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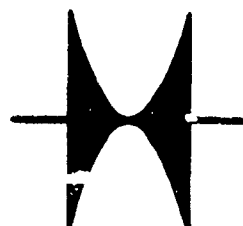
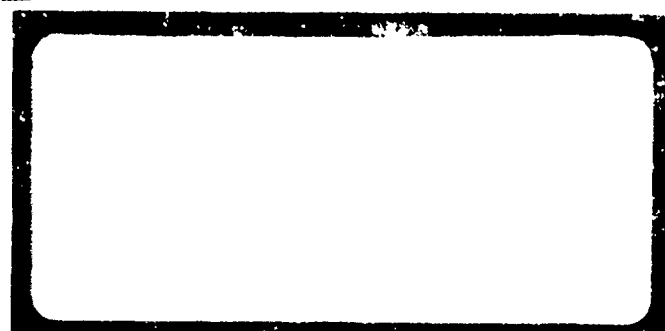
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HAMILTON WATCH

MILITARY PRODUCTS DIVISION

LANCASTER, PENNSYLVANIA

JUN 1 1962

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FINAL REPORT
FOR
JEWEL BEARING APPLICATION
TEST AND ANALYSIS

By
R. G. Fike

Contract Number: DA-36-034-ORD-3411 RD

Army Project Number: TN-2-2707

HAMILTON WATCH COMPANY
Military Products Division
Lancaster, Pennsylvania

For

U. S. Army Ordnance Arsenal, Frankford
Philadelphia 37, Pennsylvania
ATTENTION: ORDEA-1610
(Electro-Mechanical
Time Fuze Branch)

**JEWEL BEARING APPLICATION
TEST AND ANALYSIS**

**FINAL REPORT
April 9, 1962**

A. OBJECT:

To evaluate the affect on the timer escapement and gear train efficiency as a result of substituting sapphire jewelled bearings for brass at the pinion pivots. Investigate shock resistance of jewelled bearings and determine adequate shock mounting techniques.

B. SUMMARY:

The 225 government-furnished timers were checked for rate on a Gibbs recorder using a 6-1/2 oz-in dead weight drive and were regulated, as required, to produce a two-minute run within the tolerance requirement of the XM-7 Timer.

Concurrent with these preliminary tests, the design was studied and the physical size and shape of the jewels was determined. Final jewel designs are shown on Drawings 21303, 21304, and 21305.

April 1962

As a basis for comparison, the units to be jewelled were first subjected to ten (10) consecutive timing tests (130 seconds each) and ten (10) consecutive minimum torque tests. The first group was jewelled on original location at the four escapement pivots only. After testing, the results when compared to the control runs indicated no change in timing repeatability, but the minimum driving torque had increased.

Additional testing of jewelled units with the jewels mounted in carefully jig-bored and line-reamed holes also produced inconclusive results.

Sixteen (16) previously jewelled timers were fitted with new escape wheel and pinion assemblies and new lever assemblies. These pivots were burnished to an $\sqrt{8}$ finish and provided an increase in diametral clearance of .0006". The results from the tests on these units were also negative.

At this point, the data to date was reviewed with

April 1962

the project officer, and it was decided that further testing would be delayed pending his evaluation of this data and a proposal to jewel the lever pallets.

Due to a shift in personnel, a new project officer was assigned and, after a review of the program, it was decided to study the effects of vibration on jewelled timers. Tests on twelve (12) timers before and after transportation vibration indicated that vibration had no adverse effect on timing, minimum operating torque, or condition of the jewels and pivots.

C. PROCEDURE AND RESULTS:

Work on this contract started the last week of March 1961 and a comprehensive study of the actual mechanics of jewelling was made. Plate thickness, available space, endshake control, and standardization of jewels were the most important parts of this study. Layouts were made to set up the

Contract ORD-3411 R0
Final Report

April 1962

actual parameters for the jewel design. The number of different jewels required was found to be four (4); however, by reducing the pivot diameter of one of the pinions, the total was reduced to three (3).

In keeping with the required olive bombe' jewel design and the necessity to control endshake, a modified olive bombe' jewel was required. The design of these jewels is shown on Drawings 21303, 21304, and 21305. These jewels were mounted in reverse to what is customary when used with an endstone, i.e. the spherical surface serves as the bearing surface for the pivot shoulder. The Turtle Mountain Ordnance Plant supplied sapphire jewels to this design but could not supply jewels in glass. Requests to the following three domestic companies were also "no bid":

Contract ORD-3411 RD
Final Report

April 1962

Richard H. Bird Company
1 Spruce Street
Waltham 54, Massachusetts

Weston Instrument Company
Newark, New Jersey

John Worley Jewel Company
North Falmouth, Massachusetts

Since glass jewels of this design were not available, this requirement of the contract was deleted.

The 225 movement assemblies used in these tests were received on 15 May 1961. Prior to any specific testing, all units were checked for regulation and adjusted as required to produce a full two-minute run in accordance with the requirements of the XM-7 Timer. The tapes from the Gibbs Recorder for these runs were identified with the serial number and retained.

In a conference with the project officer, a plan of testing was decided upon as follows:

1. Timing Test ---

- a. Select ten (10) units at random

April 1962

- b. Run ten (10) consecutive timing tests on each unit. Timing period to be one full revolution of an input drive wheel having 30 teeth. This results in three full turns of the 10-tooth number 4 pinion.
- c. Record the time (nominal is 130 seconds)
- d. Calculate mean time, spread, and standard deviation for each unit.

2. Torque Test --

- a. Use the ten timers from the timing test.
- b. Make ten (10) consecutive runs on each timer to determine minimum operating torque.
- c. Record torque values
- d. Calculate mean torque, spread, and standard deviation for each unit.

April 1962

The test equipment used for these tests is shown in Figures 1 and 2. A mounting block is equipped with a shaft supported by two ball bearings. One end of this shaft is fitted with a 30-tooth gear and the other end is fitted with a pulley whose effective diameter is two (2) inches. A contact button near the outer edge of the pulley actuates a microswitch, thereby, starting the electric timer. Upon the completion of one full revolution, the button again actuates the switch and stops the electric timer. The elapsed time for one revolution of the pulley can then be read on the electric timer. All timing tests were run with a torque of 6-1/2 oz-in. For the torque test, the pulley is replaced by a cam-shaped pulley as shown in Figure 2. This provides a uniformly decreasing torque, and the torque range can be varied by changing the value of the weight "W".

The lubricant used throughout these tests was Hamilton Watch Company fuse oil #3358 which meets

April 1962

the requirements of Mil-L-11734.

Ten (10) standard timers were tested as described above, and the results of these tests are shown as control tests in Table 1.

These ten (10) timers were then carefully disassembled, marking each gear so that all elements of the train could be reassembled in the same relative position. The two plates containing the pivot holes for the escape arbor and the escape pinion were sent to the model shop for jewelling. The holes were reamed to size on existing location, and the jewels were pressed in place so that the surface controlling endshake was at the same elevation as the plate.

All parts were ultrasonically cleaned, and the timers were reassembled, oiled, and regulated to 81.77 cps.

These jewelled timers were then given timing and torque tests. The results are shown in Table 1

April 1962

where they can be directly compared with the results on these timers prior to jewelling. The results show that mean minimum driving torque increased for all ten timers and the range of minimum torques increased in nine out of ten cases. However, little or no change was noted in mean time or range of times.

An additional ten timer movements were disassembled and were modified to include jewels in the respective plates for upper and lower pivots of the escape lever and escape pinion. However, these jewels were mounted in accordance with drawing locations instead of matching the existing pivot hole location. Timing and torque tests were conducted on these jewelled movements. These movements were used as a control lot for evaluating the effect of standard pivots versus burnished pivots when jewelled on drawing location. After twenty (20) new escape levers and escape pinions had been burnished to provide a higher surface finish and a pivot diameter reduced by .0006", these movements were

April 1962

reassembled, and the tests were repeated on nine (9) timers, as shown on Table 3.

The above procedure was repeated on seven (7) of the initially jewelled movements and compared with the original data, as shown on Table 2. Thus, these sixteen (16) timer movements yielded two sets of data, i.e., (1) the effect of burnished pivots operating in jewels on existing location versus standard pivots, and (2) the effect of burnished pivots operating in jewels on drawing location versus standard pivots. Four (4) were left out of these tests due to rejection of reworked lever assemblies. Tables 2 and 3 show the computation of the mean values and range of the time and torque tests. These data show that there is no significant difference between the standard pivots and the burnished pivots whether jewelled on existing location or on drawing location. The values for mean time were all slightly less for the burnished pivots than for the standard pivots. This, by

April 1962

itself, is not significant since no other pattern was established.

Table 2 shows that movements utilizing burnished pivots require less operating torque than movements which do not contain burnished pivots. Also, the mean time was reduced for six out of seven movements. These data, in Table 2, would indicate, then, that there may be a slight reduction in torque with a smaller variation in timing. This, however, is questionable, and so it was decided by the Frankford Arsenal Project Officer to expose the above movements to the transportation vibration test in accordance with MIL-STD-303 to evaluate the effect of this environment on the jewelled movements. Table 4 shows the data pertaining to this test and indicates that transportation vibration environment had no significant effect on the timing and torque tests. Following these tests, a visual inspection was performed on each movement to verify the condition of the jewels and pivots. The results of this

April 1962

inspection showed no adverse effects on the jewel mountings nor on the pivots. These jewels were friction fitted or pressed directly into the brass plates with an interference fit of .0002 to .0006, inch.

All the above testing involved jewels mounted at the upper and lower pivots of the escape lever arbor and the escape wheel pinion. All subsequent testing was concerned with evaluating the results of jewelling the upper and lower pivot holes of pinions Nos. 1 thru 4. Prior to reassembly of these movements, the plates were visually inspected to verify that all jewels were flush with the proper side of the plate. These jewels were mounted on the existing pivot hole location. After these movements were assembled and regulated, timing and torque tests were run before and after exposure to the transportation vibration environment.

Reference to Table 5 shows the set of computed data for each of the three test conditions: (1) the

April 1962

control runs on the standard movements; (2) the test runs on the jewelled movements before transportation vibration; and (3) the test runs after transportation vibration. Again, there was no significant development in data from one test condition to another. The values for mean time seemed to hold fairly consistent while the mean torque values all decreased slightly for the jewelled units with the exception of one (#1188). After transportation vibration, these mean torque values experienced another slight decrease with one exception (#1090) which would serve to indicate that jewelling is not a significant factor.

D. CONCLUSIONS:

In the summary of work, it has already been indicated that the results of jewelling all pivot points had no significant effect on the performance of the timer movements. However, since each of the mean values recorded in the tables of data were

April 1962

based on only ten runs each, it is therefore difficult to predict, on the basis of these test results, how much the operating life was increased. It is reasonable to assume that pivot life and pivot hole sizes could be maintained over a greater number of operating cycles, especially the heavier loaded pivots.

This particular escapement was originally designed as a "one-shot-and-done" device and as such was not intended for repeated testing. Further, due to the laminated design and the fact that some latitude for relative movement of plates exists when the assembly screws are loose, makes "before and after" test results somewhat unsatisfactory for comparative purposes. This is especially so in the small numbers involved in this series of tests. Past experience with this same movement has shown that the simple act of loosening the nuts on the assembly screws and then tightening them again will invariably require a slight

April 1962

readjustment to bring it back into time.

It is, therefore, concluded that in order to materially improve this timer, one or more of the following changes would have to be made:

1. Tighter controls on hole locations.
2. Better finishes on holes and pivots.
3. Reduced friction between escape wheel teeth and pallet faces.
4. More positive location of plates relative to each other at assembly.
5. Better finish on gear and pinion teeth.
6. Closer control on gear and pinion concentricity.

April 1962

E. RECOMMENDATIONS:

Due to the high interest of the Hamilton Watch Company in the continued improvement and use of the Jungken's Escapement, many paper studies, as well as hardware experimentation, have been made. Some of these, such as the beryllium copper escape wheel, have resulted in improved life and operation. The following analysis was made to show that the pivot friction of the escape lever arbor is a small percentage of the friction between the escape wheel teeth and the pallet as each pallet face moves through the "lock" position.

Reference to Figure 3 shows the frictional forces acting at the arbor pivot and the pallets when each pallet is shown entering the "lock" position. These same frictional forces are also acting, but in the opposite direction, when the pallets are withdrawing from the "lock" position.

Following is an estimated value of the frictional drag on the lever as the leading corner of the

April 1962

escape wheel tooth comes in contact with the lock surface of the exit pallet "B".

The torque T_{EW} at the escape wheel is:

$$T_{EW} = \frac{T_M}{R} E$$

where T_M is the mainspring torque.

R is the overall gear train ratio from mainspring arbor gear to escape wheel pinion.

E is the estimated gear train efficiency

then the force F required to resist the escape wheel torque is:

$$F = \frac{T_{EW}}{r_b}$$

where r_b is the radial distance from the escape wheel pivot to the base circle of the tooth, and

April 1962

the normal force F_n of the wheel tooth against the pallet is:

$$F_N = \frac{F}{\cos \theta}$$

then $F_L = \mu F_n$ where μ is the coefficient of friction between the wheel tooth and the pallet "B".

Therefore, the retarding torque T_r acting on the pallet is $T_r = F_L R$.

Following is an estimated value of the frictional drag on the lever as a result of pivot friction.

Use the same value for F_n as above.

Then the drag force F_p at both upper and lower lever pivots is:

$$F_p = 2\mu F_n$$

where μ is the coefficient of friction between the armor pivots and the brass plates.

April 1962

Therefore, the retarding torque acting at the lever pivots is:

$$T_p = F_p r$$

If the coefficient of friction μ is the same between the wheel teeth and the pallet as it is between the lever pivots and the plates, then the frictional drag forces F_L and F_p will be equal.

The ratio of $\frac{T_L}{T_p}$ is:

$$\frac{T_L}{T_p} = \frac{R_L R}{2 F_p r} = \frac{R}{2r} = \frac{.071}{2(.0024)} = 3.78$$

This equation states that the lever drag at the pallet as a result of friction is 3.78 times greater than the drag in the lever as a result of pivot friction.

In line with the results of the above analysis, a design for jewelling the pallets of a Junghans's Escapement was laid out and the necessary changes

Contract ORD-3411 RD
Final Report

April 1962

to existing parts as well as new parts were detailed. This design is shown on SK 1228 and SK 1230.

It is highly recommended that any future work directed toward improving this particular type of timer include an investigation of this approach.

Contract ORD-3411 RD
Final Report

April 1962

F. DISTRIBUTION LIST:

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Hamilton Watch Company Donald K. Sites	1	1
John O. James	1	1

G. APPROVED BY:


A. D. Bell
Project Supervisor


Donald K. Sites, Director
Military Products Division


John O. James, Manager
Electromechanical Department

APPENDIX I

Table 1

Unit No.	Control Tests on Standard Pivots			Jewelled At Escape Lever & Wheel Existing Location		
	Time, Second Mean	Second Range	Torque Oz-In Mean Range	Time, Second Mean	Second Range	Torque Oz-In Mean Range
0517	129.973	.114	1.961 .237	130.017	.132	3.816 .662
1136	129.988	.097	2.179 .310	129.524	.192	3.823 .836
0522	129.827	.213	2.795 .124	129.720	.207	3.610 .286
0504	130.014	.053	2.733 .455	130.046	.323	4.093 1.063
0539	129.945	.060	2.392 .501	129.920	.139	3.453 .339
0457	130.105	.066	2.957 .423	136.176	.210	6.055 .759
0570	130.035	.053	3.213 .513	130.510	.074	3.518 1.624
0590	130.025	.084	2.328 .488	129.986	.095	3.623 .582
1098	129.501	.044	2.845 .391	129.981	.386	3.504 .550
1145	129.549	.076	2.712 .508	130.059	.087	3.357 .841

APPENDIX I

Table 2

Unit No.	Jewelled on Existing Location *			Jewelled on Existing Location Burnished Pivots *		
	Time, Second Mean	Second Range	Torque, Oz-In Mean	Torque, Oz-In Mean	Second Range	Torque, Oz-In Mean
0517	130.017	.132	3.816	129.655	.084	3.759
1136	129.524	.192	3.823	129.782	.291	2.378
0539	129.920	.139	3.453	129.451	.138	3.203
0457	130.176	.210	6.055	129.567	.212	4.455
0590	129.986	.095	3.623	129.690	.094	4.168
1098	129.981	.386	3.504	129.559	.173	2.997
1145	130.059	.087	3.357	129.788	.056	3.272
						.471
						.205
						.418
						.259
						.712
						.566
						.439

* Jewelled at Escapement Pivots only

APPENDIX I

Table 3

Unit No.	Jewelled on Drawing Location *			Jewelled on Drawing Location * Burnished Pivots *		
	Time, Second Mean	Second Range	Torque, Oz-In Mean Range	Time, Second Mean	Second Range	Torque, Oz-In Mean Range
0543	129.930	.131	3.567 .397	129.186	.579	2.724 .290
1085	130.024	.374	3.658 .629	129.690	.439	2.271 .705
1092	129.938	.286	3.236 1.121	129.840	.303	3.150 .430
1100	129.815	.245	3.228 .381	129.570	.093	3.183 .257
1118	129.860	.244	2.628 1.111	129.308	.139	3.340 .410
1148	129.765	.136	3.849 .646	129.531	.206	2.404 .413
1149	129.992	1.047	3.309 .789	129.894	.068	3.031 .390
1176	129.791	.257	3.098 .471	129.151	.440	4.194 .935
1213	129.734	.184	2.978 .281	129.554	.154	2.991 .298

* Jewelled at Escapement; Pivots only.

Contract DA-36-034-ORD-3411 RD
Final Report

APPENDIX I

Table 4

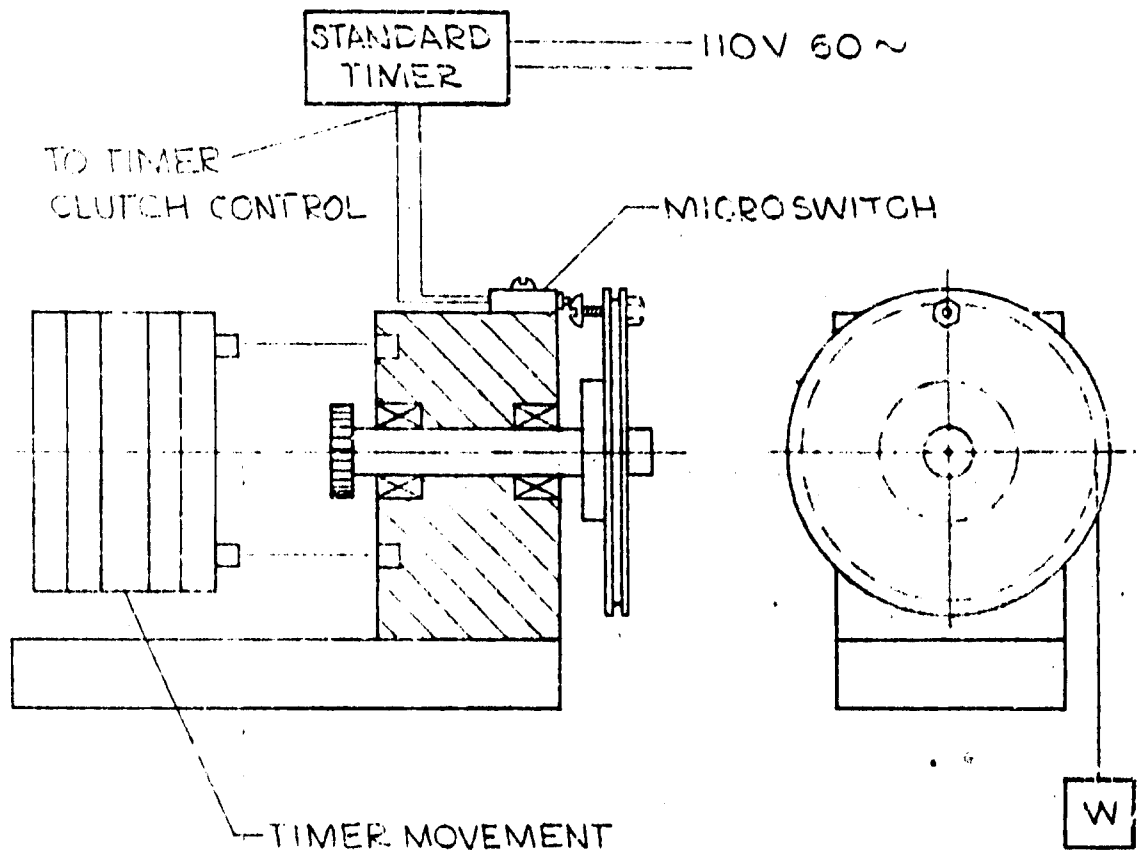
Unit No.	BEFORE Transportation Vibration Existing Location - Burnished Pivots*			AFTER Transportation Vibration Existing Location - Burnished Pivots*		
	Time, Second Mean	Second Range	Torque, Oz-In Mean	Time, Second Mean	Second Range	Torque, Oz-In Mean
0517	129.655	.084	3.759	129.571	.034	4.318
1136	129.782	.291	2.378	129.607	.175	2.574
0539	129.451	.138	3.203	129.446	.181	2.875
0457	129.567	.212	4.455	129.095	.124	3.296
0590	129.690	.094	4.168	129.654	.082	4.968
						.44
						.36
						.35
						.50
						.19

* Jewelled at Escapement Pivots only.

APPENDIX I

Table 5

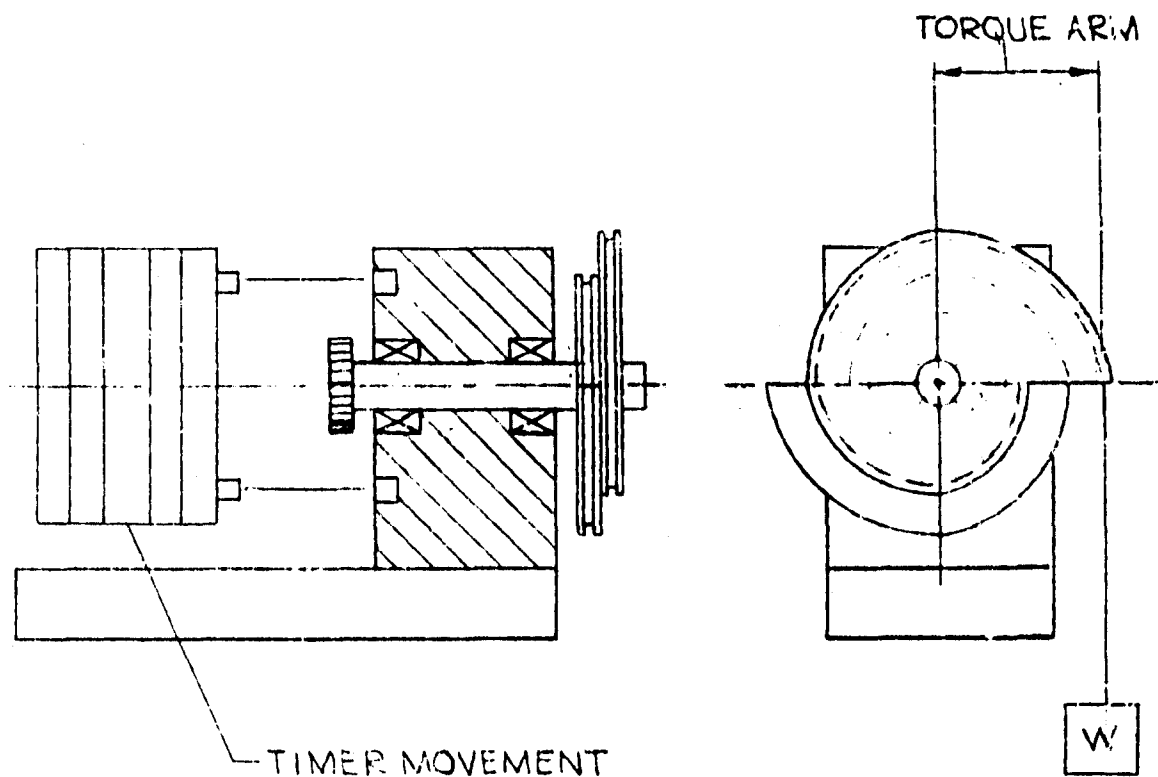
Unit No.	C O N T R O L T E S T S						Jewelled At Pivots #1, #2, #3, and #4					
	B E F O R E						A F T E R					
	Transportation Vibration Existing Location						Transportation Vibration Existing Location					
	Time, Mean	Second, Range	Torque, Mean	Oz-In, Range	Time, Mean	Second, Range	Torque, Mean	Oz-In, Range	Time, Mean	Second, Range	Torque, Mean	Oz-In, Range
0475	130.080	.123	3.217	.218	130.612	.095	2.096	.273	130.498	.336	1.899	.744
1090	130.286	.376	3.643	.486	130.128	.082	1.014	.056	130.134	.176	3.556	.497
1119	129.393	.191	3.842	.377	129.774	.086	2.423	.273	129.711	.113	2.396	.222
1152	129.187	.313	4.029	.494	129.589	.127	3.668	.328	129.418	.176	3.595	.295
1167	128.894	.346	3.724	.480	129.562	.162	2.352	.380	129.337	.437	2.278	.526
1182	130.067	.134	3.333	.205	129.788	.105	3.663	.328	129.830	.139	3.531	.331
1209	130.885	.307	3.840	.627	130.097	.265	3.371	.270	130.032	.223	2.529	.587
1212	129.973	.167	3.403	.247	129.513	.174	2.391	.162	129.577	.251	2.212	.190



DATE 6 APR 62 SCALE _____
 DRAFTSMAN EFF/CHECKER
 ENGR _____

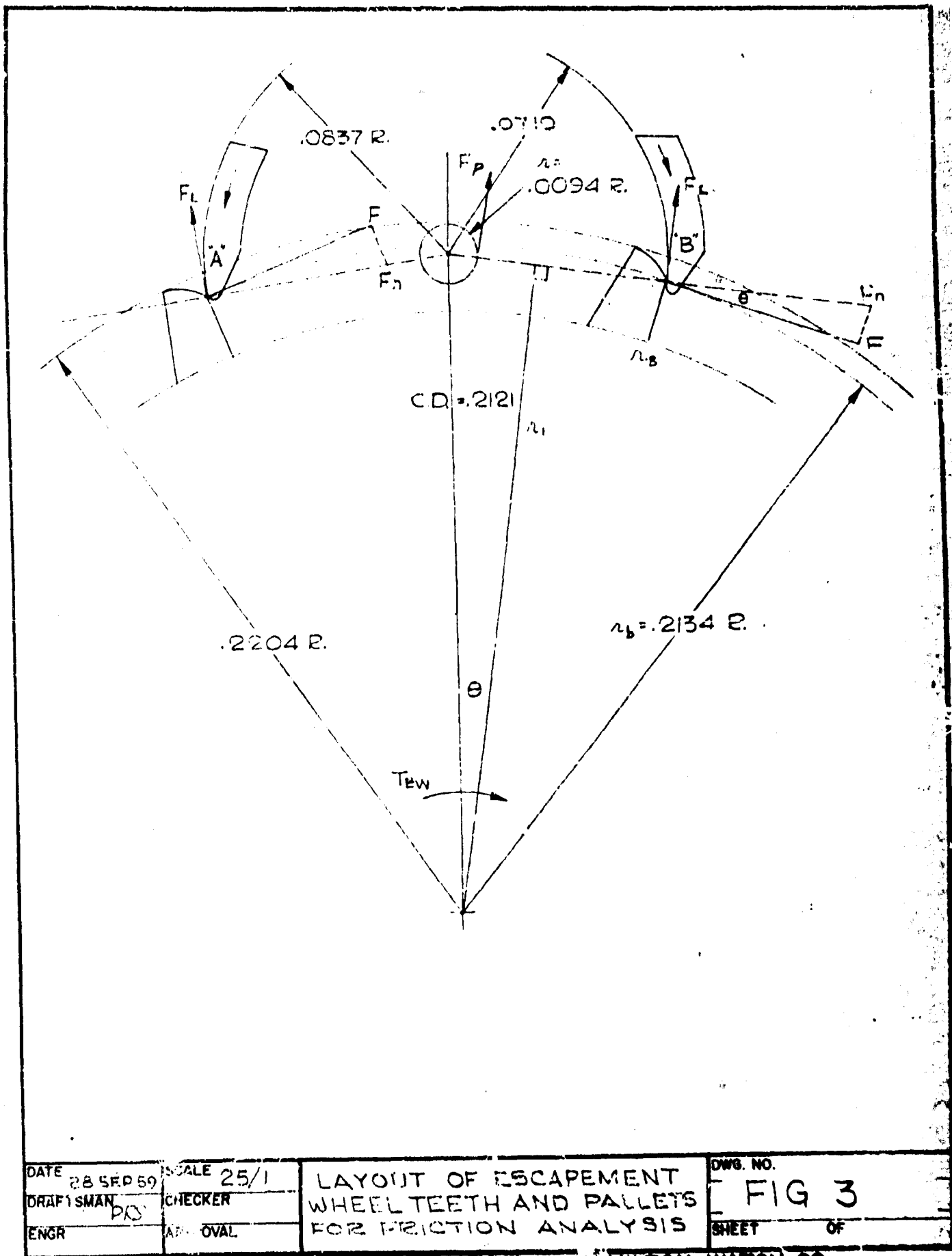
TIMING TEST FIXTURE

DWG. NO. _____ FIG. 1
 SHEET OF _____

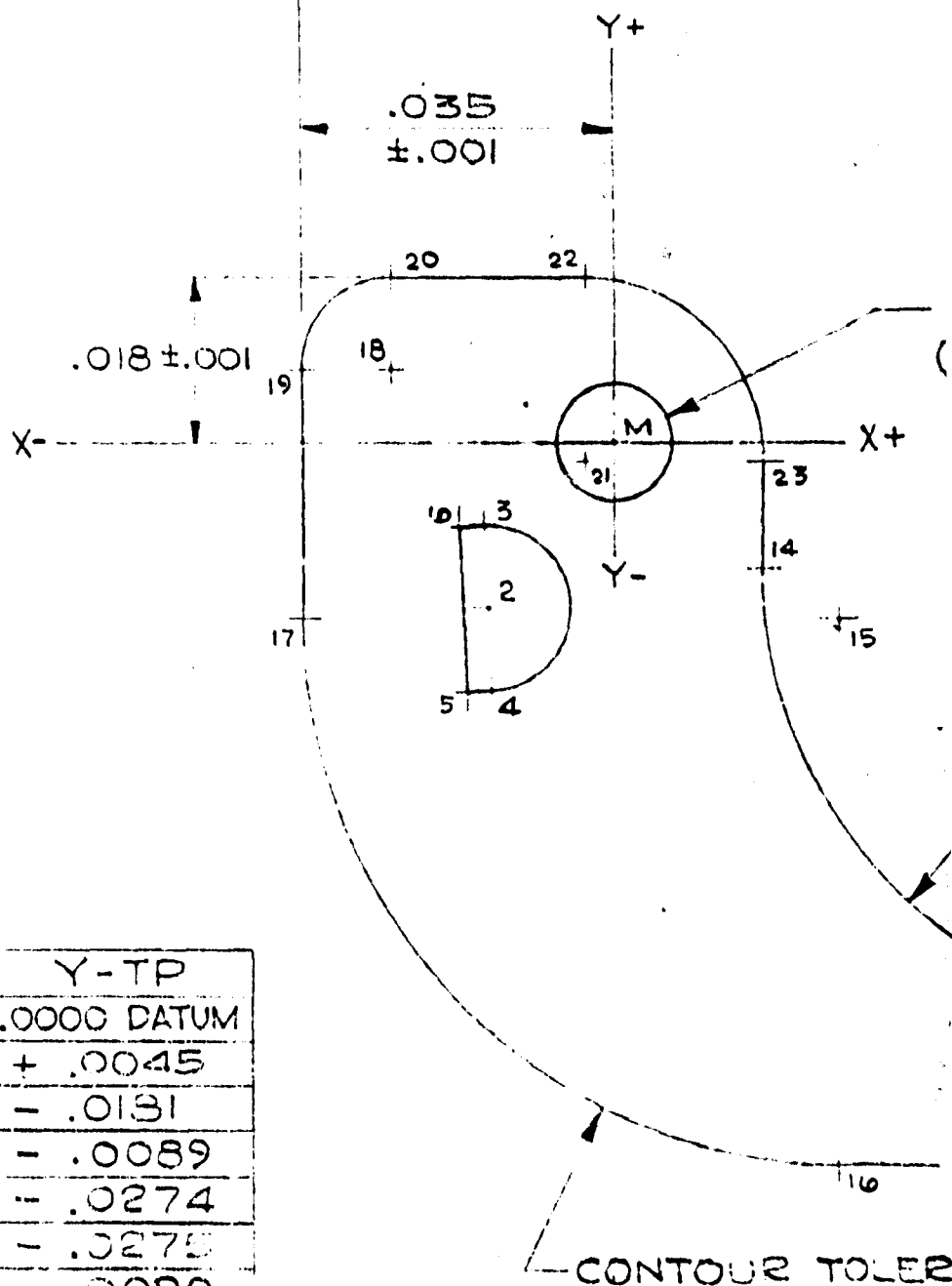


DATE 9 APR 62	SCALE	MINIMUM TORQUE TEST FIXTURE	DWG. NO.
DRAFTSMAN EFP	CHECKER		FIG. 2
ENGR	APPROVAL		SHEET OF

MILITARY PRODUCTS DIV., HAMILTON WATCH CO., LANCASTER, PA.



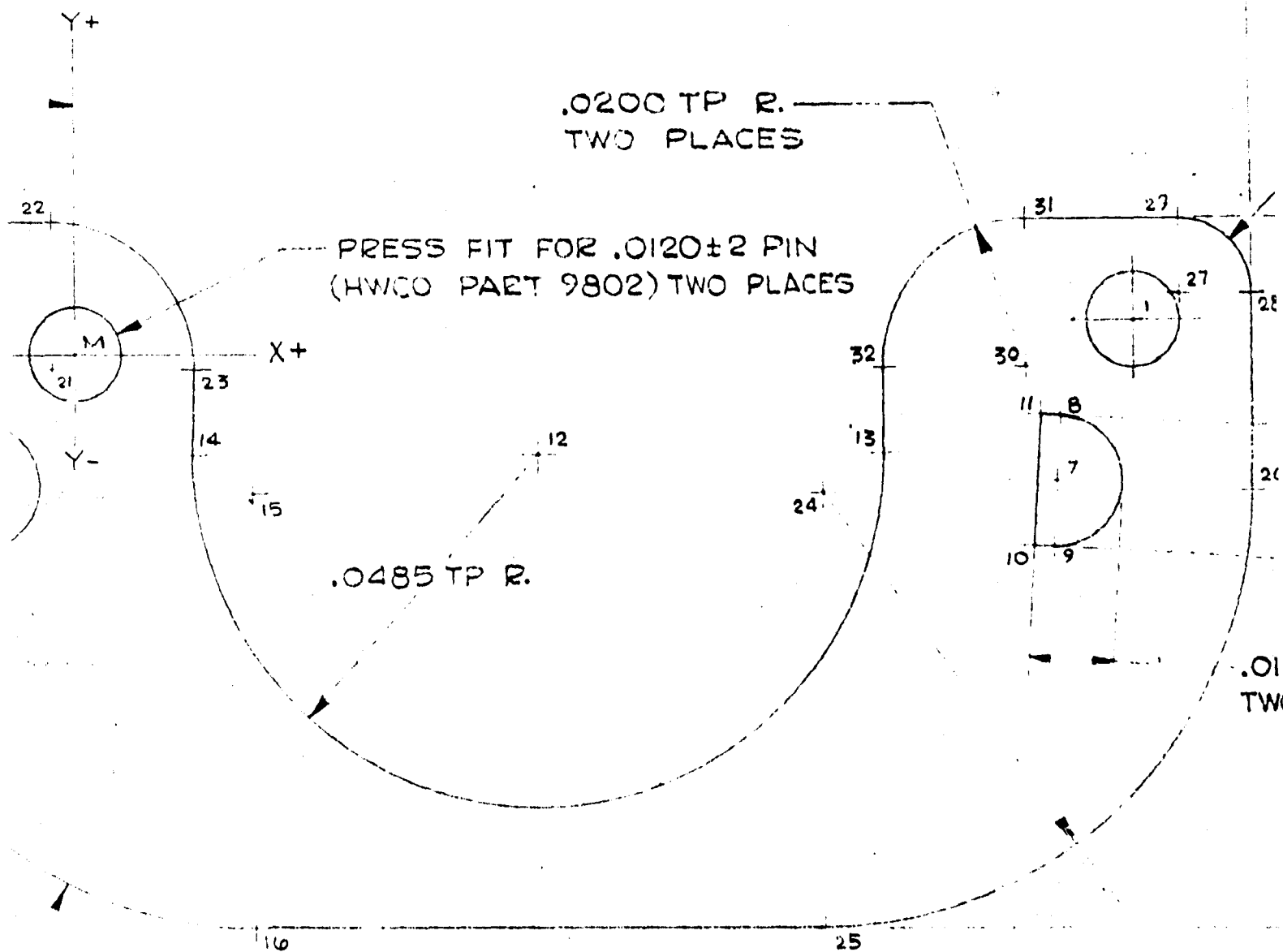
MILITARY PRODUCTS DIV., HAMILTON WATCH CO., LANCASTER, PA



POSN	X-TP	Y-TP
M	.0000 DATUM	.0000 DATUM
1	+.1485 DATUM	+ .0045
2	- .0156	- .0131
3	- .0161	- .0089
4	- .0151	- .0274
5	- .0176	- .0275
6	- .0186	- .0090
7	+ .1377	- .0132
8	+ .1377	- .0132

2

.200 REF.



-CONTOUR TOLERANCE .001 WIDE

TV

REVISIONS					
ZONE	SYM	BY	DESCRIPTION	DATE	CHKD APPD

3

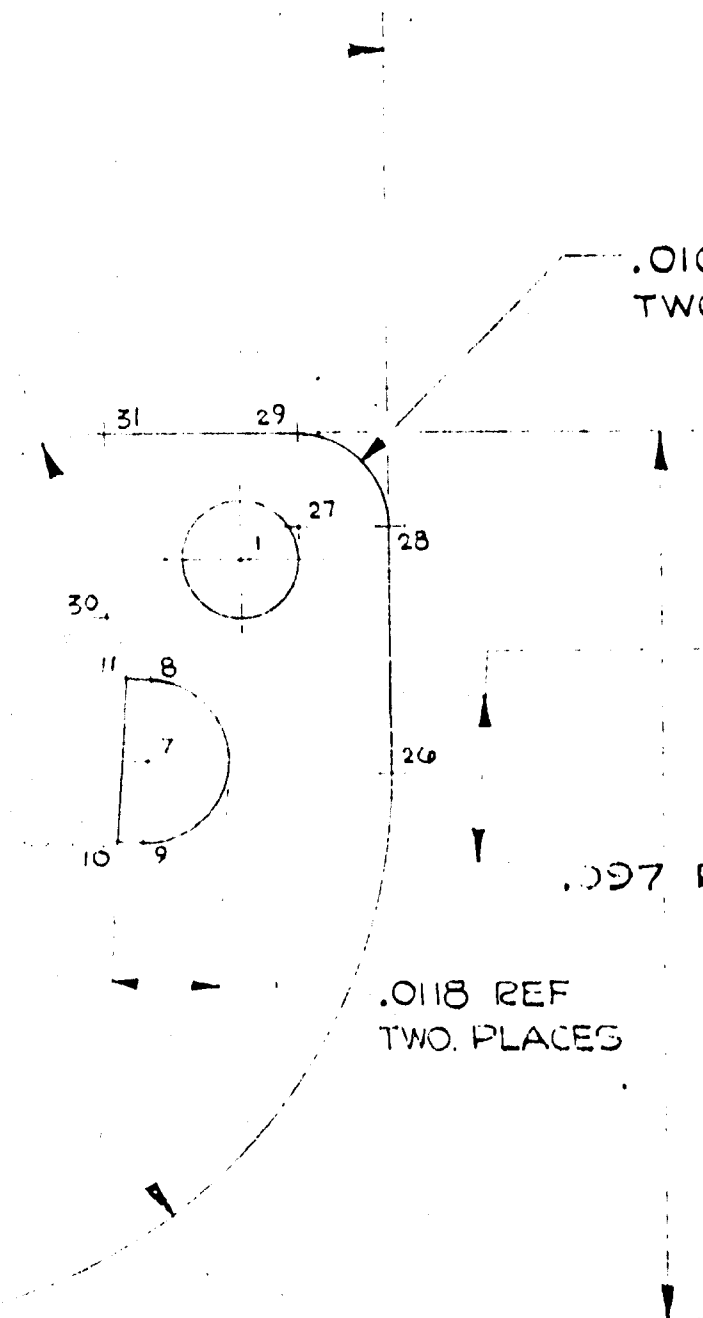
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TWO PLACES

.0185 \pm .002
TWO PLACES

.0097 REF.

.0118 REF
TWO PLACES

.0100 TP R.
TWO PLACES



POSN	X-TP	Y-TP
M	.0000 DATUM	.0000 DATUM
1	+.1485 DATUM	+ .0045
2	- .0156	- .0181
3	- .0161	- .0089
4	- .0151	- .0274
5	- .0176	- .0275
6	- .0186	- .0090
7	+ .1377	- .0182
8	+ .1382	- .0090
9	+ .1372	- .0275
10	+ .1347	- .0274
11	+ .1357	- .0089
12	+ .0650	- .0140
13	+ .1135	- .0140
14	+ .0165	- .0140
15	+ .0250	- .0190
16	+ .0250	- .0790
17	- .0350	- .0190
18	- .0250	+ .0080
19	- .0350	+ .0080
20	- .0250	+ .0180
21	- .0035	- .0020
22	- .0035	+ .0180
23	+ .0165	- .0020
24	+ .1050	- .0190
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28	+ .1650	+ .0080
29	+ .1550	+ .0180
30	+ .1335	- .0020
31	+ .1335	+ .0180
32	+ .1135	- .0020

B

A

5 4

CONTOUR TOLER

NOTES:

1. HOLE 1 & POSN 27
2. POSN 12 THRU 32
3. TWO(2) REQD PER

4

4

3

.0485 TP R.

10 9

.0118 P
TWO P.

16

25

TOUR TOLERANCE .001 WIDE

.0600
TWO

§ FROM 2 THRU 11 $\oplus .0006$ DIA
2 THRU 32 $\oplus .0014$ DIA
REQD PER UNIT

5

REQD	PART NO	DESCRIPTION
		MATERIAL .020
		HEAT TREATMENT
NEXT ASSY	USED ON	FINAL PROTECTIVE
APPLICATION		
DIMENSIONS ARE IN INCHES		
UNLESS OTHERWISE SPECIFIED		
TOLERANCES	SURFACE FINISH	
ANGLES \pm	\checkmark	
DECIMALS \pm		
FRACTIONS \pm		
		MILITARY

3

2

.097 REF.

.018 REF
TWO PLACES

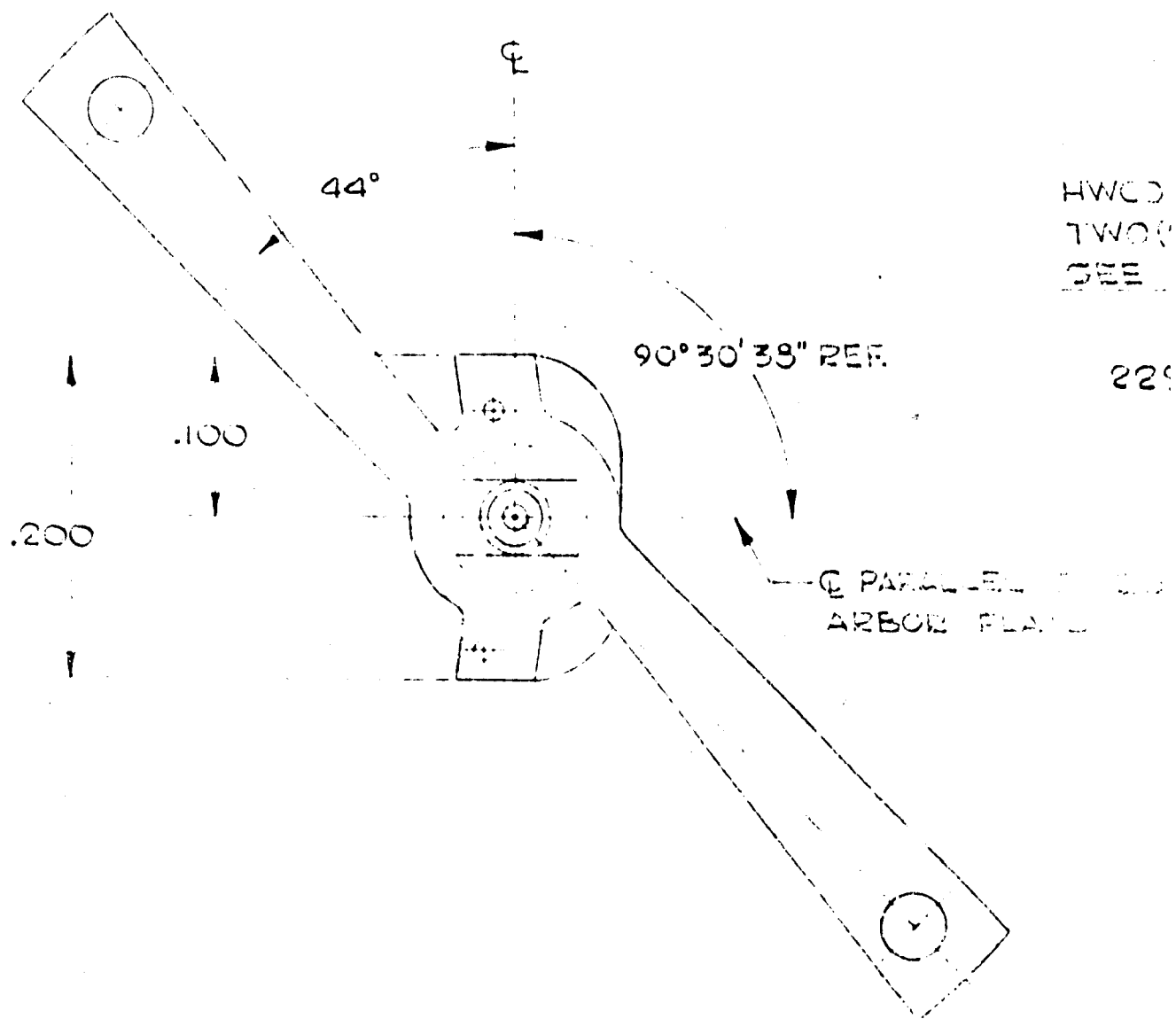
.0000 TP 2.
TWO PLACES

6

ART NO	DESCRIPTION	STOCK SIZE	MATL	MATL	SPEC	REV	ZONE
LIST OF MATERIAL							
	MATERIAL	.020 BRASS	DATE	5/31/61	ADAPTER, ESCAPEMENT LEVER		
	HEAT TREATMENT		DRAFTSMAN	BE/			
			CHECKED	RPL			
			ENGR				
			ENGR				
	FINAL PROTECTIVE FINISH		APPROVAL				
Y	USED ON						
PLICATION							
ONS ARE IN INCHES							
THERWISE SPECIFIED							
SURFACE FINISH							
J		MILITARY PRODUCTS DIV., HAMILTON WATCH CO., LANCASTER, PA.		SCALE 59/	DWG WEEK	DRAWING NO.	
				UNIT WT. ACT. CALC.	C	SK 1228	
				7x22	SHEET	OF	REV.

4

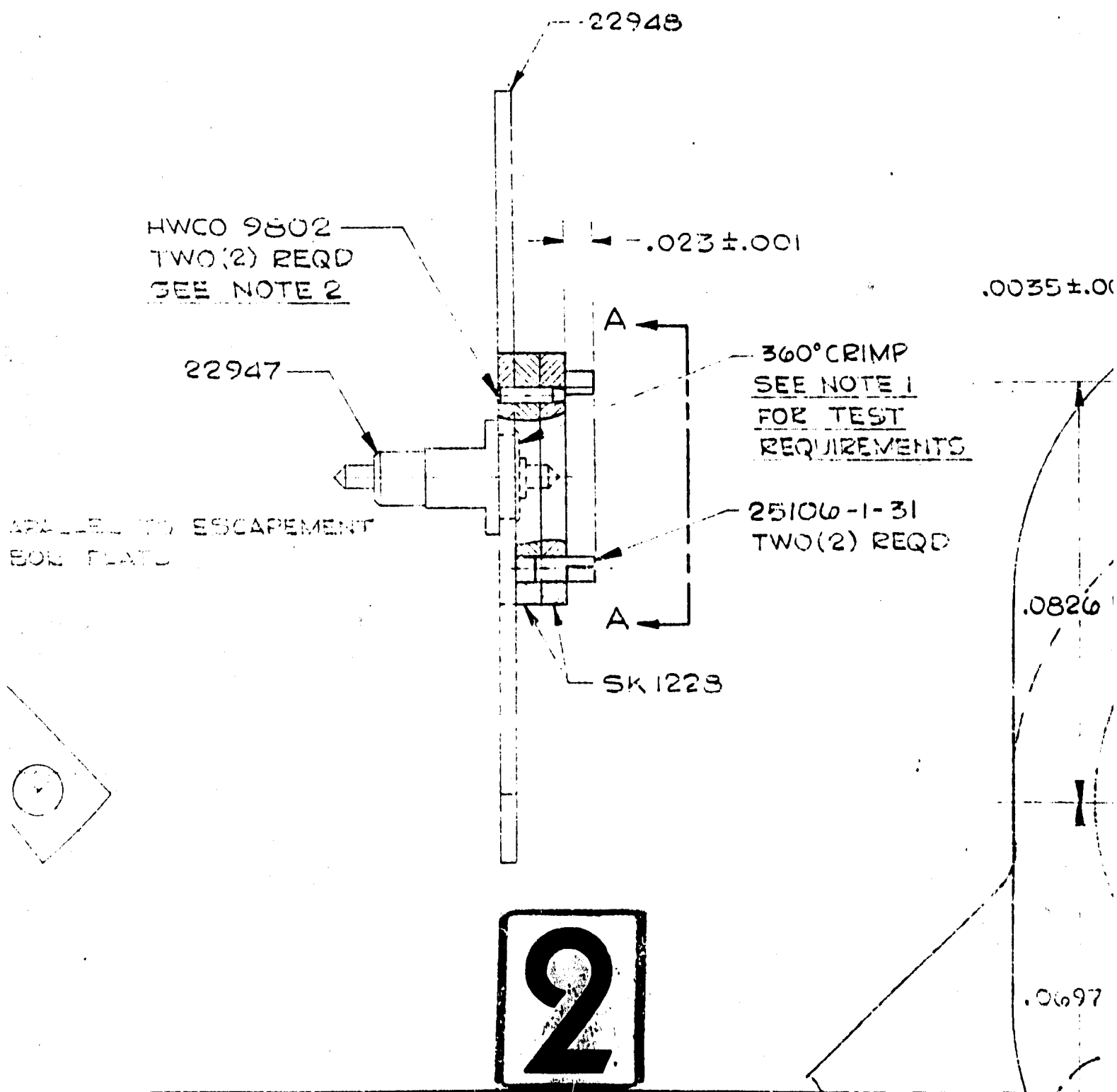
3



NOTES:

3

2



2

1

3

REVISIONS						
ZONE	SYM	BY	DESCRIPTION	DATE	CHKD	APPD

E.OOI

360° CRIMP
SEE NOTE 1
FOR TEST
REQUIREMENTS

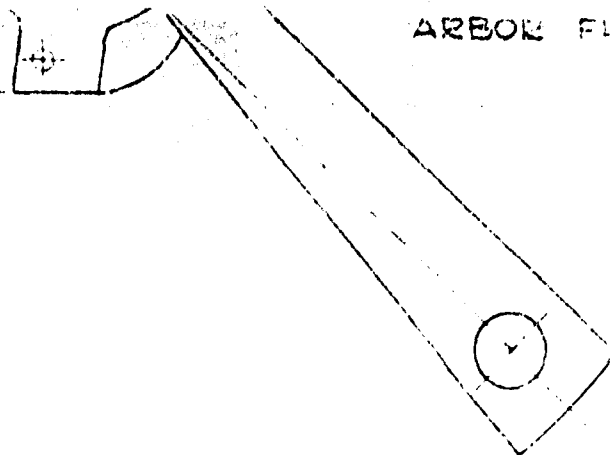
- 25106-1-31
TWO (2) REQD

 $.0035 \pm .0005$ $.0135 \pm .0004$ $.0140 \pm .0004$ $45^{\circ} 30' \pm 0^{\circ} 15'$ $.0826$ REF. 65° $.0650 \pm .0004$ $.0697$ REF. $.0835 \pm .0004$

D

C

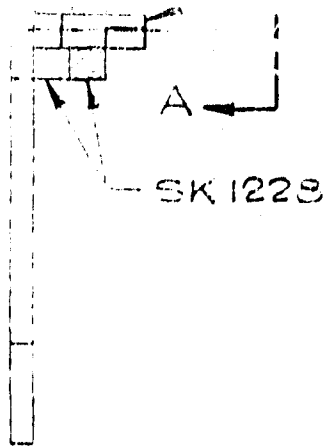
ARBOR FLAT



NOTES:

1. ASSEMBLY MUST WITHSTAND A STATIC LOAD AND .1 INCH LBS. OF TORQUE
2. PINS TO BE PRESS FITTED FLUSH WITH BO

4



FLUSH WITH BOTTOM OF LEVER

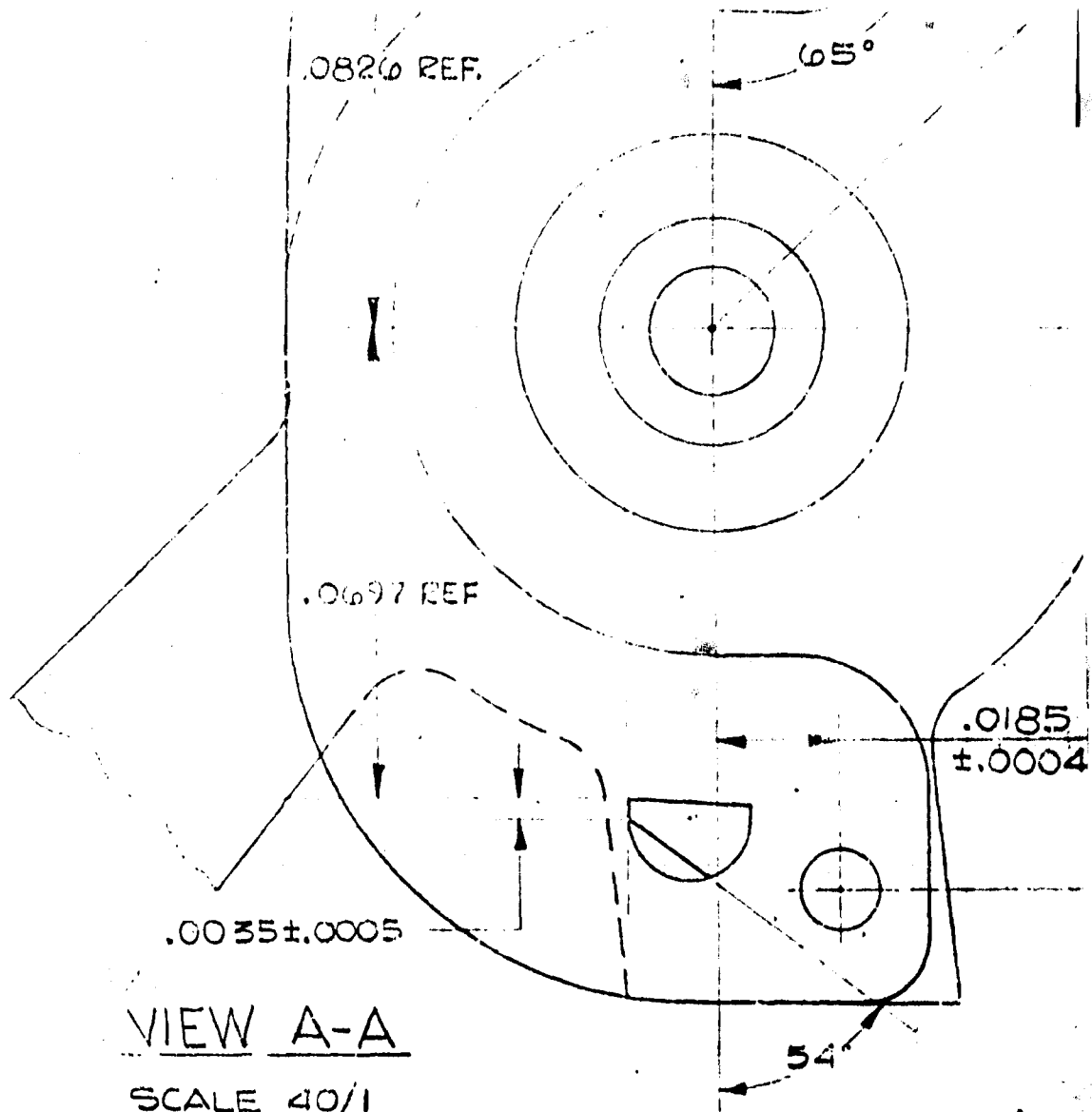
VIB

SCA

5

2	9802	PIN, 02
2	25106-1-31	FIN, 6-1-
2	SK 228	ADAP 228
1	22948	LEVER 8
1	22947	ARBO 17
REQD	PART NO	IT NO
		MA
		HE
NEXT ASSY	USED ON	
APPLICATION		ICATION
DIMENSIONS ARE IN INCHES		ARE IN
UNLESS OTHERWISE SPECIFIED		ERWISE
TOLERANCES	SURFACE FINISH	SUR
ANGLES $\pm 1^\circ$	J	CI
DECIMALS $\pm .001$		
FRACTIONS \pm		

K1225




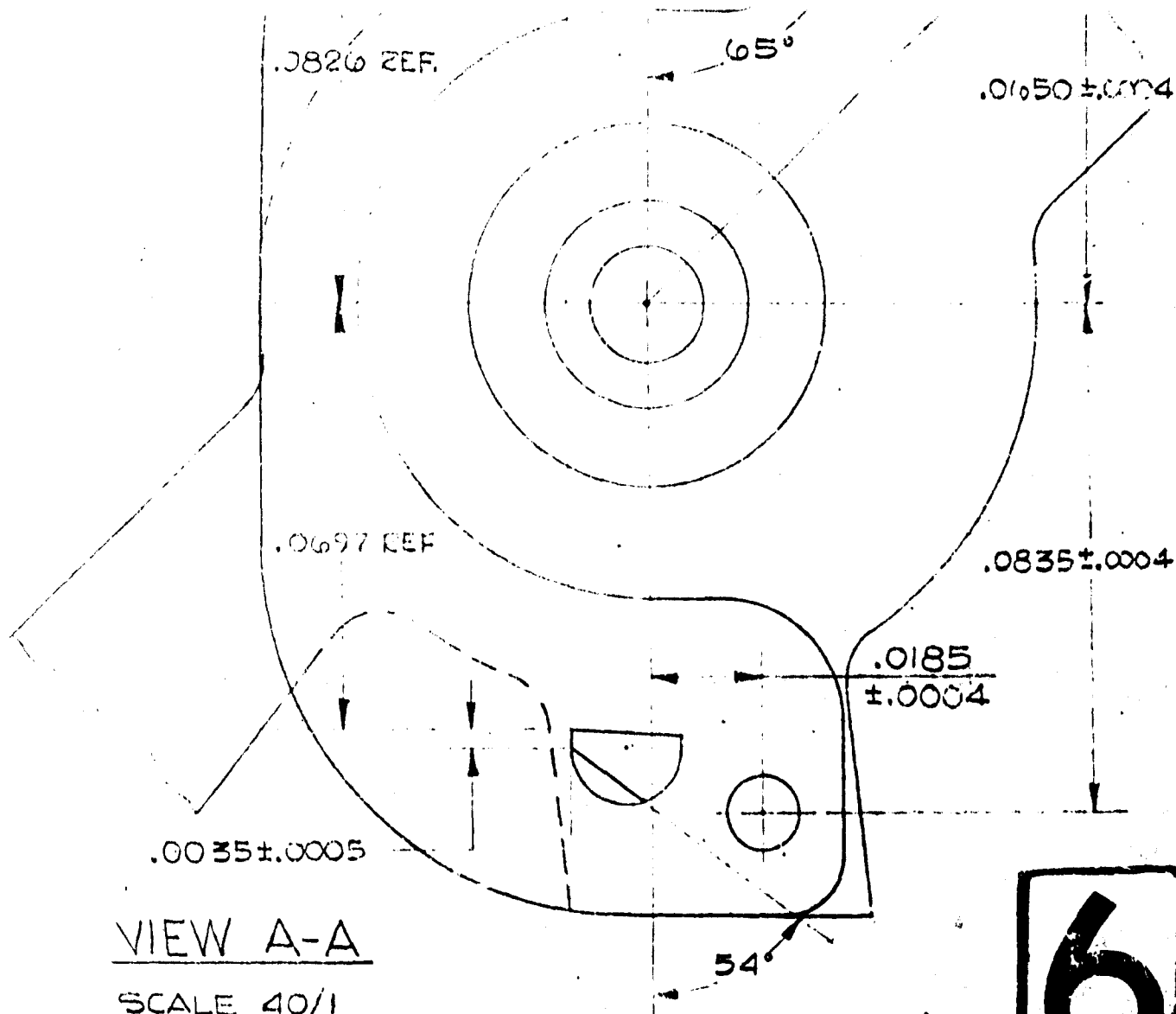
VIEW A-A

SCALE 40/1

2	9802	PIN, MINUTE	HWCO PART		
2	25106-1-31	PIN, JEWEL	HWCO PART		
2	SK 1228	ADAPTER, LEVER			
1	22948	LEVER (MODIFIED)			
1	22947	ARBOR			
REQD	PART NO	DESCRIPTION	STOCK SIZE	MATL	MATL

LIST OF MATERIAL

NEXT ASSY		USED ON	MATERIAL	DATE: 5/31/61	ESCAPEMENT SUB-ASSY (MC)
APPLICATION		FINAL PROTECTIVE FINISH	DRAFTSMAN: BE	CHECKER: RPL	
DIMENSIONS ARE IN INCHES			ENGR	ENGR	
UNLESS OTHERWISE SPECIFIED			APPROVAL		
TOLERANCES ANGLES ± DECIMALS ± FRACTIONS ±		SURFACE FINISH 		SCALE 10/1 UNIT WT. ACT. CAL.C. C 17/72	
		MILITARY PRODUCTS DIV. HAMILTON WATCH CO. LANCASTER, PA.		DRAWING NO. SK SHEET 1	



VIEW A-A

SCALE 40/1

802	PIN, MINUTE	HWCO PART
100-1-31	PIN, JEWEL	HWCO PART
1228	ADAPTER, LEVER	
1948	LEVER (MODIFIED)	
1947	ARBOR	

PART NO	DESCRIPTION	STOCK SIZE	MATL	MATL	SPEC	REV	ZONE
---------	-------------	------------	------	------	------	-----	------

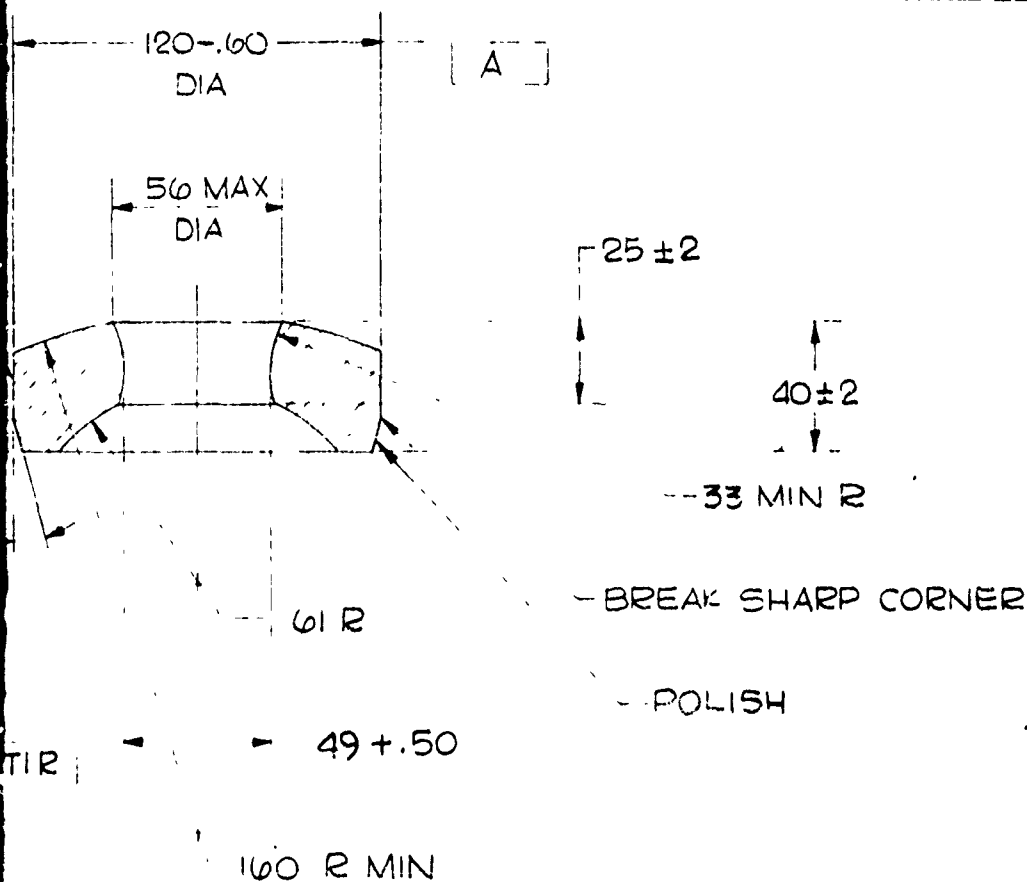
LIST OF MATERIAL

		MATERIAL	DATE 5/31/61
		HEAT TREATMENT	DRAFTSMAN BE
			PREPARED HDPL
38Y	USED ON		ENGR
APPLICATION		FINAL PROTECTIVE FINISH	ENGR
VISIONS ARE IN INCHES			APPROVAL

OTHERWISE SPECIFIED		MILITARY PRODUCTS DIV.	SCALE 10/1	DWG SIZE	DRAWING NO.
ES SURFACE FINISH		HAMILTON WATCH CO.	UNIT WT. ACT. CALC.	C	SK 1230
±1°	✓	LANCASTER, PA.		1762	SHEET OF REV.

REVISIONS

ZONE	SYM	BY	DESCRIPTION



.01 MM
 LISHED
 NISE NOTED
 ANY CHIPS OR
 AN 18X EYEGLOSS

2

REQD	PART NO	DESCRIPTION	STOCK SIZE	MATL	MATL
LIST OF MATERIAL					
		MATERIAL	DATE		
		SEE TABLE	14 APR, 1961		
		HEAT TREATMENT	DRAFTSMAN		
			CHECKER		
NEXT ASSY		USED ON	ENGR		
APPLICATION		FINAL PROTECTIVE FINISH	ENGR		
DIMENSIONS ARE IN INCHES			APPROVAL		
UNLESS OTHERWISE SPECIFIED					
TOLERANCES					
ANGLES ±					
DECIMALS ±					
FRACTIONS ±					
J					
		MILITARY PRODUCTS DIV., HAMILTON WATCH CO., LANCASTER, PA			
		SCALE 5/1			
		UNIT WT CALC			
		B			
		DRAWN			
		2			
		SHEET			

REVISIONS

ZONE	SYM	BY	DESCRIPTION	DATE	CHKD	APPD

A

25 ± 2

40 ± 2

--33 MIN R

--BREAK SHARP CORNER

--POLISH

61 R

49 ± .50

60 R MIN

3

REQD	PART NO	DESCRIPTION	STOCK SIZE	MATL	MATL	SPEC	REV	ZONE
LIST OF MATERIAL								
MATERIAL		SEE TABLE		DATE		14 APR, 1961		
HEAT TREATMENT		CHECKER		DRAFTSMAN		PP		
NEXT ASSY		USED ON		ENGR		JFI		
APPLICATION		FINAL PRO		ENGR		ESCAPEMENT & DIAMON		
DIMENSIONS ARE IN INCHES		PROTECTIVE FINISH		APPROVAL		JEWEL		
UNLESS OTHERWISE SPECIFIED		SURFACE FINISH		SCALE		DWG SIZE		DRAWING NO
TOLERANCES		J		5/16		B		21303
ANGLES ±		MILITARY PRODUCTS DIV.,		UNIT WT.		11x17		SHEET OF 1 REV
DECIMALS ±		HAMILTON WATCH CO.,		ACT				
FRACTIONS ±		LANCASTER PA						

4

3

JEWEL	MATERIAL
A	SYNTHETIC SAPPHIRE
B	GLASS



RIBBON, DULL FINISH

15 MAX

$15^{\circ} \pm 3^{\circ}$

U A 33 12

3

2

ZONE

230-60 DIA

A

70 MAX
DIA.

57 MIN R

ISH

MAX

43 ± 2

110 ± 2

PEAK SHAEP C

15° ± 3°

POLISH

125 R

4.25 ± 2

33 ± 00 DIA

2

2

1

REVISIONS

ZONE	SYM	BY	DESCRIPTION	DATE	CHKD	APPD

A

57 MIN R

43±2

76±2

BREAK SHARP CORNER

POLISH

3

C

15 MAX

 $15^{\circ} \pm 3^{\circ}$

⑥A.25 T.R.

B

NOTES

1. ALL SURFACES TO BE POLISHED
EXCEPT WHERE OTHERWISE NOTED
2. ALL DIMENSIONS ARE IN .01 MM
3. OLIVE HOLE: TO BE FREE OF ANY CHIPS OR
SCRATCHES VISIBLE WITH AN 18X EYEGLASS

A

4

3

4

15 MAX

70 ± 2

BREAK SH

15° ± 3°

- POLISH -

125 R

ⓈA.25 TIR

58 ± .00 DIA

FINISHED
NOTED
M
ANY CHIPS OR
AN 8X EYEGLASS

325 R MIN

5

REQD	PART NO	DESCR
		MATERIAL
		HEAT TREAT
NEXT ASSY		FINAL NOTE
APPLICATION		
DIMENSIONS ARE IN INCHES		
UNLESS OTHERWISE SPECIFIED		
TOLERANCE	SURFACE FINISH	
ANGLES ±	J	
DECIMALS ±		
FRACTIONS ±		

3

2


45±2

7/6±2

---BREAK SHARP CORNER

-POLISH

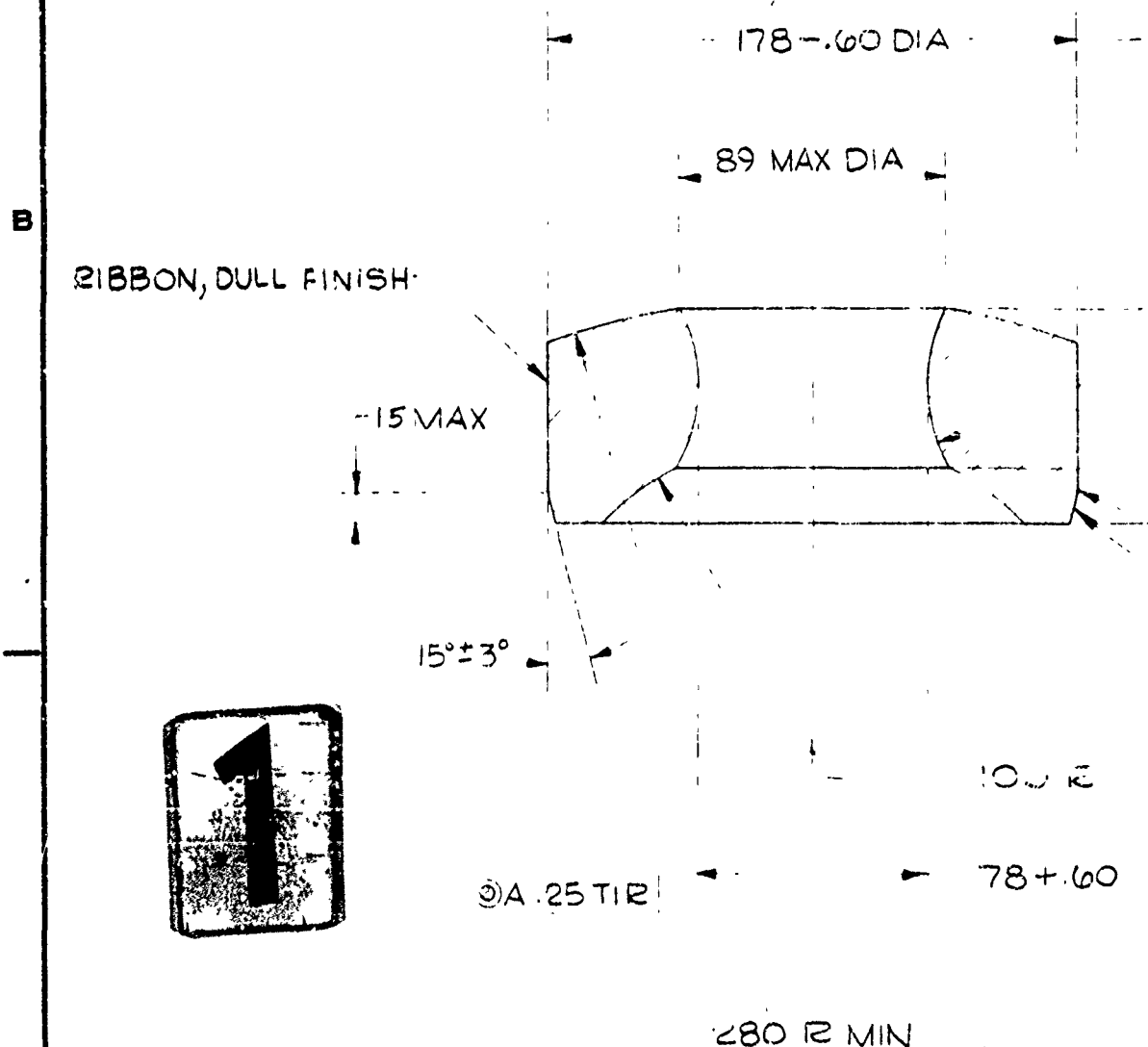
6

REQD	PART NO	DESCRIPTION	STOCK SIZE	MATL	MATL	SPEC	REV	ZONE
LIST OF MATERIAL								
		MATERIAL	DATE	#2 PINION JEWEL				
		SEE TABLE	20 APR 1961					
		HEAT TREATMENT	DRAPSMAN PRS					
			CHECKER					
			ENGR					
NEXT ASSY	USED ON			ENGR				
APPLICATION		FINAL PROTECTIVE FINISH		ENGR				
DIMENSIONS ARE IN INCHES				APPROVAL				
UNLESS OTHERWISE SPECIFIED		 MILITARY PRODUCTS DIV. MILTON WATCH CO., LANCASTER PA	SCALE	DWG	DRAWING NO			
TOLERANCES	SURFACE FINISH		1/2"	SIZE	21304			
ANGLES ±	7		UNIT WT	C	SHEET 1 OF 1			
DECIMALS ±	✓		ACT	7x22	REV			
FRACTIONS ±	✓							

2

1

JEWEL	MATERIAL
A	SYNTHETIC SAPPHIRE
B	GLASS



NOTES

1. ALL DIMENSIONS ARE IN .01 MM
2. ALL SURFACES TO BE POLISHED EXCEPT WHERE OTHERWISE NOTED
3. LIVE HOLE TO BE FREE OF ANY CHIPS OR SCRATCHES VISIBLE WITH AN 8X EYEGLASS

REQD	PART
	NEXT ASSY
	APPL
	DIMENSIONS
	UNLESS OTHERWISE SPECIFIED
	TOLERANCES
	ANGLES ± .001
	DECIMALS ± .001
	FRACTIONS ± .001

3

2

1

REVISIONS

ZONE	SYM	BY	DESCRIPTION	DATE

78-.60 DIA

A

9 MAX DIA

51 MIN R

30±2

09±2

-BREAK SHARP CORNER

-POLISH

100 R

78+.60

2

80 R MIN

NOTED
HIPS OR
EYEGLASS

REQD	PART NO	DESCRIPTION	STOCK SIZE	MATL	MATL	SPEC
LIST OF MATERIAL						
MATERIAL		DATE		19 APR 1961		
SEE TABLE		DRAFTSMAN		F25		
HEAT TREATMENT		CHECKED		XSL		
NEXT ASSY		USED ON		ENGR		
APPLICATION		FINAL PROTECTIVE FINISH		ENGR		
DIMENSIONS ARE IN INCHES		APPROVAL		APPROVAL		
UNLESS OTHERWISE SPECIFIED		MILITARY PRODUCTS DIV.,		SCALE 5/1		
TOLERANCES		HAMILTON WATCH CO.,		UNIT WT. ACT CALC		
ANGLES ±		LANCASTER, PA.		DWG. NO. B		
DECIMALS ±				DRAWING NO. 2130		
FRACTIONS ±				SHEET 1 OF 1		

3

2

1

REVISIONS						
ZONE	SYM	BY	DESCRIPTION	DATE	CHKD	APPD

51 MIN R

50±2 69±2


BREAK SHARP CORNER

-POLISH

100 R

78+60

3

RECD	PART NO	DESCRIPTION	STOCK SIZE	MATL	MATL	SPEC	REV	ZONE
LIST OF MATERIAL								
MATERIAL		DATE		#3 & #4 DIALION JEWEL				
SEE TABLE		19 APR 1961						
HEAT TREATMENT		CHECKER						
ENGINEER		ENGINEER						
APPLICATION		FINAL PROTECTIVE FIN		APPROVAL				
DIMENSIONS ARE IN INCHES								
UNLESS OTHERWISE SPECIFIED		 MILITARY PRODUCTS DIV HAMILTON WATCH CO., LANCASTER, PA		SCALE 5/1	DWG SIZE B	DRAWING NO 21305		
TOLERANCES				UNIT WT	SHEET 1 OF 1			
ANGLES ±				ACT	REV			
DECIMALS ±								
FRACTIONS ±								