NAME
SHAFT

USED ON 535A HUGHES
DWN. SCALE 2:1
P/L PAGE ITEM
REQ.
NEXT ASSEMBLY

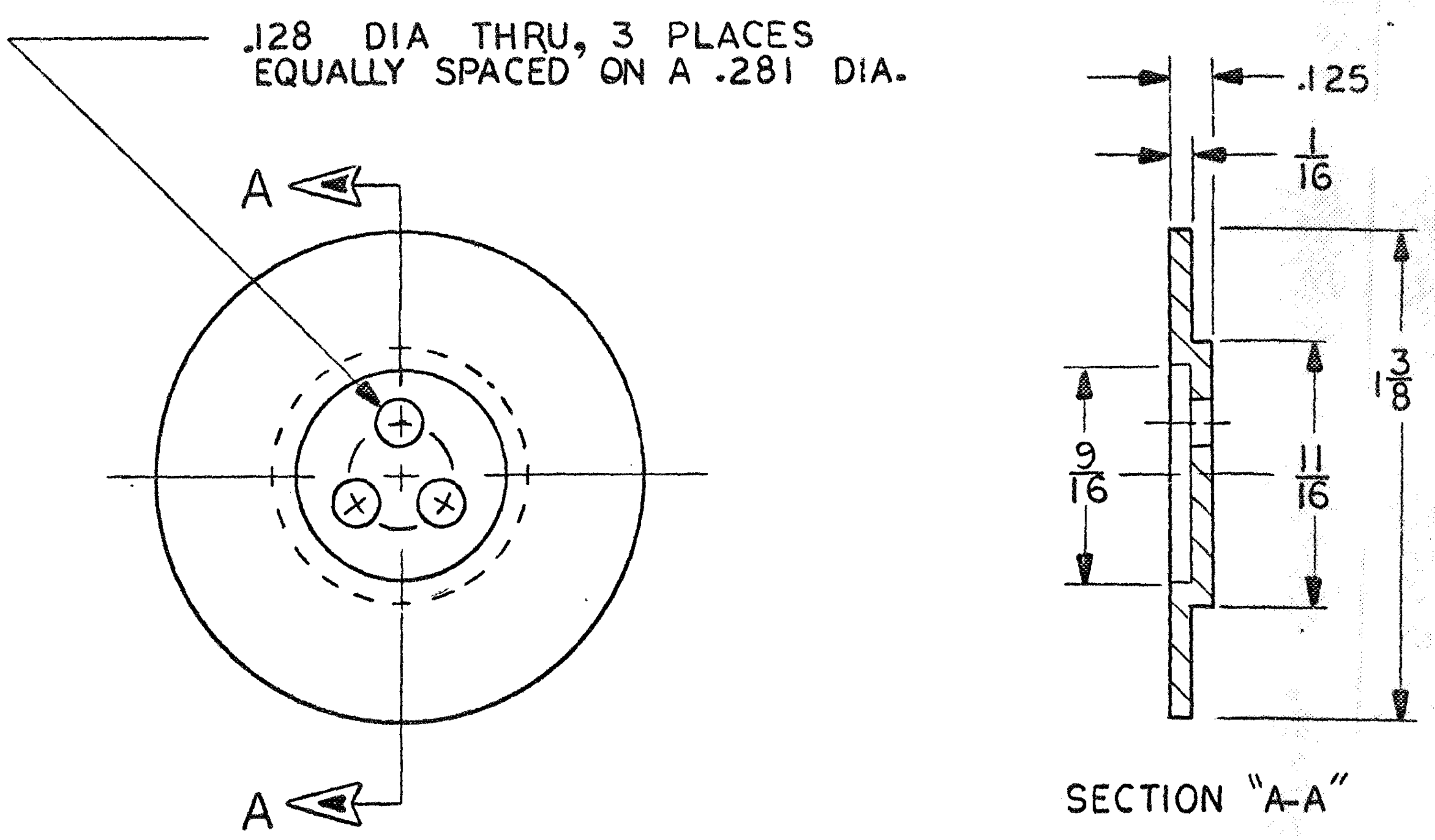
RELEASED
DATE 8-1-68

BALDWIN ELECTRONICS, INC.
LITTLE ROCK, ARKANSAS

B 905-4705 REV. H

7

905-4708



NOTES:
1 - MATERIAL: CRES BAR PER QQ-S-763 CLASS 304 CONDITION A
2 - FINISH: PASSIVATE PER MIL-STD-171 (ORD) FINISH NUMBER 5.4.2
3 - UNLESS OTHERWISE SPECIFIED:
A. 63 ALL OVER
B. REMOVE ALL BURRS AND BREAK SHARP EDGES .015 R MAX.

RELEASED
DATE 8-1-68

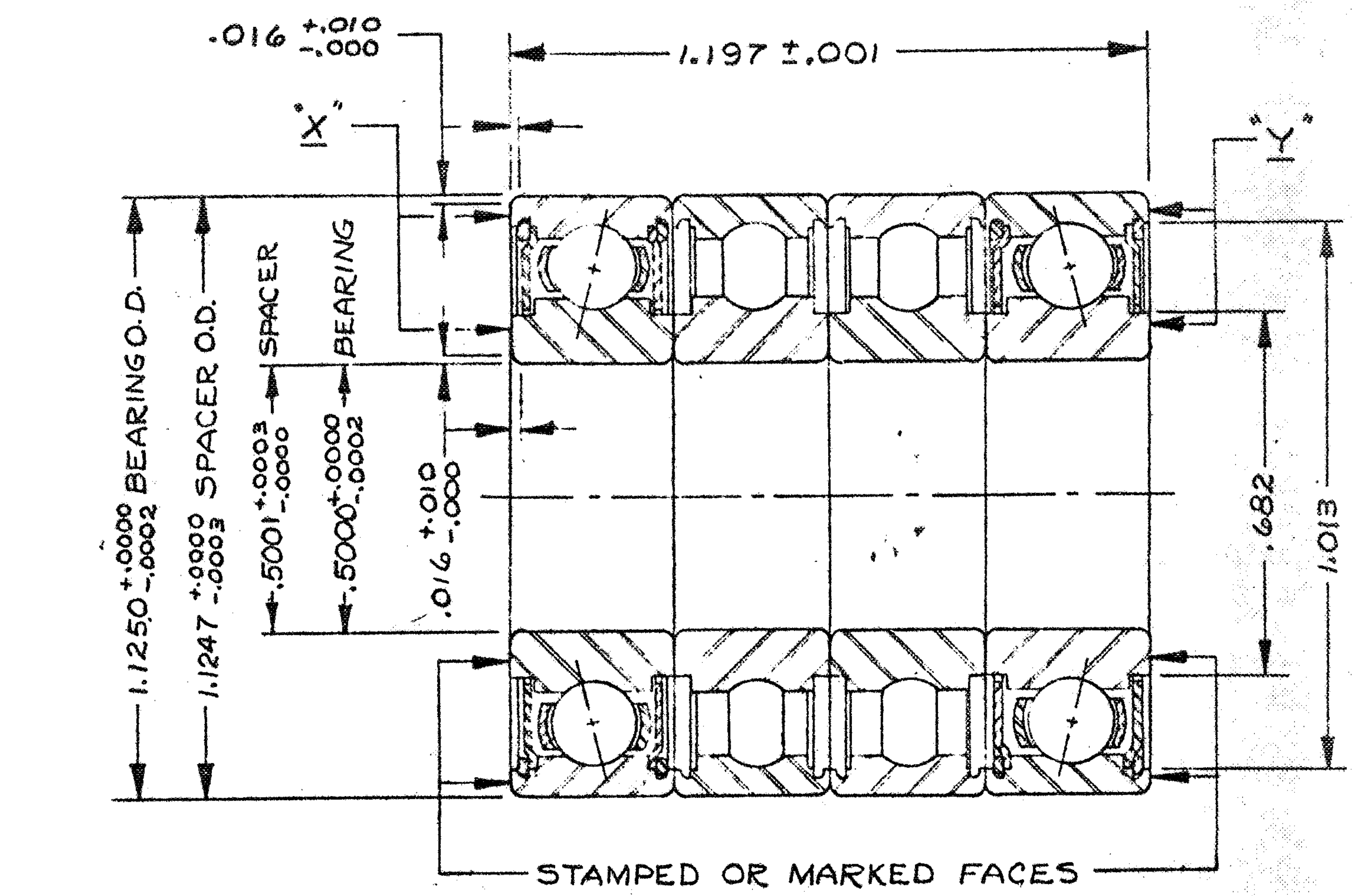
APR 22 1970

A	REVISED & REDRAWN PER E-1413 6-21-68 JA

REVISIONS

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE: ANGLES ± ½° FRACTIONS ±.015 2 PLACE DECIMALS ± 3 PLACE DECIMALS ± .005	ALL DRAWINGS AND SPECIFICATIONS ARE AND REMAIN THE PROPERTY OF BALDWIN ELECTRONICS, AND MUST BE RETURNED TO IT. ALL SPECIFICATIONS ARE CONFIDENTIAL AND ARE NOT TO BE DISCLOSED TO ANY PERSONS OTHER THAN THOSE TO WHOM THEY ARE SENT. NO DRAWINGS, SPECIFICATIONS OR OTHER DATA BELONGING TO BALDWIN ELECTRONICS WHICH MAY BE FURNISHED TO MANUFACTURERS OR OTHERS FOR ANY PURPOSE ARE TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

DWN. ANDRAS	PART NAME CLAMP, DISK			
DATE 6-20-68				
CH'D.				
APP'D. J. Hill	USED ON 535A (HUGHES)			
APP'D.	DWN. SCALE 2/1	P/L	PAGE	ITEM
FINISH	REQ. 1	NEXT ASSEMBLY		
BALDWIN ELECTRONICS, INC. LITTLE ROCK, ARKANSAS	B	905-4708	REV. A	



SPECIFICATIONS:

10 - 5/32" BALLS PER BEARING
TOLERANCES - BARDEN PRECISION
MATERIALS - RINGS & BALLS - 440C STAINLESS STEEL
RETAINER - 2 PIECE PRESSED 430 STAINLESS STEEL
SHIELDS & WIRES - 302 STAINLESS STEEL
RADIAL PLAY - .0002 - .0004
PRELOAD - 5 LBS WHEN ASSEMBLED WITH SPACER AS SHOWN
FLUSHNESS - FACES "X" & "Y" WITHIN .0002 MAX. AS PRELOADED
LUBRICATION - MIL-G-3278A (ESSO-BEACON 325) BARDEN CODE G2

SPACERS - MAY BE AS SHOWN OR 1 PIECE CONSTRUCTION: VENDORS OPTION.

VENDOR: THE BARDEN CORP.
PART NO. SR8SSX5DB5G2

APR 22 1970

B	REVISED RER E-1448	9-24-68	SKB
A	REVISED PER E-1337	3-11-68	

REVISIONS

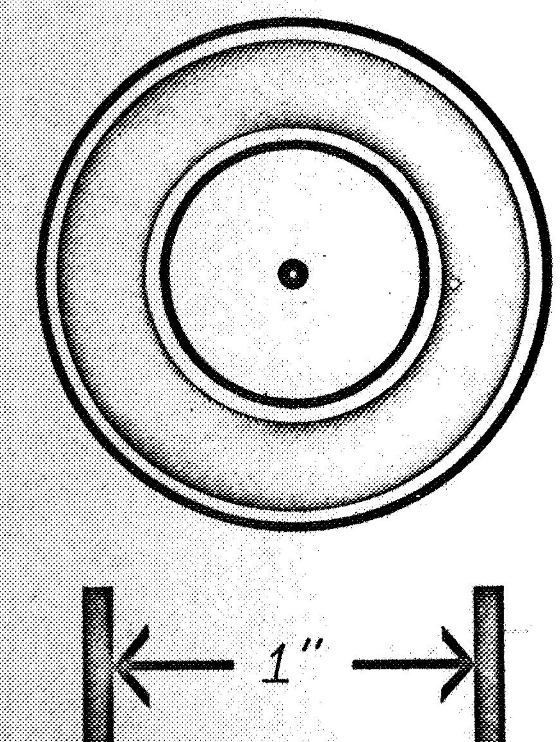
UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:
ANGLES ± ½°
FRACTIONS ±
2 PLACE DECIMALS ±
3 PLACE DECIMALS ± .005

DWN BREWER	PART NAME BEARINGS & SPACERS			
DATE 2-4-66				
CH'D.				
APP'D.	USED ON 500 SERIES			
APP'D.	DWN. SCALE	P/L	PAGE	ITEM
FINISH	REQ.	NEXT ASSEMBLY		
BALDWIN ELECTRONICS, INC. LITTLE ROCK, ARKANSAS	B	905-9123	REV. B	

RELEASED
DATE FEB 15 1966

| C

REVISIONS



APR 22 1970

RELEASED DATE

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:
ANGLES ± ½°
FRACTIONS ±
2 PLACE DECIMALS ±
3 PLACE DECIMALS ± .005

DWN. WWW	PART NAME
DATE 6-25-69	CONNECTOR RING
CH'D.	
APP'D.	USED ON NAS8-24273
APP'D.	DWN. SCALE / P/L / PAGE / ITEM
FINISH	REQ. / NEXT ASSEMBLY
BALDWIN ELECTRONICS, INC. LITTLE ROCK, ARKANSAS	C X-450 / REV.

BALDWIN ELECTRONICS, INC.

1101 McAlmont Street • P.O. Box 627 • Little Rock, Arkansas

ENCODER ENGINEERING DEPT.

NAME R. J. P[illegible]

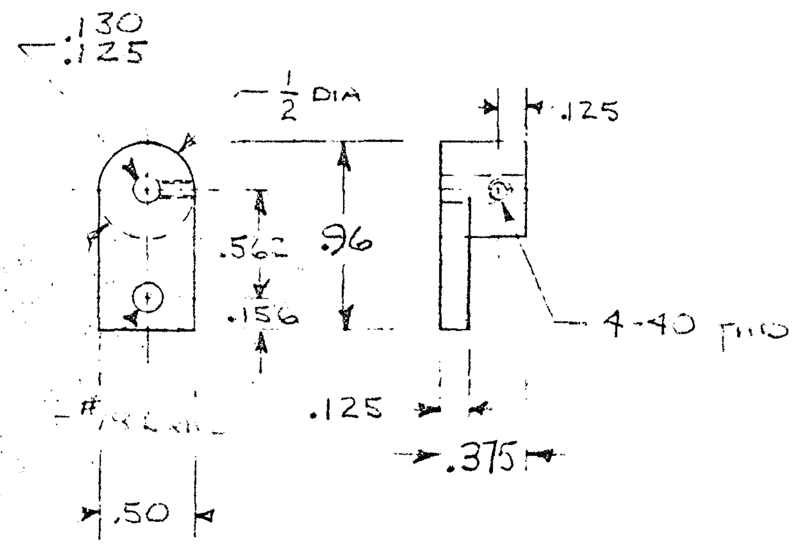
DATE 7/2[illegible]/65

SUBJECT STATOR HOLDER

NASA ENCODER

SHEET NO. 1 OF 1

JOB NO. 25[illegible]2



MAT'L: ALUM.

BALDWIN ELECTRONICS, INC.

1101 McAlmont Street • P.O. Box 627 • Little Rock, Arkansas

ENCODER ENGINEERING DEPT.

NAME R.J. [illegible]

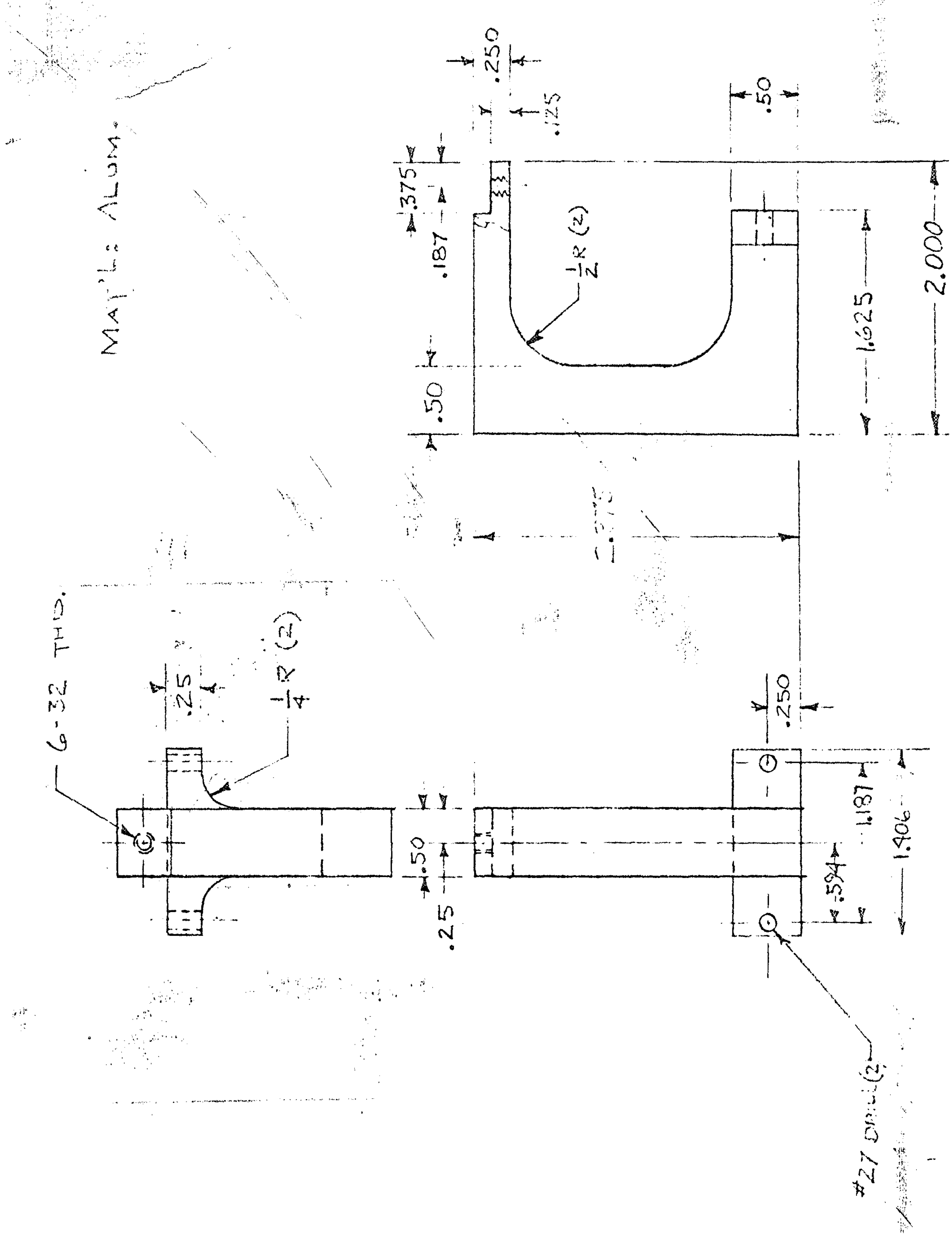
DATE 7/28/[illegible]

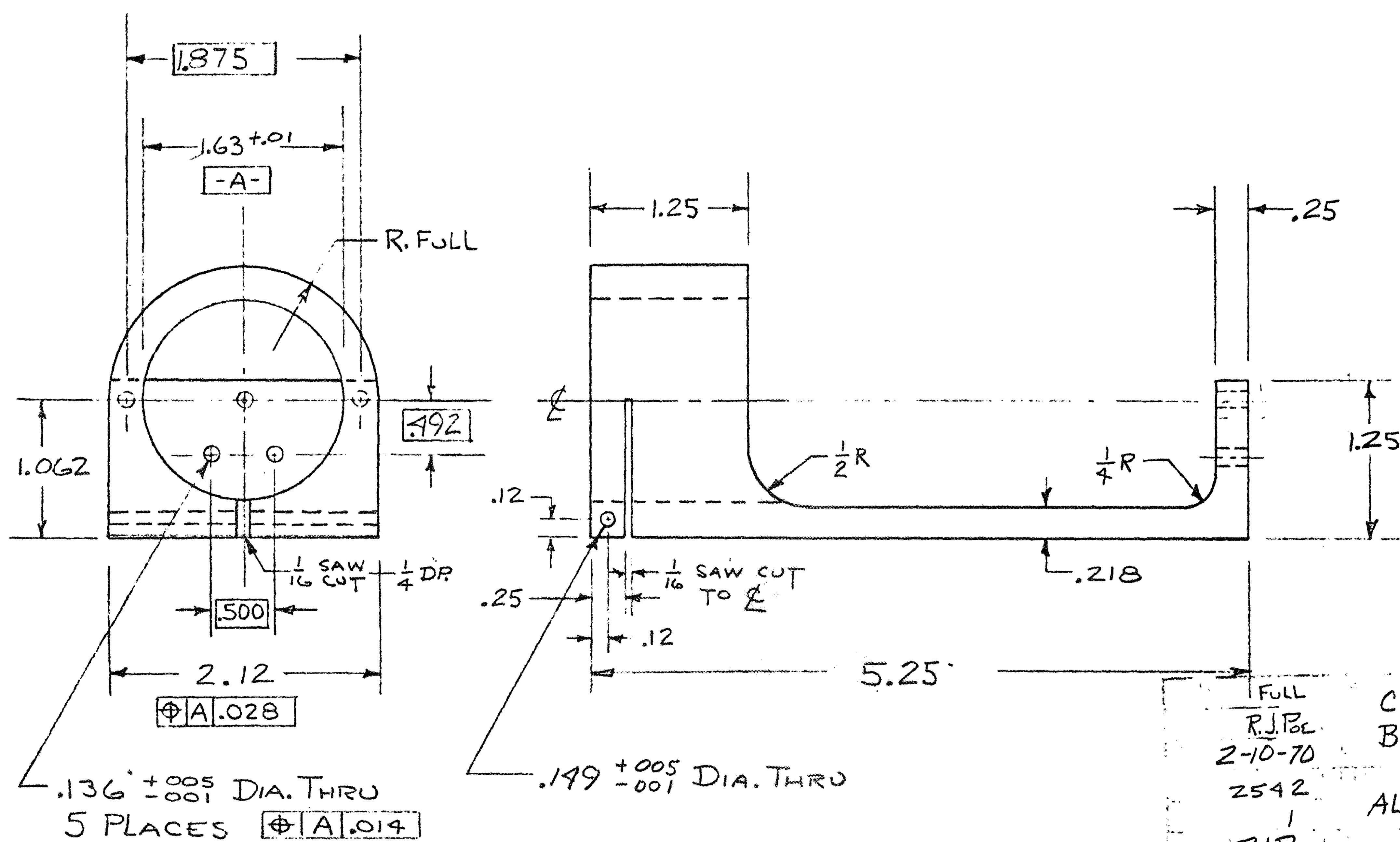
SUBJECT BRACKET

NASA ENCODER

SHEET NO. 1 OF 1

JOB NO. [illegible]





FULL	COLD ELECTRON GUN BEARING FLANGE CLAMP
R.J. Poe	
2-10-70	
2542	ALUMINUM
1	
R.J. Poe	SB-3155
R.J. Poe	

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TIMING DIAGRAM
FIG. 1