

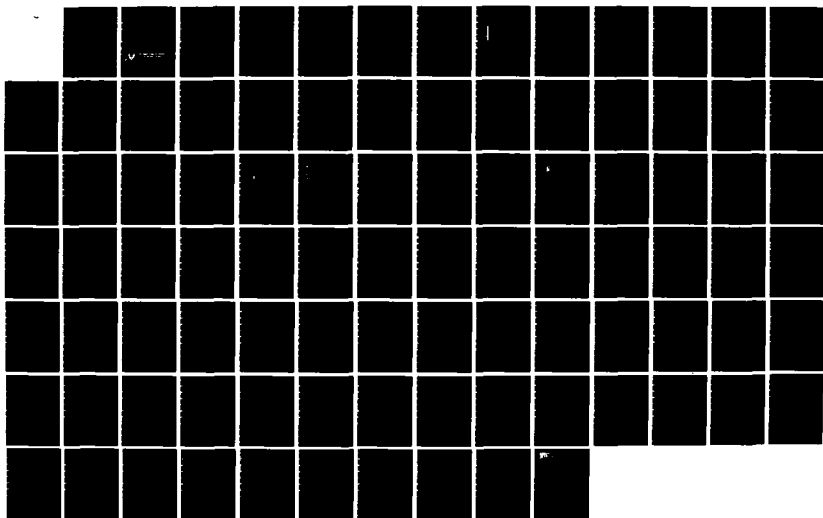
AD-A139 036

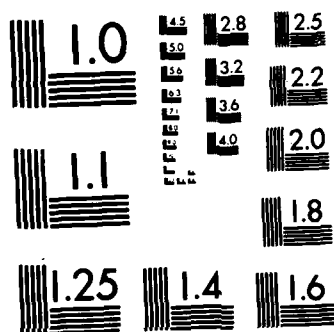
M577 MODULAR SETBACK PIN COMPUTER SIMULATION AND
AUTOMATED ASSEMBLY AND TESTING(U) HAMILTON TECHNOLOGY
INC LANCASTER PA K C GIURLANDO MAR 84 ARLCD-CR-83045
DAAK10-82-C-0132 F/G 19/1

1/1

UNCLASSIFIED

NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

12

AD-A139036

AD

AD-E401 136

TECHNICAL REPORT ARLCD-CR-83045

**M577 MODULAR SETBACK PIN COMPUTER SIMULATION
AND AUTOMATED ASSEMBLY AND TESTING**

**KENNETH C. GIURLANDO
HAMILTON TECHNOLOGY, INC.
P. O. BOX 4787
LANCASTER, PA 17604**

MARCH 1984

DTIC FILE COPY



**U.S. ARMY ARMAMENT RESEARCH AND DEVELOPMENT CENTER
LARGE CALIBER WEAPON SYSTEMS LABORATORY
DOVER, NEW JERSEY**

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

**DTIC
ELECTE
APR 13 1984**

E

84 04 09 029

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

The citation in this report of the names of commercial firms or commercially available products or services does not constitute official endorsement by or approval of the U.S. Government.

Destroy this report when no longer needed. Do not return to the originator.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Contractor Report ARLCD-CR-83045	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) M577 MODULAR SETBACK PIN COMPUTER SIMULATION AND AUTOMATED ASSEMBLY AND TESTING		5. TYPE OF REPORT & PERIOD COVERED Final May 1982 - June 1983
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) KENNETH C. GIURLANDO		8. CONTRACT OR GRANT NUMBER(s) DAAK10-82-C-0132
9. PERFORMING ORGANIZATION NAME AND ADDRESS HAMILTON TECHNOLOGY, INC. P.O. BOX 4787 LANCASTER, PA 17604		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS ARDC, TSD STINFO DIV (DRSMC-TSS) DOVER, NJ 07801		12. REPORT DATE March 1984
		13. NUMBER OF PAGES 97
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) ARDC, LCWSL NUCLEAR AND FUZE DIV (DRSMC-LCN-T) DOVER, NJ 07801		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES The initial development of the modular setback pin was conducted by Hamilton Technology, Inc., under contract number DAAK10-77-C-0152 (CPFF).		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) M577 fuze Modular setback pin MSP computer simulation MSP automated assembly and testing equipment Die cast MSP		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The objective of this project was to conduct a computer simulation of the modular setback pin (MSP) motion under setback. The simulation relates time to function, setback magnitude, and nine MSP design features. A second objective was to evaluate possible methods of automating the assembly and testing of the MSP. A history of previous ballistic testing and design changes is also included.		

CONTENTS

	Page
INTRODUCTION	1
OPERATION	5
COMPUTER SIMULATION	7
AUTOMATED ASSEMBLY	10
MANUFACTURABILITY	14
ENGINEERING TEST PROGRAM	15
CONCLUSIONS AND RECOMMENDATIONS	23
APPENDIXES	
A. REQUIRED DRAWING CHANGES	25
B. MODULAR SETBACK PIN EQUATIONS OF MOTION	41
C. MODULAR SETBACK PIN COMPUTER SIMULATION PROGRAM	45
D. EVALUATION OF COMPUTER SIMULATION PARAMETERS	49
E. SETBACK MAGNITUDE VERSUS TIME REQUIRED FOR MSP TO FUNCTION	59
F. A RELATIVE COMPARISON OF NINE DESIGN FEATURES AS THEY RELATE TO DROP HEIGHT	63
G. ETCHING PROCEDURE FOR THE MSP HOUSING	91
H. M577 MODULAR SETBACK PIN BALLISTIC TESTING SUMMARY	94
DISTRIBUTION LIST	99

Accession For	
NTIS GRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By _____	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	



FIGURES

	Page
1 Modular Setback Pin Exploded View	2
2 #4 Plate Mating Geometry	3
3 Assembly Procedure	4
4 Lock Down Feature of Setback Module	6
5 Velocity Change Vs Setback Curve	8
6 Modular Setback Automated Testing Machine	12
7 First Modification	16
8 Second Modification	17
9 Third Modification	19
10 Alternate Lock Down Position	20
11 Fourth Modification	21
12 Lock Down Feature with Die Change	24

INTRODUCTION

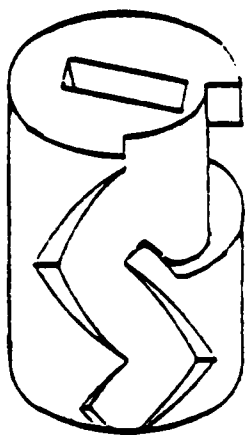
The modular setback pin (MSP) was designed to operate in both the timer and trigger of the M577 mechanical time fuze. The device senses all standard gun firing environments and differentiates between them and handling shocks, including drops of 40 feet and higher. Further, the unit locks in the functioned position (down) after the setback pulse ceases. This prohibits the setback pin from interfering with the operation of the spin detent. Three parts make up the module as shown in fig. 1: two state-of-the-art zinc die castings and a coil spring. Due to the setback module's extremely small size, it may be applied to a variety of other artillery fuzes, taking advantage of its unique operating features. The complete drawings are shown in Appendix A. Also included in Appendix A are additional drawing changes required to accommodate the MSP. Parts required to be modified include the timer spin detent, all timer plates and the trigger spacer.

The primary functional feature of the setback pin is the Z-shaped groove in its side. The groove continues circumferentially around to the far side of the pin, then extends straight down to the bottom of the pin. There is a slot in the top of the pin to allow a screwdriver-type tool to rotate the pin. This pin is hollow to allow the spring to ride inside it.

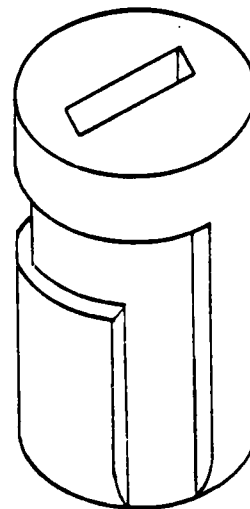
The main functional feature of the housing is the diamond-shaped cam on its inside surface. Extending upward from the bottom of the housing is a spring support pin which acts as a guide to keep the spring from buckling. There is a section of the mounting flange removed in order to allow the module to be mounted as close to the outside of the M577 timer as possible. There are also two flats on opposite sides of the flange to enable the module to be constrained from rotating by a mating geometry in the plates in which the setback module is mounted. This is shown in figure 2.

The module is assembled by placing one end of the spring in the setback pin and the other end over the spring support pin of the housing. The vertical section of the pin groove is then positioned over the housing cam and the pin is slid into the housing fully. After this operation the pin is rotated one-half turn, this engages the cam with the zig-zag section of the groove as is shown in fig. 3. The pin can then be compressed. As the pin is compressed, it oscillates rotationally.

A computer-aided study to determine the time required for the MSP to function under various setback loads is described in this report. A modified version of this program determined the relative importance of nine design features as they relate to drop height. Limited physical testing was also conducted. A study and conceptual layout of automated assembly and testing equipment for the MSP are also described.



PIN



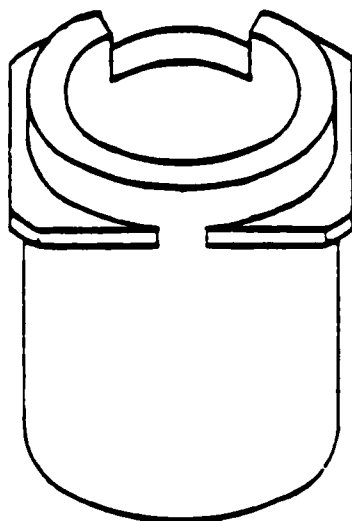
ENTRANCE GROOVE



SPRING



ACTUAL SIZE



HOUSING

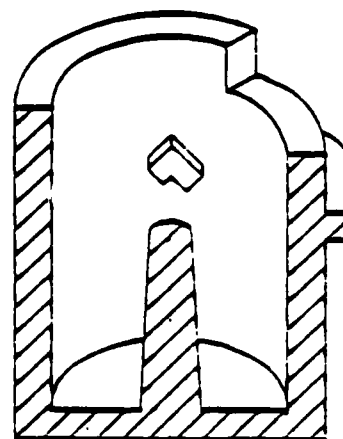


FIGURE 1
EXPLODED VIEW

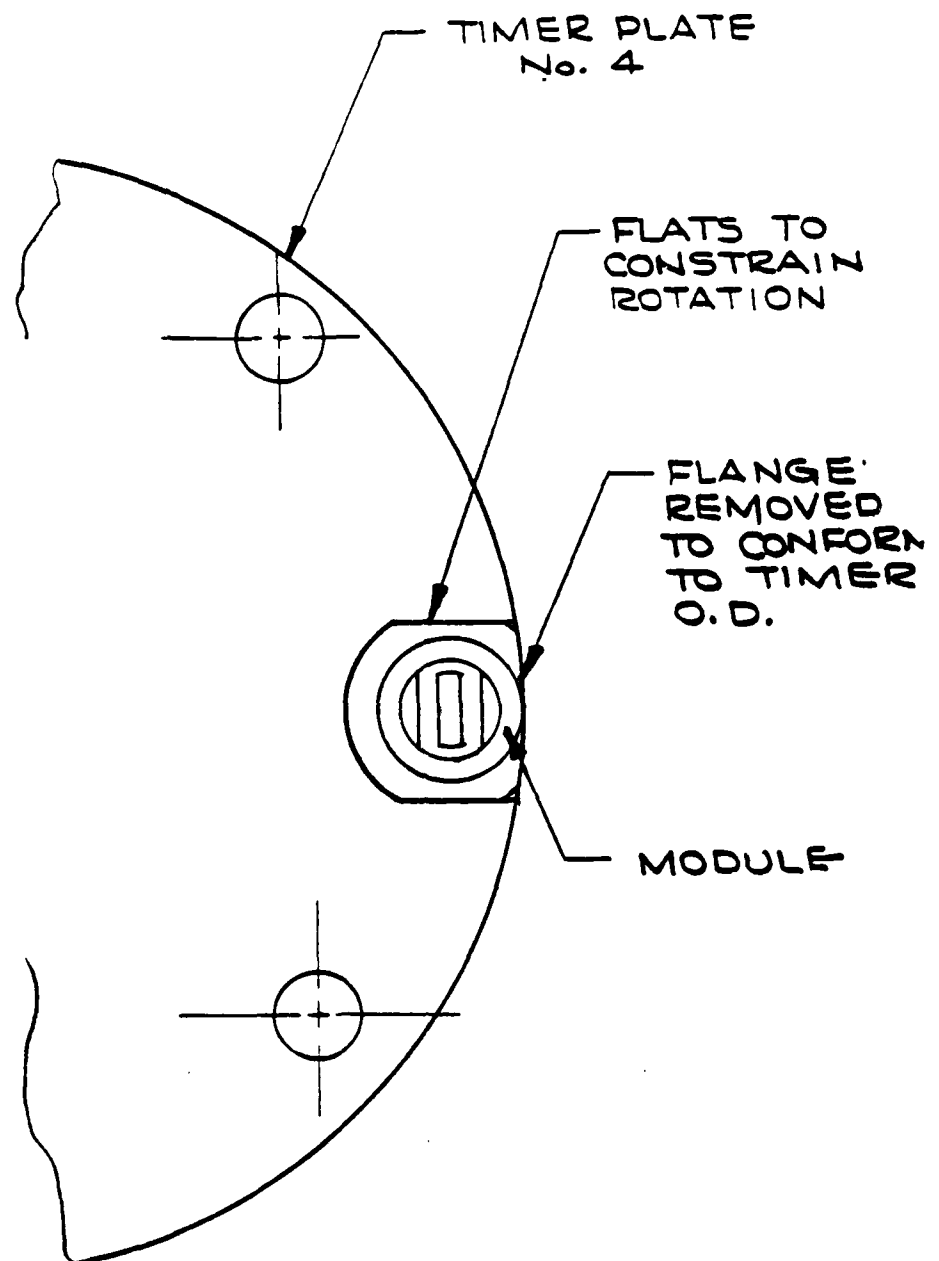


FIGURE 2
NO. 4 PLATE MATING GEOMETRY

OPERATION

The unique operating feature of the modular setback pin is the rotational oscillation it exhibits while being compressed. Because of this, the MSP functions as a crude runaway escapement, integrating setback and time. As the setback pin is compressed, the housing cam encounters sharp changes in the direction of the pin groove (see fig. 3). Each time the pin groove changes direction, the pin which, of course, is turning in the same direction as the groove, must stop momentarily before turning in the new direction. The pin must then be re-accelerated to continue its travel down the groove. This is analogous to the motion of the balance (sometimes called the lever) in a runaway escapement. Because the pin does actually stop, the kinetic energy it has when it reaches the end of a leg of the track is expended upon impact of the corner. Therefore, energy must be resupplied to continue motion. This energy is supplied by the setback force. Should the setback force not be present, the pin, instead of continuing to compress, will be returned by its spring to the safe position. Herein lies the key to the pin's ability to differentiate between the setback forces of gun-firing and the forces from handling shocks. Handling shocks have too short a duration to re-accelerate the pin at the beginning of the second and third legs of the Z-groove. A standard setback pin would compress regardless of the duration, as long as the setback force was great enough. Whereas, the MSP must "sense" a combination of setback and duration in order for it to arm.

An additional feature of the modular setback pin is its ability to lock down in the functioned position. When the setback pin is completely compressed, it is designed to come to rest directly under a notch in the housing which will catch the pin after cessation of setback (see fig. 4). The MSP will then remain in the down position unless the pin is manually twisted in the counter-clockwise direction. This lockdown feature allows the setback pin to be effectively separated from the spin detent, once it has seen the required setback pulse. Such a feature would also be useful during assembly since many of the testing and assembly operations require that the setback pin be temporarily compressed.

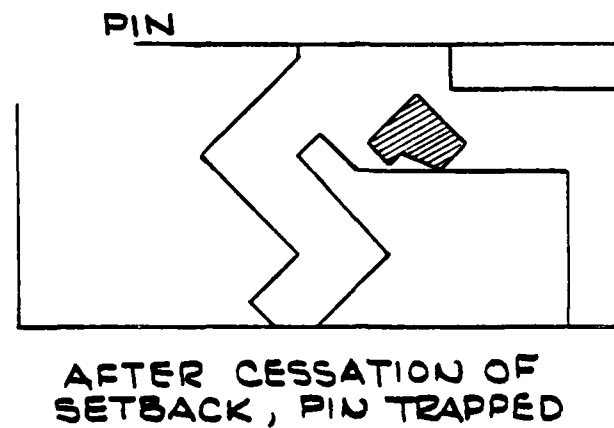
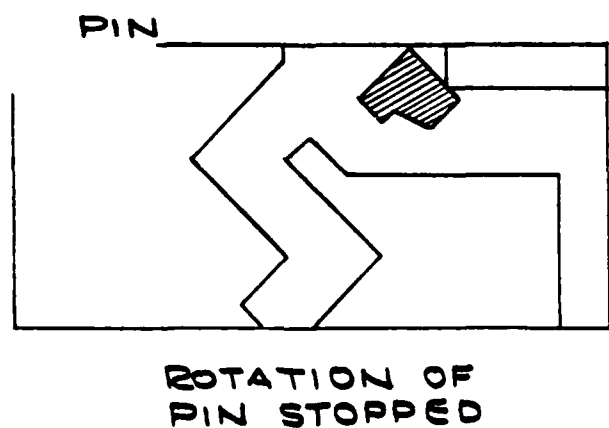
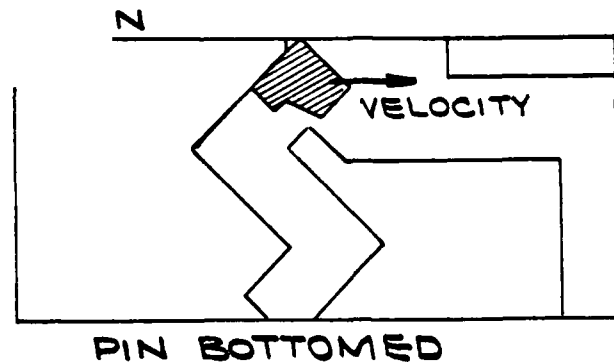
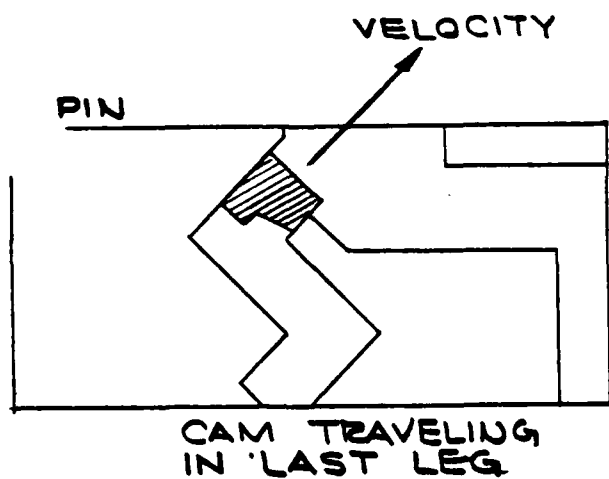


FIGURE 4
LOCK-DOWN FEATURE OF
MODULE

COMPUTER SIMULATION

The equations of motion for the setback pin have been developed by D. L. Overman of Harry Diamond Laboratories and are shown in Appendix B. Due to the complexity of the setback pin motion, certain simplifying assumptions were necessary to reduce the equations of motion to a workable level. These assumptions are as follows:

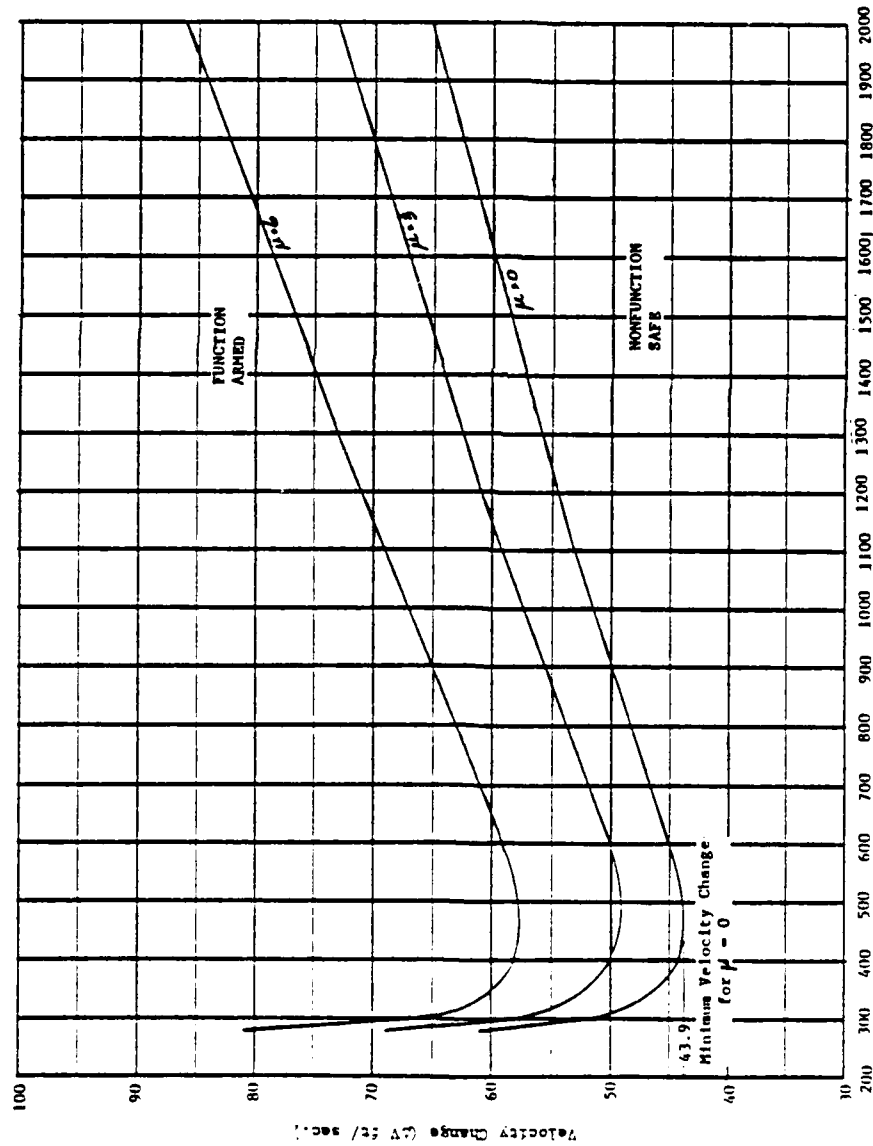
- o Collisions at the end of each stage are completely inelastic.
- o The spring is linear.
- o No friction occurs due to side loads.
- o The setback pulse is rectangular.

The assumption of a rectangular setback pulse provides a conservative estimate of the maximum safe drop height. Also, the maximum safe drop height is calculated assuming an ideal impact surface. Under all other conditions, the MSP would require a higher drop height in order to arm.

Using these equations of motion, a computer program was written (Appendix C). An evaluation of the parameters used in the program is shown in Appendix D. The quantity computed by the program is the minimum velocity change required to cause the setback pin to function. The computation is iterated for a variety of values of acceleration, generating a curve of minimum velocity change versus acceleration. A typical curve is shown in fig. 5. This process is then further iterated for a variety of friction coefficients, since it is not possible to make an accurate determination for the value of the friction coefficient in this case. Each curve defines the boundary between a function and a non-function zone. For values of velocity change and acceleration above the curve, the pin will function; and for values below the curve, it will not. Upon examination of the curve shown in fig. 5, it can be seen there is a minimum value of velocity change. For the "no friction" curve in fig. 5, the minimum velocity change is approximately equal to 43.9 ft/sec. An increase in the setback level does not reduce the velocity change required to cause the pin to function. This is due to the fact that the setback duration must also satisfy the MSP before it will function. From this minimum velocity change a drop height can be calculated [Drop Height = $(V_2 - V_1)^2 / 2g$]. The drop height for this no friction curve is about 30 ft. This is the minimum height that the MSP can be dropped from in order to cause it to arm. Below this minimum drop height there is no possible impact surface condition that can cause a combination of acceleration and duration great enough to force the unit to function. This is the maximum safe drop height.

This computer program is used to estimate the required time for the MSP to function at various setback loads, thus simulating different weapon systems. Once the design characteristics of the MSP (i.e., spring strength, helix angle, etc.) have been established, the only other factor which affects the time of

MINIMUM VELOCITY CHANGE VS. ACCELERATION



K = .0474 INCH
R = .0575 INCH
AL = 51.14 DEG
MU = 0 FRICTION
G1 = 100 G'S
G2 = 300 G'S
X1 = .0327 INCH
X2 = .0654 INCH
X3 = .0327 INCH
A1 = 300 G'S
AF = 2000 G'S
I = 50 G'S

SETBACK (G'S)	VELOCITY (FT/SEC)	TIME (SEC)
300	51.8948	5.37647E-03
350	45.9048	4.07648E-03
400	44.3107	3.44305E-03
450	41.9363	3.03463E-03
500	44.087	2.74054E-03
550	44.5074	2.51515E-03
600	45.0796	2.3352E-03
650	45.7416	2.18722E-03
700	46.4582	2.06281E-03
750	47.2078	1.96435E-03
800	47.9768	1.88396E-03
850	48.7562	1.8281E-03
900	49.5401	1.71084E-03
950	50.3243	1.64645E-03
1000	51.1062	1.58843E-03
1050	51.8835	1.5358E-03
1100	52.6551	1.4878E-03
1150	53.4201	1.44378E-03
1200	54.1777	1.40325E-03
1250	54.9276	1.36576E-03
1300	55.6697	1.33098E-03
1350	56.4034	1.29857E-03
1400	57.1292	1.26831E-03
1450	57.8469	1.23996E-03
1500	58.5564	1.2133E-03
1550	59.258	1.18826E-03
1600	59.9519	1.1646E-03
1650	60.6379	1.14223E-03
1700	61.3165	1.12105E-03
1750	61.9878	1.10094E-03
1800	62.6516	1.08182E-03
1850	63.3088	1.06362E-03
1900	63.9589	1.04627E-03
1950	64.6021	1.02969E-03
2000	65.2389	1.01384E-03

MAX DROP HEIGHT = 29.9993 FT

FIGURE 5
CURVES

setback duration required for the pin to function, is the magnitude of the setback force. Hence, in order to determine the time required for the MSP to function in a particular gun, it is only necessary to know the setback associated with that gun for a particular charge. A list of setback versus duration is shown in Appendix E. The design characteristics used in this program are taken from units used in the final ballistic test conducted in May 1983.

In actual use, the setback duration required to function will vary from 1.3 milliseconds with a 4.2" mortar in Zone 0 to .3 milliseconds in a 105mm Howitzer Zone 7.

A modified version of this program is also used to provide a comparison of the relative importance of nine design features as they relate to the maximum safe drop height (see Appendix F). This information can be very useful in determining more exactly what tolerances are acceptable. This may be important because the current need to chemically etch each part lends itself to large dimensional variations between lots.

AUTOMATED ASSEMBLY

Since the MSP is a self-contained entity capable of being assembled and tested outside the fuze, it is a natural candidate for automation. The following is a conceptual study of automated assembly and testing equipment. The automated assembly portion of this study was conducted in cooperation with Mikron Haesler Limited.

For the purpose of assembling the MSP, Mikron Haesler has proposed using a modified Polyfactor machine, type 90-1-18. The machine is a fully automatic rotary transfer assembly machine comprised of 18 stations, and all feeding, transfer and inspection devices, including laboratory feed bowls and a memory/control system. In addition to normal main machine control, this memory/control system will be used in conjunction with inspection devices located around the machine. The inspection devices are utilized to verify the "condition" of the piece parts as they are introduced to the machine fixtures. Conditions such as presence and position would be "sensed." The information obtained by the individual inspection devices is relayed and accumulated by the memory/control system which, subsequently, instructs the succeeding work, and transfer units, to suspend or continue operations relative to the component piece part condition. The memory section also instructs the ejection stations to separate "good" units from "faulty" or incomplete units. This ability could be utilized to detect broken housing spring supports at Station 12 (see Operation Sequence). This is the biggest part defect we have seen thus far.

All of the component piece parts contained in the assembly, with the exception of the spring, are proposed to be vibratory bowl fed. The spring will be produced by an automatic spring winder at the assembly machine. These springs will be 100% tested immediately after assembly and the reject rate can be recorded by the memory/control. If the reject rate becomes too high, the memory/controller can be programmed to stop operations and wait for adjustments.

The following is the operation sequence for the assembly of the MSP submitted to HTI by Mikron Haesler. The machine is designed to run at a four-second cycle rate, but this time can be reduced if need be. The price for this Polyfactor assembly machine, including a "Modicon" brand memory/control system and a factory trial run, was quoted at approximately \$247,000.*

Sequence of Operation:

<u>Station</u>	<u>Operation</u>	<u>Equipment</u>
1	Feed and transfer "setback pin" nest (1)	Bowl Feeder
2	Inspect presence and position "setback pin"	
3	Invert "setback pin" if required	
4	Orient "setback pin"	
5	Transfer "setback pin" to nest (2)	

* 1983 dollars

<u>Station</u>	<u>Operation</u>	<u>Equipment</u>
6	Inspect presence and position "setback pin"	
7	Vacant	
8	Feed and transfer "spring" nest (2)	Spring Winder
9	Inspect presence and position "spring"	
10	Feed and transfer "housing " nest (3)	Bowl Feeder
11	Orient "housing"	
12	Inspect presence and position "housing"	
13	Transfer "housing" and rotate to lock-in position	
14	Inspect presence, position and movement of "housing"	
15	Vacant	
16	Eject and separate good/bad assemblies	
17	Eject partial assemblies	
18	Inspect empty nests	

After the assembly operations have been completed, the units would automatically be loaded onto a testing machine. HTI has envisioned the testing machine to be comprised of six (6) 10" spin tables all mounted on a 44" diameter rotary table (see fig. 6). The cycle rate for the testing fixture would be geared to the rate of the assembly machine. By doing this, the machine could take advantage of the setback pin positioning already done by the assembly machine. Each of the six spin tables would hold ten setback pins and would be controlled by identical stepper motors mounted underneath the large table. A controller at each of the six divisions of the large index table determines the action of the individual internal spin tables; that is, as the large table indexes, the controller's electrical contacts for each of the six fixed positions is engaged for the individual motor at that position. The motor, which first "homes" into a constant nest position, then makes ten consecutive steps for one revolution, or spins at a preset speed depending on the controller setup.

Setback units are transferred from the assembly machine to the testing machine at station no. 1. The large table then indexes to station no. 2. Setback units that arm at station no. 2 (non-arm spin) are photo-optically detected for lack of pin projection and ejected at station 3. Any units that fail to arm at station 4 are photo-optically detected for pin projection and automatically ejected at station 5. All parts off of station number 6 are good and the spin table is emptied in preparation for reloading at station number 1.

SPECIAL AUTOMATIC TESTING MACHINE MODULAR SETBACK PIN

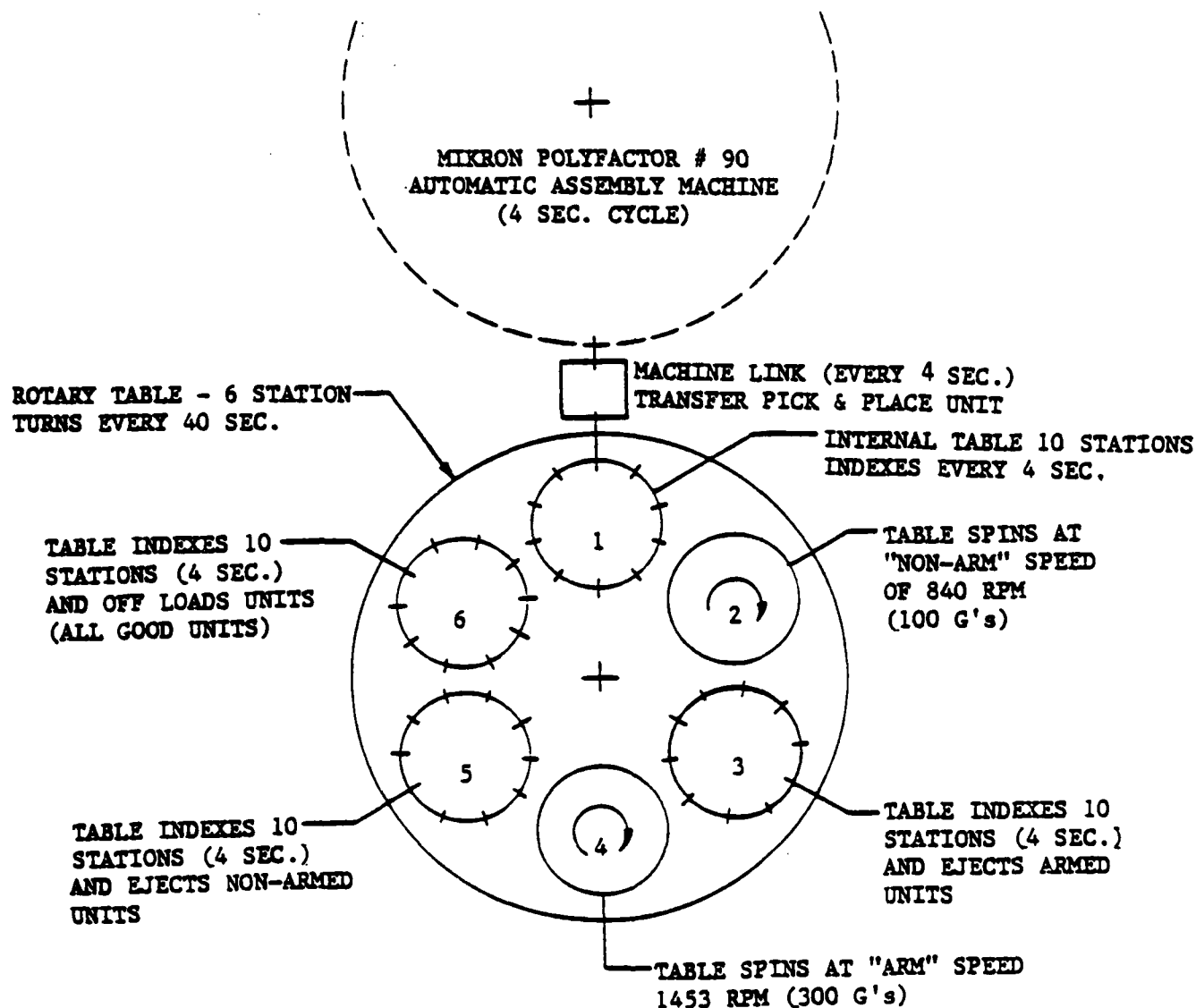


FIGURE 6
AUTOMATIC TESTING MACHINE

Inspections for presence would be performed after each loading and unloading operation. The location of these devices and the transfer units themselves would be on a stationary surface just outside the large index table. It is HTI's estimate that this test machine can be designed, built and installed for approximately \$160,000.*

* 1983 dollars

MANUFACTURABILITY

To manufacture the die castings for the modular setback pin, state-of-the-art die-making techniques were involved. A special tool was built to generate the helical-radial sides of the Z-groove and cam. This was used to make a 10:1 scale model of the complex surfaces. From those models, the dies were made by a reducing pantograph.

When the first parts were made from these dies it was found that a serious problem existed in measuring the complex surfaces. A number of methods were considered and all were eliminated as being unfeasible, except for the toolmaker's microscope. Even this proved inadequate, since its repeatability in this application was greater than the tolerance on the dimensions being measured.

Ultimately, the criterion for acceptance of the parts was their ability to interact properly. As cast, the parts would not fit together, the cam being too large for the track - or the track being too small for the cam. The critical dimensions were then adjusted by chemical etching, first by a proprietary process by the manufacturer, then by a final etching of the housing at HTI. This etch schedule is given in Appendix G. Because the etching done by the manufacturer was not tightly controlled by the manufacturer, it was necessary to vary the in-house etch time on a lot-to-lot basis.

The parts used in the final testing had some secondary operations used in their manufacture for reasons of efficiency. Specifically, these were cutting the slot in the housing and cutting the flats on the housing's mounting flange. In production, these features will be cast. It was simply faster to machine them than to change the dies at that point. The same argument applies to the changes to the timer spin detent, which is also a zinc die casting.

ENGINEERING TEST PROGRAM

A complete modular setback pin ballistic test summary is shown in Appendix H. The first fuzes with modular setback pins were tested in May, 1980, with the results shown in Table 1.

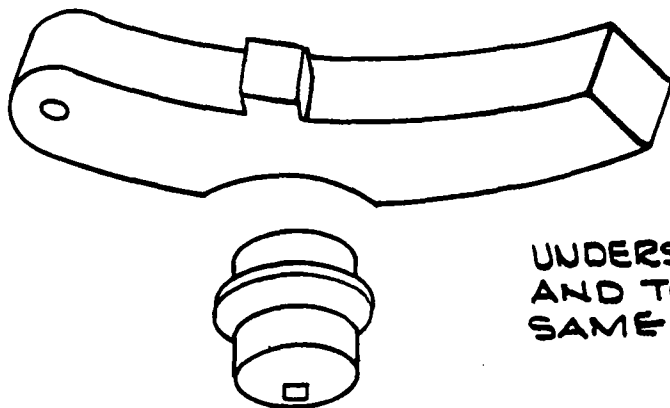
<u>Gun</u>	<u>Zone</u>	<u>Fuze setting</u>	<u>Rounds fired</u>	<u>Rounds functioned</u>
105-mm	7	50 s	5	5
8-in	1	15 s	5	2
155-mm	1	PD	5	5

TABLE 1

The success in the low zone PD test, compared to the high dud rate in the low zone airburst test, suggested that the problem was in the timer setback pin, and not the setback pin in the trigger. The duds were recovered, and it was found that the timers had either stopped or had never run. The reason for this was not apparent. In the same time period, five fuzes were air gun tested at approximately 30,000 g. Of the ten modules involved, five had the cams sheared off the inside of their housings.

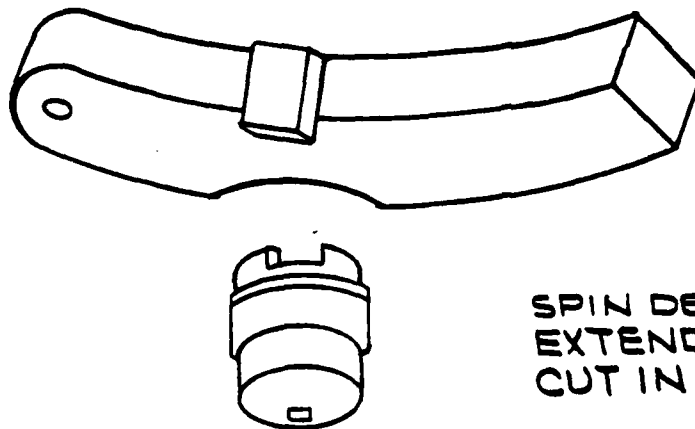
Based on the results, two new tests were planned. Twenty-four fuzes were built for an 8-in., zone 1, vertical recovery test, and twelve fuzes were built for a 105-mm 8, recovery vehicle test. These were fired in August 1980. In all of the high zone tests, the modules functioned properly. The modules were functional afterwards, indicating the cam had sufficient strength for normal gun firing. In the low zone recovery test, four fuzes failed to function. On examination, it was found that the timers had not run. While the reason for this was not apparent, it was found that a modification made to the spin detent, to allow it to pass over the setback pin module, also allowed the balance wheel to be released under some conditions. Modifications to the spin detent and housing, as shown in figure 7, solved this problem. The lug on the spin detent, which engages the balance wheel was extended downward, and the housing was notched to allow the extended lug to pass outward.

Sixteen fuzes of the first modification design were built and fired in recovery vehicles at low zone. On November 1980, twelve fuzes were recovered, and two of these had failed to function. It was found that in the fuzes, which had functioned properly, the pins were retracted and locked down. In the failed units, the pins were fully up. While no reason for this was apparent, it was found that the modules were free to rotate, which could have allowed the housing slot to move out of line with the path of the spin detent lug. To solve this problem, the shape of the housing's mounting flange was altered to have flats, as shown in figure 8. The opening in plate 4 was modified to have a matching shape. It was speculated that another possible cause of the failures was a marginal strength spring, although the springs tested satisfactorily.



UNDERSIDE OF SPIN DETENT
AND TOP OF HOUSING ON
SAME PLANE

ORIGINAL DESIGN
FOR MODULAR CONCEPT



SPIN DETENT LUG
EXTENDED AND NOTCH
CUT IN HOUSING

FIRST MODIFICATION

FIGURE 7
INTERACTION OF TIMER SPIN
DETENT AND HOUSING

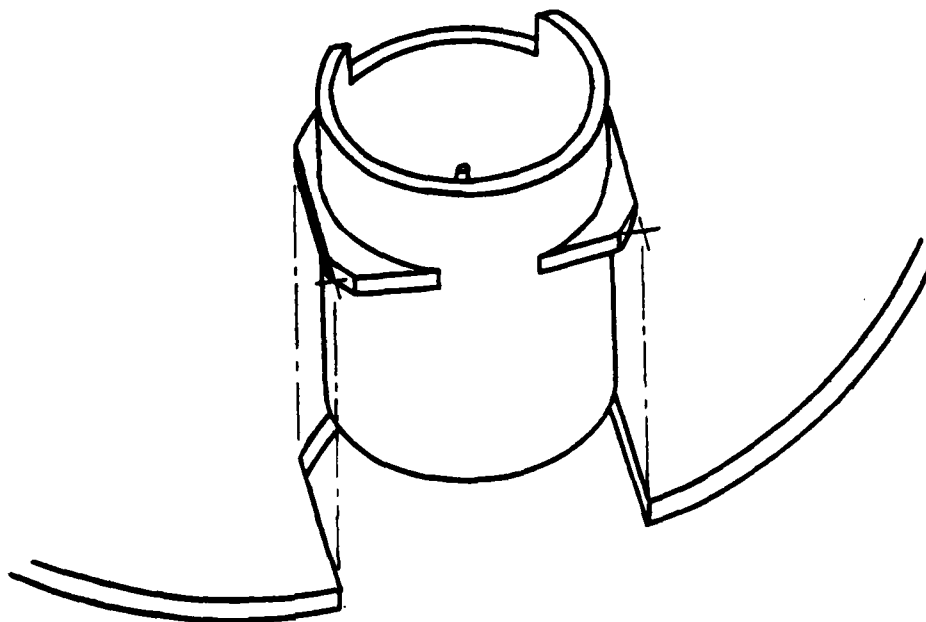


FIGURE 8
SECOND MODIFICATION
FLATS ON HOUSING AND PLATE 4 TO PREVENT
ROTATION

statically, they could possibly be too strong in a dynamic environment. In further analysis, a comparison was made between the two enclosures in which the modules are placed in the fuze, since all failures had been encountered in timers, and none in triggers.

It was determined, the greatest difference between the two locations was that the timer no. 1 plate forms a wall outward of the pin, as shown in figure 8, and there is no similar feature in the trigger where the pin stands free.

Two groups of twenty test fuzes each were built. Both groups had the flats on the mounting flange. One group had weaker springs, and the other group had material removed from the sidewall of plate no. 1, as shown in figure 9. Eighteen fuzes from each group were fired in recovery vehicles at low zone in March, 1981. The group with the weaker springs had a high failure rate. Those with the relief cut in plate no. 1 had two failures of the timer to operate. However, in each of these latter failures, the pins were down and locked, yet the spin detents were still blocked.

On close examination, it was found that the top of each locked-down pin was slightly above the housing, rather than flush with it. The reason for this is the interaction of the Z-groove and diamond cam, as shown in figure 10. While the locked position was designed to be as shown in the upper view, which puts the top of the pin flush with the top of the housing, the configuration shown in the lower view also provides effective locking, but in this case the pin is approximately .015" above the top of the housing. It was not feasible to lower the module, nor to reduce its size further. Therefore, it was decided to remove some material from the spin detent, allowing it to pass over the pin in either of the locked-down configurations. This is shown in fig. 11.

Thirty fuzes were built using the configuration described above, and including all previous modifications. These were fired in June of 1981, in low zone recovery vehicles. All fuzes were recovered and all were found to have functioned properly.

Based on these previous results, a larger test program with 200 units was prepared. The test started; however, due to a large number of duds, it had to be stopped prematurely. Thirty recovery rounds were fired to analyze the problem. Fifteen were fired in the 155-mm zone 8, cold, and set for 75 seconds. Four of the fuzes failed to function but, when the setback pins were examined, all were found to have locked down in the timer and all but one were locked down in the trigger. The other fifteen rounds were fired in the 155-mm zone 1, cold, and set for thirty seconds. Only eight of the fifteen rounds functioned; however, there were just two setback pins in the timer that were not locked down, and one in the trigger. So, although the setback pins could not be blamed for the entire problem, there were nevertheless some difficulties with the setback pins. All of the work accomplished up to this point was done on a previous MSP contract, number DAAK10-77-C-0152 (CPFF).

On this latest MSP contract (DAAK10-82-C-0132), a test program involving 121 units was planned. The following changes were performed to these MSP units:

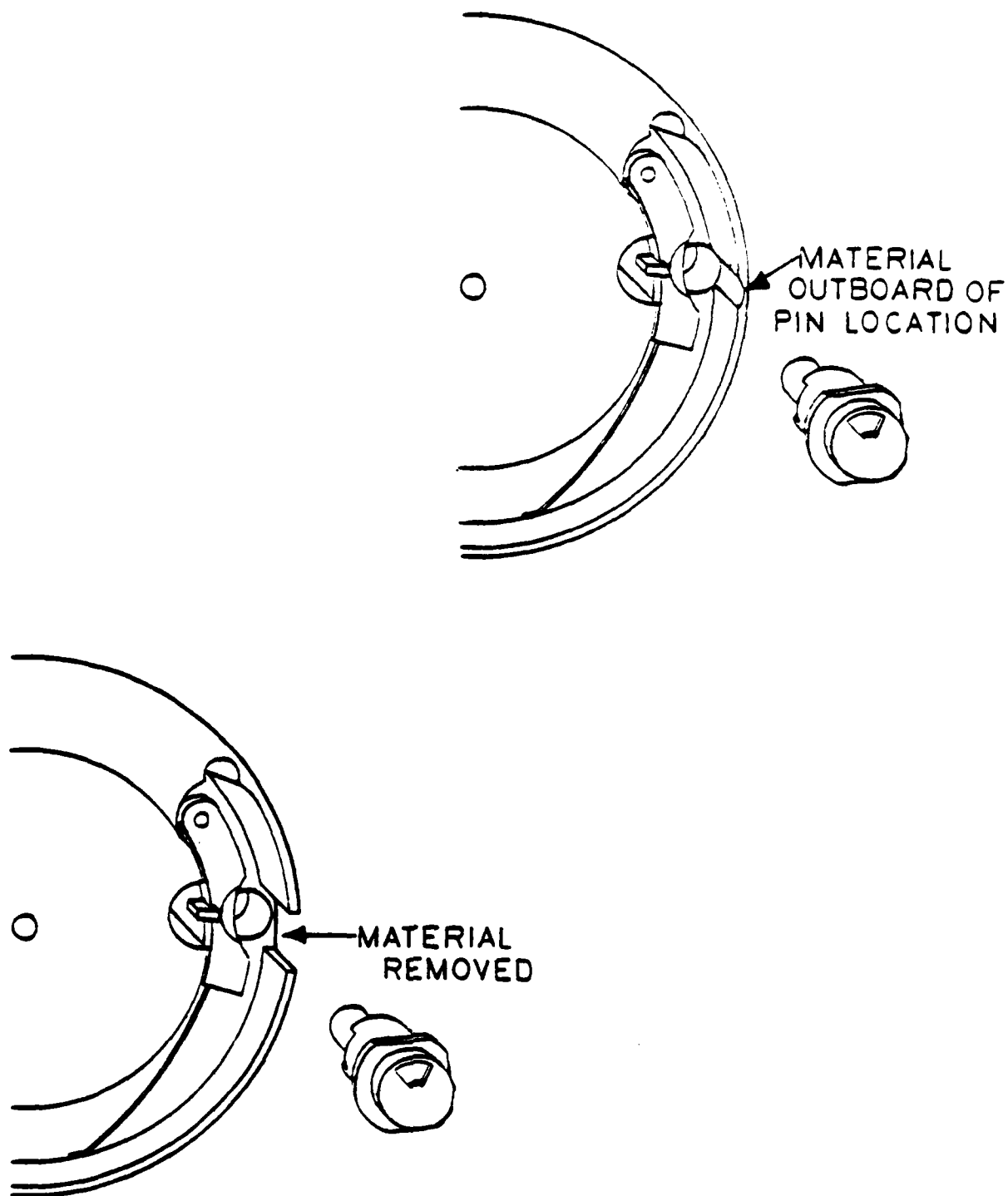
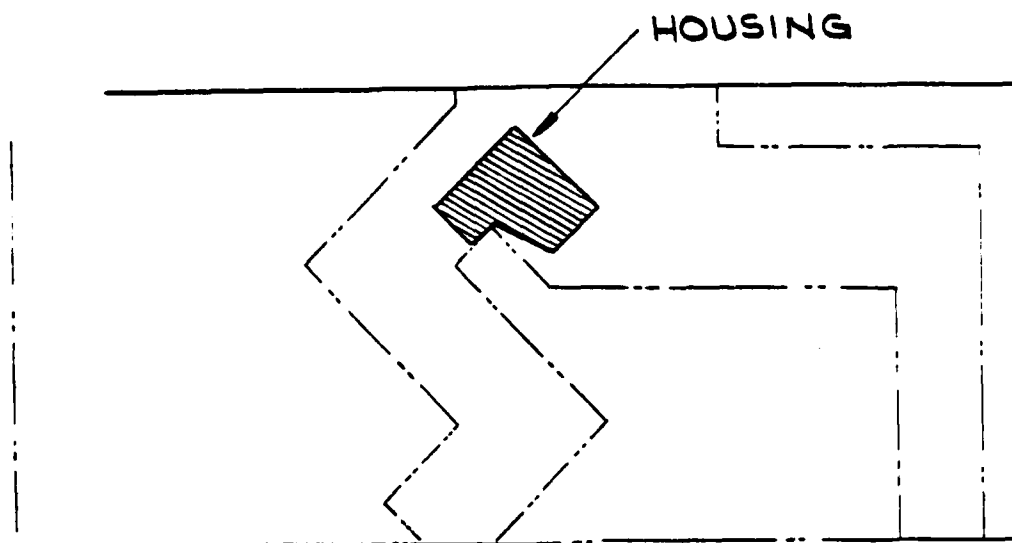
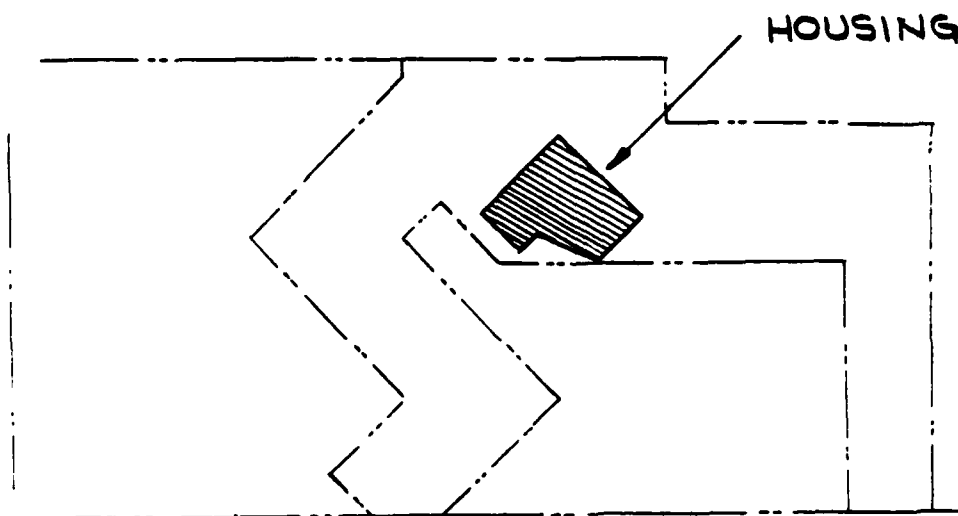


FIGURE 5
THIRD MODIFICATION
MATERIAL REMOVED FROM SIDEWALL
OF PLATE NO. 1

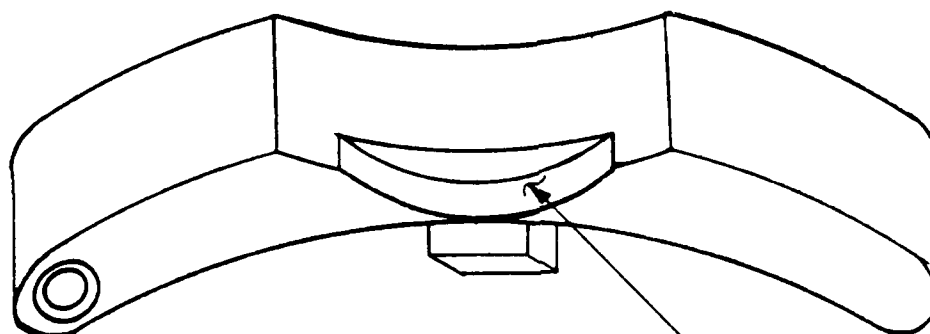


INTENDED LOCK POSITION



ALTERNATE LOCK POSITION

FIGURE 10
RELATIVE LOCATIONS
OF Z-TRACK & CAM



MATERIAL REMOVED TO ALLOW
CLEARANCE FOR PIN IN
ALTERNATE LOCK-DOWN
CONFIGURATION

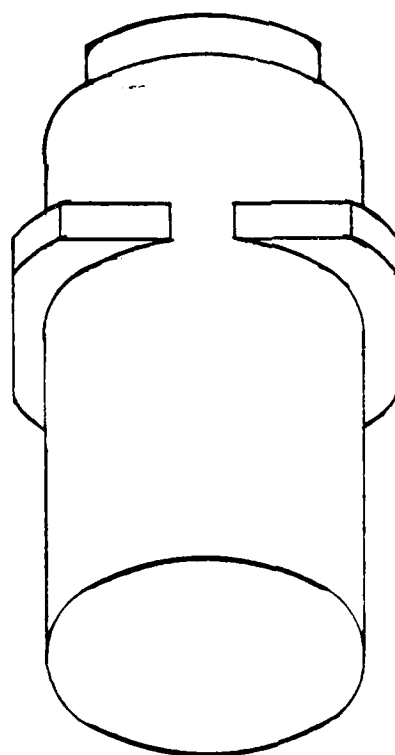


FIGURE 11
FOURTH MODIFICATION

Lighter Springs

All units tested incorporated a lighter spring that required an average of 256g's to compress them. Previously, springs required about 600g's. Although the springs were lighter, these units were still able to pass a 40-foot drop test.

100% Cycling

After a light etching, all units were cycled at least 70 times. The major problem we have been experiencing with these MSP units is that the cam in the housing is oversized. Cycling reduces this cam size without reducing the size of the rest of the unit as etching does.

100% Centrifuge Testing with a 400g Function Cut-off Point

All units that required more than 400g's to function were rejected. There was no definitive cut-off point in previous tests.

NO Vydux

The units tested had no lubrication at all. Since Vydux wears away with prolonged friction, it would serve no purpose to have it in these units which were to be cycled 70 times. Also, the Vydux could possibly get gummy in the cold test and do more harm than good.

With the aforementioned changes made, a 121 fuze ballistic test was performed. This latest test was a 100% success. All 242 setback pins in 121 fuzes functioned properly. Even the 8" zone 1/2, which had two duds in the control group, functioned perfectly. The control group may have experienced a "cross-over" problem. This is a situation in which the setback force subsides before the spin detents have a chance to move out. The setback pin would then come back up locking out the spin detent. This cannot happen with the MSP since it is designed to lock down after setback.

There were three duds in the rough handling group; however, such fuzes are only required to be safe to handle and fire. The X-rays of these rough handling duds did show the modular setback pins in the safe position after rough handling.

The most significant change made to this last test was the 100% cycling. Cycling the units assured that they were capable of moving freely. This would not be necessary if the parts were made to drawing tolerances. The complete success of this latest ballistic test proves the present MSP configuration can be both reliable and safe.

CONCLUSIONS AND RECOMMENDATIONS

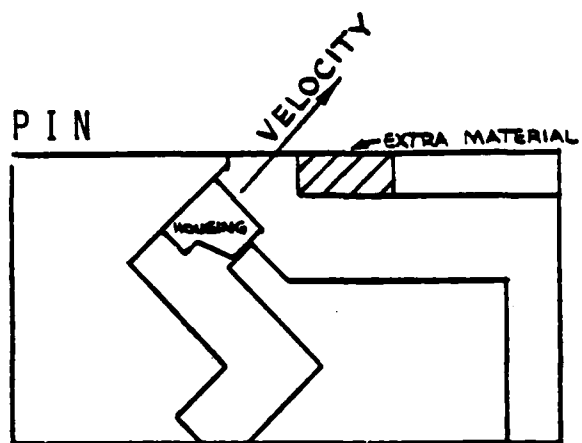
The modular setback pin described in this report has shown the potential to improve the reliability of the M577 fuze. The MSP provides excellent performance in all drop test environments and functions reliably in all gun-firing environments. Its ability to lock down after setback can eliminate the "crossover problem." The MSP has the potential to be less expensive to manufacture than the present setback pin systems. The MSP also offers ease of assembly due to its self-contained design; the fact that the same unit can be used in both the trigger and timer and because of its ability to lock down during testing. Also, the MSP can be tested outside the fuze prior to assembly.

Although the MSP design has proven feasible, an additional engineering effort will be required before it is ready for production. This is due to the extreme complexity of the die-cast housing and pin. The parts presently used do not fit together as cast; they had to be etched in order to reduce the size of the housing cam. Of course, this also reduced the dimensions which were not oversized causing additional problems. Cycling, as was done in the last ballistic test, could eliminate this problem but would be extremely costly for production size quantities. Therefore, to correct this problem, the manufacture of a new Housing die insert will be necessary. However, care must be taken to avoid the problems encountered with the first die.

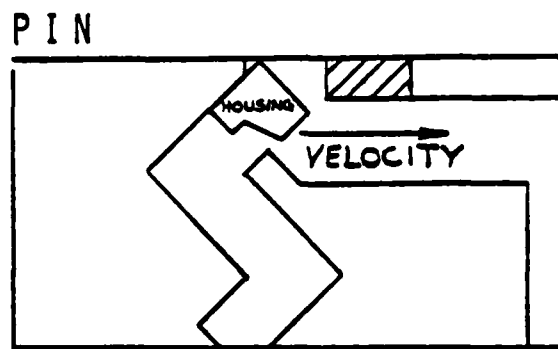
The root of these difficulties is our inability to accurately measure these complex surfaces. We were therefore forced into the undesirable position of accepting parts based on their ability to interact properly. Etching had to be performed on a trial and error basis. This problem of accurate measuring must be addressed before production can be considered practical.

Therefore, it is recommended that additional engineering work be performed to reduce these problems before implementation. Using the computer study supplied in this report, it may be possible to increase some non-critical tolerances and increase the Z-groove width to ease manufacturing and reduce the need for etching. One possible method for the accurate measurement of these die cast parts is to section sample parts in such a manner that critical dimensions could be measured along flat surfaces. This method would not be useful in measuring one particular part, but rather a large group of parts. Die casting generally produces parts with a high degree of consistency so once the dimensions of one part is known it can be assumed that all the parts will be very similar. Reproducibility is exceptionally exact with the state-of-the-art processes used by Gries Dynacast to make the MSP. Other difficulties such as the cam shearing in the 30,000g air gun test and the breaking of the housing spring supports could also be avoided. This may be accomplished by going to a stronger material such as Zamak No. 5. The problems caused by allowing two lock down positions could be eliminated with a minor die change that would force the cam into its original lock down configuration (see figure 12). Also, the need for a cutout on the no. 1 plate should be further investigated.

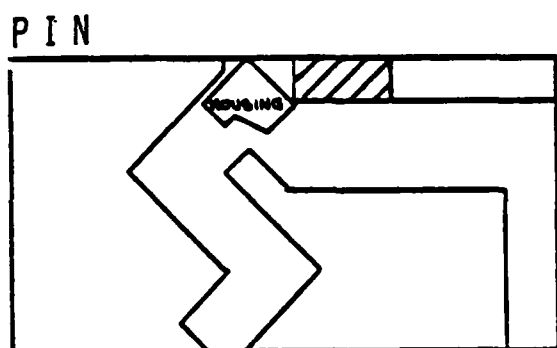
The MSP design has proven to be beneficial in terms of reliability; but, due to the manufacturing difficulties, it is not being recommended for implementation at this time.



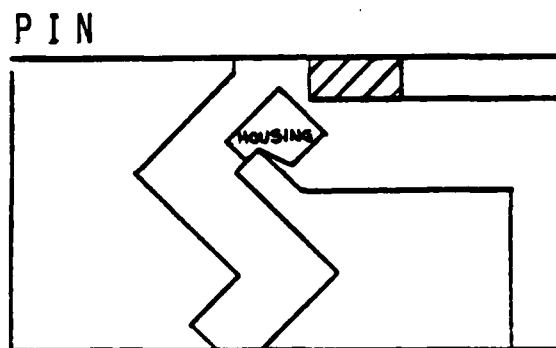
CAM TRAVELING IN
LAST LEG



PIN BOTTOMED



ROTATION OF PIN STOPPED

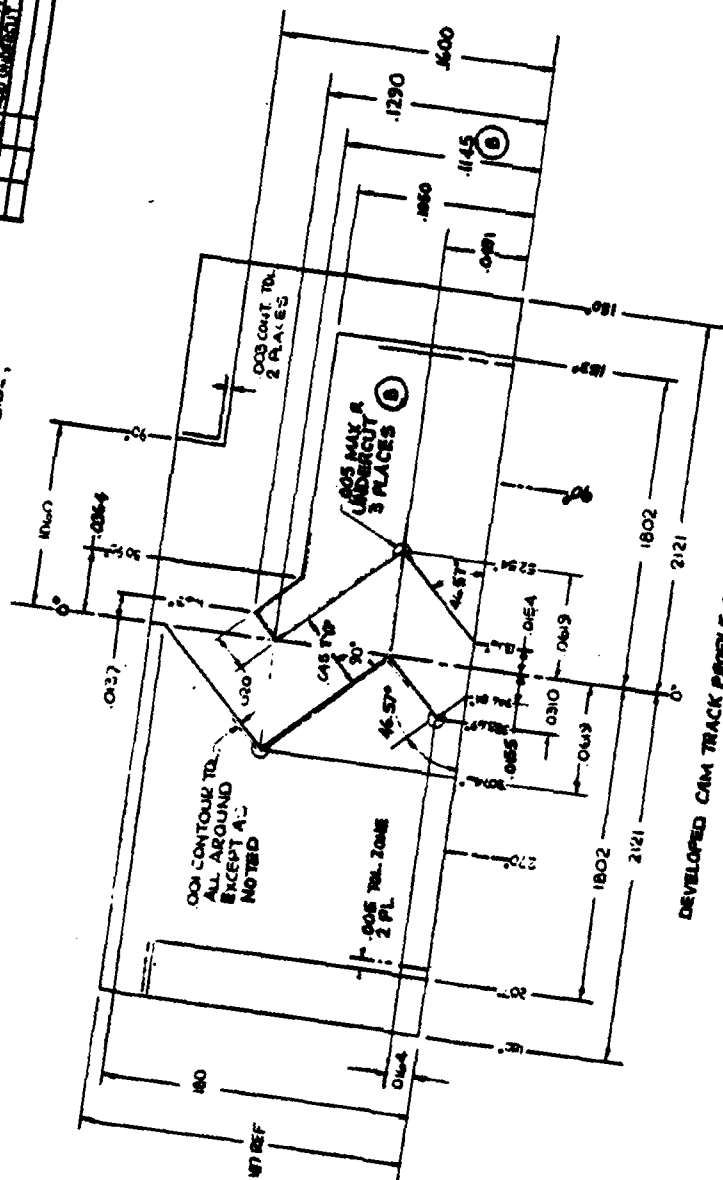


AFTER CESSATION OF
SETBACK, PIN TRAPPED

FIGURE #12
LOCK-DOWN FEATURE WITH DIE CHANGE

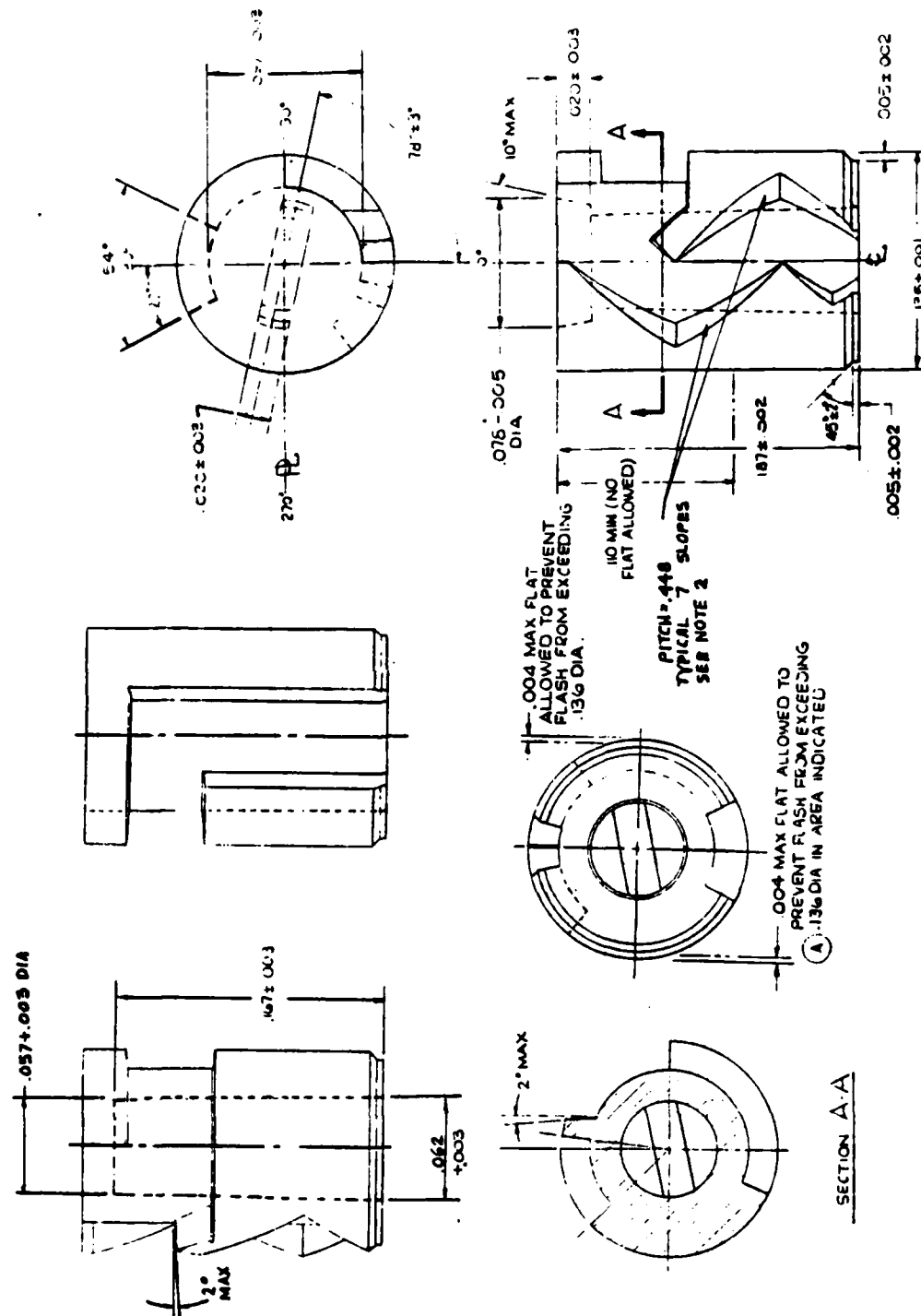
APPENDIX A
REQUIRED DRAWING CHANGES

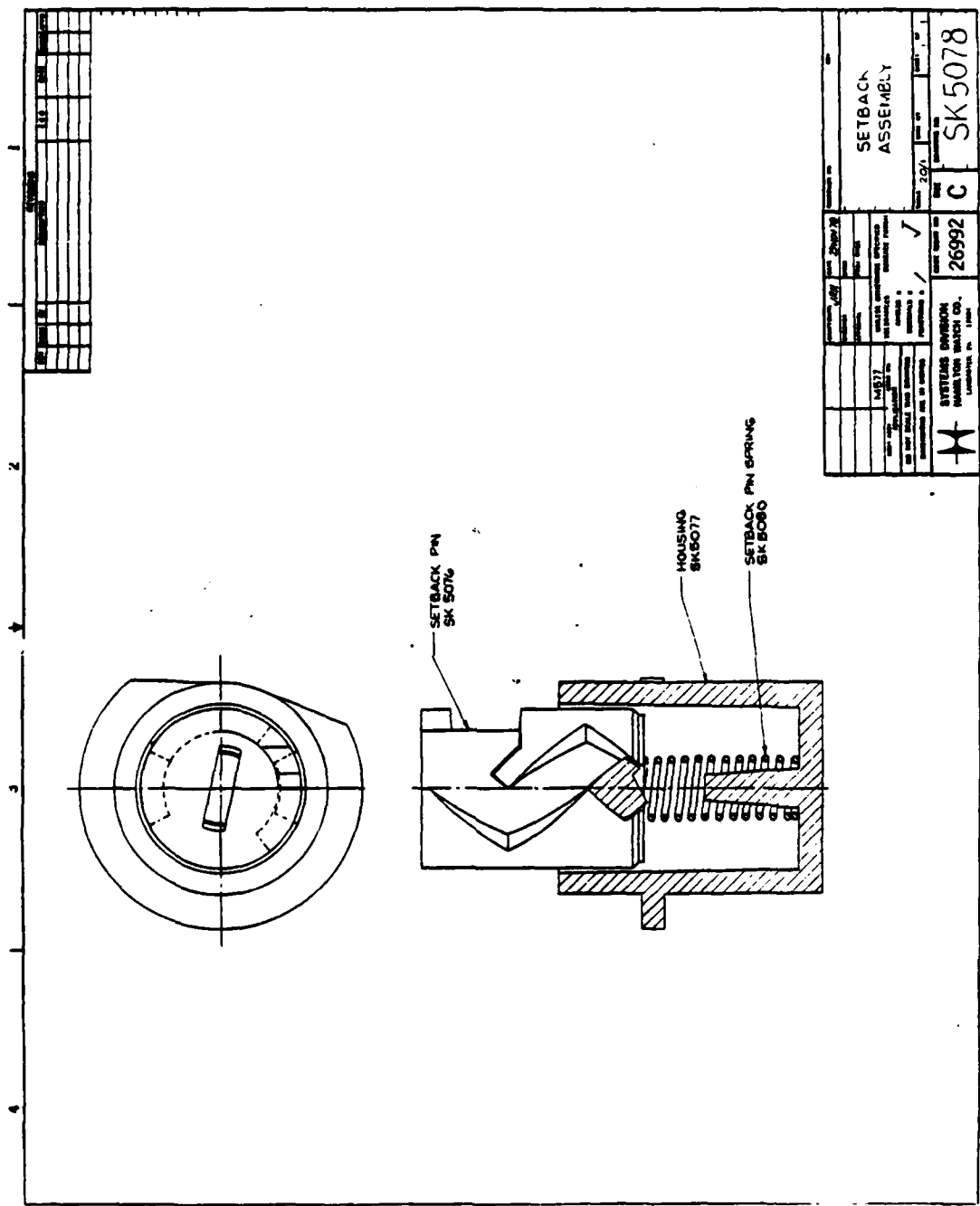
1. MATERIAL - ZINC ALLOY DIE CASTING.
2 WORKING SURFACES OF CAM TO BE RADIAL TO LONGITUDINAL
3 OF AXIS AS SHOWN.
4. UNLESS OTHERWISE NOTED: DRAFT ANGLES NOT TO EXCEED 2° PER SIDE,
FILLET AND CORNERS .004 R MAX.
WITH HOUSING PART NO. 5K 5077



FULL SIZE

[illegible]





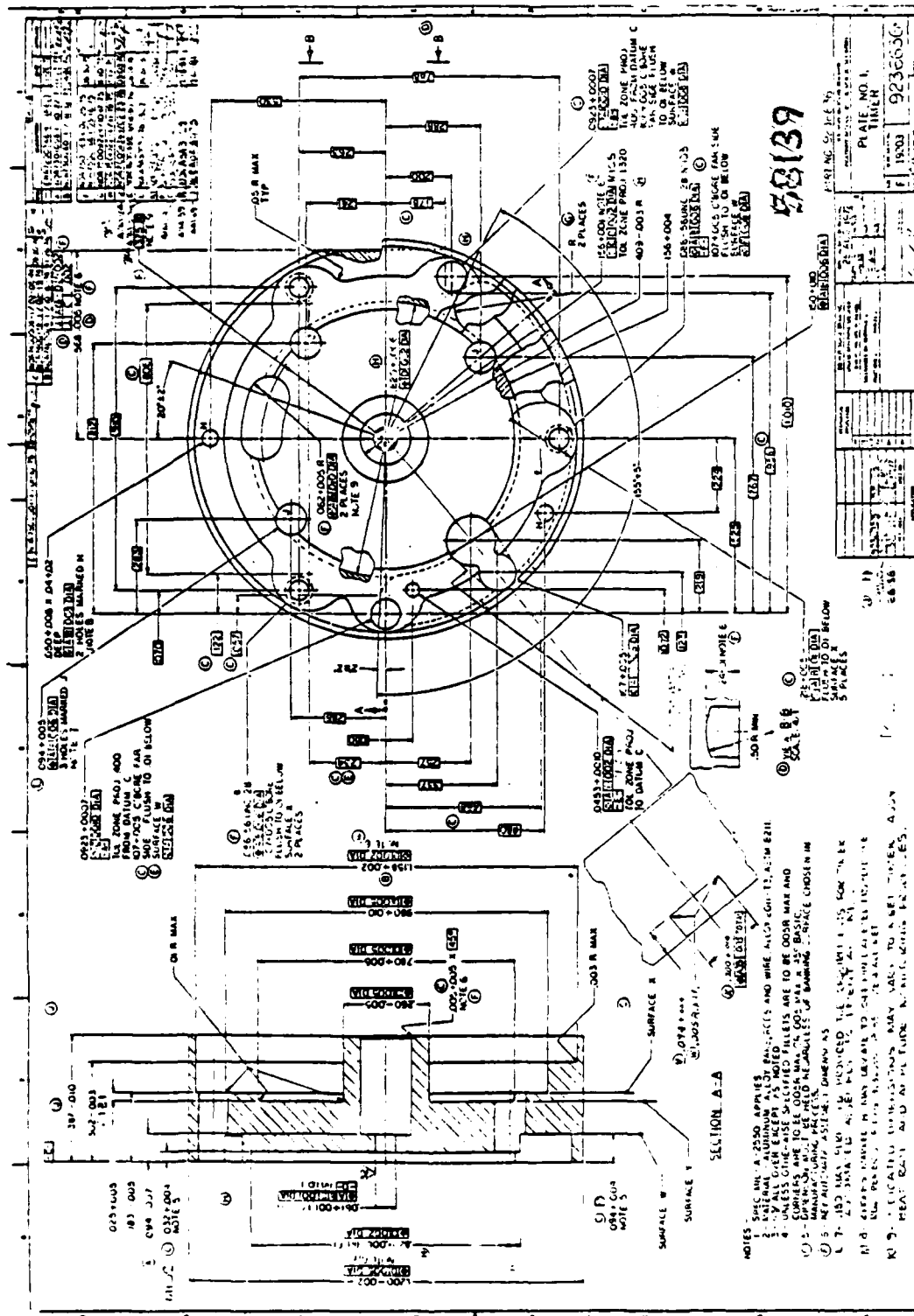
SPRING DATA

1. MATERIAL - CRES 302
2. DIRECTION OF WIND - LEFT HAND
3. SPRING MUST OPERATE FREELY IN .057 DIA BORE
AND OVER .035 DIA PIN
4. LOADS - .119 LB. MIN. (54 GM.) @ .29% LENGTH
.228 LB. MAX (103 GM.) @ .164 LENGTH

1. WIRE SIZE -.006 DIA
2. TOTAL NO. OF TURNS -25
3. STYLE OF ENDS - 1 CLOSED ON EACH END
4. OUTSIDE DIA - .050
5. FREE LENGTH - .426

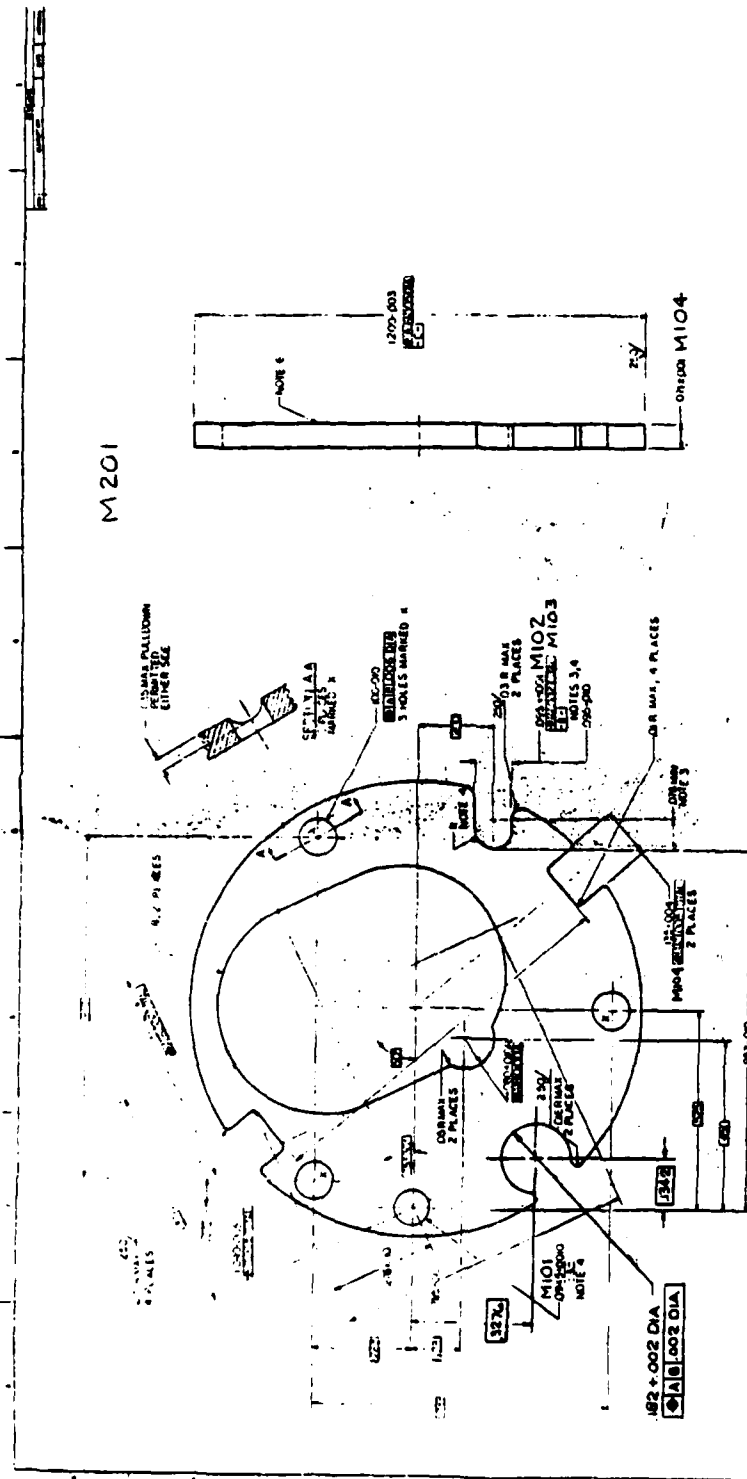
[illegible]

	SYSTEMS DIVISION HAMILTON WATCH CO., LANCASTER, PA. 17604		CODE IDENT NO. 26992		DATE 1-3-79		CUSTOMER NO. SPRING		DRAWING NO. SK 5080		
	DRAFTSMAN JRH		CHECKER		APPROVAL		PROJ. ENGR		SCALE		
NEXT ASBY APPLICATION		USED ON		UNLESS OTHERWISE SPECIFIED SURFACE FINISH		TOLERANCES		ANGLES 2		DECIMALS 2	
DO NOT SCALE THIS DRAWING		FRACTIONS 2		/		/		UNIT WT		SHEET 1 OF 1	
DIMENSIONS ARE IN INCHES		/		/		/		/		/	



53139

005796

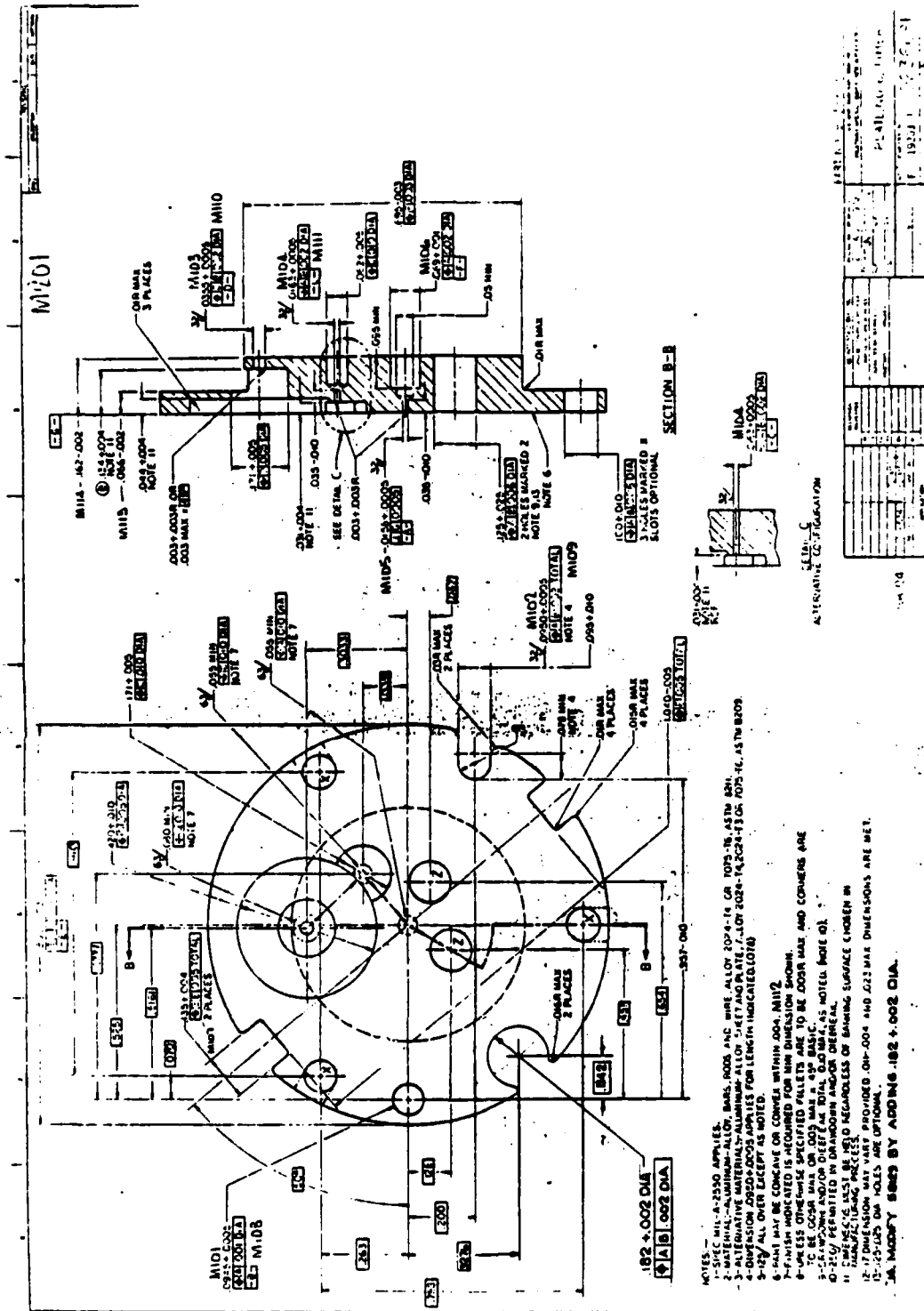


- NOTES
1. ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED.
 2. ALL DIMENSIONS ARE TO BE TAKEN FROM THE OUTSIDE UNLESS OTHERWISE SPECIFIED.
 3. ALL DIMENSIONS ARE TO BE TAKEN FROM THE CENTERLINE UNLESS OTHERWISE SPECIFIED.
 4. ALL DIMENSIONS ARE TO BE TAKEN FROM THE INSIDE UNLESS OTHERWISE SPECIFIED.
 5. ALL DIMENSIONS ARE TO BE TAKEN FROM THE INSIDE UNLESS OTHERWISE SPECIFIED.
 6. ALL DIMENSIONS ARE TO BE TAKEN FROM THE INSIDE UNLESS OTHERWISE SPECIFIED.
 7. ALL DIMENSIONS ARE TO BE TAKEN FROM THE INSIDE UNLESS OTHERWISE SPECIFIED.

REV. 2
A/M 24

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	-----

SK 5141



SK 5142

REV E
A/M 31

APPENDIX B
MODULAR SETBACK PIN
EQUATIONS OF MOTION

M577 Modular Setback Pin

Minimum Velocity Change for Function - Computer Program

Equations from D. L. Overman (Oct. 73)

$$V_{min} = \sum_{i=1}^f V_i$$

$$V_i = A \sqrt{\frac{g K_i}{B}} \cos^{-1} \left[1 - \frac{\frac{F}{A - G_1} \Delta x_i}{\sum_{i=1}^{i-1} \Delta x_i} \right]$$

$$K_i = 1 + \left(\frac{k}{r} \right)^2 \left[\frac{1 + \mu \tan \alpha_i}{\tan \alpha_i (\tan \alpha_i - \mu)} \right]$$

$$\tan \alpha_i = \frac{L_i}{2\pi r}$$

$$B = \frac{G_2 - G_1}{\sum_{i=1}^f \Delta x_i}$$

Variables

DLO Comp. Prog.

k	K	radius of gyration	inches
r	R	radius of interaction	inches
L		helix lead	in/turn
	AL	helix lead angle	degrees
μ	MU	coefficient of friction	
G_1	G1	spring bias, safe position	g's
G_2	G2	spring bias, armed position	g's
Δx_i		length of i th leg	inches
	X1	length of first leg	inches
	X2	length of second leg	inches
	X3	length of third leg	inches
A		driving acceleration	g's
	AI	driving acceleration, first iteration	g's
	AF	driving acceleration, final iteration	g's
	I	increment of iteration	g's

$F = 1$ for all legs except final

$$F = \frac{G_2 - .5 B \Delta x_F}{A}$$

APPENDIX C
MODULAR SETBACK PIN
COMPUTER SIMULATION PROGRAM

APPENDIX C MODULAR SETBACK PIN COMPUTER SIMULATION

```

10 DEF FNACS(X)=ATN(SQR((1-X^2)/X^2))
20 DEF FNNCS(X)=(PI/2-FNACS(X))+PI/2
30 PI=3.141592654#
40 READ K,R,A4,G1,G2,X1,X2,X3,M1,A5,A6,I
50 DATA .0474,.0575,51.14,138,247,.0327,.0654,.0327,.3,300,2000,25
60 INPUT "MU=";M1
70 INPUT "AI=";A5
80 INPUT "AF=";A6
90 INPUT "I=";I
100 PRINT "-----"
110 PRINT "      K=";K;" INCH"
120 PRINT "      R=";R;" INCH"
130 PRINT "      AL=";A4;" DEG"
140 PRINT "      MU=";M1;" FRICTION"
150 PRINT "      G1=";G1;" G/S"
160 PRINT "      G2=";G2;" G/S"
170 PRINT "      X1=";X1;" INCH"
180 PRINT "      X2=";X2;" INCH"
190 PRINT "      X3=";X3;" INCH"
200 PRINT "      AI=";A5;" G/S"
210 PRINT "      AF=";A6;" G/S"
220 PRINT "      I=";I;" G/S"
230 PRINT "-----"
240 PRINT "SETBACK          TIME "
250 PRINT " (G/S)          (SEC)"
260 A4=A4*2*PI/360
270 X=TAN(A4)
280 IF M1>X THEN PRINT "TOO MUCH FRICTION"
290 K1=1+(K/R)^2*((1+M1*X)/(X*(X-M1)))
300 S9=X1+X2+X3
310 B=(G2-G1)/S9
320 S8=SQR(.386+.088*K1/B)
330 F1=I
340 S1=0
350 S2=X1
360 S3=X1+X2
370 FOR A=A5 TO A6 STEP I
380 F3=(G2-.5*B*X3)/A
390 A1=1-F1*X1/((A-G1)/B-S1)
400 A2=1-F1*X2/((A-G1)/B-S2)
410 A3=1-F3*X3/((A-G1)/B-S3)
420 Z1=ABS(A1)
430 Z2=ABS(A2)
440 Z3=ABS(A3)
450 IF Z1>1 OR Z2>1 OR Z3>1 THEN P3=1:GOTO 630
460 IF A1=0 THEN B1=PI/2
470 IF A2=0 THEN B2=PI/2
480 IF A3=0 THEN B3=PI/2
490 IF A1<0 THEN B1=FNNCS(A1)
500 IF A2<0 THEN B2=FNNCS(A2)
510 IF A3<0 THEN B3=FNNCS(A3)
520 IF A1>0 THEN B1=FNACS(A1)
530 IF A2>0 THEN B2=FNACS(A2)
540 IF A3>0 THEN B3=FNACS(A3)
550 V1=A*S8*B1
560 V2=A*S8*B2
570 V3=A*S8*B3
580 V=(V1+V2+V3)/12
590 IF A=A5 THEN V9=V
600 IF V<V9 THEN V9=V:H=1
610 IF V>V9 AND H=1 THEN H=2
620 T=V/(A*32.174)
630 IF P3=1 THEN PRINT A;"          PIN WILL NOT ARM WITH GIVEN DATA"
640 IF P3=0 THEN PRINT A,V,T
650 P3=0
660 NEXT A
670 PRINT "-----"
680 D9=.5*V9^2/32.174
690 IF H=2 THEN PRINT "MAX SAFE DROP HEIGHT=";D9;" FT"
700 IF H<>2 THEN PRINT "INSUFFICIENT RANGE TO DETERMINE MAX SAFE DROP HEIGHT"
710 END

```

APPENDIX D
EVALUATION OF COMPUTER
SIMULATION PARAMETERS

Appendix D Evaluation of Parameters used in Computer Program

Radius of gyration is defined by:

$$I = K^2 M$$

and

$$I = \int r^2 dm$$

where

I = moment of inertia

K = radius of gyration

M = mass of pin

dm = element of mass

r = distance from axis to element of mass

The moment of inertia of a complex body can be computed by breaking it into smaller bodies and adding the moments of inertia of its components, thus:

$$I = \sum I_i$$

The pin is divided into the following component bodies:

1. Main cylinder
2. Internal cylinder
3. Screwdriver slot
4. Entry groove
5. Circumferential groove
6. Zig-zag groove
7. Bottom groove

The moment of inertia of each is computed by:

1. Main cylinder

$$I_1 = 1/2 M r^2$$

$$M_1 = \rho \pi r^2 \ell$$

where:

r = radius of cylinder .0675 in.

ℓ = length of cylinder .187 in.

ρ = density of zinc (experimentally determined) .22 lb./in.³

$$I_1 = 1.341 \times 10^{-6} \text{ lb. in.}^2$$

$$M_1 = 5.889 \times 10^{-4} \text{ lb.}$$

2. Internal cylinder

r = .032 in.

ℓ = .167 in.

$$M_2 = 1.182 \times 10^{-4} \text{ lb.}$$

$$I_2 = 6.052 \times 10^{-8} \text{ lb. in.}^2$$

3. Screwdriver slot

$$M_3 = \rho 2\ell hb$$

$$I_3 = M \left(\frac{\ell^2}{3} + \frac{h^2}{12} \right)$$

ℓ = half of slot length .0365

h = width of slot .020

b = height of slot .020

$$M_3 = 6.424 \times 10^{-6} \text{ lb.}$$

$$I_3 = 3.067 \times 10^{-9} \text{ lb. in.}^2$$

4. Entry groove

$$I_4 = \int r^2 dm$$

$$M_4 = \int dm$$

$$dm = \rho \theta h r dr$$

$$M_4 = \rho \theta h \int r dr$$

$$I_4 = \rho \theta h \int r^3 dr$$

$$M_4 = \frac{1}{2} \rho \theta h (r_2^2 - r_1^2)$$

$$I_4 = \frac{1}{4} \rho \theta h (r_2^4 - r_1^4)$$

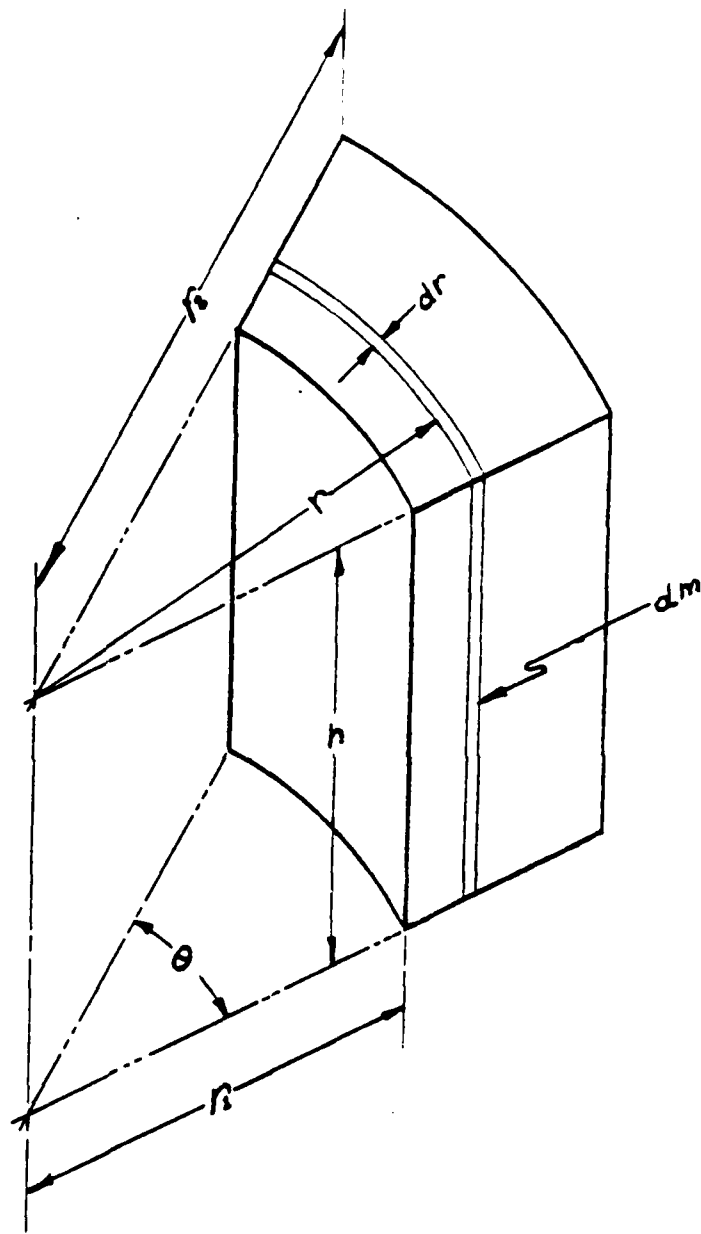
dm = element of mass

r = radius to dm

dr = thickness of dm

h = height of groove .160 in.

θ = angle subtended by groove .945 radians



r_1 = inside radius of groove .048 in.

r_2 = outside radius of groove .068 in.

$M_4 = 3.858 \times 10^{-5}$ lb.

$I_4 = 1.337 \times 10^{-7}$ lb. in.²

5. Circumferential groove

$M_5 = 1/2 \rho \theta h r_2^4 - r_1^2$

$I_5 = 1/4 \rho \theta h r_2^4 - r_1^4$

$\theta = 2.466$ radians

$h = .055$ in.

$M_5 = 3.461 \times 10^{-5}$ lb.

$I_5 = 1.199 \times 10^{-7}$ lb. in.²

6. Zig-zag groove

$M_6 = 1/2 \rho \theta h r_2^2 - r_1^2$

$I_6 = 1/4 \rho \theta h r_2^4 - r_1^4$

$\theta = .917$ radians

$h = .187$ in.

$M_6 = 4.376 \times 10^{-5}$ lb.

$I_6 = 1.516 \times 10^{-7}$ lb. in.²

7. Bottom groove

$M_7 = \rho \pi h (r_2^2 - r_1^2)$

$I_7 = 1/2 M_7 (r_2^2 + r_1^2)$

$h = .0075$ in.

$r_1 = .063$ in.

$r_2 = .068$ in.

$M_7 = 3.395 \times 10^{-6}$ lb.

$I_7 = 1.458 \times 10^{-8}$ lb. in.²

The total mass is:

$$M = M_1 - M_2 - M_3 - M_4 - M_5 - M_6 - M_7$$

$$M = 3.439 \times 10^{-4} \text{ lb.}$$

The total moment of inertia is:

$$I = I_1 - I_2 - I_3 - I_4 - I_5 - I_6 - I_7$$

$$I = 8.576 \times 10^{-7} \text{ lb. in.}^2$$

The radius of gyration, k , is determined by:

$$K = \left(\frac{I}{M}\right)^{1/2}$$

$$K = .0499 \text{ in.}$$

Radius of interaction

The radius of interaction is approximated as occurring at half of the depth of the groove, or .058 inches.

Helix Lead Angle

The helix lead angle is taken at the radius of interaction.

$$AL = \tan^{-1} (a/c)$$

where:

AL = helix lead angle

a = axial displacement = .0654 in. for second leg

c = circumferential displacement = .0532 in. at .058 in. radius

AL = 50.87° , or .888 radians

Spring forces

The spring is specified as:

.119 lb. at .296 in.

.228 lb. at .164 in.

The spring rate is therefore:

$$R = -.8258 \text{ lb./in.}$$

and the spring equation is:

$$F = -.8258 L + .3634$$

Starting and finishing spring lengths are:

$$L_1 = .2986 \text{ in.}$$

$$L_2 = .1715 \text{ in.}$$

So starting and finishing spring forces are:

$$F_1 = .1168 \text{ lb.}$$

$$F_2 = .2218 \text{ lb.}$$

Since the pin weight was determined to be 3.341×10^{-4} lb, the starting and finishing loads in g's are:

$$G_1 = 350 \text{ g}$$

$$G_2 = 664 \text{ g}$$

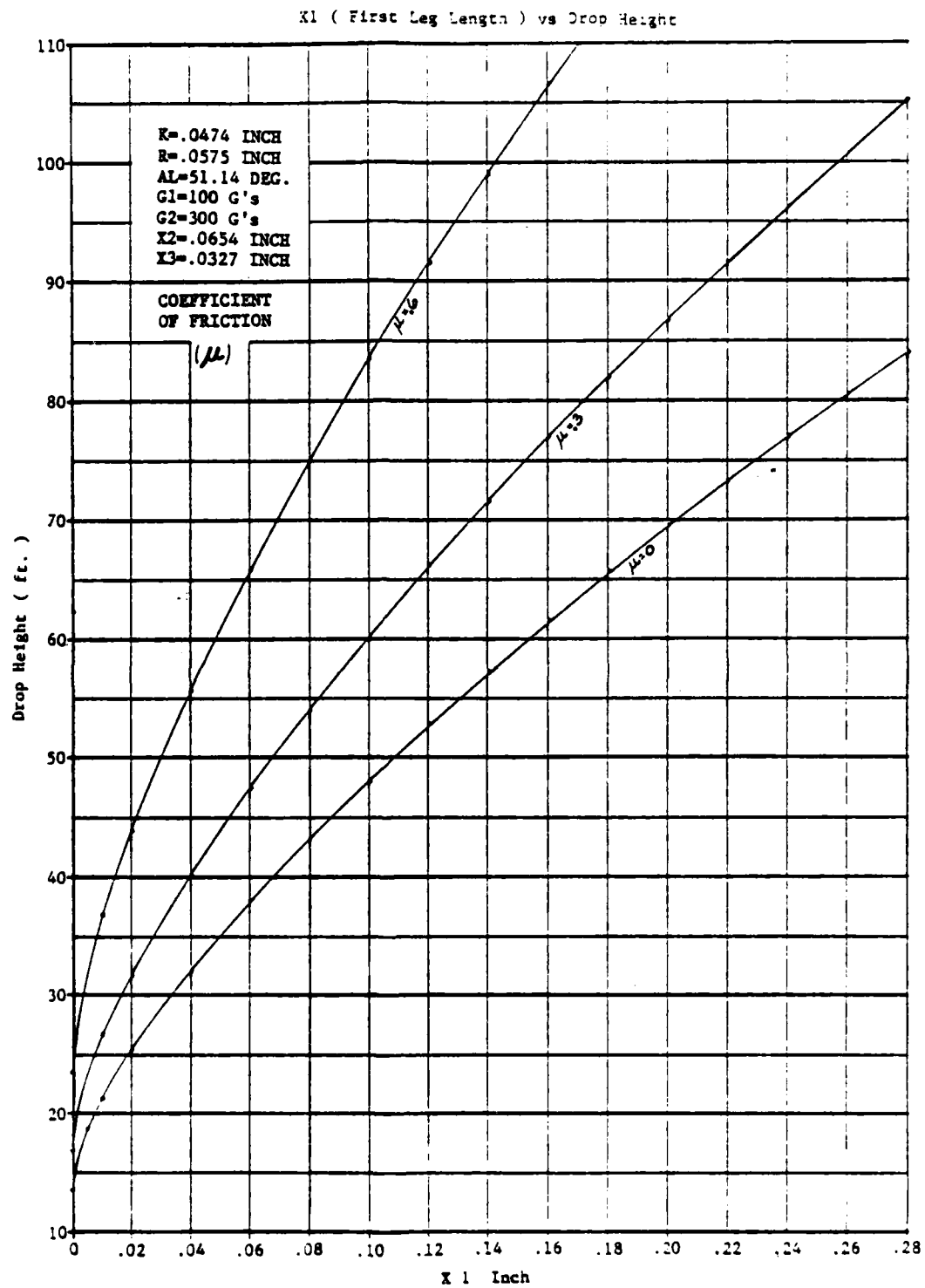
APPENDIX E
SETBACK MAGNITUDE
VERSUS
TIME REQUIRED FOR
MSP TO FUNCTION

SETBACK VERSUS TIME REQUIRED TO FUNCTION

61

APPENDIX F

A RELATIVE COMPARISON OF NINE DESIGN FEATURES
AS THEY RELATE TO DROP HEIGHT



 K= .0474 INCH
 N= .0575 INCH
 AL= 51.14 DEG
 MU= 0 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(X1) (IN)	DROP HEIGHT (FT)
0.000	13.683
0.005	18.829
0.010	21.416
0.015	23.592
0.020	25.555
0.025	27.378
0.030	29.100
0.035	30.743
0.040	32.322
0.045	33.846
0.050	35.324
0.055	36.761
0.060	38.162
0.065	39.529
0.070	40.867
0.075	42.177
0.080	43.463
0.085	44.725
0.090	45.965
0.095	47.185
0.100	48.386
0.105	49.570
0.110	50.736
0.115	51.887
0.120	53.023
0.125	54.144
0.130	55.252
0.135	56.348
0.140	57.431
0.145	58.502
0.150	59.562

0.155	60.611
0.160	61.650
0.165	62.680
0.170	63.699
0.175	64.710
0.180	65.712
0.185	66.705
0.190	67.691
0.195	68.668
0.200	69.638
0.205	70.601
0.210	71.556
0.215	72.505
0.220	73.447
0.225	74.383
0.230	75.312
0.235	76.236
0.240	77.153
0.245	78.065
0.250	78.971
0.255	79.872
0.260	80.768
0.265	81.659
0.270	82.544
0.275	83.425
0.280	84.301
0.285	85.173
0.290	86.040
0.295	86.903
0.300	87.761

 K= .0474 INCH
 R= .0575 INCH
 AL= 51.14 DEG
 MU= .3 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 AI= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(X1) (IN) DROP HEIGHT (FT)

0.000	17.075	0.160	76.933
0.005	23.496	0.165	78.218
0.010	26.725	0.170	79.490
0.015	29.441	0.175	80.752
0.020	31.890	0.180	82.002
0.025	34.165	0.185	83.242
0.030	36.314	0.190	84.471
0.035	38.364	0.195	85.691
0.040	40.334	0.200	86.902
0.045	42.237	0.205	88.103
0.050	44.081	0.210	89.295
0.055	45.874	0.215	90.479
0.060	47.622	0.220	91.655
0.065	49.329	0.225	92.822
0.070	50.998	0.230	93.982
0.075	52.633	0.235	95.134
0.080	54.237	0.240	96.280
0.085	55.812	0.245	97.417
0.090	57.360	0.250	98.549
0.095	58.882	0.255	99.673
0.100	60.381	0.260	100.790
0.105	61.858	0.265	101.902
0.110	63.314	0.270	103.007
0.115	64.750	0.275	104.106
0.120	66.167	0.280	105.200
0.125	67.567	0.285	106.287
0.130	68.949	0.290	107.369
0.135	70.316	0.295	108.446
0.140	71.668	0.300	109.517
0.145	73.004		
0.150	74.327		
0.155	75.637		

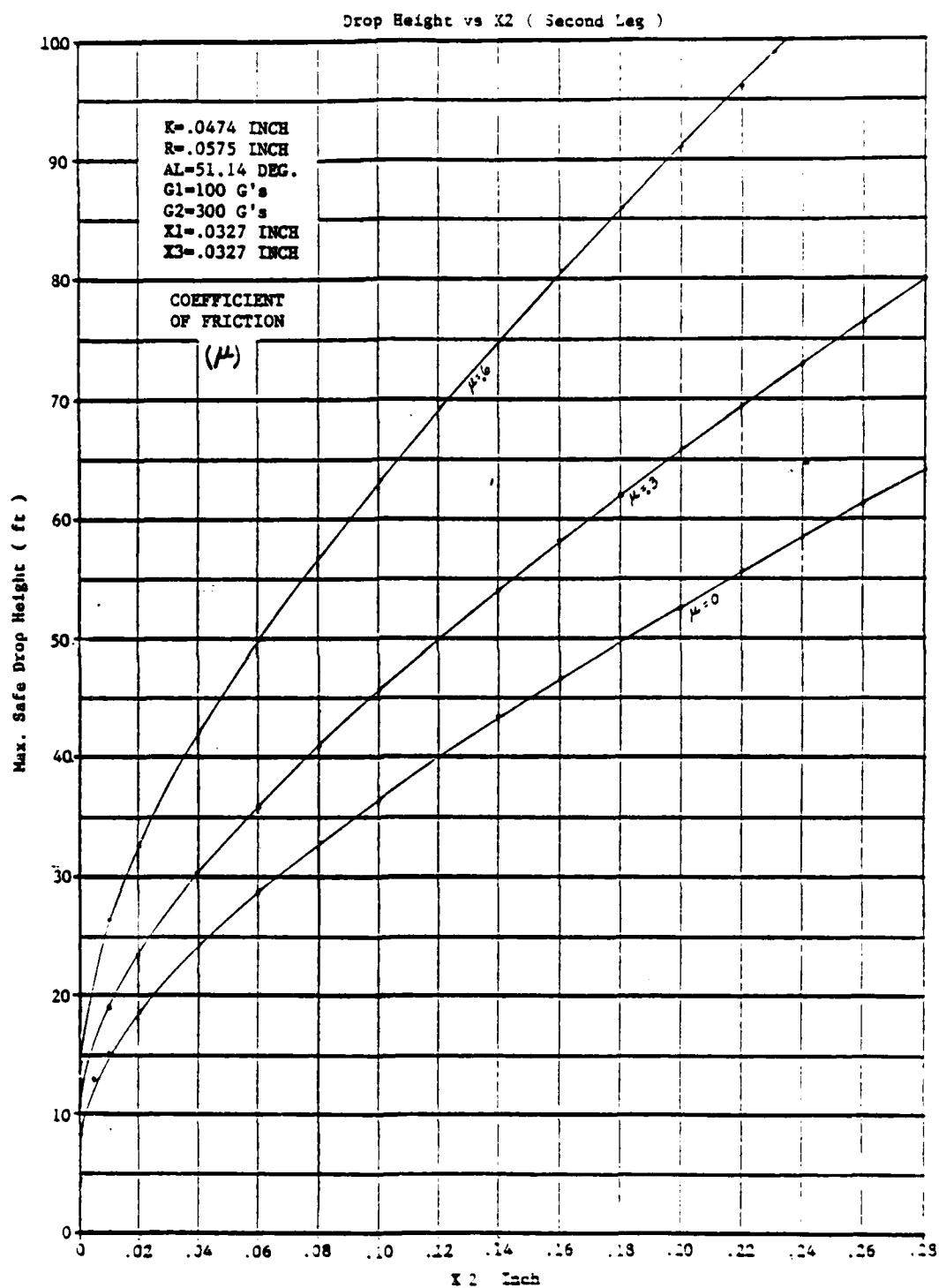
```

*****
K= .0474 INCH
R= .0575 INCH
AL= 51.14 DEG
MU= .6 FRICTION
Q1= 100 G'S
Q2= 300 G'S
X1= .0327 INCH
X2= .0654 INCH
X3= .0327 INCH
A1= 301 G'S
AF= 2000 G'S
I= 1 G'S
*****

```

(X1) (IN) DROP HEIGHT (FT)

0.000	23.641	104.725
0.005	32.533	106.520
0.010	37.003	108.298
0.015	40.763	110.060
0.020	44.154	111.806
0.025	47.304	113.538
0.030	50.279	115.254
0.035	53.118	116.957
0.040	55.846	118.646
0.045	58.480	120.322
0.050	61.034	121.985
0.055	63.516	123.636
0.060	65.936	125.275
0.065	68.299	126.903
0.070	70.610	128.519
0.075	72.875	130.125
0.080	75.095	131.721
0.085	77.276	133.306
0.090	79.419	134.882
0.095	81.527	136.448
0.100	83.602	138.004
0.105	85.647	139.552
0.110	87.663	141.091
0.115	89.651	142.621
0.120	91.613	144.143
0.125	93.551	145.657
0.130	95.466	147.163
0.135	97.358	148.661
0.140	99.229	150.152
0.145	101.080	151.635
0.150	102.912	



 K= .0474 INCH
 R= .0575 INCH
 AL= 51.14 DEG
 MU= 0 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(X2) (IN)	DROP HEIGHT (FT)	
0.000	8.401	45.942
0.005	13.078	46.733
0.010	15.351	47.517
0.015	17.213	48.294
0.020	18.855	49.065
0.025	20.354	49.830
0.030	21.748	50.589
0.035	23.063	51.342
0.040	24.314	52.091
0.045	25.512	52.833
0.050	26.665	53.571
0.055	27.780	54.305
0.060	28.861	55.033
0.065	29.913	55.758
0.070	30.938	56.478
0.075	31.940	57.193
0.080	32.921	57.905
0.085	33.882	58.613
0.090	34.825	59.317
0.095	35.752	60.018
0.100	36.664	60.715
0.105	37.562	61.409
0.110	38.446	62.099
0.115	39.319	62.786
0.120	40.180	63.470
0.125	41.031	64.151
0.130	41.872	64.829
0.135	42.703	65.504
0.140	43.525	66.176
0.145	44.339	66.846
0.150	45.144	
		0.155
		0.160
		0.165
		0.170
		0.175
		0.180
		0.185
		0.190
		0.195
		0.200
		0.205
		0.210
		0.215
		0.220
		0.225
		0.230
		0.235
		0.240
		0.245
		0.250
		0.255
		0.260
		0.265
		0.270
		0.275
		0.280
		0.285
		0.290
		0.295
		0.300

K= .0474 INCH
R= .0575 INCH
AL= 51.14 DEG
AU= .3 FRICTION
Q1= 100 G'S
Q2= 300 G'S
X1= .0327 INCH
X2= .0654 INCH
X3= .0327 INCH
A1= 301 G'S
AF= 2000 G'S
I= 1 G'S

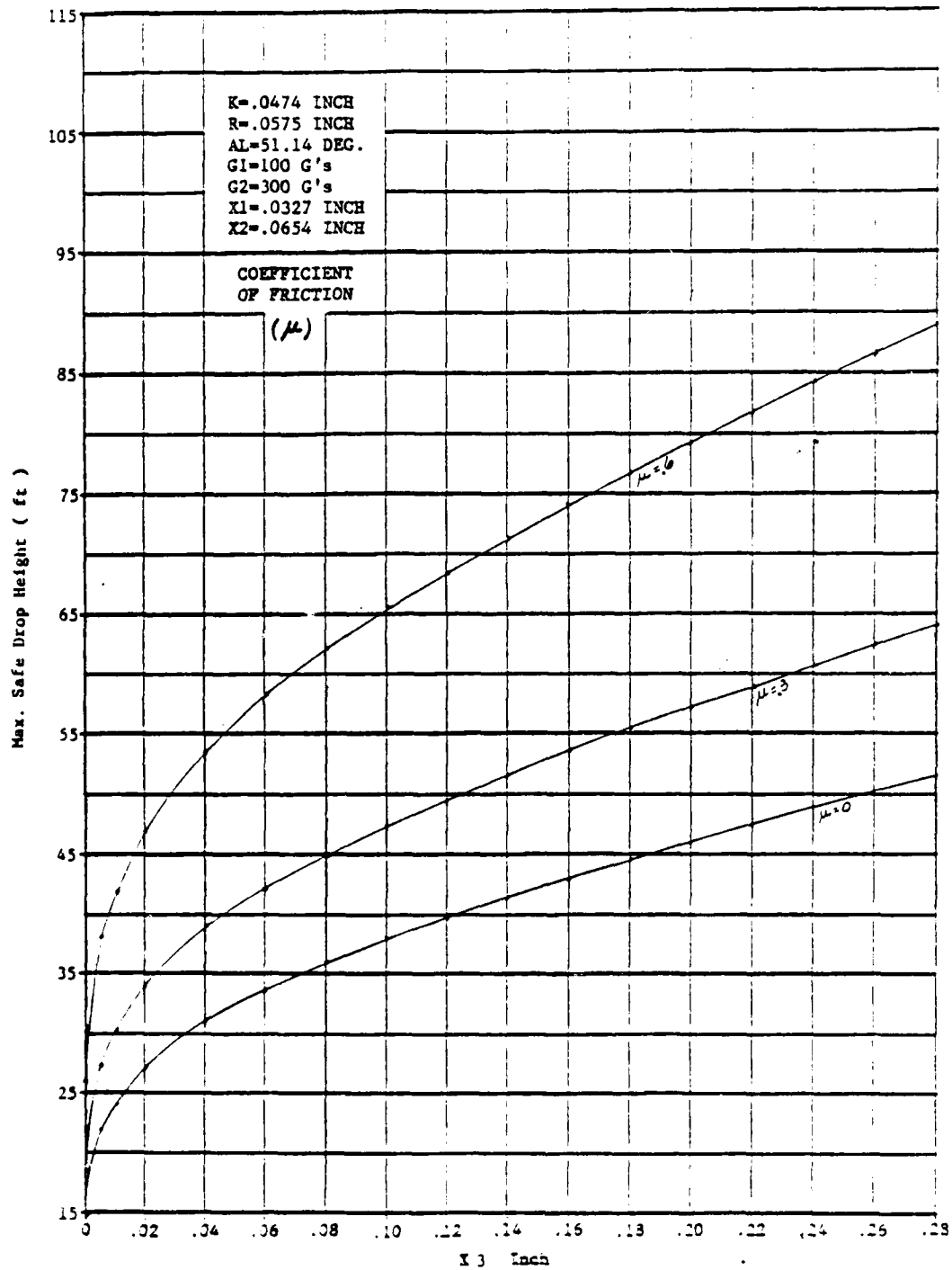
(X2) (IN) DROP HEIGHT (FT)

0.000	10.484	0.155	57.331
0.005	16.320	0.160	58.318
0.010	19.157	0.165	59.296
0.015	21.480	0.170	60.266
0.020	23.529	0.175	61.228
0.025	25.399	0.180	62.183
0.030	27.140	0.185	63.130
0.035	28.781	0.190	64.070
0.040	30.341	0.195	65.004
0.045	31.836	0.200	65.931
0.050	33.275	0.205	66.852
0.055	34.666	0.210	67.767
0.060	36.016	0.215	68.676
0.065	37.328	0.220	69.580
0.070	38.608	0.225	70.478
0.075	39.858	0.230	71.372
0.080	41.082	0.235	72.260
0.085	42.281	0.240	73.143
0.090	43.458	0.245	74.022
0.095	44.615	0.250	74.896
0.100	45.753	0.255	75.766
0.105	46.873	0.260	76.632
0.110	47.977	0.265	77.493
0.115	49.066	0.270	78.351
0.120	50.141	0.275	79.204
0.125	51.203	0.280	80.054
0.130	52.252	0.285	80.901
0.135	53.289	0.290	81.742
0.140	54.315	0.295	82.581
0.145	55.330	0.300	83.417
0.150	56.336		

 K= .0474 INCH
 H= .0575 INCH
 AL= 51.14 DEG
 MU= .6 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 AL= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(X2) (IN)	DROP HEIGHT (FT)	
0.000	14.616	79.380
0.005	22.596	80.746
0.010	26.524	82.100
0.015	29.741	83.443
0.020	32.578	84.775
0.025	35.167	86.096
0.030	37.577	87.408
0.035	39.849	88.710
0.040	42.010	90.003
0.045	44.080	91.286
0.050	46.072	92.561
0.055	47.998	93.828
0.060	49.866	95.087
0.065	51.684	96.339
0.070	53.455	97.583
0.075	55.186	98.820
0.080	56.881	100.049
0.085	58.541	101.273
0.090	60.171	102.489
0.095	61.773	103.700
0.100	63.348	104.904
0.105	64.899	106.102
0.110	66.428	107.295
0.115	67.936	108.482
0.120	69.424	109.664
0.125	70.894	110.841
0.130	72.346	112.012
0.135	73.782	113.178
0.140	75.203	114.340
0.145	76.609	115.497
0.150	78.001	

Drop Height vs X3 (Third Leg)



 K= .0474 INCH
 R= .0575 INCH
 AL= 51.14 DEG
 MU= 0 FRICTION
 U1= 100 G'S
 U2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(X3) (IN)	DROP HEIGHT (FT)	
0.000	15.046	42.602
0.005	21.078	42.991
0.010	24.358	43.375
0.015	26.048	43.756
0.020	27.393	44.134
0.025	28.524	44.509
0.030	29.510	44.880
0.035	30.389	45.249
0.040	31.186	45.615
0.045	31.924	45.979
0.050	32.610	46.340
0.055	33.254	46.699
0.060	33.865	47.056
0.065	34.446	47.410
0.070	35.003	47.763
0.075	35.540	48.114
0.080	36.058	48.462
0.085	36.560	48.809
0.090	37.048	49.154
0.095	37.523	49.498
0.100	37.988	49.840
0.105	38.442	50.180
0.110	38.888	50.519
0.115	39.325	50.856
0.120	39.755	51.192
0.125	40.178	51.526
0.130	40.595	51.859
0.135	41.006	52.191
0.140	41.412	52.521
0.145	41.814	52.851
0.150	42.210	
		0.155
		0.160
		0.165
		0.170
		0.175
		0.180
		0.185
		0.190
		0.195
		0.200
		0.205
		0.210
		0.215
		0.220
		0.225
		0.230
		0.235
		0.240
		0.245
		0.250
		0.255
		0.260
		0.265
		0.270
		0.275
		0.280
		0.285
		0.290
		0.295
		0.300

K= .0474 INCH
R= .0575 INCH
AL= 51.14 DEG
MU= .3 FRICTION
G1= 100 G'S
G2= 300 G'S
X1= .0327 INCH
X2= .0654 INCH
X3= .0327 INCH
A1= 301 G'S
AF= 2000 G'S
I= 1 G'S

----- DROP HEIGHT (FT) -----

(X3) (IN)		
0.000	18.776	53.164
0.005	23.421	53.648
0.010	30.396	54.128
0.015	32.506	54.604
0.020	34.184	55.075
0.025	35.595	55.542
0.030	36.825	56.006
0.035	37.923	56.466
0.040	38.920	56.923
0.045	39.838	57.377
0.050	40.694	57.828
0.055	41.498	58.276
0.060	42.260	58.721
0.065	42.986	59.163
0.070	43.681	59.603
0.075	44.350	60.041
0.080	44.996	60.476
0.085	45.623	60.909
0.090	46.232	61.340
0.095	46.825	61.768
0.100	47.405	62.195
0.105	47.972	62.619
0.110	48.528	63.042
0.115	49.074	63.463
0.120	49.610	63.882
0.125	50.138	64.299
0.130	50.659	64.715
0.135	51.172	65.129
0.140	51.679	65.541
0.145	52.179	65.952
0.150	52.674	

```

*****
K= .0474 INCH
R= .0575 INCH
AL= 51.14 DEG
MU= .6 FRICTION
G1= 100 G'S
G2= 300 G'S
X1= .0327 INCH
X2= .0654 INCH
X3= .0327 INCH
AL= 301 G'S
AF= 2000 G'S
I= 1 G'S
*****

```

(X3) (IN)	DRIP HEIGHT (FT)
0.000	25.997
0.005	37.914
0.010	42.085
0.015	45.006
0.020	47.330
0.025	49.284
0.030	50.987
0.035	52.506
0.040	53.887
0.045	55.159
0.050	56.343
0.055	57.457
0.060	58.512
0.065	59.517
0.070	60.479
0.075	61.406
0.080	62.301
0.085	63.168
0.090	64.011
0.095	64.833
0.100	65.635
0.105	66.421
0.110	67.190
0.115	67.946
0.120	68.689
0.125	69.420
0.130	70.141
0.135	70.851
0.140	71.553
0.145	72.246
0.150	72.931

```

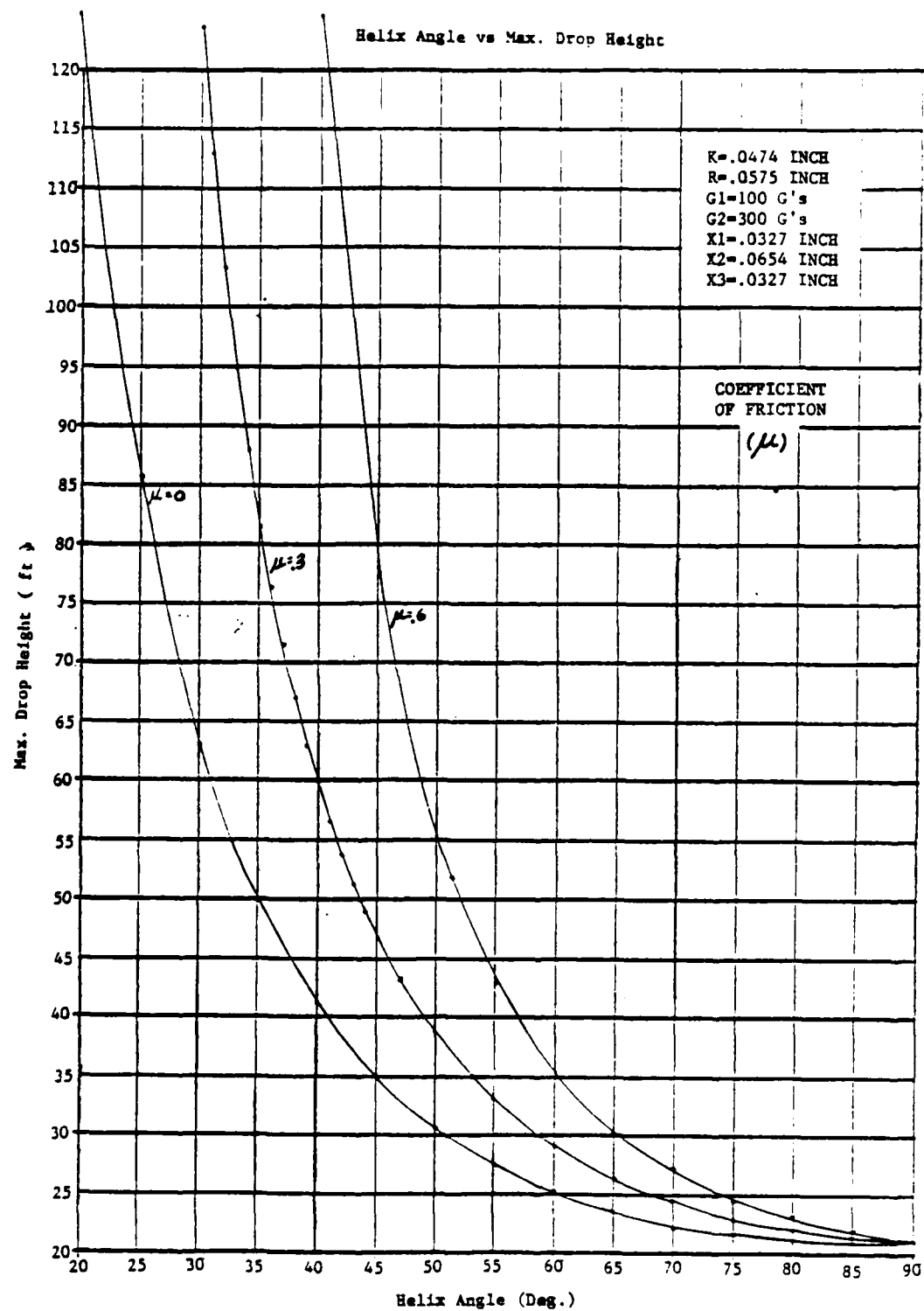
0.155
0.160
0.165
0.170
0.175
0.180
0.185
0.190
0.195
0.200
0.205
0.210
0.215
0.220
0.225
0.230
0.235
0.240
0.245
0.250
0.255
0.260
0.265
0.270
0.275
0.280
0.285
0.290
0.295
0.300

```

```

73.609
74.280
74.944
75.603
76.255
76.903
77.545
78.182
78.815
79.443
80.067
80.687
81.304
81.916
82.525
83.131
83.734
84.333
84.929
85.523
86.114
86.701
87.287
87.869
88.450
89.027
89.603
90.176
90.747
91.316

```



 K= .0474 INCH
 R= .10575 INCH
 AL= 51.14 DEG
 MU= 0 FRICTION
 U1= 100 G'S
 U2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2100 G'S
 I= 1 G'S

(AL) (DEG)	DROP HEIGHT (FT)	
1.000	29.996	29.996
2.000	29.996	29.996
3.000	29.996	29.996
4.000	29.996	29.996
5.000	29.996	29.996
6.000	29.996	29.996
7.000	29.996	29.996
8.000	29.996	29.996
9.000	29.996	29.996
10.000	29.996	29.996
11.000	29.996	29.996
12.000	29.996	29.996
13.000	29.996	29.996
14.000	29.996	29.996
15.000	29.996	29.996
16.000	29.996	29.996
17.000	29.996	29.996
18.000	29.996	29.996
19.000	29.996	29.996
20.000	29.996	29.996
21.000	29.996	29.996
22.000	29.996	29.996
23.000	29.996	29.996
24.000	29.996	29.996
25.000	29.996	29.996
26.000	29.996	29.996
27.000	29.996	29.996
28.000	29.996	29.996
29.000	29.996	29.996
30.000	29.996	29.996
31.000	29.996	29.996
32.000	29.996	29.996
33.000	29.996	29.996
34.000	29.996	29.996
35.000	29.996	29.996
36.000	29.996	29.996
37.000	29.996	29.996
38.000	29.996	29.996
39.000	29.996	29.996
40.000	29.996	29.996
41.000	29.996	29.996
42.000	29.996	29.996
43.000	29.996	29.996
44.000	29.996	29.996
45.000	29.996	29.996

46.000
 47.000
 48.000
 49.000
 50.000
 51.000
 52.000
 53.000
 54.000
 55.000
 56.000
 57.000
 58.000
 59.000
 60.000
 61.000
 62.000
 63.000
 64.000
 65.000
 66.000
 67.000
 68.000
 69.000
 70.000
 71.000
 72.000
 73.000
 74.000
 75.000
 76.000
 77.000
 78.000
 79.000
 80.000
 81.000
 82.000
 83.000
 84.000
 85.000
 86.000
 87.000
 88.000
 89.000
 90.000

 K= .0474 INCH
 R= .0575 INCH
 AL= 51.14 DEG
 MU= .3 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

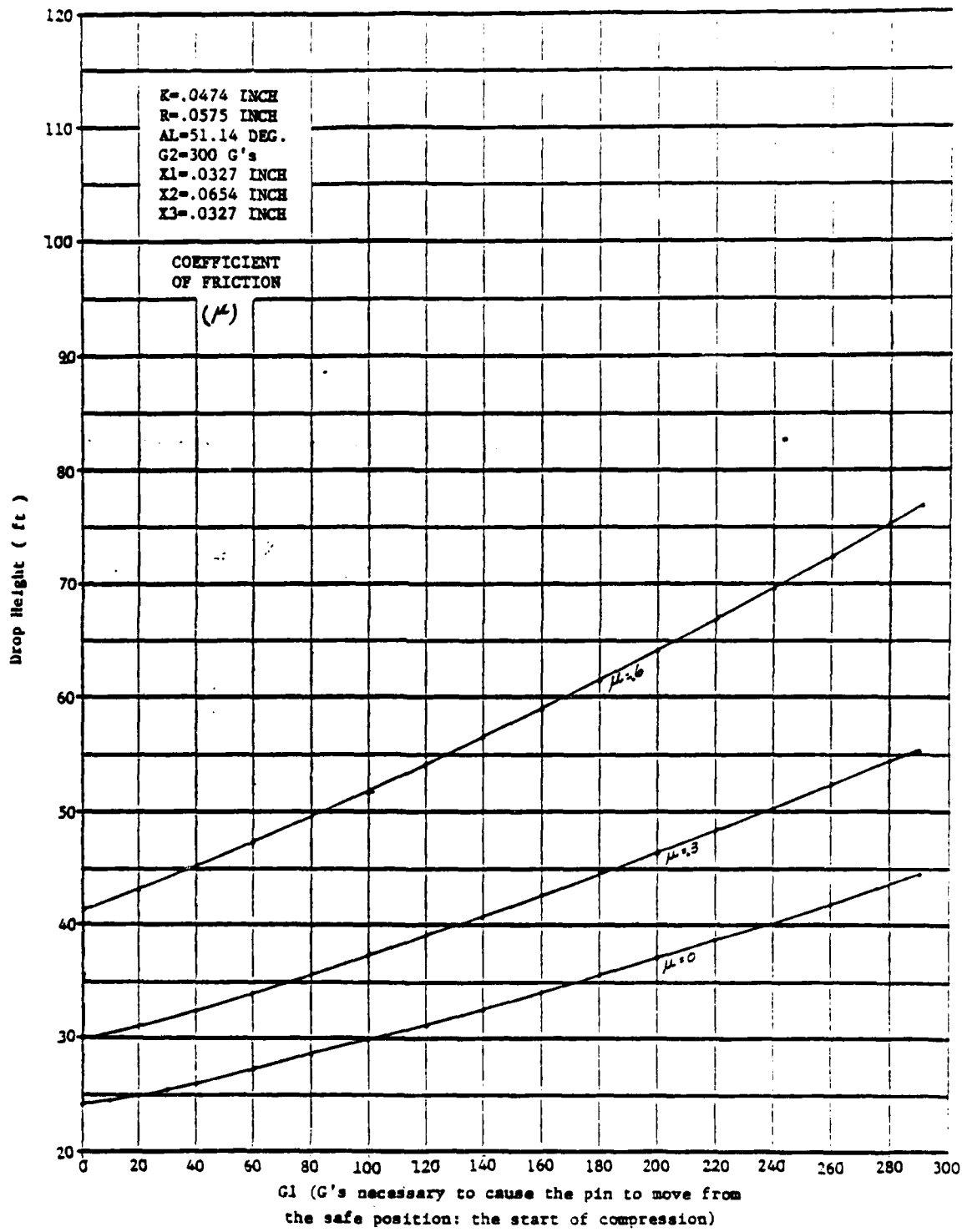
(AL) IDEG)	DROP HEIGHT (FT)	
1.000	37.432	37.432
2.000	37.432	37.432
3.000	37.432	37.432
4.000	37.432	37.432
5.000	37.432	37.432
6.000	37.432	37.432
7.000	37.432	37.432
8.000	37.432	37.432
9.000	37.432	37.432
10.000	37.432	37.432
11.000	37.432	37.432
12.000	37.432	37.432
13.000	37.432	37.432
14.000	37.432	37.432
15.000	37.432	37.432
16.000	37.432	37.432
17.000	37.432	37.432
18.000	37.432	37.432
19.000	37.432	37.432
20.000	37.432	37.432
21.000	37.432	37.432
22.000	37.432	37.432
23.000	37.432	37.432
24.000	37.432	37.432
25.000	37.432	37.432
26.000	37.432	37.432
27.000	37.432	37.432
28.000	37.432	37.432
29.000	37.432	37.432
30.000	37.432	37.432
31.000	37.432	37.432
32.000	37.432	37.432
33.000	37.432	37.432
34.000	37.432	37.432
35.000	37.432	37.432
36.000	37.432	37.432
37.000	37.432	37.432
38.000	37.432	37.432
39.000	37.432	37.432
40.000	37.432	37.432
41.000	37.432	37.432
42.000	37.432	37.432
43.000	37.432	37.432
44.000	37.432	37.432
45.000	37.432	37.432
		46.000
		47.000
		48.000
		49.000
		50.000
		51.000
		52.000
		53.000
		54.000
		55.000
		56.000
		57.000
		58.000
		59.000
		60.000
		61.000
		62.000
		63.000
		64.000
		65.000
		66.000
		67.000
		68.000
		69.000
		70.000
		71.000
		72.000
		73.000
		74.000
		75.000
		76.000
		77.000
		78.000
		79.000
		80.000
		81.000
		82.000
		83.000
		84.000
		85.000
		86.000
		87.000
		88.000
		89.000
		90.000

 K= .0474 INCH
 R= .0575 INCH
 AL= 51.14 DEG
 MU= .6 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(AL.) (DEG)	DROP HEIGHT (FT)	
1.000	51.827	51.827
2.000	51.827	51.827
3.000	51.827	51.827
4.000	51.827	51.827
5.000	51.827	51.827
6.000	51.827	51.827
7.000	51.827	51.827
8.000	51.827	51.827
9.000	51.827	51.827
10.000	51.827	51.827
11.000	51.827	51.827
12.000	51.827	51.827
13.000	51.827	51.827
14.000	51.827	51.827
15.000	51.827	51.827
16.000	51.827	51.827
17.000	51.827	51.827
18.000	51.827	51.827
19.000	51.827	51.827
20.000	51.827	51.827
21.000	51.827	51.827
22.000	51.827	51.827
23.000	51.827	51.827
24.000	51.827	51.827
25.000	51.827	51.827
26.000	51.827	51.827
27.000	51.827	51.827
28.000	51.827	51.827
29.000	51.827	51.827
30.000	51.827	51.827
31.000	51.827	51.827
32.000	51.827	51.827
33.000	51.827	51.827
34.000	51.827	51.827
35.000	51.827	51.827
36.000	51.827	51.827
37.000	51.827	51.827
38.000	51.827	51.827
39.000	51.827	51.827
40.000	51.827	51.827
41.000	51.827	51.827
42.000	51.827	51.827
43.000	51.827	51.827
44.000	51.827	51.827
45.000	51.827	51.827

46.000
47.000
48.000
49.000
50.000
51.000
52.000
53.000
54.000
55.000
56.000
57.000
58.000
59.000
60.000
61.000
62.000
63.000
64.000
65.000
66.000
67.000
68.000
69.000
70.000
71.000
72.000
73.000
74.000
75.000
76.000
77.000
78.000
79.000
80.000
81.000
82.000
83.000
84.000
85.000
86.000
87.000
88.000
89.000
90.000

G1 (Lower Spring Index) vs Drop Height



 K= .0474 INCH
 R= .0575 INCH
 AL= 51.14 DEG
 MU= 0 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(G1) (G'S)	DROP HEIGHT (FT)
0.000	23.976
10.000	24.519
20.000	25.075
30.000	25.643
40.000	26.226
50.000	26.821
60.000	27.430
70.000	28.052
80.000	28.687
90.000	29.335
100.000	29.996
110.000	30.669
120.000	31.355
130.000	32.053
140.000	32.762
150.000	33.482
160.000	34.213
170.000	34.954
180.000	35.704
190.000	36.464
200.000	37.232
210.000	38.009
220.000	38.793
230.000	39.584
240.000	40.382
250.000	41.186
260.000	41.996
270.000	42.811
280.000	43.631
290.000	44.455

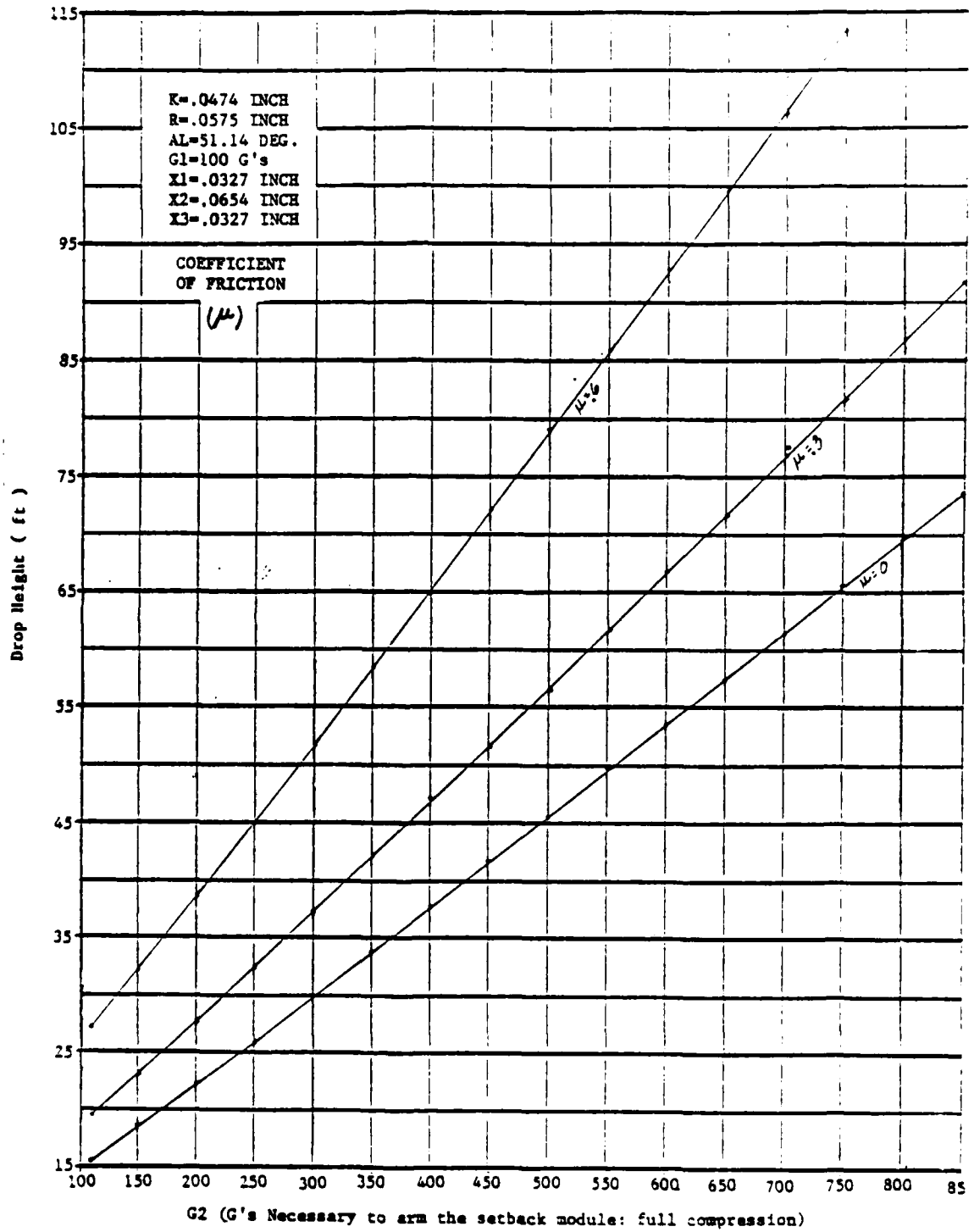
 K= .0474 INCH
 R= .0575 INCH
 AL= 51.14 DEG
 MU= .3 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(G1) (G'S)	DROP HEIGHT (FT)
0.000	29.920
10.000	30.597
20.000	31.290
30.000	32.000
40.000	32.727
50.000	33.470
60.000	34.229
70.000	35.006
80.000	35.798
90.000	36.607
100.000	37.432
110.000	38.272
120.000	39.128
130.000	39.998
140.000	40.883
150.000	41.782
160.000	42.694
170.000	43.619
180.000	44.555
190.000	45.503
200.000	46.462
210.000	47.431
220.000	48.410
230.000	49.397
240.000	50.393
250.000	51.396
260.000	52.407
270.000	53.424
280.000	54.448
290.000	55.476

 K= .0474 INCH
 R= .0575 INCH
 AL= 51.14 DEG
 MU= .6 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(G1) (G'S)	DROP HEIGHT (FT)
0.000	41.426
10.000	42.364
20.000	43.324
30.000	44.307
40.000	45.313
50.000	46.341
60.000	47.393
70.000	48.468
80.000	49.565
90.000	50.685
100.000	51.827
110.000	52.991
120.000	54.175
130.000	55.381
140.000	56.606
150.000	57.850
160.000	59.113
170.000	60.393
180.000	61.690
190.000	63.003
200.000	64.330
210.000	65.672
220.000	67.027
230.000	68.394
240.000	69.773
250.000	71.162
260.000	72.562
270.000	73.970
280.000	75.387
290.000	76.811

G2 (Top Spring Index) vs Drop Height



K= .0474 INCH
 R= .0575 INCH
 AL= 51.14 DEG
 MU= 0 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(G2) (G'S) DROP HEIGHT (FT)

110.000	16.779	510.000	46.508
120.000	16.475	520.000	47.299
130.000	17.180	530.000	48.091
140.000	17.894	540.000	48.883
150.000	18.616	550.000	49.676
160.000	19.346	560.000	50.469
170.000	20.082	570.000	51.262
180.000	20.823	580.000	52.055
190.000	21.570	590.000	52.848
200.000	22.321	600.000	53.642
210.000	23.076	610.000	54.436
220.000	23.835	620.000	55.230
230.000	24.597	630.000	56.024
240.000	25.362	640.000	56.818
250.000	26.129	650.000	57.612
260.000	26.899	660.000	58.407
270.000	27.670	670.000	59.202
280.000	28.444	680.000	59.997
290.000	29.219	690.000	60.792
300.000	29.996	700.000	61.587
310.000	30.774	710.000	62.382
320.000	31.553	720.000	63.177
330.000	32.334	730.000	63.973
340.000	33.116	740.000	64.768
350.000	33.898	750.000	65.564
360.000	34.682	760.000	66.359
370.000	35.466	770.000	67.155
380.000	36.251	780.000	67.951
390.000	37.037	790.000	68.747
400.000	37.823	800.000	69.543
410.000	38.611	810.000	70.339
420.000	39.398	820.000	71.136
430.000	40.186	830.000	71.932
440.000	40.975	840.000	72.728
450.000	41.764	850.000	73.525
460.000	42.554	860.000	74.321
470.000	43.344	870.000	75.118
480.000	44.134	880.000	75.914
490.000	44.925	890.000	76.711
500.000	45.716	900.000	77.508

K= .0474 INCH
R= .0575 INCH
AL= 51.14 DEG
MU= .3 FRICTION
G1= 100 G'S
G2= 300 G'S
X1= .0327 INCH
X2= .0654 INCH
X3= .0327 INCH
A1= 301 G'S
AF= 2000 G'S
I= 1 G'S

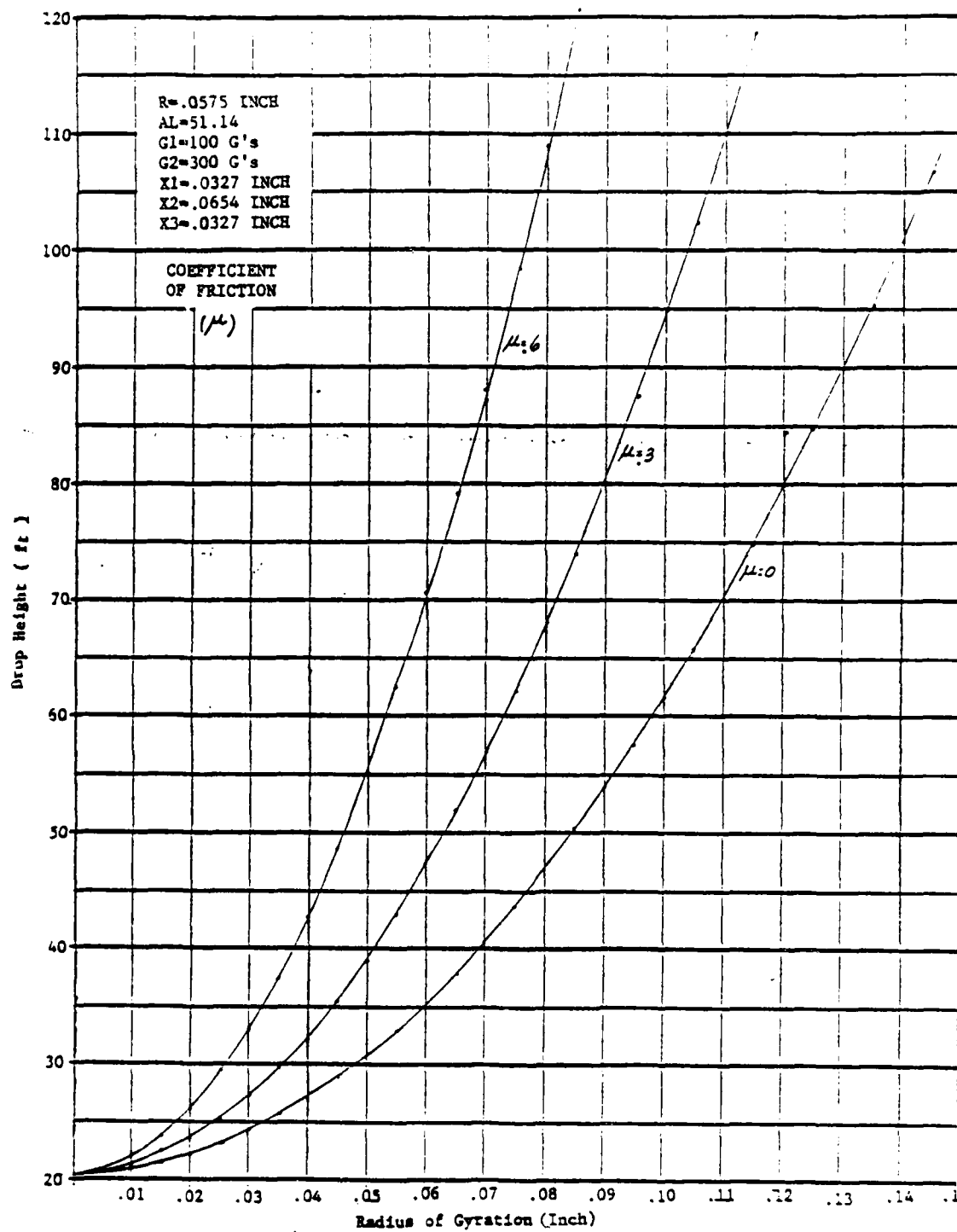
(G2) (G'S) DROP HEIGHT (FT)

110.000	19.691	510.000	58.037
120.000	20.559	520.000	59.025
130.000	21.439	530.000	60.013
140.000	22.330	540.000	61.002
150.000	23.231	550.000	61.991
160.000	24.142	560.000	62.980
170.000	25.060	570.000	63.970
180.000	25.985	580.000	64.959
190.000	26.917	590.000	65.949
200.000	27.855	600.000	66.940
210.000	28.797	610.000	67.930
220.000	29.744	620.000	68.921
230.000	30.695	630.000	69.912
240.000	31.649	640.000	70.903
250.000	32.607	650.000	71.895
260.000	33.567	660.000	72.886
270.000	34.530	670.000	73.878
280.000	35.495	680.000	74.870
290.000	36.462	690.000	75.862
300.000	37.432	700.000	76.854
310.000	38.403	710.000	77.846
320.000	39.375	720.000	78.839
330.000	40.349	730.000	79.831
340.000	41.325	740.000	80.824
350.000	42.301	750.000	81.817
360.000	43.279	760.000	82.810
370.000	44.258	770.000	83.803
380.000	45.238	780.000	84.796
390.000	46.218	790.000	85.790
400.000	47.200	800.000	86.783
410.000	48.182	810.000	87.776
420.000	49.165	820.000	88.770
430.000	50.149	830.000	89.764
440.000	51.133	840.000	90.758
450.000	52.118	850.000	91.752
460.000	53.103	860.000	92.745
470.000	54.089	870.000	93.739
480.000	55.075	880.000	94.734
490.000	56.062	890.000	95.728
500.000	57.049	900.000	96.722

 K= .0474 INCH
 R= .0575 INCH
 A1= 51.14 DEG
 MU= .6 FRICTION
 G1= 100 G'S
 G2= 100 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(G2) (G'S)	DROP HEIGHT (FT)	
110.000	27.264	81.724
120.000	28.465	83.093
130.000	29.683	84.462
140.000	30.917	85.831
150.000	32.165	87.200
160.000	33.426	88.571
170.000	34.697	89.941
180.000	35.979	91.312
190.000	37.269	92.683
200.000	38.567	94.055
210.000	39.872	95.426
220.000	41.183	96.798
230.000	42.499	98.171
240.000	43.820	99.544
250.000	45.146	100.916
260.000	46.476	102.290
270.000	47.809	103.663
280.000	49.146	105.036
290.000	50.485	106.410
300.000	51.827	107.784
310.000	53.172	109.158
320.000	54.518	110.533
330.000	55.867	111.907
340.000	57.217	113.282
350.000	58.570	114.657
360.000	59.923	116.032
370.000	61.279	117.407
380.000	62.635	118.782
390.000	63.993	120.158
400.000	65.352	121.533
410.000	66.712	122.909
420.000	68.073	124.285
430.000	69.435	125.661
440.000	70.797	127.037
450.000	72.161	128.413
460.000	73.525	129.790
470.000	74.890	131.166
480.000	76.256	132.542
490.000	77.622	133.919
500.000	78.989	
510.000	80.356	
520.000		
530.000		
540.000		
550.000		
560.000		
570.000		
580.000		
590.000		
600.000		
610.000		
620.000		
630.000		
640.000		
650.000		
660.000		
670.000		
680.000		
690.000		
700.000		
710.000		
720.000		
730.000		
740.000		
750.000		
760.000		
770.000		
780.000		
790.000		
800.000		
810.000		
820.000		
830.000		
840.000		
850.000		
860.000		
870.000		
880.000		
890.000		
900.000		

Radius of Gyration vs Drop Height



 K= .0474 INCH
 R= .0575 INCH
 AL= 51.14 DEG
 MU= 0 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(R) (IN)	DROP HEIGHT (FT)
0.005	1235.200
0.010	324.409
0.015	155.744
0.020	96.712
0.025	69.389
0.030	54.546
0.035	45.597
0.040	39.788
0.045	35.806
0.050	32.957
0.055	30.850
0.060	29.247
0.065	27.999
0.070	27.009
0.075	26.211
0.080	25.557
0.085	25.015
0.090	24.561
0.095	24.177
0.100	23.949

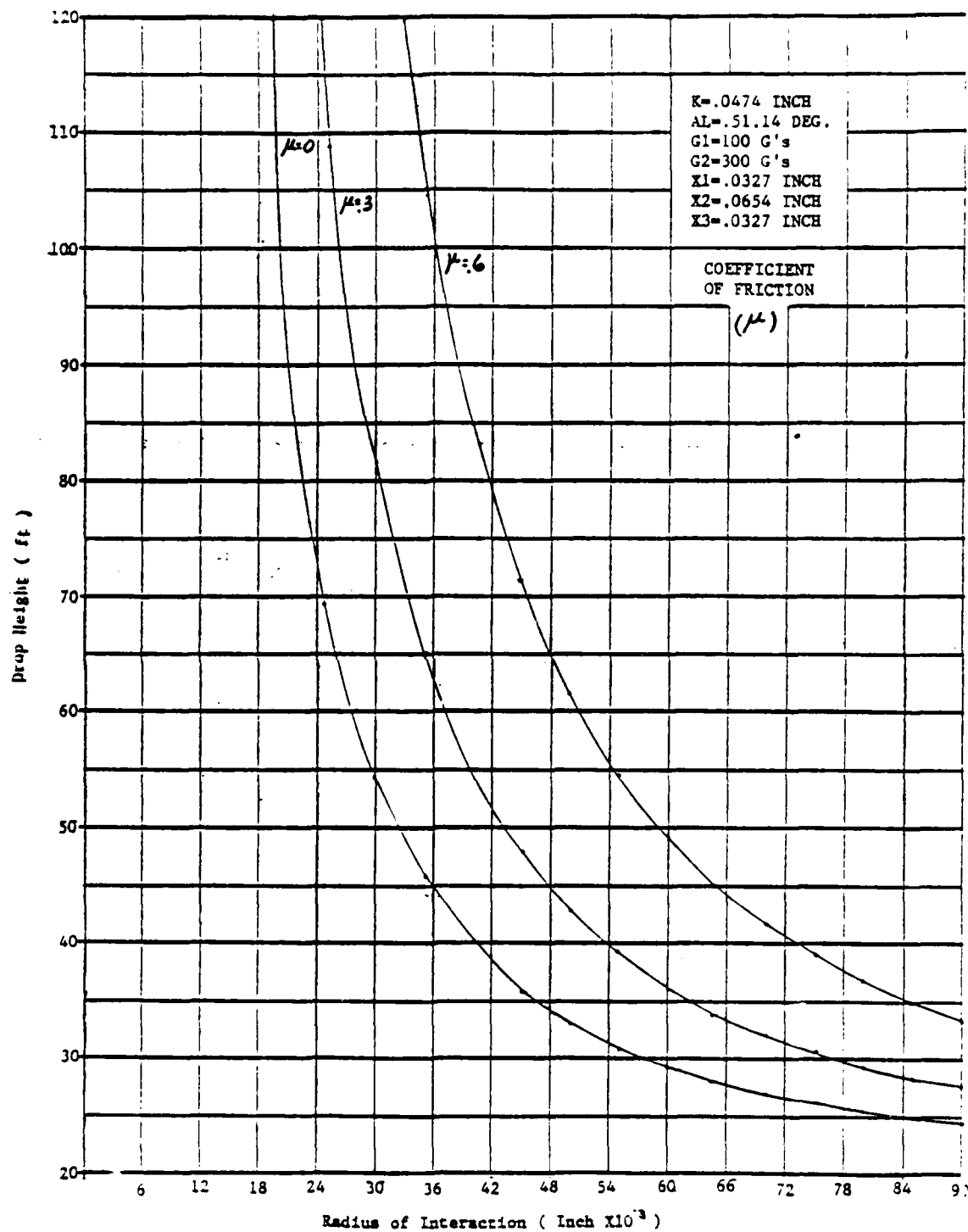
 K= .0474 INCH
 R= .0575 INCH
 AL= 51.14 DEG
 MU= .3 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(R) (IN)	DROP HEIGHT (FT)
0.005	2218.600
0.010	570.259
0.015	265.012
0.020	158.175
0.025	108.725
0.030	81.863
0.035	65.666
0.040	55.154
0.045	47.946
0.050	42.791
0.055	38.977
0.060	36.076
0.065	33.818
0.070	32.027
0.075	30.581
0.080	29.398
0.085	28.418
0.090	27.597
0.095	26.901
0.100	26.308

 K= .0474 INCH
 R= .0575 INCH
 AL= 51.14 DEG
 MU= .6 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(R) (IN)	DROP HEIGHT (FT)
0.005	4122.380
0.010	1046.210
0.015	476.543
0.020	277.161
0.025	184.976
0.030	134.746
0.035	104.519
0.040	84.900
0.045	71.450
0.050	61.829
0.055	54.711
0.060	49.296
0.065	45.083
0.070	41.740
0.075	39.043
0.080	36.835
0.085	35.006
0.090	33.472
0.095	32.175
0.100	31.067

Drop Height vs Radius of Interaction



 K= .0474 INCH
 R= .0575 INCH
 AL= 51.14 DEG
 MU= 0 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(K) (IN)	DROP HEIGHT (FT)
0.005	20.916
0.010	21.222
0.015	21.733
0.020	22.448
0.025	23.368
0.030	24.492
0.035	25.820
0.040	27.353
0.045	29.089
0.050	31.031
0.055	33.176
0.060	35.526
0.065	38.081
0.070	40.840
0.075	43.903
0.080	46.970
0.085	50.342
0.090	53.918
0.095	57.698
0.100	61.683

 K= .0474 INCH
 R= .0575 INCH
 AL= 51.14 DEG
 MU= .3 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(K) (IN)	DROP HEIGHT (FT)
0.005	20.998
0.010	21.553
0.015	22.478
0.020	23.772
0.025	25.436
0.030	27.470
0.035	29.874
0.040	32.648
0.045	35.791
0.050	39.305
0.055	43.188
0.060	47.441
0.065	52.064
0.070	57.057
0.075	62.419
0.080	68.152
0.085	74.254
0.090	80.726
0.095	87.568
0.100	94.779

 K= .0474 INCH
 R= .0575 INCH
 AL= 51.14 DEG
 MU= .6 FRICTION
 G1= 100 G'S
 G2= 300 G'S
 X1= .0327 INCH
 X2= .0654 INCH
 X3= .0327 INCH
 A1= 301 G'S
 AF= 2000 G'S
 I= 1 G'S

(K) (IN)	DROP HEIGHT (FT)
0.005	21.158
0.010	22.194
0.015	23.919
0.020	26.335
0.025	29.441
0.030	33.237
0.035	37.723
0.040	42.899
0.045	48.766
0.050	55.323
0.055	62.570
0.060	70.507
0.065	79.134
0.070	88.452
0.075	98.459
0.080	109.157
0.085	120.545
0.090	132.624
0.095	145.392
0.100	158.851

APPENDIX G
ETCHING PROCEDURE
FOR HOUSING

M577 Modular Setback Pin

Etching procedure for housings - to reduce cam size

Process reduces housing OD from .1775" to .1764"

Bright Dip Solution

ref: Metal Finishing Handbook 1981, Page 182

263g. Chromic Acid
23g. Sodium Sulphate
1000 ml. D.I. Water
room temperature

Zn. Cleaner

Patclin #357 Zinc Cleaner
45 g/l
150°F

Procedure:

1. Degrease in chloroethene; dry.
2. Agitate in bright dip for 60 seconds; rinse.
3. Remove smut in Zinc cleaner in ultrasonic cleaner, approx. 3 mins.
4. Rinse and dry.

APPENDIX H
M577 MODULAR SETBACK PIN
BALLISTIC TESTING SUMMARY

DG/"C"/KG

M577 MODULAR SETBACK PIN
BALLISTIC TESTING SUMMARY

HAT LOT NUMBER	TOTAL FUZES TESTED	DATE SHIPPED	GUN & ZONE	FUZES FUNCTIONED	UNITS THAT COULD BE EVALUATED	
					TIMERS FUNCTIONED	TRIGGERS FUNCTIONED
E022	15	21 May 80	105mm Z7 155mm Z1 PD 8-inch Z1	5/5 5/5 2/5	5/5 - 2/5	5/5 5/5 5/5
E028	32	15 July 80	8" Z1 105mm Z8	20/24 8/8	20/24 8/8	24/24 8/8
E031	12	6 Oct. 80	155mm Z1	10/12	10/12	-
E030	20	7 Oct. 80	8-inch Z1	20/20	20/20	-
E044 E045	36	10 Dec. 80	155mm Z1 155mm Z1	16/18 11/18	16/18 11/18	- -
E051	30	14 May 81	155mm Z1	30/30	30/30	-
E056	102	Sept. 81 (Rough Handling) (Recovery) (Recovery)	155mm Z8	15/20	15/15	15/15
			105mm Z7	7/10	7/7	7/7
			8-inch Z1	6/10	8/8	10/10
			105mm Z7	24/32	24/24	24/24
			155mm Z8	11/15	15/15	14/15
E107 *	106	May 83 (Rough Handling)	155mm Z1	8/15	13/15	14/15
			155mm Z8	20/20	20/20	20/20
			8-inch Z1	20/20	20/20	20/20
			8-inch Z½	15/15	15/15	15/15
			4.2-inch incr7	15/15	15/15	15/15
E113 *	15	May 83	105mm Z7	13/16	13/13	16/16
			155mm Z1 (Recovery)	15/15	15/15	15/15

* For more complete information on this test see Page

ENGINEERING TEST

SUPP #4-TPR-2594 (YPG)*

WEAPON	ZONE	TEMP	SET TIME	REL	$\bar{X}$	σ	LPD
(2) 155MM, M198	8(M203)	+1450F	105.0	20/20	105.312	.335	-
(1) 155MM, M198	8(M203)	+1450F	105.0	20/20	105.128	.299	-
(1) 8 INCH, M2A1	1	-350F	25.0	20/20	24.870	.055	0
(2) 8 INCH, M2A1	1	-350F	25.0	20/20	24.880	.057	0
(1) 8 INCH, M2A1	1/2	+700F	15.0	13/15	14.947	.066	0
(2) 8 INCH, M2A1	1/2	+700F	15.0	15/15	14.943	.059	0
(1) 4.2 INCH, M30	7 INCR	+700F	13.0	15/15	13.064	.071	-
(2) 4.2 INCH, M30	7 INCR	+700F	13.0	15/15	13.029	.059	-
(3) 105MM, M103	7	+700F	50.0	13/16	50.054	.073	0
(1) 155MM, M1	1	+700F	PD/FUNCT	20/20	-	-	-
(2) 155MM, M1	1	+700F	PD/FUNCT	20/20	-	-	-
(4) 155MM, M198	1	+700F	15.0	15/15	-	-	-

*LEGEND: (1) HAMILTON LOT 83D0000E108 - CONTROL RDS.

(2) HAMILTON LOT 83D0000E107 - RDS. ASSEMBLED W/PIN ASSEMBLED IN TIMER AND TRIGGER (ZIG-ZAG).

(3) HAMILTON LOT 83D0000E107 - SEQ. ROUGH HANDLED - 8RDS @ -350F, 8 RDS @ +1450F.

(4) HAMILTON LOT 83D0000E113 - (15) TEST RDS - 5 EA RECOVERY VEHICLES WERE FIRED.

13,14 MAY 1983

DISTRIBUTION LIST

Commander
Armament Research and Development Center
U.S. Army Armament, Munitions and Chemical Command
ATTN: DRSMC-TSS(D) (5)
DRSMC-LCN-T(D) (5)
Dover, NJ 07801

Administrator
Defense Technical Information Center
ATTN: Accessions Division (12)
Cameron Station
Alexandria, VA 22314

Director
U.S. Army Materiel Systems Analysis Activity
ATTN: DRXSY-MP
Aberdeen Proving Ground, MD 21005

Commander
Chemical Research and Development Center
U.S. Army Armament, Munitions and Chemical Command
ATTN: DRSMC-CLJ-L(A)
DRSMC-CLB-PA(A)
APG, Edgewood Area, MD 21010

Director
Ballistics Research Laboratory
Armament Research and Development Center
U.S. Army Armament, Munitions and Chemical Command
ATTN: DRSMC-BLA-S(A)
Aberdeen Proving Ground, MD 21005

Chief
Benet Weapons Laboratory, LCWSL
Armament Research and Development Center
U.S. Army Armament, Munitions and Chemical Command
ATTN: DRSMC-LCB-TL
Watervliet, NY 12189

Commander
U.S. Army Armament, Munitions and Chemical Command
ATTN: DRSMC-LEP-L(R)
Rock Island, IL 61299

Director
U.S. Army TRADOC Systems
Analysis Activity
ATTN: ATAA-SL
White Sands Missile Range, NM 88002

END

FILMED

4-84

DTIC