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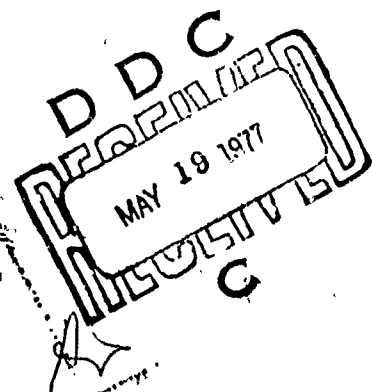
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**A MATHEMATICAL MODEL
OF THE 30 MM ADVANCED
MEDIUM CALIBER WEAPON SYSTEM
(AMCAWS-30)**

MICHAEL R. KANE

APRIL 1977

FINAL REPORT



ADA 039713



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The numerical integration is done using the HPCG subroutine out of the IBM SSP Math Library. The total program is modularized and inclusions of additional parts or design changes in the weapon can be incorporated without extensive revision of the program. The program is written in FORTRAN.

A MATHEMATICAL MODEL OF THE 30 MM
ADVANCED MEDIUM CALIBER WEAPON SYSTEM
(AMCAWS-30)*

by

Michael R. Kane

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ACKNOWLEDGMENT

This work was undertaken to meet the DARCOM project requirement while the author was engaged in DARCOM sponsored long term CAD-E training at the University of Michigan. The project was completed after the author returned to the advanced concepts group of Gen. T. J. Rodman Laboratory at Rock Island Arsenal.

Prof. M. A. Chace (Chairman, CAD-E Department) of the University of Michigan was the faculty advisor for the project. His guidance was invaluable.

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ABSTRACT

A mathematical model for the AMCAWS-30MM weapon is developed using the generalized d'Alembert force equations. The development of the one degree of freedom differential equation of motion for the weapon is shown. The equation accounts for operations including feed, eject, chamber locking, round crush-up, chamber translation, face cam rotation, and drum cam rotation. The resultant equation is numerically integrated to obtain the time response of position, velocity, acceleration, and force for the major components. The solution is based on the known drive motor characteristics.

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*The AMCAWS-30MM weapon is currently under development in the Advanced Concepts Group, Aircraft and Air Defense Weapons Systems Directorate, General Thomas J. Rodman Laboratory, Rock Island, Ill. (SARRI-LW-A).

AMCAWS is a 30 millimeter single barrel weapon that utilizes an aluminum cased, fully telescoped, and consolidated propellant round with ballistic characteristics slightly better than GAU-8 rounds. The prototype weapon fires ten round bursts at a nominal rate of 120 spm. The second prototype weapon has a nominal rate in excess of 400 spm.



ADVANCED MEDIUM CALIBER
AIRCRAFT WEAPON SYSTEM
- AMCAWS 30 -

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1. OBJECTIVE

The first prototype AMCAWS-30 weapon capable of operation in an automatic mode has existed since 2 May 74. That prototype has since shown a high degree of reliability in many ten round bursts and other lesser firing schedules.

Those first automatic firings were the result of a design process historically similar to the design of other medium caliber weapons. A new concept, approach, or need leads the designer to develop the design, using tools generally available to the draftsman (assemblies, sections, blowups, etc.). Parts are sized by a coarse static force analysis or by the intuition of the designer. Operational or dynamic forces are not investigated extensively. The drive motor, for example, on the AMCAWS was chosen because it was available and it was felt that it was "big enough". Throughout the complete design cycle including the initial layouts, a few part redesigns, and a very circumspect assembly there were several questions that begged answers. The questions included:

- (1) What is the complete position description of all the major components during a firing cycle?
- (2) What is the response of the weapon as a whole to different drive motors?
- (3) What are the forces between parts during weapon operation?
- (4) What is the effect on weapon performance when parts are redesigned?

The AMCAWS-30 mathematical model provides the ability to answer these questions. The model is one degree of freedom and accounts for inertial, translational, and dissipative forces. Modeled components include the feed,

eject, chamber, lock, and the drum/face cams. The model employs generalized d'Alembert forces to develop the differential equation of motion and uses functional relationships developed by a preliminary program to establish a component's positional dependence on a single coordinate, the motor input angle.

The purpose of this report is threefold. First, it is intended to document the computer programs that make up the AMCAWS mathematical model package. The programs are discussed and listed in the appendices and contain excellent internal documentation. Second, the report is to describe the operational characteristics of the weapon. A brief ammunition description is in the next section and a detailed ammunition description can be found in the ammunition final report (1)* Third, the report will document the actual modeling procedure.

The model package discussed in this report treats only the first prototype weapon. The procedure employed, is, however, general and can be applied to a wide variety of weapon systems and subsystems.

*Numbers in parentheses designate References at end of paper.

2. AMMUNITION WEAPON DESCRIPTION

The AMCAWS 30 weapon is the result of an advanced development program for a high performance 30mm automatic weapon system. The weapon has been designed, developed and fabricated in-house at Rock Island Arsenal. The weapon is externally powered and various cams accomplish the feeding, firing, and ejecting of the round. The weapon treated by this report is the first prototype weapon which fires up to ten round bursts at a 121 shots per minute (spm) rate. Parenthetically, the second prototype weapon has a design rate of 500 spm. The second prototype is, as of the date of this report, some 90% fabricated. While the detailed description of the first prototype weapon may seem long and involved, the weapon itself can be characterized as clean and simple. Various cams ensure positive motions and the lateral feeding and ejecting of ammunition permits the absence of some of the more complicated extracting mechanisms used on more conventional weapons.

2.1 AMMUNITION

The AMCAWS 30 ammunition (Figure 1) is an aluminum cased and fully telescoped round. The case is one piece and has a .75 degree radial taper to the base. The main charge is consolidated and concentric about the projectile. The full weight of the round is about 9595 grains (1.37 pounds). Extraction forces after firing are very low. A complete ammunition description can be found in the ammunition final report (1).

2.2 DRUM CAM

The drum cam assembly (Figure 2) has several functions. Torque from the drive unit is transmitted to the weapon through the 151 tooth external gear on the outside diameter of the drum. An internal cam path (Figure 3)

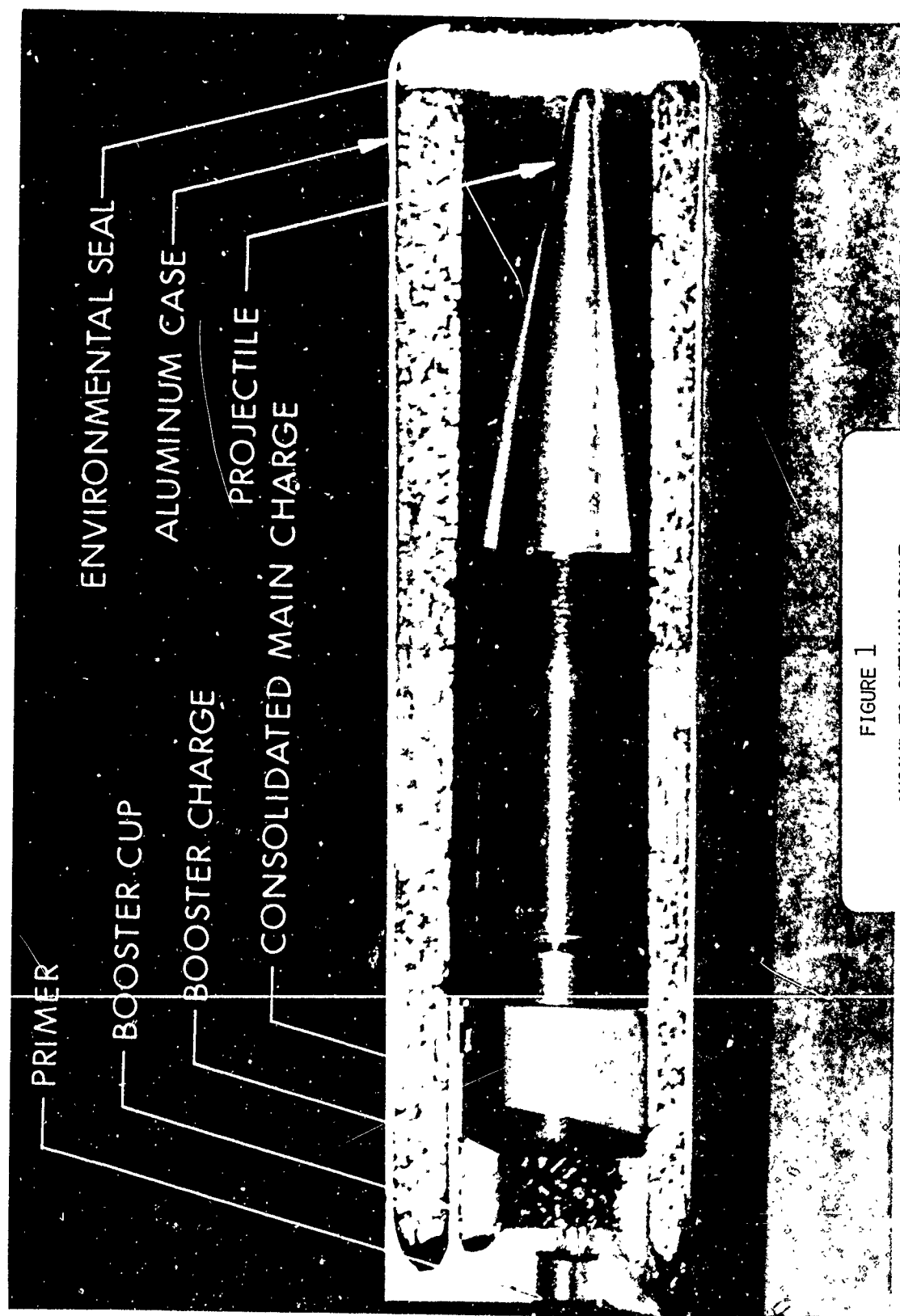


FIGURE 1
AVCAVS-30 CUTAWAY ROUND



FIGURE 2

DRUM CAM ASSEMBLY AND DRIVE TRAIN



FIGURE 3
INTERNAL DRUM CAM CAM-PATH

controls the chamber motion of the weapon. A follower stud cantilevered from the chamber and passing through a receiver slot follows the drum cam path, thus providing the proper chamber motion. A lump cam fixed to the inside diameter of the drum initiates the lock and unlock sequence (Figure 4). The drum cam is concentric to the weapon centerline (Figure 5) and is located over the rear half of the receiver. The face cam is locked to the front of the drum cam at weapon assembly (Figure 4).

2.3 FACE CAM

The face cam (Figure 6,7) has cam paths that control the feed and eject functions for the weapon. The face cam is fixed to the drum cam at weapon assembly and is thus timed to the chamber and locking motions. The feed cam path (Figure A1-10) is followed by the feed rocker arm which transmits rotation to the feeding pawls through the feed shaft. The feed shaft is the center of rotation of the rocker and the pawls and is fixed via supports to the receiver. The total feed mechanism (Figure 8) places a new round of ammunition at the center of the chamber. While the new round is being placed, the fired case is being ejected from the system. The eject cam path (Figure A1-9) is followed by the eject rocker arm which transmits rotation to the eject pawl through the eject shaft. The center of rotation of this rocker and pawl is the eject shaft which is fixed to the receiver. The total eject mechanism (Figure 9) must allow the fired round to escape the chamber centerline. This is accomplished by waiting until the chamber is fully rearward and swinging the pawl up into an exposed chamber area so that the fired round can pass under the pawl. As the fired round is passing under the pawl the pawl moves down into a dwell position that will cause a positive stop for the new round being presented. After the stop is made the pawl swings out of the chamber area so that the chamber can be brought forward for a firing.

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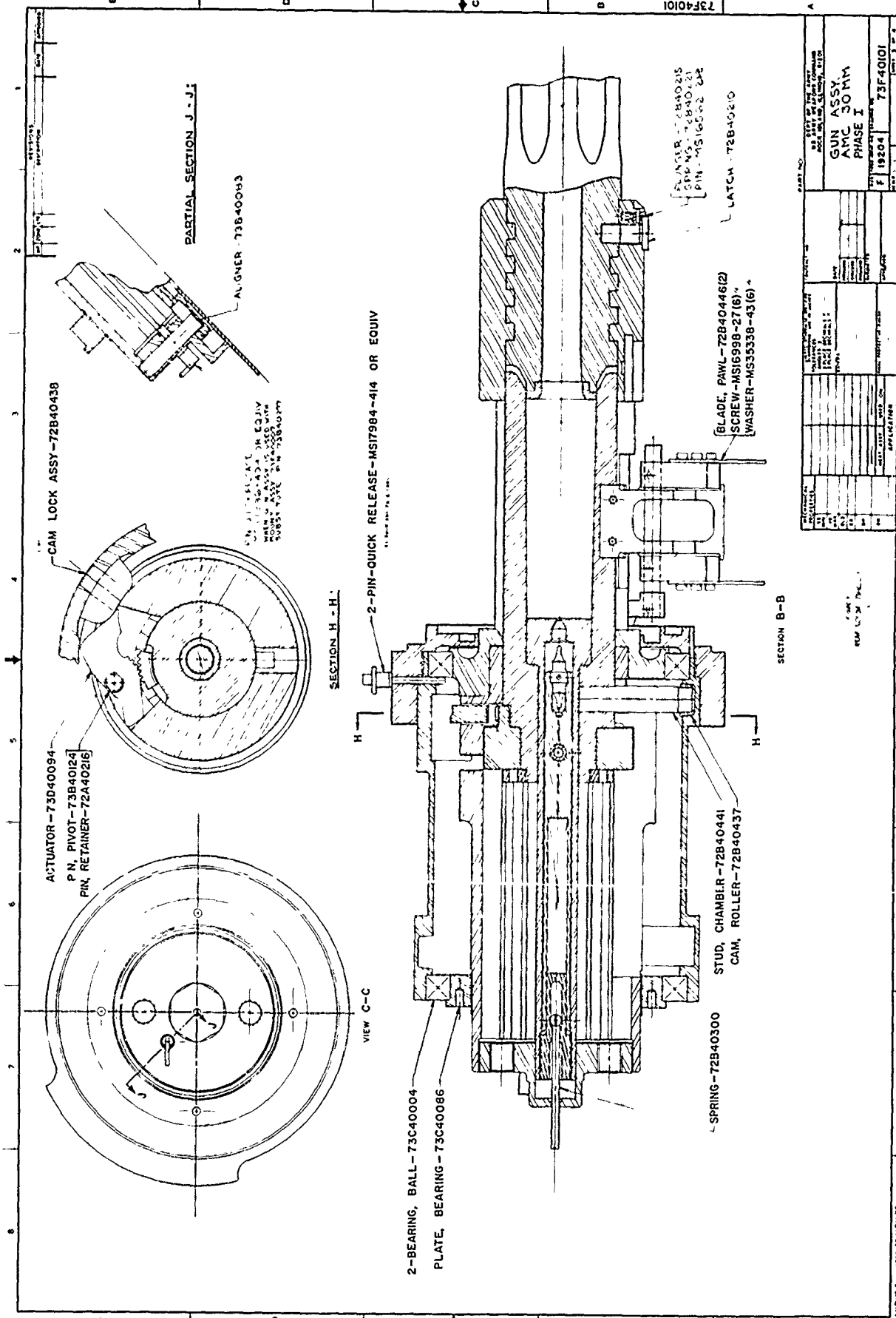
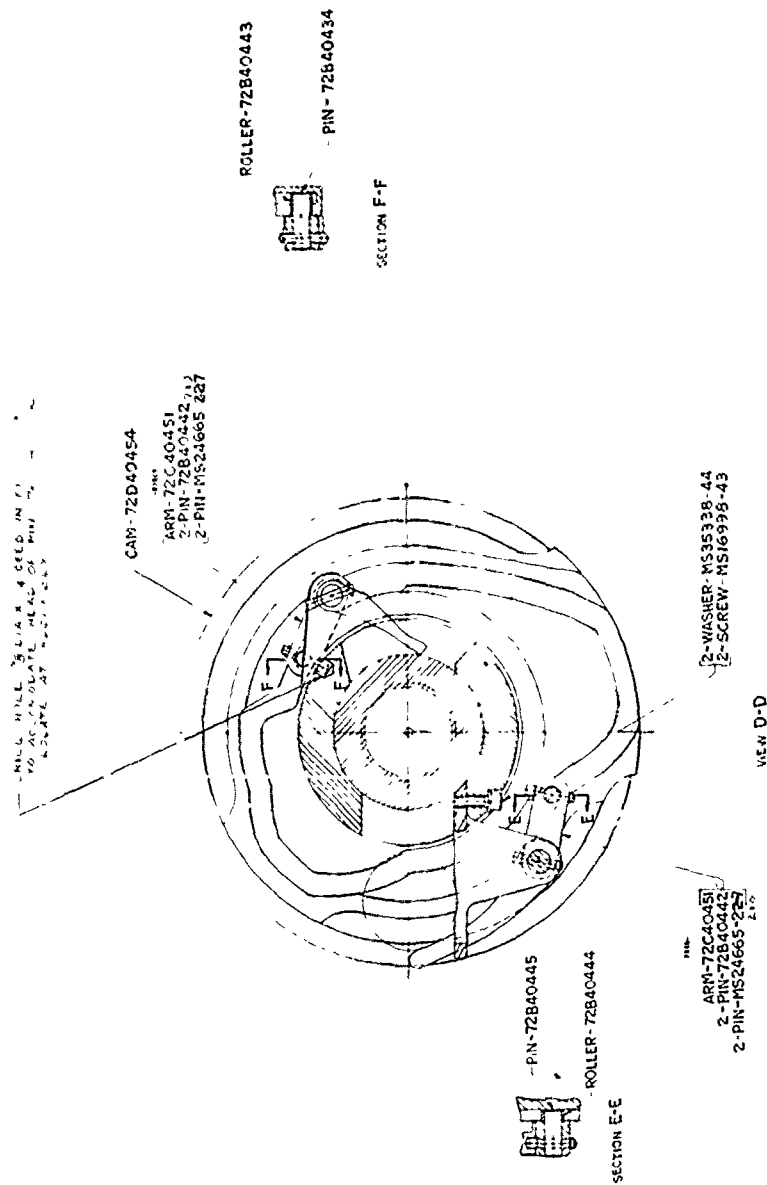


Fig. 4



FIGURE 6
FACE CAM FROM EJECT SIDE

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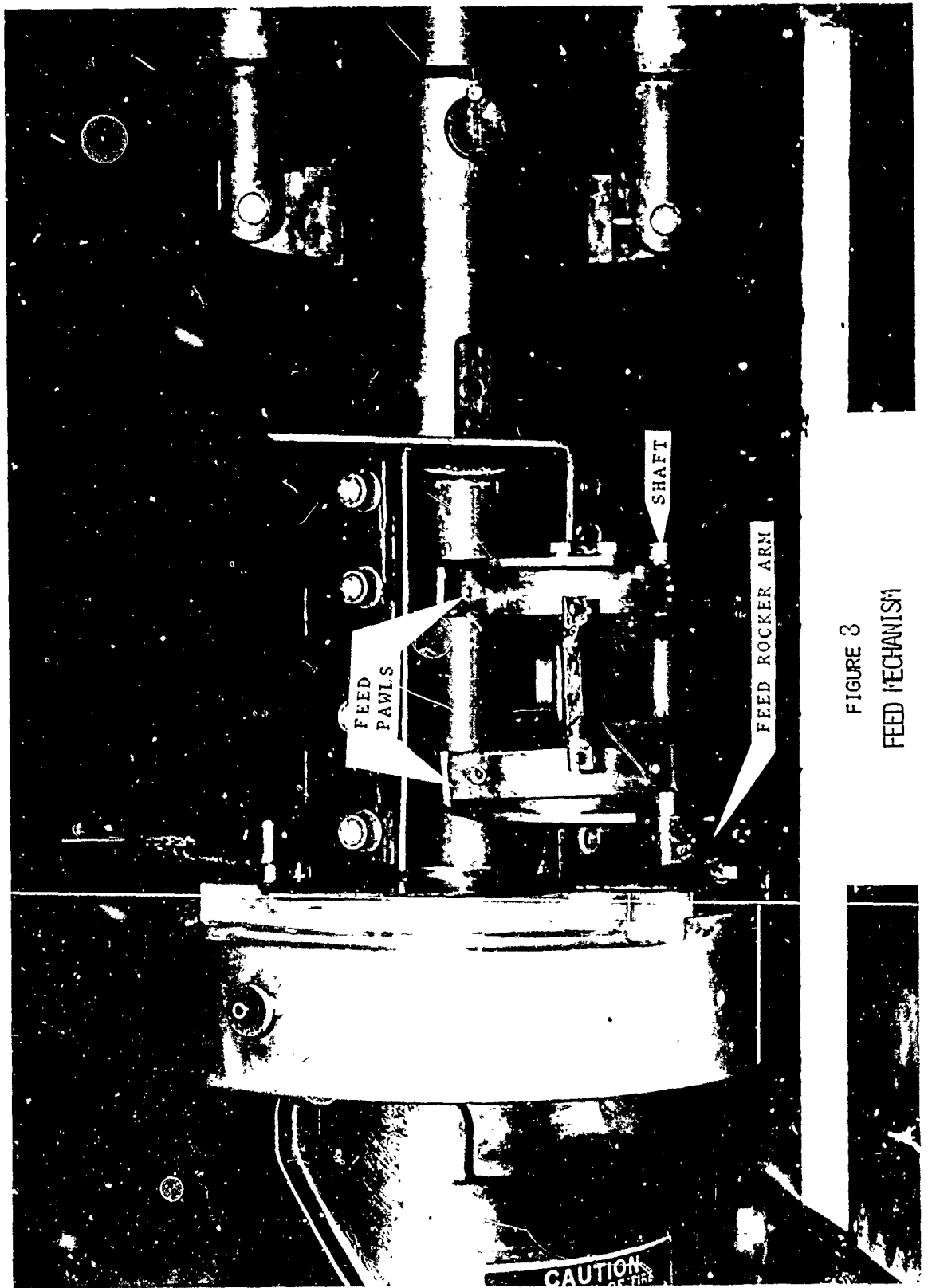


FIGURE 3
FEED MECHANISM

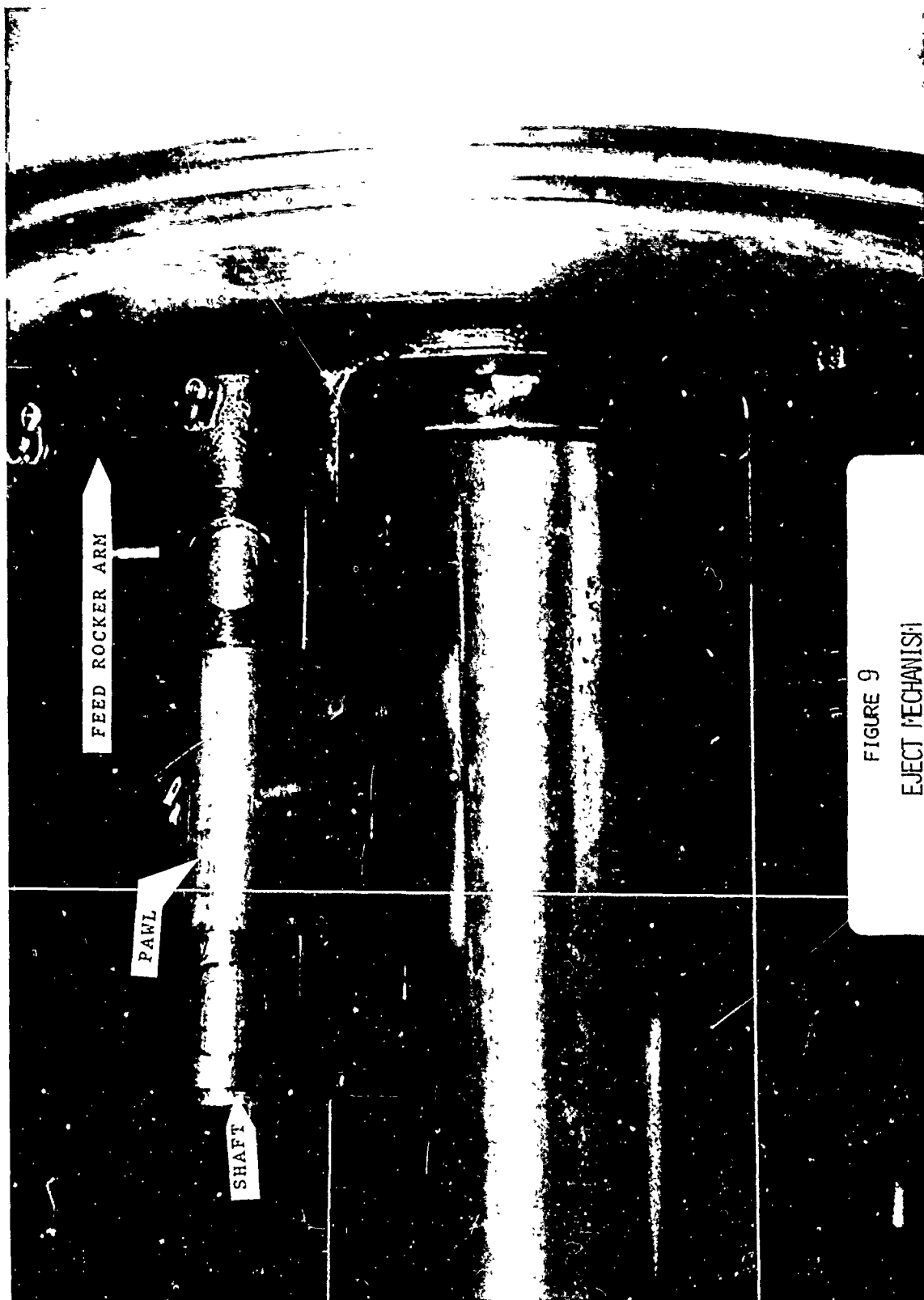


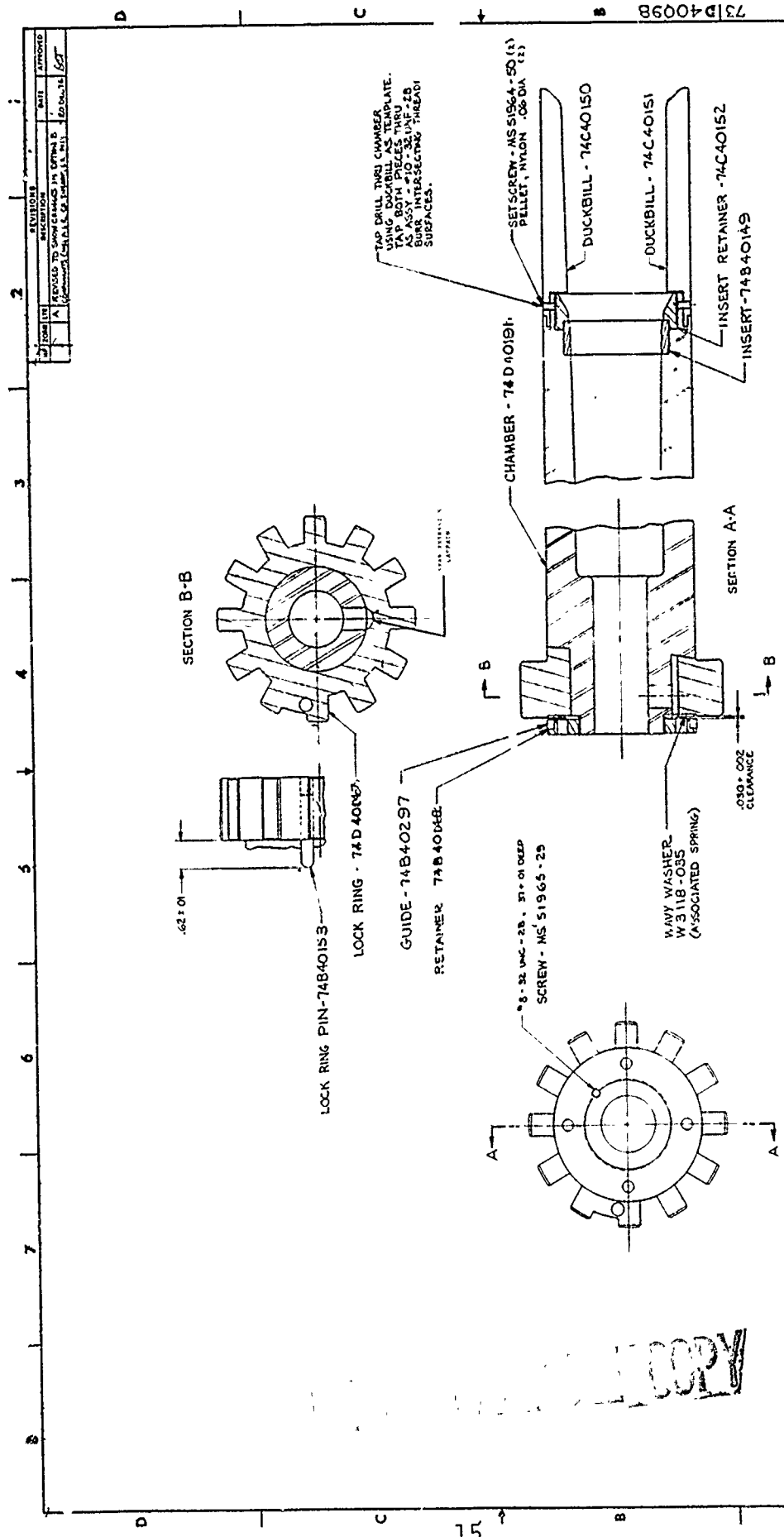
FIGURE 9
EJECT MECHANISM

2.4 LOCKING/SEAR ASSEMBLIES

As the cam drum rotates, the lump cam, located on the cam drum inside diameter (Figure 4) contacts the actuator. The unidirectional rotary motion of the cam drum is changed to a bidirectional oscillating motion of the actuator by their cam/follower relationship. The motion (Figure A1-13) is controlled by the profile of the contact surface of the actuator. As the lump cam moves along the actuator, it forces (cams) the actuator to rotate about its own pivot point. As the actuator rotates, it in turn rotates the lock ring to its locked position via a set of gear teeth on the actuator and mating teeth on the lock ring. Once in the locked position, the lump cam rides on the dwell portion of the actuator profile. Since the lump cam and actuator are in constant contact during this period no motion can occur, thus positive locking during the total lock dwell results. As the lump cam moves along the actuator, it contacts the unlock portion of the actuator profile. The actuator is forced (cammed) back to its original position and through the gear teeth it returns the lock ring to its original unlocked position.

Located on the inside diameter of the lock ring is a small cam path (Figure 10). Riding on this small cam path is a bean-like object called a sear extension (Figure 11). As the lock ring is rotated, the small cam path lifts the sear extension. When the lock ring reaches its fully locked position, the sear extension is at the top of the small cam path and just enough lift has occurred so that the sear extension releases the weapon's main sear in the bolt assembly. If the lock ring does not turn to full lock, the sear extension cannot reach full lift. This feature prevents the gun from being fired in any position other than the desired full lock position.

Since the lock ring is concentric about the longitudinal axis of the gun, the load on the receiver is also concentric about this axis, and therefore induces no bending moments to the receiver.



REVISIONS		DATE		BY	
1	INITIALS	2	DATE	3	BY
DESCRIPTION					
A. REDUCED TO SHOW CHAMBER IN DETAIL B. CHAMBER AND LOCK ASSY					
DATE: 15 SEP 1973					
DRAWN BY: J. J. B. / J. J. B.					
CHECKED BY: J. J. B. / J. J. B.					
APPROVED BY: J. J. B. / J. J. B.					
TITLE: CHAMBER AND LOCK ASSY					
PART NO: 73 D 4 0098					
DATE: 19204					
BY: J. J. B. / J. J. B.					
FOR: J. J. B. / J. J. B.					
APPLICATION: J. J. B. / J. J. B.					

Fig. 10

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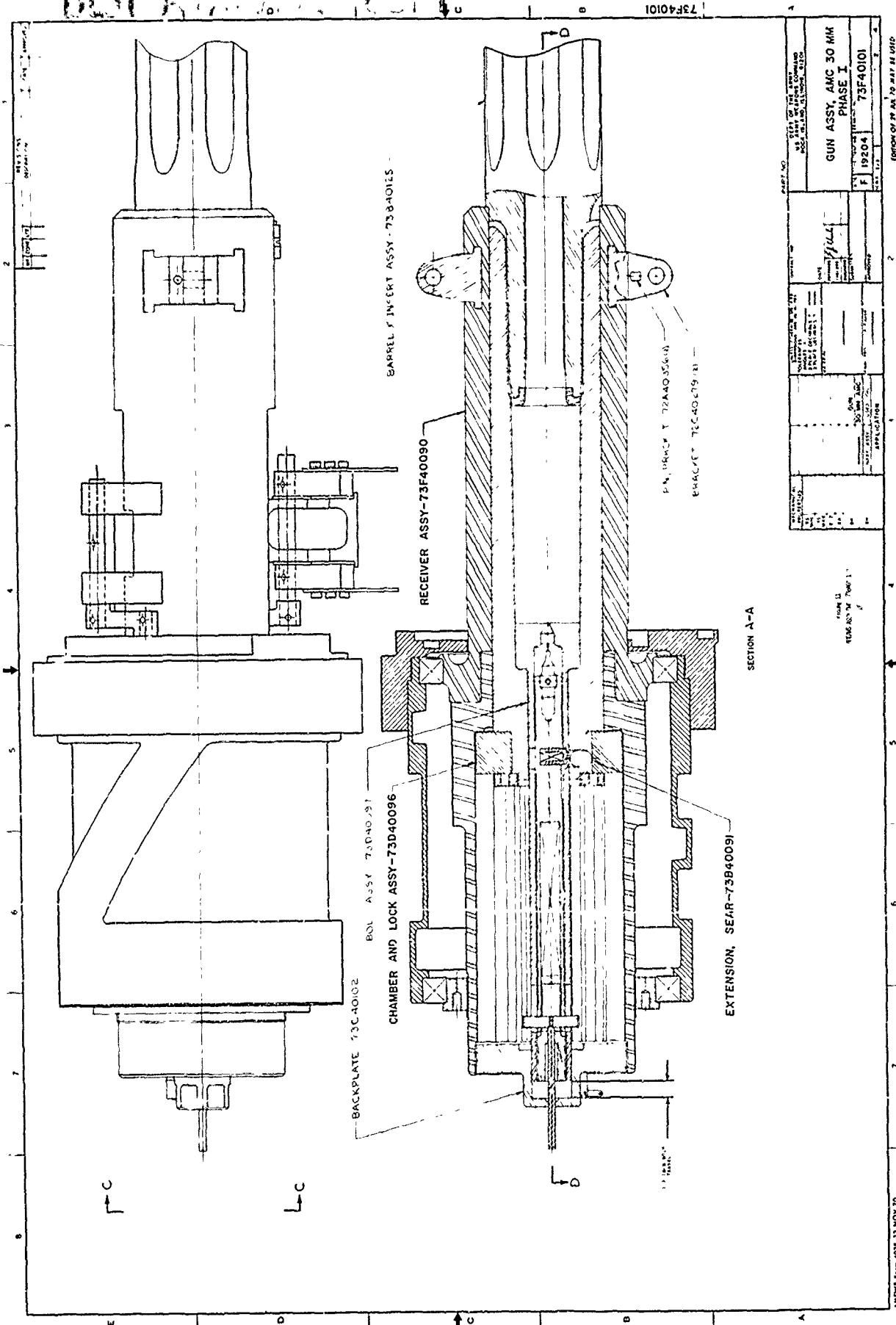


Fig. 11

2.5 BOLT

The bolt assembly is pictured in Figure 12. The firing pin is contained in the bolt housing and is driven by a spring with a rate (at assembled height) of about seven pounds per inch. The firing pin is held in a ready-to-fire position by the sear extending through the sear hole in the bolt housing. The firing pin is seared off as discussed in the Locking/Sear explanation. The firing pin can only be released from its ready-to-fire position when the weapon is fully locked. The bolt has about one-half inch of total travel relative to the receiver along the centerline of the weapon. In operation, the firing pin is seared off by the action of fully locking the lock ring. The firing pin drives forward and discharges the round. A fixed time elapses that allows the projectile to exit the barrel and the high pressure exhaust gases to bleed off. The lock ring unlocks and the chamber begins to move back. The fired round's case, the chamber assembly, and the bolt assembly move rearward as a unit for about the half inch indicated in Figure 11 and 13. At this point the bolt housing impacts the backplate and the force of this impact frees the round case from the chamber wall. The chamber assembly continues to move over the now stationary bolt assembly, thus exposing the fired round (Figure 14). The chamber-lock ring assembly moves rearward so far as to interfere with the bolt crosspin (Figure 12) and move it from the fully forward position (because the firing pin has been seared off) to its fully rearward position (as shown). In the fully rearward position, the firing spring is recompressed and the sear drops into the sear hole. The chamber is also fully rearward and load/eject operations take place. The bolt is ready for another cycle. The shoulder of the chamber interferes with the shoulder on the bolt head to bring the bolt away from the baseplate (Figure 13) and secure the round for the next firing. Figure 15 shows a round and all the components in a now ready to fire position.

AMCAWS 30 MM

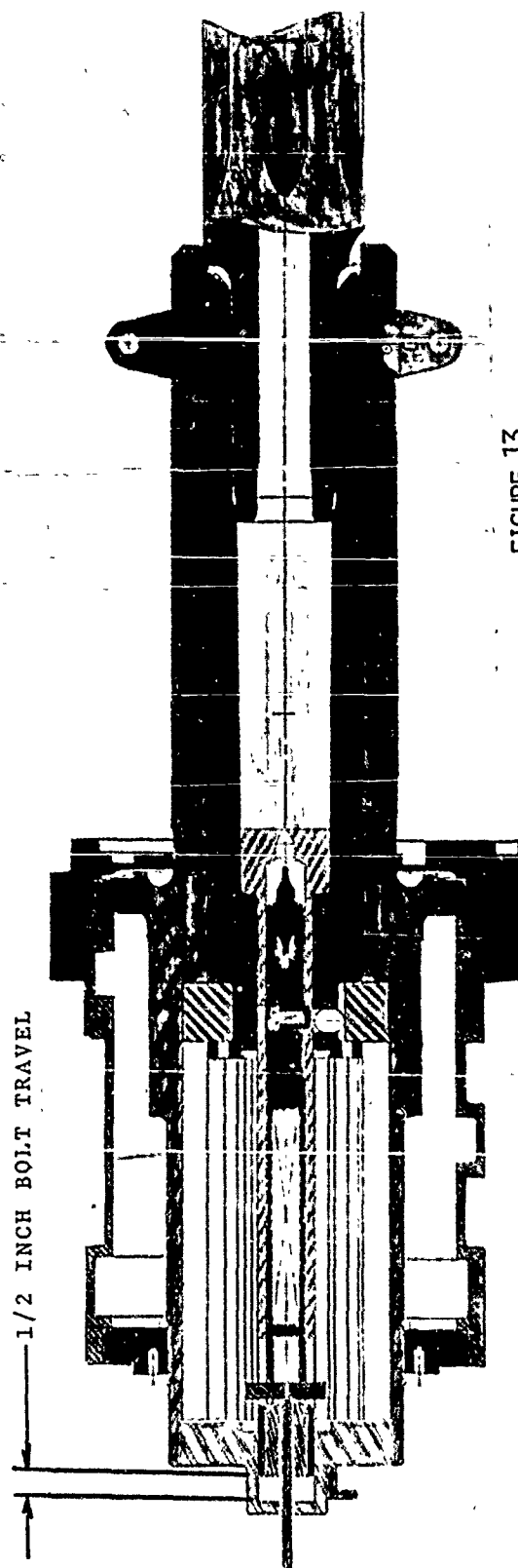


FIGURE 13
AMCAWS LAYOUT

ROUND FUNCTION IN THE AUTOMATIC WEAPON

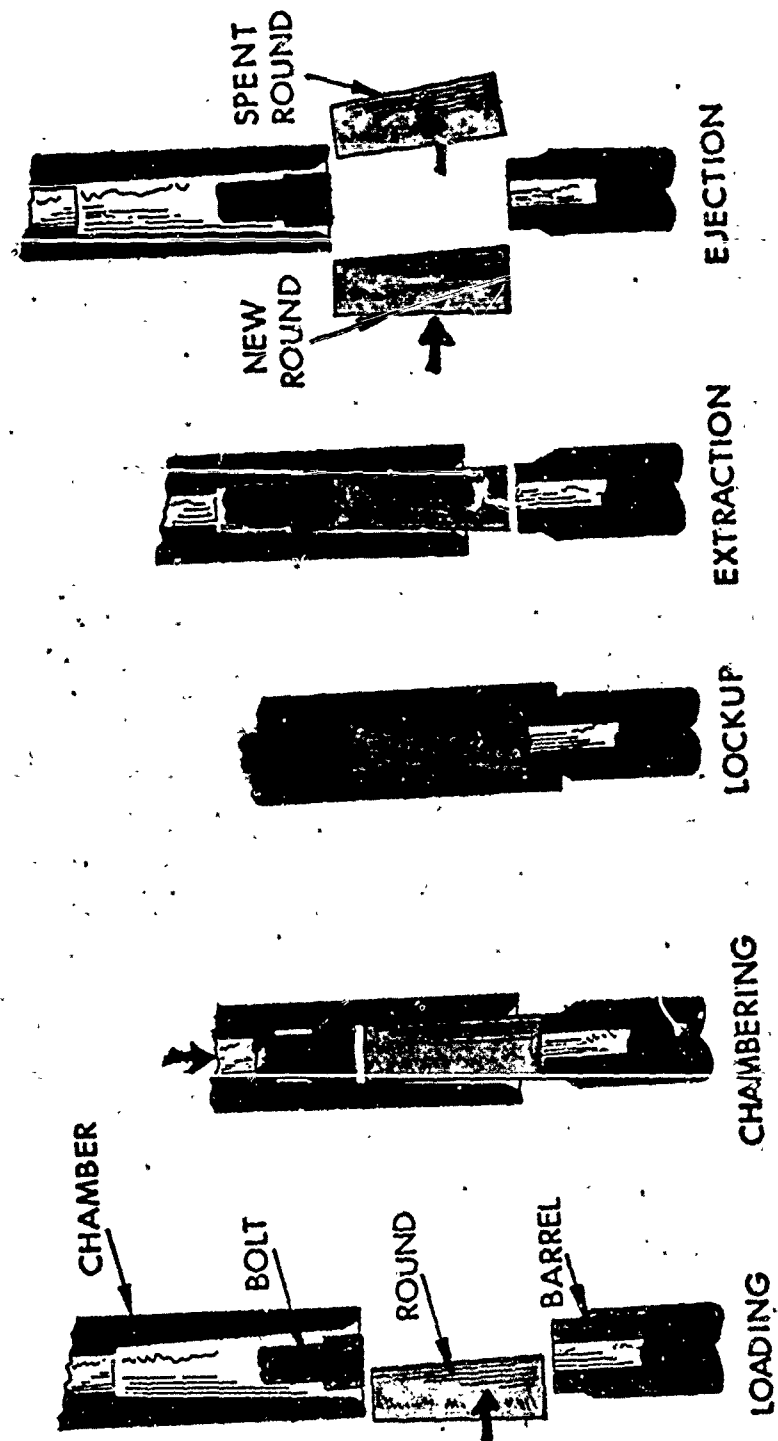


FIGURE 14
ROUND FUNCTION SEQUENCE

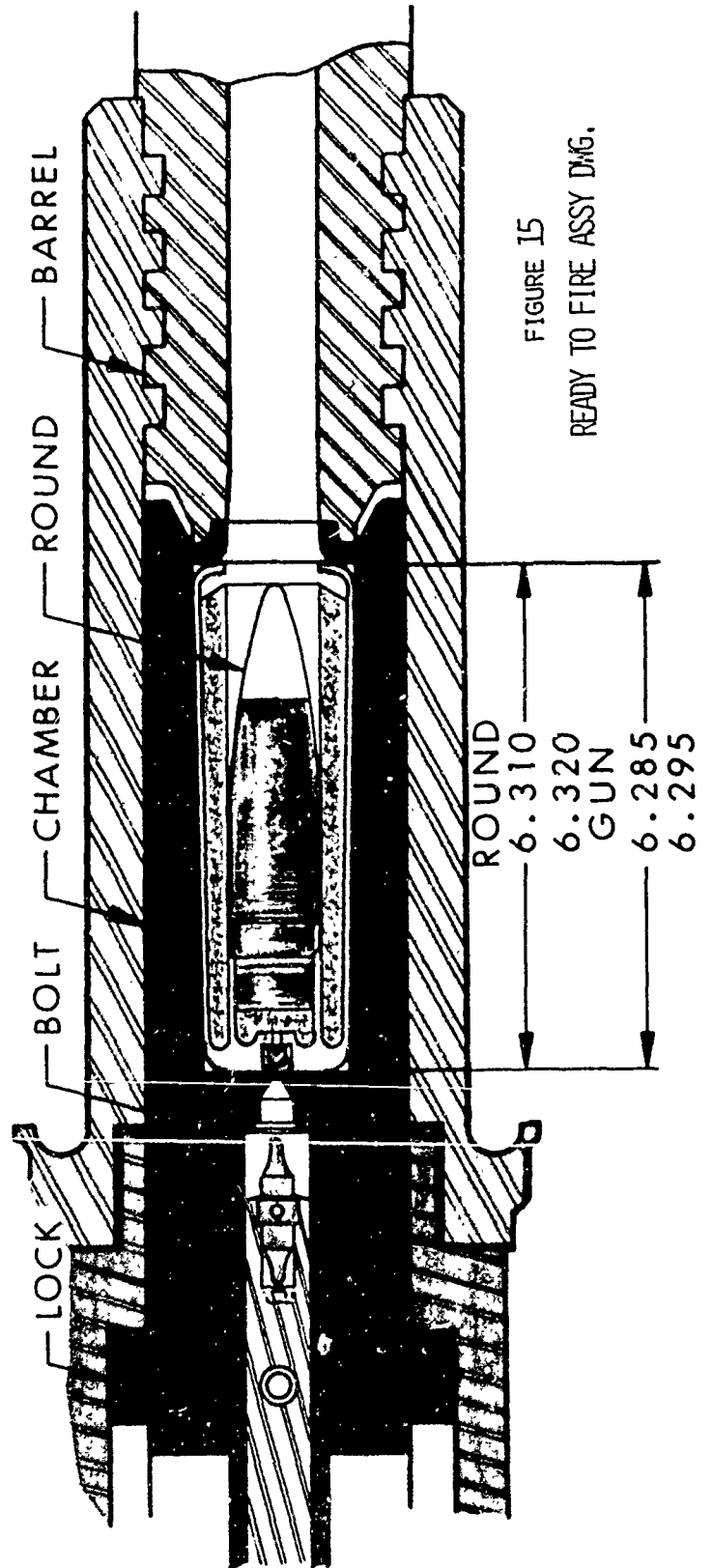
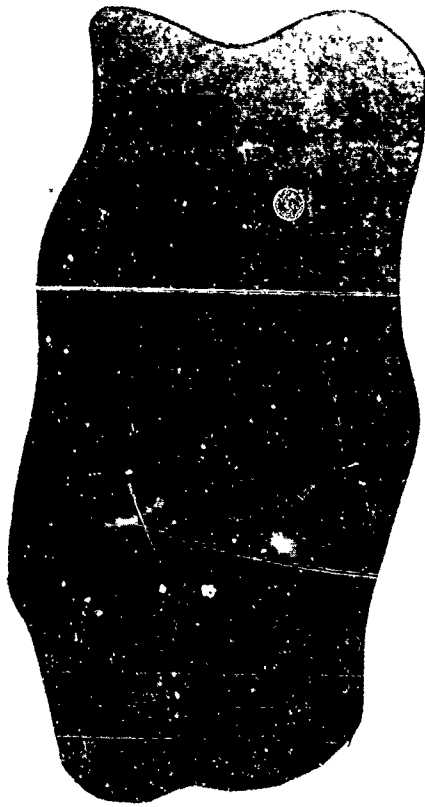
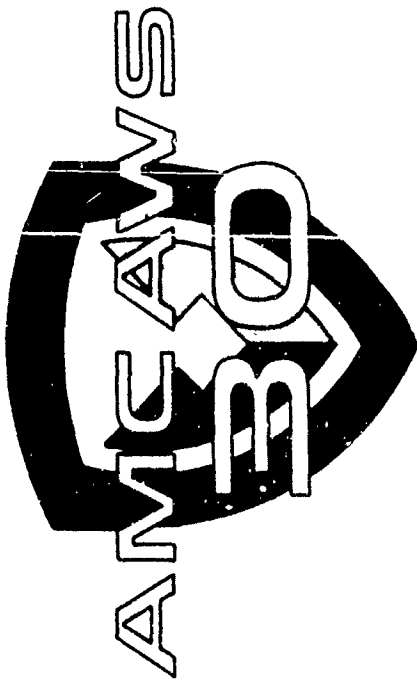


FIGURE 15
READY TO FIRE ASSY DMG.

2.6 CHAMBER

The chamber is pictured in Figure 10 with the lock ring in place. The chamber is translated by the action of the drum cam path through the follower stud. The stud is cantilevered from the chamber to the drum cam path. The stud is constrained to move within the receiver slot shown in Figure 16. In the automatic weapon assembly the handle seen in Figure 16 is replaced by the follower stud.

The follower stud is cantilevered as shown in Figure 4. The duckbills of Figure 10 are essentially extensions of the top and bottom of the chamber and serve to keep the round very close to the weapon's centerline during feed and eject. The matching tapers on the chamber and round cause line to line fit of the round and the chamber during the lockup phase of Figure 14. The chamber provides the support during the peak pressures, although the round itself performs all obturation functions (1). Figures 13 and 14 show the chamber's relationships to the other components just prior to firing.

2.7 RECEIVER

The receiver (Figure 17) essentially acts as a housing for the chamber and bolt assemblies. The front end of the receiver has a set of lugs which hold the barrel. The rear of the receiver has flanges cut that match the lock ring lugs (Figure 10) and against which the lock ring lugs seat during firing. In the unlocked position the lock ring lugs (thus the chamber) can move down the receiver, but the locking operation turns the lock ring 15°, which lines up the lock ring lugs and the corresponding receiver flanges. The receiver is slotted (Figure 16 and 17) to provide a guide for the chamber-to-drum cam path follower stud. The forward area of the receiver, near the barrel lugs, is cut to allow brackets that connect to the buffer packs. The receiver window, just to the rear of the barrel lugs, is cut to allow the ammunition to be fed and ejected.

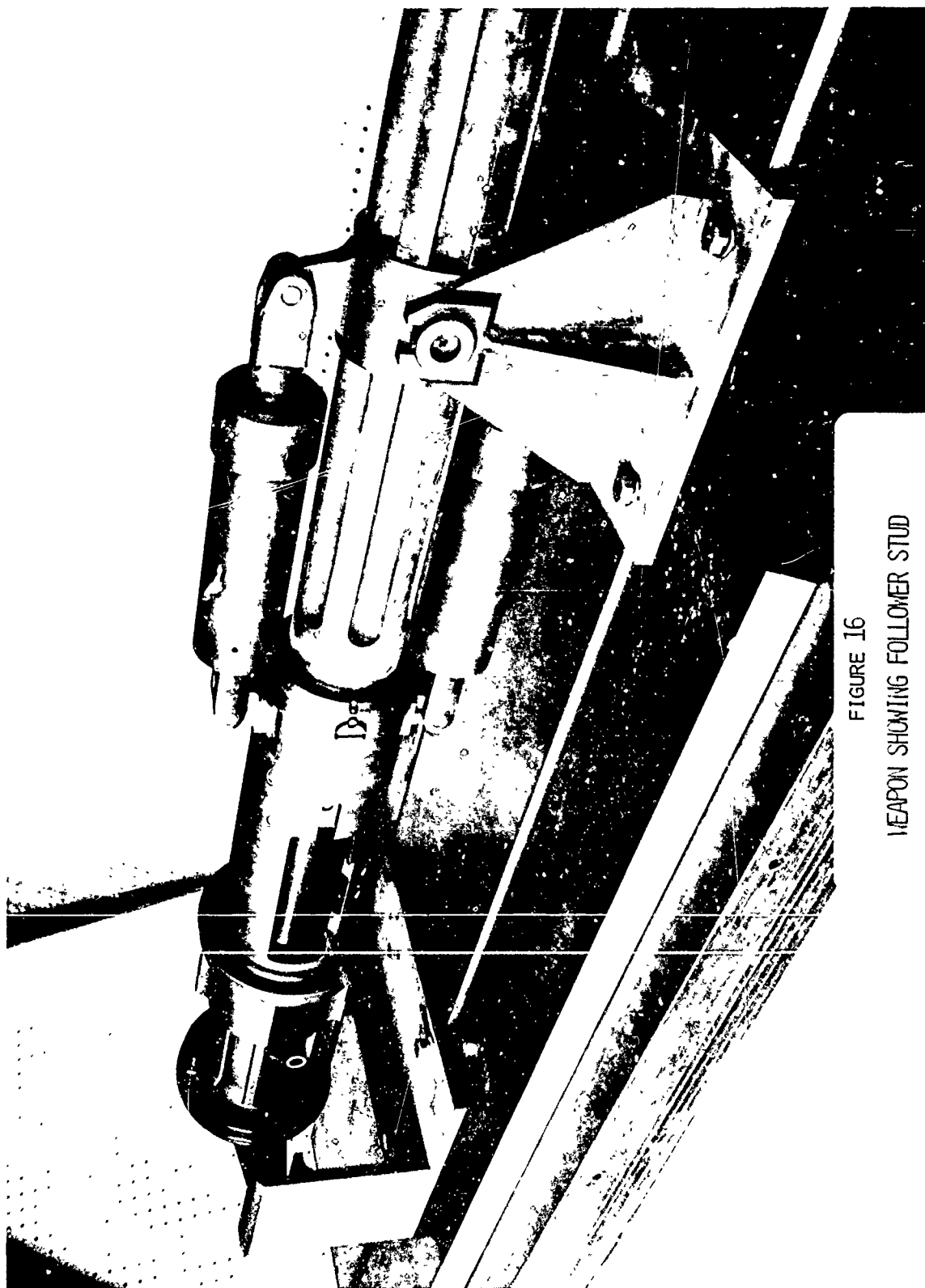
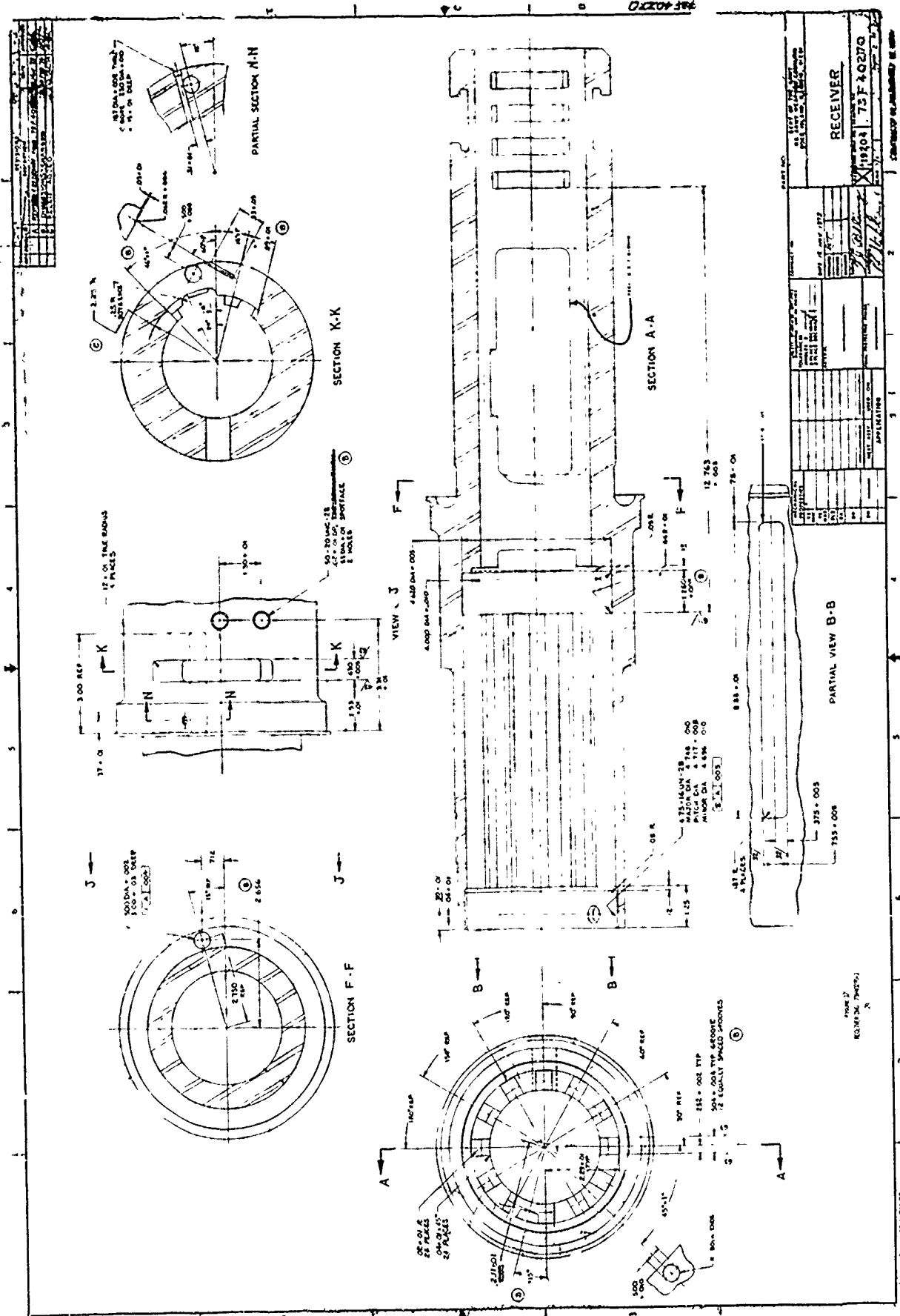


FIGURE 16
WEAPON SHOWING FOLLOWER STUD



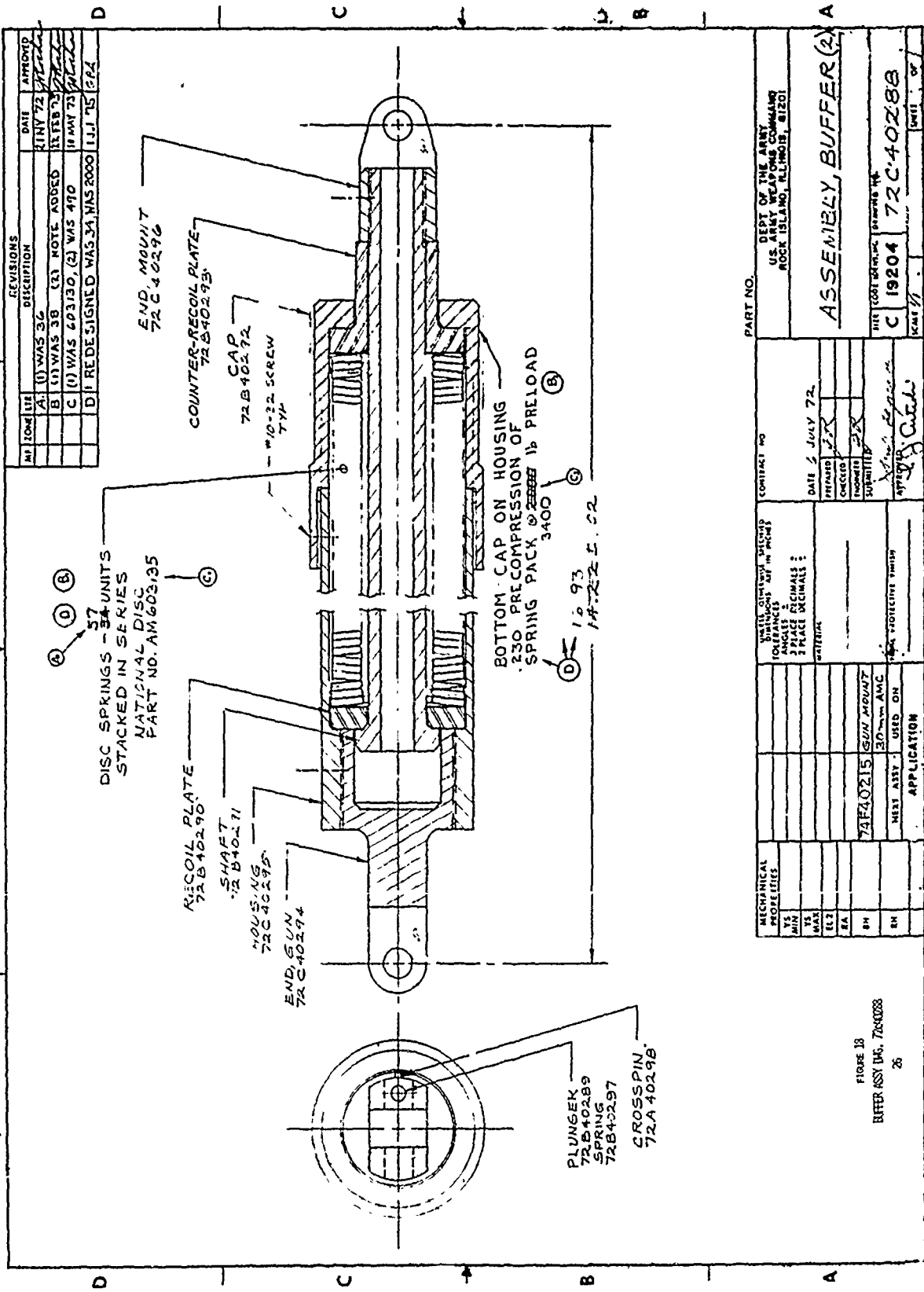
2.8 BUFFERS

The buffer assembly drawing (Figure B) shows one of the two identical buffers. The buffers are mounted on the top and bottom of the weapon, as can be seen in Figure 19. The ring seen in Figure 16 onto which the front end of the buffer packs fasten clears the barrel and allows the barrel to move up and back within it. The ring has trunion mounts on both sides which allows the gun to fasten onto its firing platform. As can be seen from the assembly drawing (Figure 18) the buffers have the same preload and spring-rate in both recoil and counter-recoil. These two spring factors are variable simply by changing the belville spring packs. Currently the weapon has nineteen sets of double springs in each buffer pack which gives a preload and rate per buffer of 3500 pounds and 10,700 pounds per inch respectively, although Figure 18 indicates triple spring sets in an elongated buffer.

Upon firing, a peak force of up to 200,000 pounds is developed against the flange lugs on the receiver. This force (more properly, the firing impulse) is transmitted through the receiver to the buffers which lengthen to absorb the recoil energy of the firing. The buffer begins to counter recoil and eventually damps out prior to the next shot. Typically recoil is (for the preload and rate discussed) 1.20 inch and the counterrecoil is .75 inch. The system is completely damped in .120 seconds or 1/5 of a cycle at 121 spm.

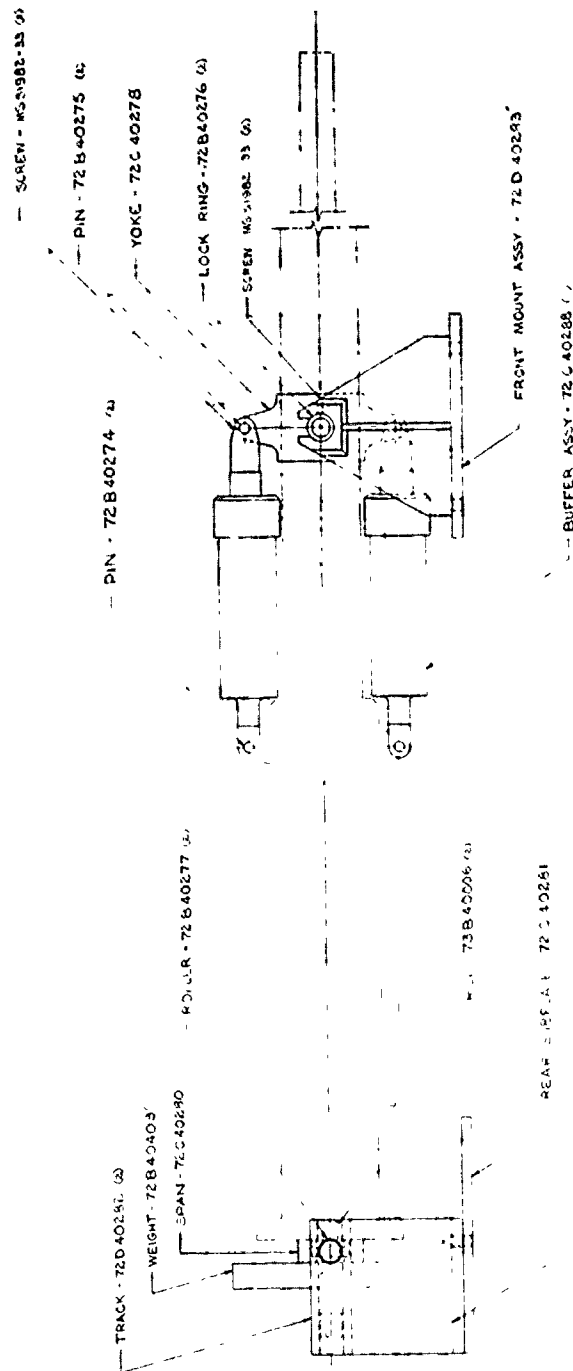
2.9 BARREL

The barrel joins the receiver with a set of lugs as shown in Figure 15. Mechanically the barrel acts only as a recoiling mass although rifling torques (2) might be significant in a multiple degree of freedom model. Note the cut away portion of the barrel at the muzzle end in Figure 13. This gives clearance to the chamber duckbills (Figure 10) during the chamber forward portion of the firing cycle.



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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

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2.10 DRIVE TRAIN

The gear drive assembly (Figures 2 and 20) allows four final shots per minute rates, 90, 121, 181, and 242. The prototype weapon is limited to 121 spm because there is insufficient lock time (time necessary to sear off the firing pin, obtain projectile exit, and bleed of the high-pressure gasses) designed into the drum cam path to allow the higher rates. At 121 spm the 59 tooth gear from the motor drives a 120 tooth pickup gear. The 16 tooth pinion gear which is part of the shaft for the 120 tooth gear then drives the 151 tooth gear on the outside diameter of the drum cam (Figure 2). The torque-speed curve for the motor is shown in Figure 21. This curve is from data supplied by Aeronutronic-Ford. The drive motor itself is from an XM-140 system. Since a firing occurs once every 360° rotation of the drum cam, a quick calculation indicates in the 121 spm configuration a firing cycle completes every 6910° rotation of the 59 tooth motor gear. The 59 tooth gear angle is the input angle for the mathematical model developed. Zero degrees input angle is defined so that the drum cam is also at zero degrees (as a reference, the weapon actually fires when the drum cam is at about 33° rotation, or 541° rotation of the 59 tooth gear).

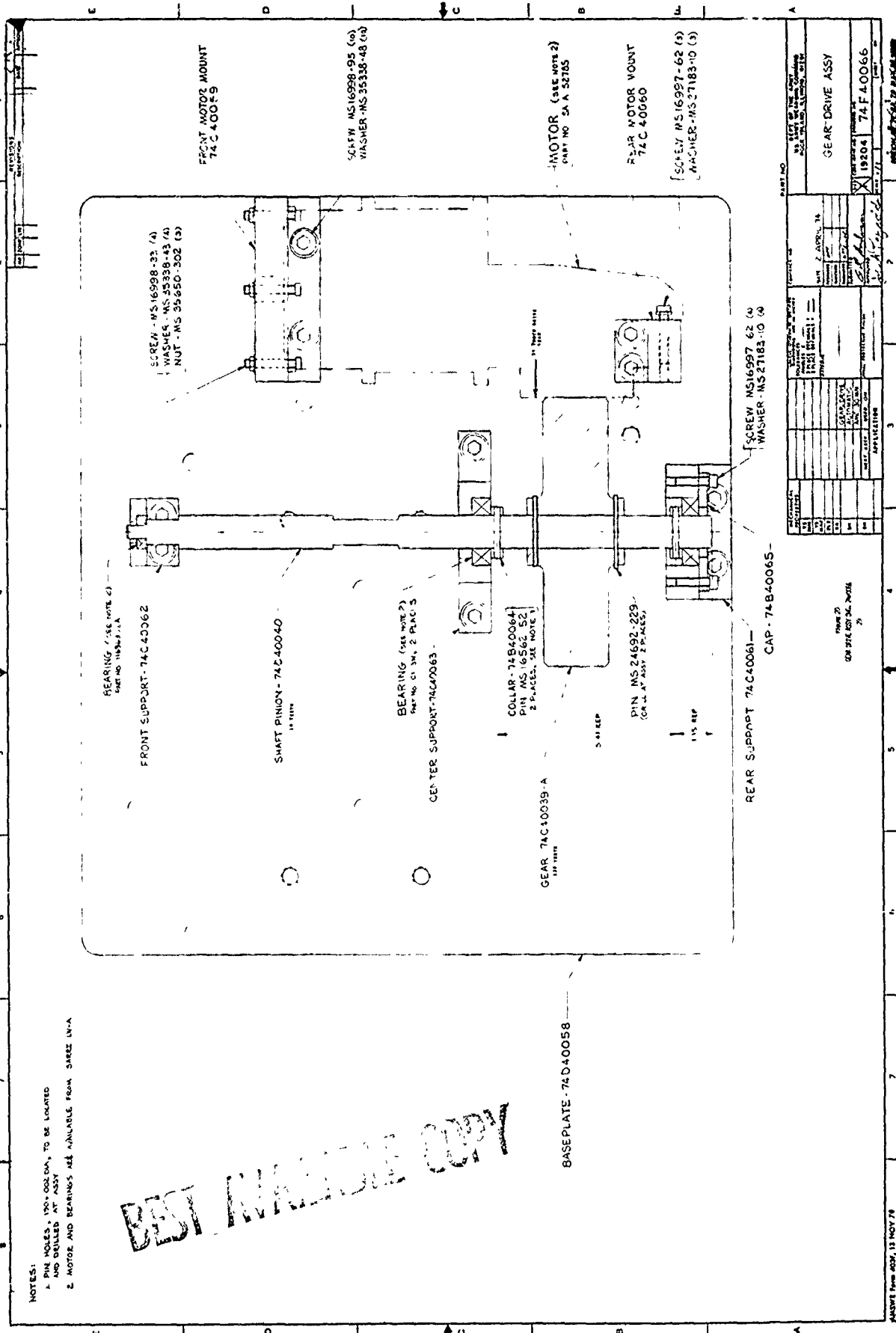
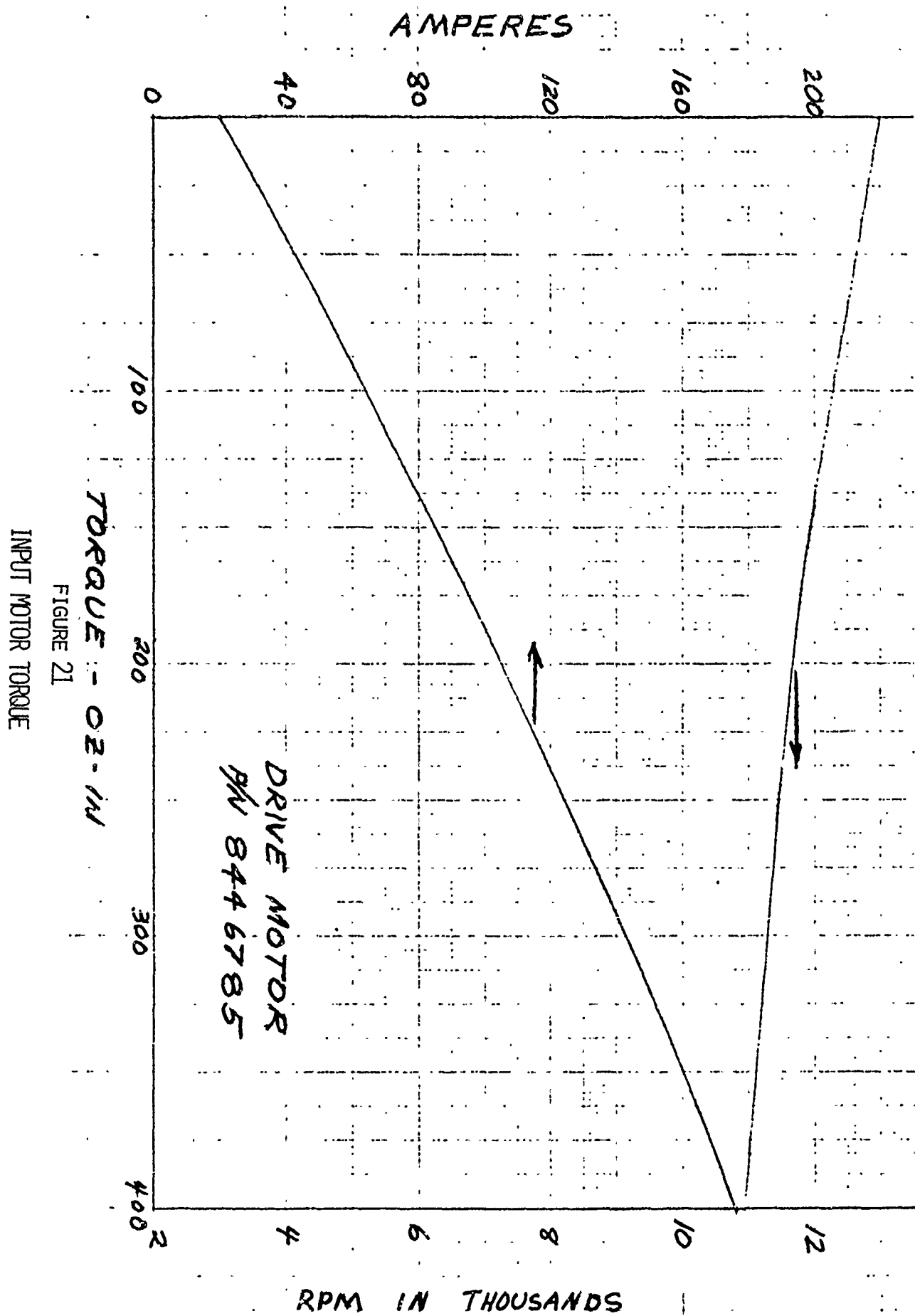


Fig. 20



3. GENERALIZED d'ALEMBERT FORCE METHOD

Obtaining the differential equation of motion for a dynamic system is obviously one of the important things that must be done in order to achieve the position description (the solution) of the system. Utilization of d'Alembert's principal ($F - M\ddot{a} = 0$) and virtual work arguments allows a derivation of the generalized d'Alembert equation, with constraints (5). The equation

$$\sum_{j=1}^M \vec{F}_j \cdot \frac{\partial \vec{a}_j}{\partial \dot{q}_i} - \sum_{\ell=1}^L \vec{\lambda}_\ell \cdot \frac{\partial \phi_\ell}{\partial \dot{q}_i} = 0 \quad (3.1)$$

explained more fully in Appendix 2 and Table 3.1, allows the methodical generation of the differential equation of motion. The d'Alembert equation as expressed in Eq. (3.1) handles, for a generalized coordinate set and any degree of freedom, external forces applied to the system, d'Alembert forces, and closed loop constraints. The formulation is not limited to linear or "linearized" motion, in fact, DRAM (6) is based on Eq. (3.1) and the DRAM program development is partly based on a need for a general program to facilitate computer aided design of large, linear or non-linear, displacement systems of the type found in most machines.

The d'Alembert equation (3.1) reduces to

$$\sum_{j=1}^M \vec{F}_j \cdot \frac{\partial \vec{a}_j}{\partial \dot{\phi}_2} = 0 \quad (3.2)$$

for the AMCAWS 30 system (Appendix 2). The AMCAWS system is somewhat simple, having only one degree of freedom. Representation of the AMCAWS system as single degree of freedom is achieved by the representation of the various weapon cams as motion generators. Another simplifying factor is that AMCAWS is essentially a two dimensional system.

Since there are over twenty effective forces that must be considered, an explanation of the procedure used to obtain the differential equation of motion

using the AMCAWS weapon as an example would be unnecessarily detailed. The example chosen for illustration is the simple pendulum shown in Figure 22.

The pendulum is a one degree of freedom system in two dimensions. Eq. (3.2) holds and using the terms indicated in Figure 22 Eq. (3.2) can be written

$$\sum_{j=1}^3 \vec{F}_j \cdot \frac{\partial \vec{a}_1}{\partial \theta_2} = 0 \quad (3.3)$$

There are three effective forces (rotational and translational d'Alembert forces and gravity) acting on the pendulum bar, hence $j = 1, 2, 3$. $\vec{a}_j$ is a vector from some point in ground to the point of application of the $\vec{F}_j$ being considered. θ_2 is the angle of the bar measured as indicated in the figure and is, of course, the degree of freedom.

The blow-by-blow procedure of determining the differential equation of motion is a relatively straightforward application of vector analysis.

For $j=1$, $\vec{F}_1$ is the rotational d'Alembert force $-I_2 \ddot{\theta}_2 \hat{k}$.

$$\vec{F}_1 = -I_2 \ddot{\theta}_2 \hat{k} \quad (3.4)$$

$\ddot{\theta}_2$ is the second time derivative of θ_2 (angular acceleration in two dimensions). $\hat{k}$ is the unit vector about which the rotation takes place and is defined in Figure 22 (all the coordinates in this report are right-handed). I_2 is the moment of inertia of part 2 about the center of rotation, point 0. Note that part 1 is, by convention, ground.

The point of application from some point in ground to the point of application of $\vec{F}_1$ is $\vec{a}_1$ with

$$\vec{a}_1 = \vec{\text{const}} + \theta_2 \hat{k} \quad (3.5)$$

SIMPLE PENDULUM

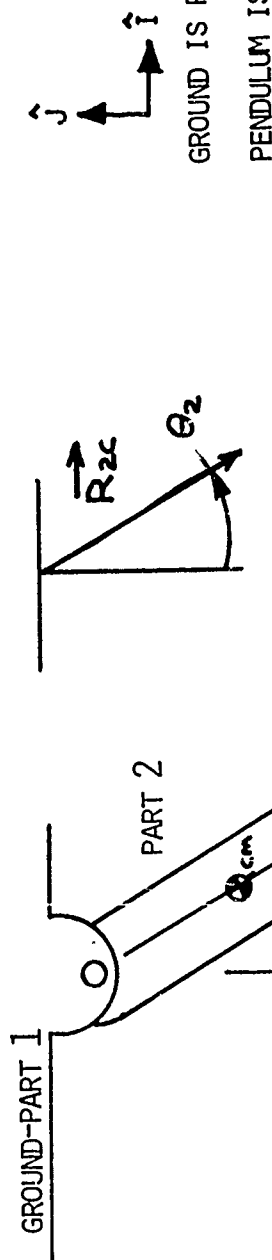


TABLE 1			
J	$\vec{F}_J$	$\vec{A}_J$	$\vec{F}_J \cdot \frac{\partial \vec{A}_J}{\partial \theta_2}$
1	$-M \hat{j}$	$\vec{R}_{2c}$	$-R_{2c} M_2 G \sin \theta_2$
2	$-M \ddot{\vec{R}}_{2c}$	$(\hat{k} \times \vec{R}_{2c})$	$-R_{2c} M_2 \ddot{\theta}_2$
3	$-I_2 \ddot{\theta}_2$	$\theta_2 \hat{k}$	$-I_2 \ddot{\theta}_2$

SUMMATION OF THE DOT PRODUCT TERMS

$$-(I_2 + M_2 R_{2c}^2) \ddot{\theta}_2 - M_2 R_{2c} G \sin \theta_2 = 0$$

AND AFTER REARRANGEMENT AND SUBSTITUTION (RHS -- RIGHT HAND SIDE)

$$[A] \{ \ddot{\theta} \} = \{ RHS \}$$

FIGURE 22

SIMPLE PENDULUM

The partial derivative with respect to θ_2 is

$$\frac{\partial \vec{a}_1}{\partial \theta_2} = \hat{k}. \quad (3.6)$$

The dot product is then

$$\vec{F}_1 \cdot \frac{\partial \vec{a}_1}{\partial \theta_2} = -I \ddot{\theta}_2 \quad (3.7)$$

for $j=2$, $\vec{F}_2$ is the translational d'Alembert force $-\ddot{m} \vec{p}_{2c}$. $\ddot{\vec{p}}_{2c}$ is the second time derivative of a vector from a point in ground to the center of mass of the bar.

Since

$$\vec{p}_{2c} = \text{const} + \vec{r}_{2c}, \quad (3.8)$$

$\ddot{\vec{p}}_{2c}$ is identically $\ddot{\vec{r}}_{2c}$. The point of application of $\vec{F}_2$ from the ground point is $\vec{a}_2$, with

$$\vec{a}_2 = \text{const} + \vec{r}_{2c} \quad (3.9)$$

$$\text{and } * \frac{\partial \vec{a}_2}{\partial \theta_2} = (\hat{k} \times \vec{r}_{2c}). \quad (3.10)$$

$\ddot{\vec{r}}_{2c}$ must be expanded, eventually into $\hat{i}$ and $\hat{j}$ components. In two dimensions,

$$\ddot{\vec{r}}_{2c} = \ddot{r}_{2c} \hat{r}_{2c} + 2\dot{r}_{2c} \dot{\theta}_2 (\hat{k} \times \hat{r}_{2c}) - \dot{\theta}_2^2 \vec{r}_{2c} + \ddot{\theta}_2 (\hat{k} \times \vec{r}_{2c}) \quad (3.11)$$

Since the bar is of fixed length there is no change in length in time and

$$\dot{r}_{2c} = \ddot{r}_{2c} = 0 \quad (3.12)$$

$$* \frac{\partial \vec{r}_{2c}}{\partial \theta_2} = \frac{\partial \vec{r}_{2c}}{\partial t} \frac{\partial t}{\partial \theta_2} = \frac{\dot{\vec{r}}_{2c}}{\dot{\theta}_2} = \frac{\dot{\theta}_2 (\hat{k} \times \vec{r}_{2c})}{\dot{\theta}_2} = (\hat{k} \times \vec{r}_{2c}) \quad \text{where } \vec{r}_{2c} \text{ is inextensible and moves entirely in a plane.}$$

yielding for Eq. (3.11)

$$\ddot{\vec{r}}_{2c} = \ddot{\theta}_2 (\hat{k} \times \vec{r}_{2c}) - \dot{\theta}_2^2 \vec{r}_{2c}. \quad (3.13)$$

Thus

$$\vec{F}_2 = -m_2 \{ \ddot{\theta}_2 (\hat{k} \times \vec{r}_{2c}) - \dot{\theta}_2^2 \vec{r}_{2c} \} \quad (3.14)$$

and the dot product becomes

$$\vec{F}_2 \cdot \frac{\partial \vec{a}_2}{\partial \theta_2} = -m r_{2c}^2 \ddot{\theta}_2. \quad (3.15)$$

for $j=3$, $\vec{F}_3$ is the gravity force. The gravity field is considered to act at the mass center with

$$\vec{F}_3 = -mg \hat{j}. \quad (3.16)$$

The point of application (a_3) is vector a_2 . The dot product for $j=3$ is then

$$\vec{F}_3 \cdot \frac{\partial \vec{a}_3}{\partial \theta_2} = \vec{F}_3 \cdot \frac{\partial \vec{a}_2}{\partial \theta_2} = (-mg \hat{j}) \cdot (\hat{k} \times \vec{r}_{2c}) = -r_{2c} mg \sin \theta_2 \quad (3.17)$$

The sum of the right hand sides of equations (3.7), (3.15), and (3.17), when set to zero, is the differential equation of motion for the pendulum system of Figure 28.

$$\sum_{j=1}^3 \vec{F}_j \cdot \frac{\partial \vec{a}_j}{\partial \theta_2} = -I \ddot{\theta}_2 - m r_{2c}^2 \ddot{\theta}_2 - r_{2c} mg \sin \theta_2 = 0 \quad (3.18)$$

$$= -(I + m r_{2c}^2) \ddot{\theta}_2 - r_{2c} mg \sin \theta_2 = 0 \quad (3.19)$$

Eq. (3.19) is the differential equation of motion. Generally, in development of such an equation, translational d'Alembert forces and gravity forces are lumped, since they have the same point of application. A tabular form of bookkeeping, such as used throughout Appendix 2 and in Table 1, is useful in documenting the procedure without undue space or verbiage. Table 1 is the development of the differential equation of motion for the system of Figure 22 with the translational d'Alembert force and gravity force combined.

The equation of motion for this particular example is easily obtained with any number of other approaches. The simplicity of the generalized d'Alembert Force procedure claimed is not overwhelmingly apparent in a trivial example such as the pendulum, but for additional degrees of freedom or a single degree-of-freedom system with as many effective forces as the AMCAWS 30 the method provides an efficient well defined procedure for generating the differential equation of motion for dynamic systems.

4. MATHEMATICAL MODEL FOR AMCAWS 30

The AMCAWS 30 MM weapon system, while seemingly difficult to describe (Section 2), is easily modeled. This is because the model need not be as detailed as the description. Many parts can be lumped, other parts can be ignored, and some complex operating characteristics can be simplified (as long as accuracy is maintained).

The component actions and interactions of major interest are those associated with feeding, ejecting, chambering, and locking. Drive motor torque requirements are also of major interest. A discussion of the simplifications and a defense of why some parts and components are not included is pertinent.

The greatest simplification in the model evolves from the fact that AMCAWS is one degree-of-freedom. The specification of the input angle (which is, again, the degree-of-freedom) in turn specifies all the positions of the major components listed. The specification of the first and second time derivatives of the input motor in turn specifies all the component velocities and forces. This fact can be exploited by creating a table that allows each component's position to be described as a function of the input angle. This has been done and is the Functional Relationships Computer Program (FRCP, Appendix 1). The FRCP, using the geometric constraints of the cams and followers, generates an extensive table of each component's position versus motor input angle. While the FRCP is more fully discussed in Appendix 1, briefly the program is a FORTRAN description of the weapon that has the positional table as primary output. The program traces through one firing cycle in 360 steps. For a given weapon geometric configuration (cam rises, follower arm lengths as opposed to a given weapon mass configuration), the FRCP need be run only once. The single degree of freedom allows an

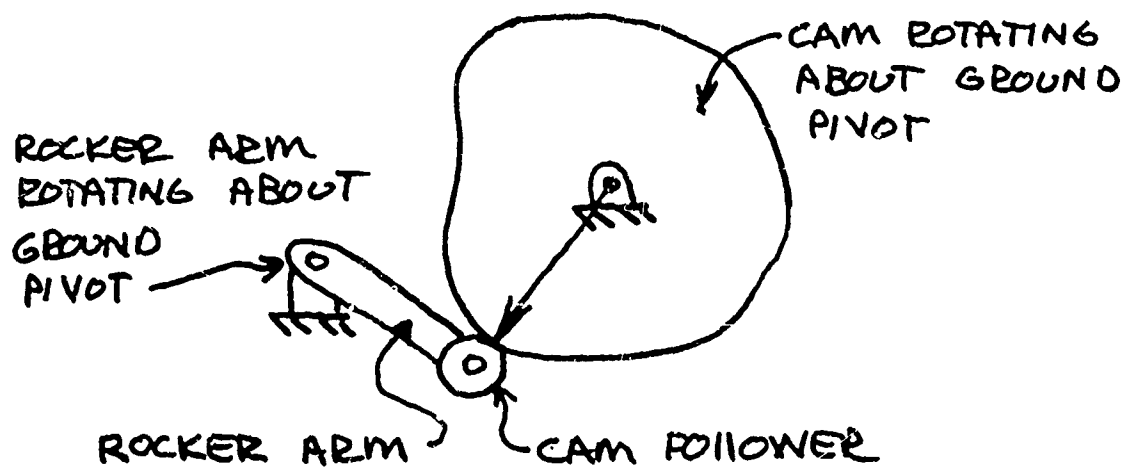
"uncoupling" of the major components and allows each one to be considered separately. The FRCP develops the positional response of each component with respect to the degree-of-freedom (input angle). The tables enable the dynamic program (Appendix 3) to treat each component as essentially a separate problem completely unrelated to any other component. Appendix 2, which is the detailed development of the differential equation of motion for the AMCAWS-30, does exactly that. The simplification is that each component has a "local" degree-of-freedom which is explicitly a function of the motor input angle. The terms contributing to the equation of motion are easily identified and calculated in terms of the local coordinate. As a final step the dot product terms of the components are expressed in terms of the motor input angle. The dynamic effects of an individual component on the rest of the system are correctly accounted for when the terms from each component are summed, but this interaction need not be considered when developing the terms for the individual component.

A second simplification occurs in the FRCP itself. The feed system (Figure 7) is composed of a face cam path of some width, a roller bearing follower of diameter slightly less than the cam path width and the rocker arm which transmits motion through the shaft to the dual feed pawls. The cam path to rollerbearing contact is an example of contact between higher pairs (as contrasted with lower pairs) and position, velocity, and force solution are not trivial (3,4) in terms of difficulty of incorporation into the dynamic model itself and CPU time of running. While the higher order pairs (all the cam contacts) could all be simulated with the generalized d'Alembert force procedure (4) the increase in accuracy of the positional solution and the velocity and force solutions is not felt to be significant enough to warrant inclusion at this time. The simplification

made is, for the feed and eject slides, a pinned linkage (shown in Figure 23). The length of bars corresponds to the rise of the cam for the given rotation. The internal angles of the linkage are computed and eventually all the angles of Figure 23 can be computed. The positional solution for the feed and eject components are achieved in this manner. The velocity and acceleration solutions are accomplished in the dynamic model. Part to part forces, such as cam path to roller bearing are determined as the result of force equilibrium. The recasting of the higher pair feed and eject contacts into lower pair pinned joints is an important simplification.

There are other higher pair contacts that have been recast into more easily solved problems. The drum cam-chamber motion is through a follower or the stud. The FRCP treats chamber motion entirely as a result of a displacement function, the function itself being the rise versus rotation data on the drum cam drawing. The gear sets in the drive assembly are higher order pairs. The common simplification of assuming no losses through an individual set and assigning a total loss proportional to the power transmission through the entire assembly is made in the dynamic model. The live round being fed into the chamber is a higher pair contact, since the round slides on the feed pawl surface during the load cycle. This pair has been ignored by placing the actual ammunition mass at the pawl end during the time the round is being placed into the chamber and setting that mass to zero while the feed pawls retract. The lump cam-clevis pair for the locking ring is a higher order pair. The position solution for this pair was achieved by a 10x cardboard model of the cam surfaces. Quite sophisticated.

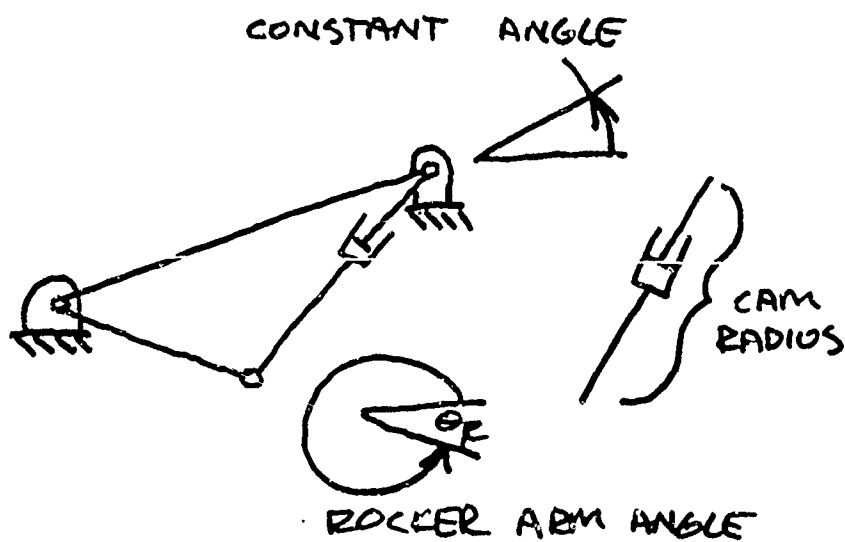
Two major assemblies are not explicitly in the model. The bolt assembly appears as a translating mass in the chamber routines and the sear spring compression is treated as a spring force acting on the chamber. The firing



- GENERAL CAM MECHANISM -

FIGURE 23
CAM CONTACT "PINNED LINKAGE"

41



SIMPLIFIED CAM
- PINNED LINKAGE -

pin travel after sear off is not pertinent to the overall model and is not modeled. The buffer assembly is not treated at all. This, in effect, ignores any recoil of the weapon due to the round impulse. The recoil of the weapon is an independent degree-of-freedom that could be included at a later date if deemed necessary. Firing pin motion could also be treated as even another degree-of-freedom. Neither of these two possible additional degrees of freedom is important to the major parameters of current interest (feeding, ejecting, chambering, locking, torque).

The power input into the weapon system is modeled as a torque versus RPM curve (Figure 21) for the drive motor. A table lookup yields the torque input to the system from the drive motor for any specified RPM. Evaluating different motors is only a matter of substituting the different torque curves.

An extremely important aspect of the model is the drag forces and other sources of power loss through the weapon. These are not yet implemented.

The mathematical model is the differential equation of motion for the system described. The complete equation for that system is

$$\begin{aligned}
 \ddot{\theta}_2 & - I_{59} - C^2 I_{120} \\
 & - (\dot{\theta}_3')^2 (I_{\text{drum}} + I_{\text{face}}) \\
 & - (\dot{\theta}_4')^2 [F I_{\text{pawl}} + F I_{\text{rock}} + F I_{\text{shaft}} + F M_{\text{pawl}} (F P_{\text{cm}})^2 \\
 & \quad + F M_{\text{rock}} (F R_{\text{cm}})^2 + F M_{\text{ammo}} (F P_e)^2] \\
 & - (\dot{\theta}_5')^2 [E I_{\text{pawl}} + E I_{\text{rock}} + E I_{\text{shaft}} + E M_{\text{pawl}} (E P_{\text{cm}})^2 \\
 & \quad + E M_{\text{rock}} (E R_{\text{cm}})^2] \\
 & - (\dot{\theta}_6')^2 (I_{\text{lock}}) \\
 & + (R_7')^2 (V_{\text{CHMBR}})
 \end{aligned}$$

$$\begin{aligned}
& +\ddot{\theta}_2^2 - \theta_3' \theta_3'' (I_{\text{drum}} + I_{\text{face}}) \\
& - \theta_4' \theta_4'' [F I_{\text{pawl}} + F I_{\text{rock}} + F I_{\text{shaft}} \\
& \quad + F M_{\text{pawl}} (F P_{\text{cm}})^2 + F M_{\text{rock}} (F R_{\text{cm}})^2 \\
& \quad + F M_{\text{ammo}} (P E)^2] \\
& - \theta_5' \theta_5'' [E I_{\text{pawl}} + E I_{\text{rock}} + E I_{\text{shaft}} \\
& \quad + E M_{\text{pawl}} (E P_{\text{cm}})^2 + E M_{\text{rock}} (E R_{\text{cm}})^2] \\
& - \theta_6' \theta_6'' (I_{\text{lock}}) \\
& + R_7' R_7'' (V_{\text{chmbr}}) \\
& + T_{\text{motor}} - C_{\text{motor}} \\
& - \theta_4' [E M_{\text{pawl}} (E P_{\text{cm}}) g \cos \theta_4 - E M_{\text{rock}} (E R_{\text{cm}}) g \cos \theta_{\text{rf}} + T_{\text{feed}}] \\
& - \theta_5' [E M_{\text{pawl}} (E P_{\text{cm}}) g \cos \theta_5 + E M_{\text{rock}} (E R_{\text{cm}}) g \cos \theta_{\text{rf}}] \\
& - \theta_6' (T_{\text{lock}}) \\
& - R_7' [C_{\text{CRUSH}} - C_{\text{SEAR}} + C_{\text{fchmbr}} (R_7' \dot{\theta}_2 / \text{ABS}(R_7' \dot{\theta}_2))] \\
& = 0
\end{aligned} \tag{4.1.a}$$

which is rewritten

$$a\ddot{\theta} + b\dot{\theta}^2 = 0 \tag{4.1.b}$$

This ordinary differential equation is integrated numerically using the HPCG routine out of the IBM-SSP library (all the routines used by the FRCP and the dynamic program are included with their respective listings). HPCG uses Hamming's predictor-corrector method coupled with a Ralston modified Runge-Kutta procedure for start-up values (7). HPCG is quite general because it requires two user supplied external subroutines FCT and OUTP. FCT is the routine that must evaluate the constants of Eq. (4.1.b) and OUTP is the output vehicle for HPCG.

The construction of the dynamic program is shown in Figure 24. The OUTP and FCT blocks are expanded in Figures 24 and 25, respectively. Both the dynamic program and the FRCP are reasonably well documented and so a more

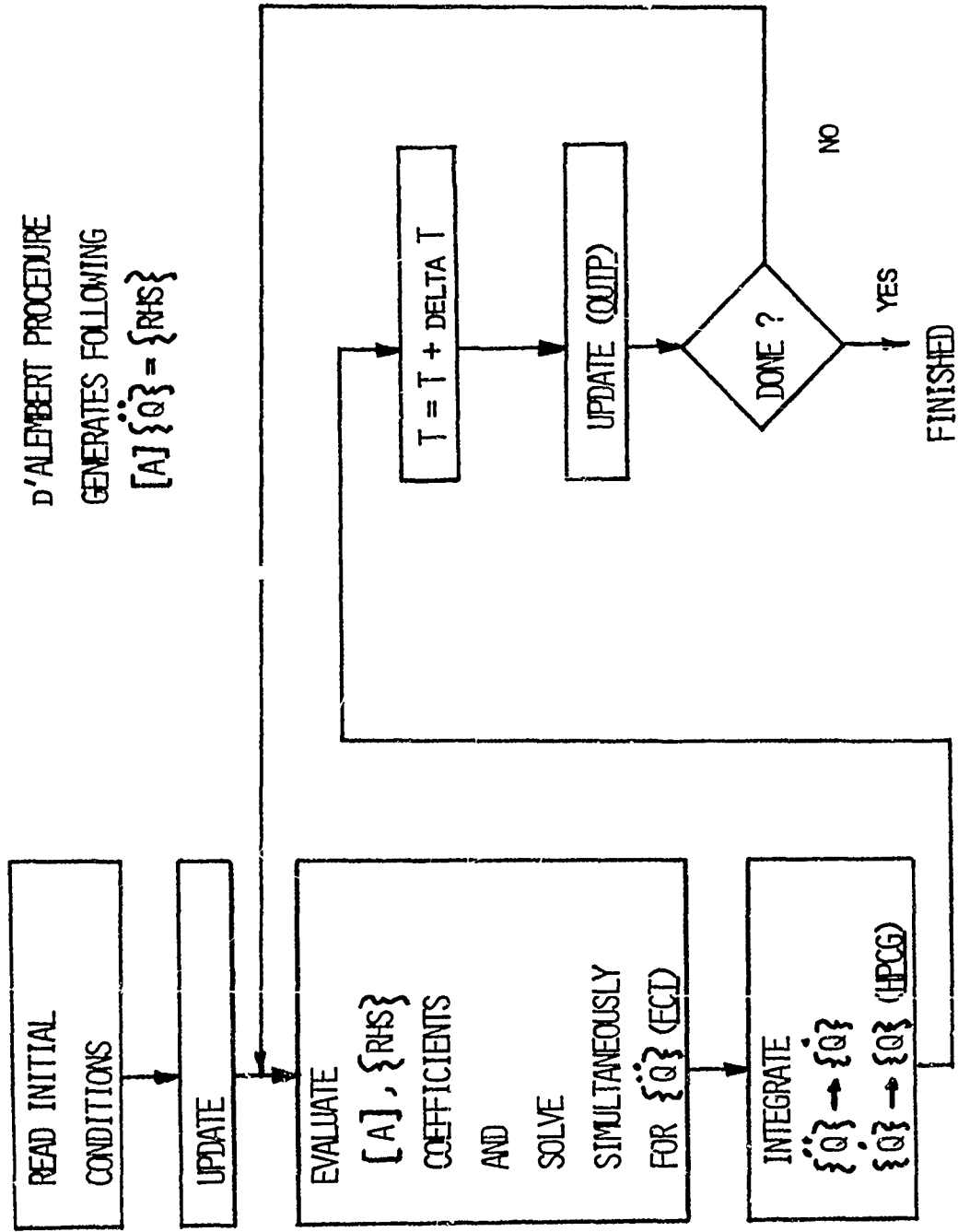


FIGURE 24
DYNAMIC PROGRAM BLOCK DIAGRAM

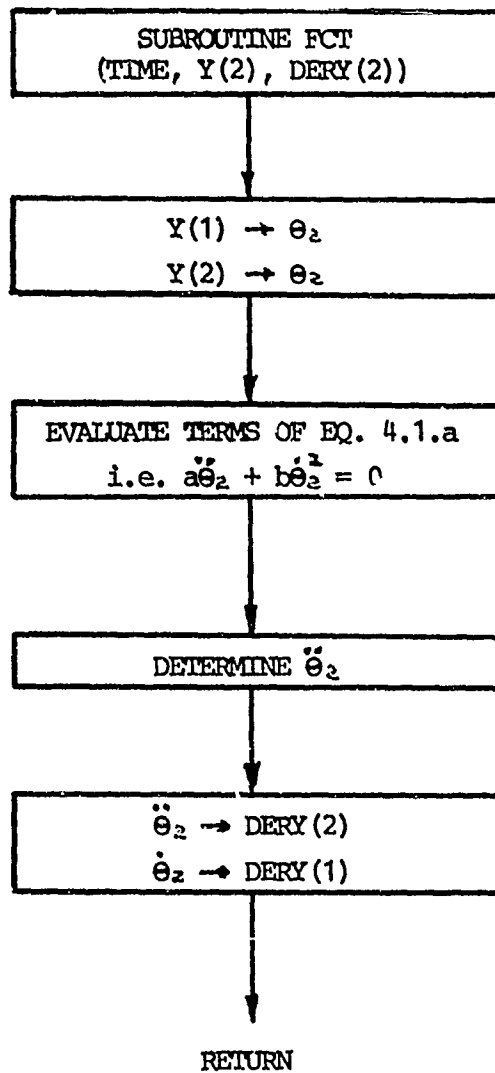


FIGURE 25
FCT BLOCK DIAGRAM
45

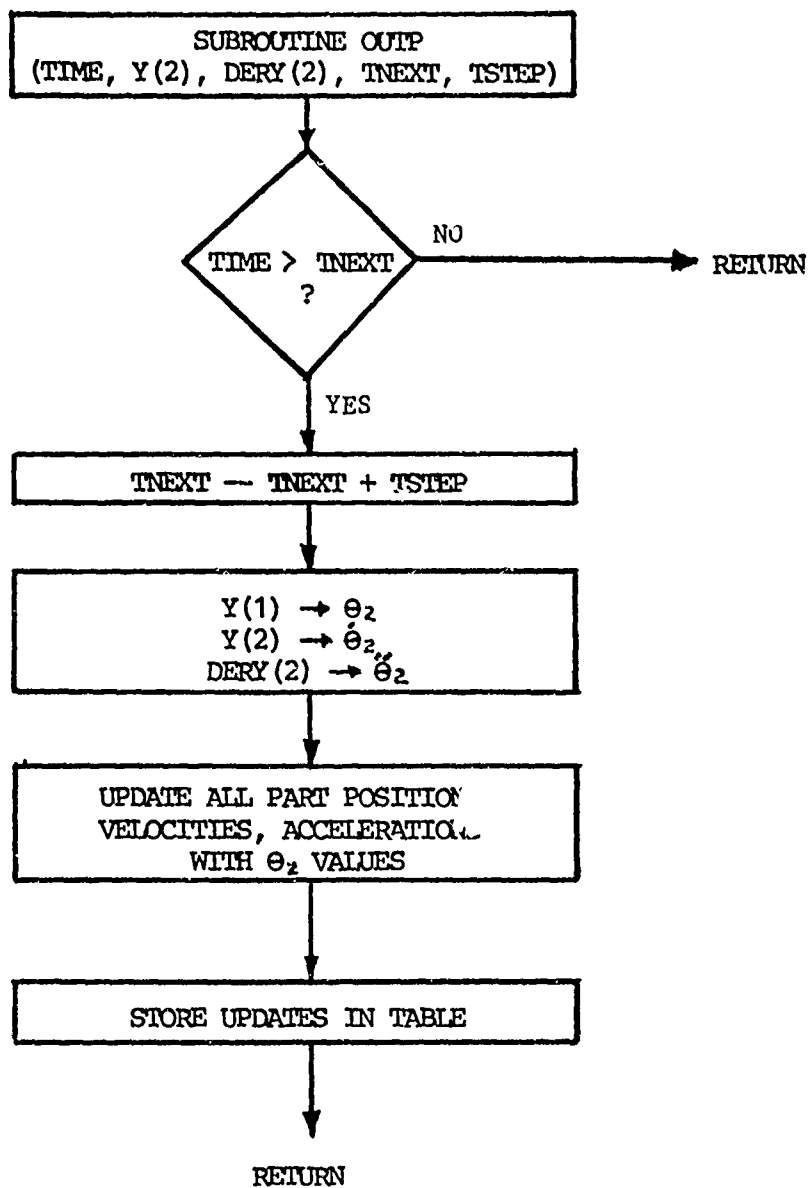


FIGURE 26
OUTP BLOCK DIAGRAM

detailed description of the program can be found in Appendix 4 and 1. The program has some interactive capability in input which was used during initial development on MTS (Michigan Terminal System, University of Michigan) but difficulty of doing interactive work and limited disk availability at AVSCOM almost demands the dynamic program be run with its batch default.

The batch default causes the dynamic program to have the following initial conditions:

Initial motor input angle position	= 0
Initial motor input velocity	= 0
Initial motor input acceleration	= 0
Initial time	= 0
Final time	= 2.5 sec
Output steps every .01 seconds	

Figures 27 through 29 show the response of the motor input angle for a typical run.

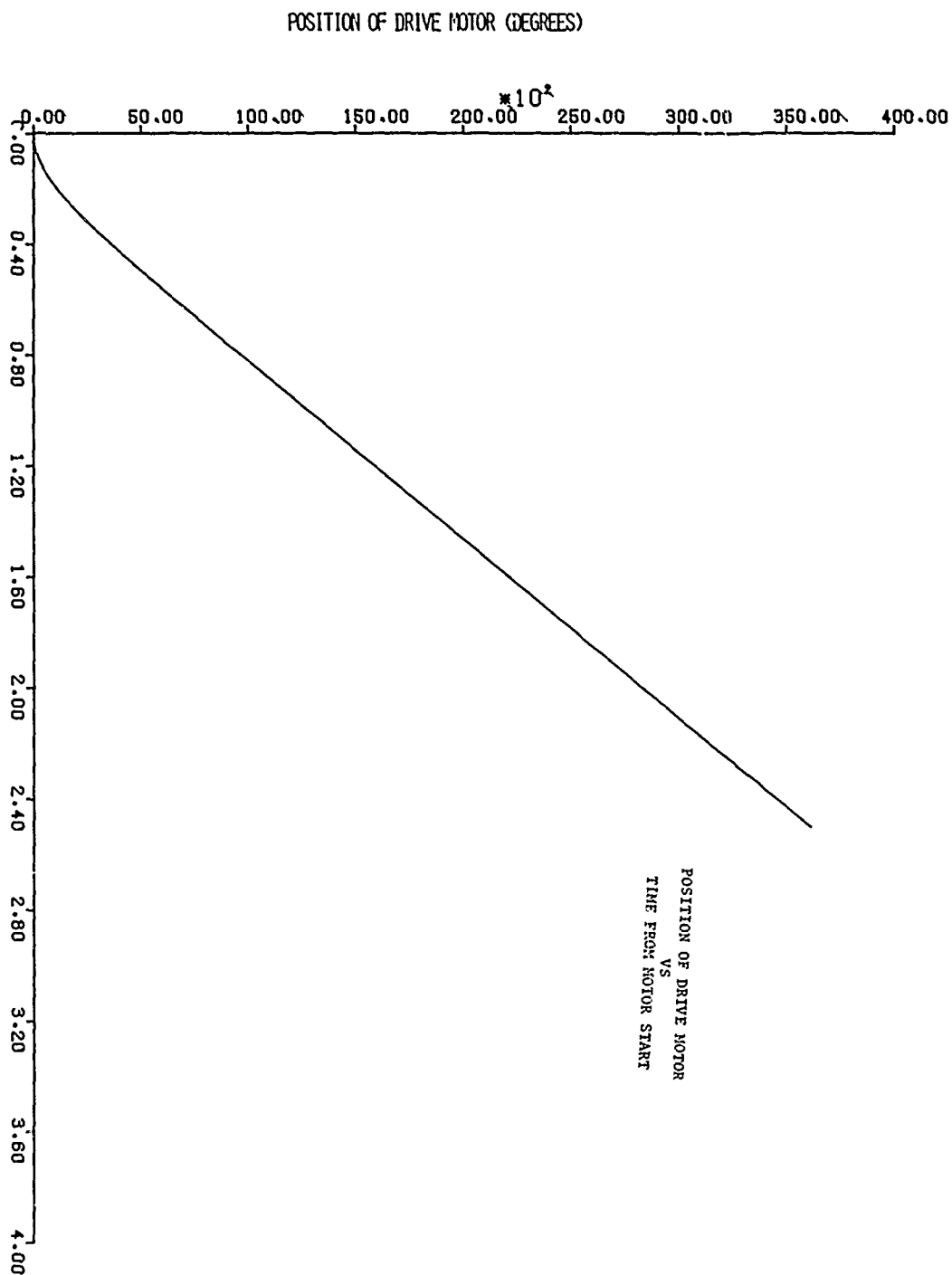
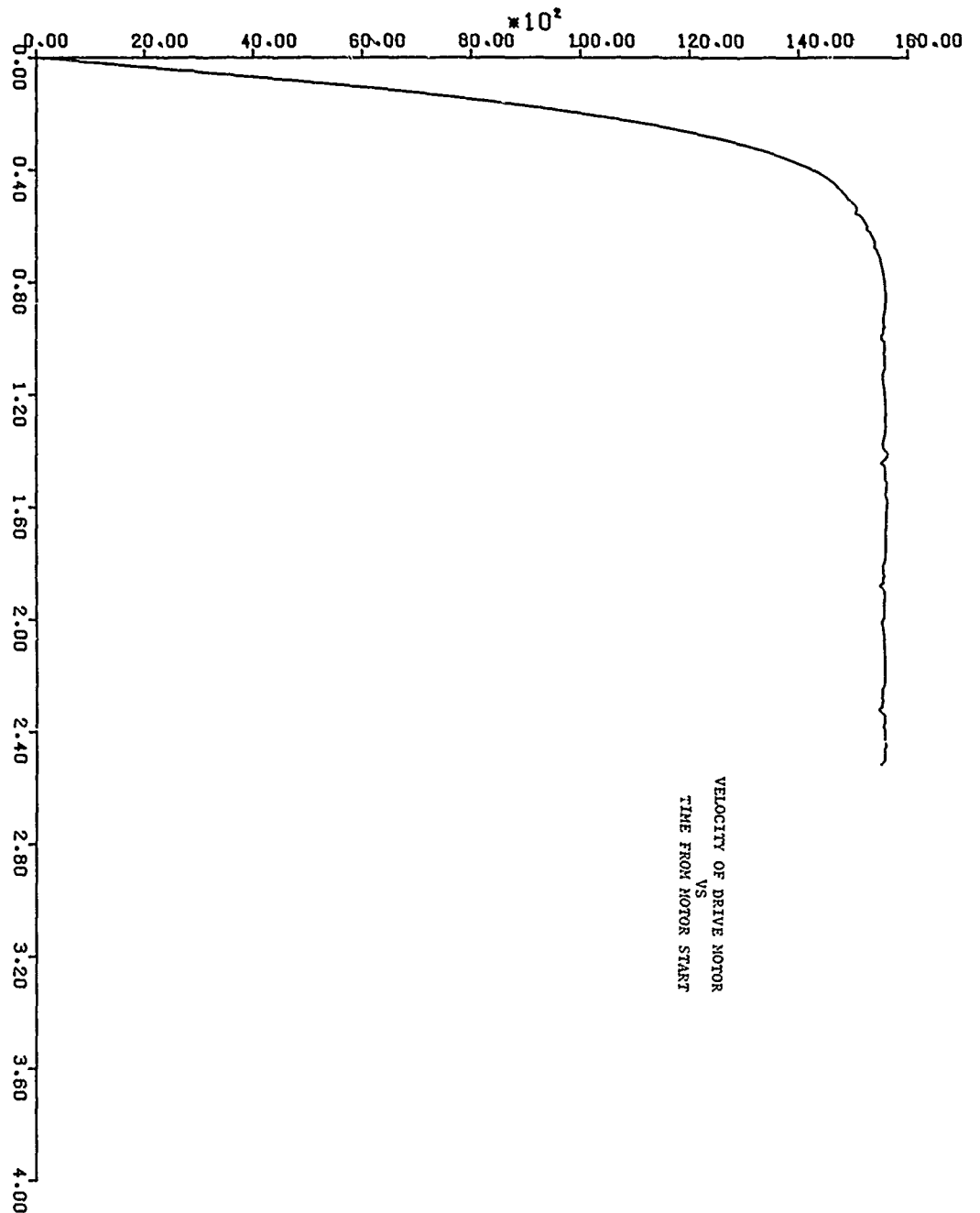


FIGURE 27
DRIVE MOTOR POSITION VS TIME

VELOCITY OF DRIVE MOTOR
(DEGREES/SECOND)



VELOCITY OF DRIVE MOTOR
VS
TIME FROM MOTOR START

DRIVE MOTOR VELOCITY VS TIME

FIGURE 28

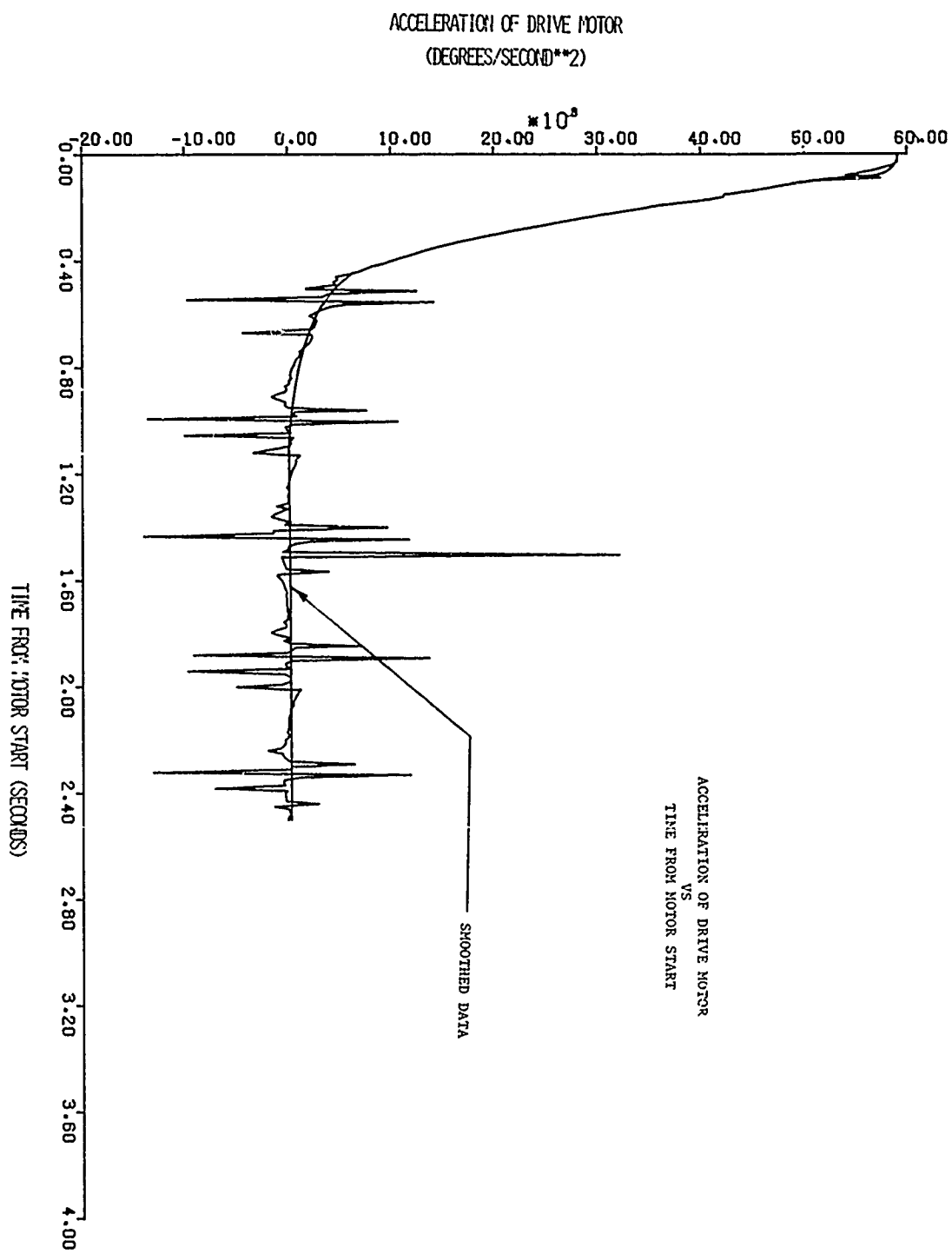


FIGURE 29
DRIVE MOTOR ACCELERATION VS TIME

5. MODEL INPUT

The mathematical model for the AMCAWS-30 uses as input a table of position solutions for each major component versus input motor angle. The range of values for the table is such that one complete firing cycle is described. The table is shown in Table 5.1 along with a description of the element entries. The table, although on disk file, is constructed as if it were on 80 character cards and thus the resulting 2 card groups seen in Table 5.1. Format for the table is format (' ', I5, 3F16.4) and format (' ', I5, 4F16.4) for the two lines. This position table is the only input necessary to the AMCAWS-30 mathematical modeling program.

The table itself is, as discussed, generated by the functional relationships computer program (FRCP) which is listed in Appendix A-3. The inputs here consist of smoothed drawing data for the single turn cam AMCAWS weapon. The data required for the FRCP is data for the feed cam, eject cam, drum cam and lock cam. This data is taken from the engineering drawings for these components. The drawing data was tabulated and read into the FRCP with a

Format (2F17.4)

statement.

There are no other inputs to either program.

Since the mathematical model program is based on its numerical integration routine, it is essential that the input data have no discontinuities about which the integrating routine would cycle and ultimately stop. This did occur with the original drawing data and thus the "sharp" corners were smoothed with a cubic fitting routine that forced a match in the zero and first derivatives at the end points of each region to be smoothed. The smoothing is done on the drawing data and thus the table output is also smoothed. Comparisons between original and smoothed drawing data can be seen in Figures 30, 31 and 32. The drum cam data was well behaved enough to use without smoothing and is shown in Figure 33.

The smoothing routine and program listing can be found in Appendix A-5.

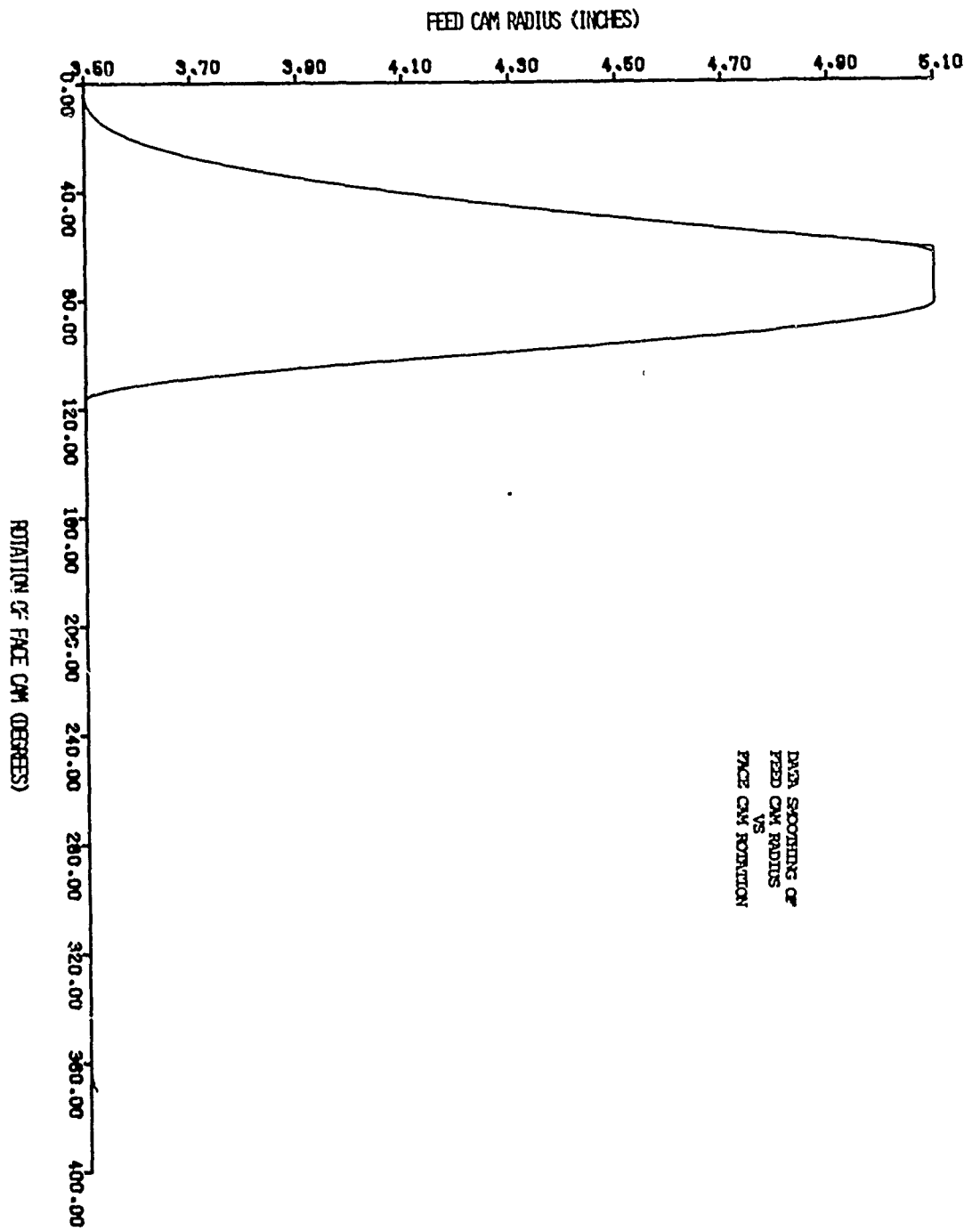


FIGURE 30
SCOOTED FEED DATA

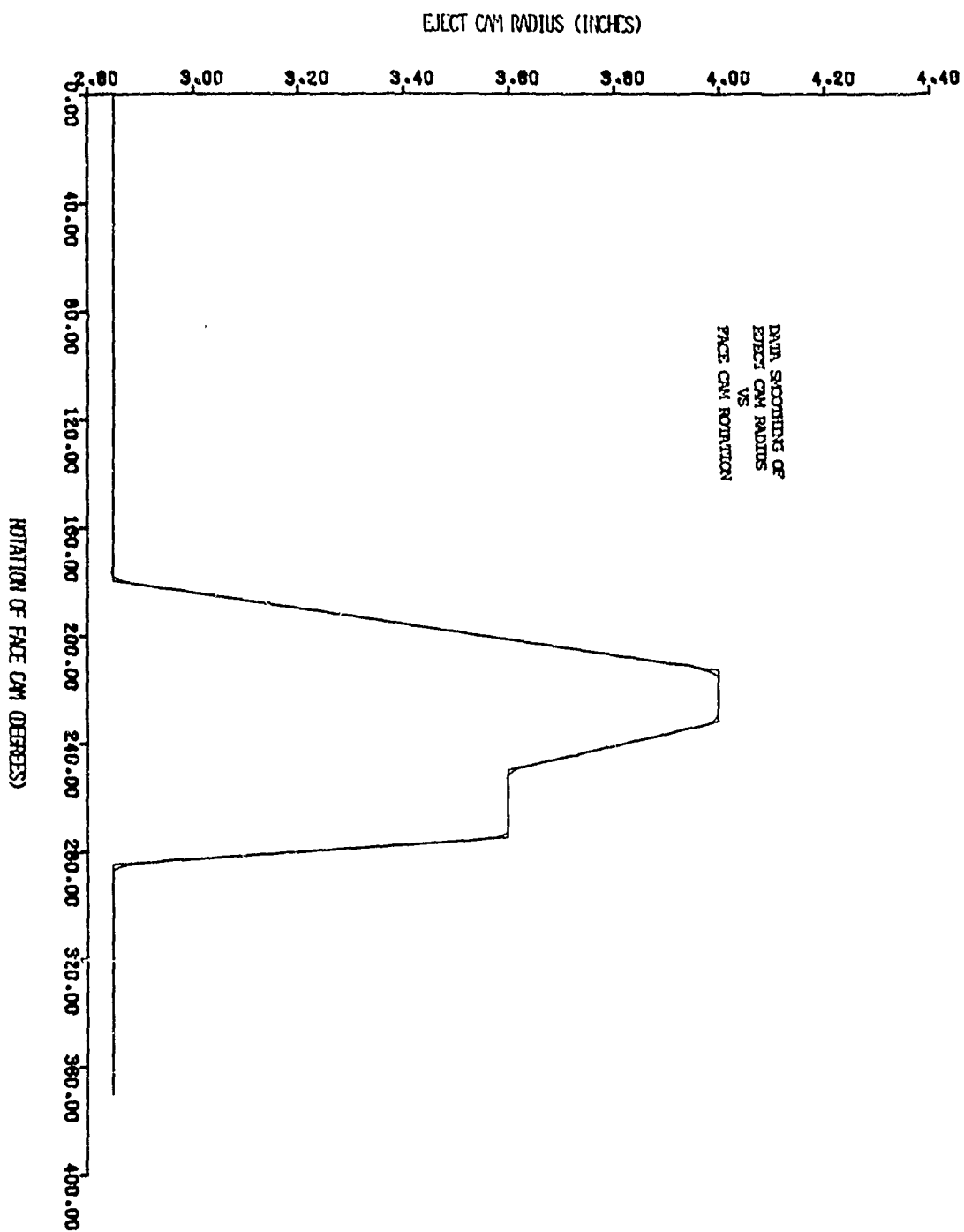


FIGURE 31
SCOOTED EJECT DATA

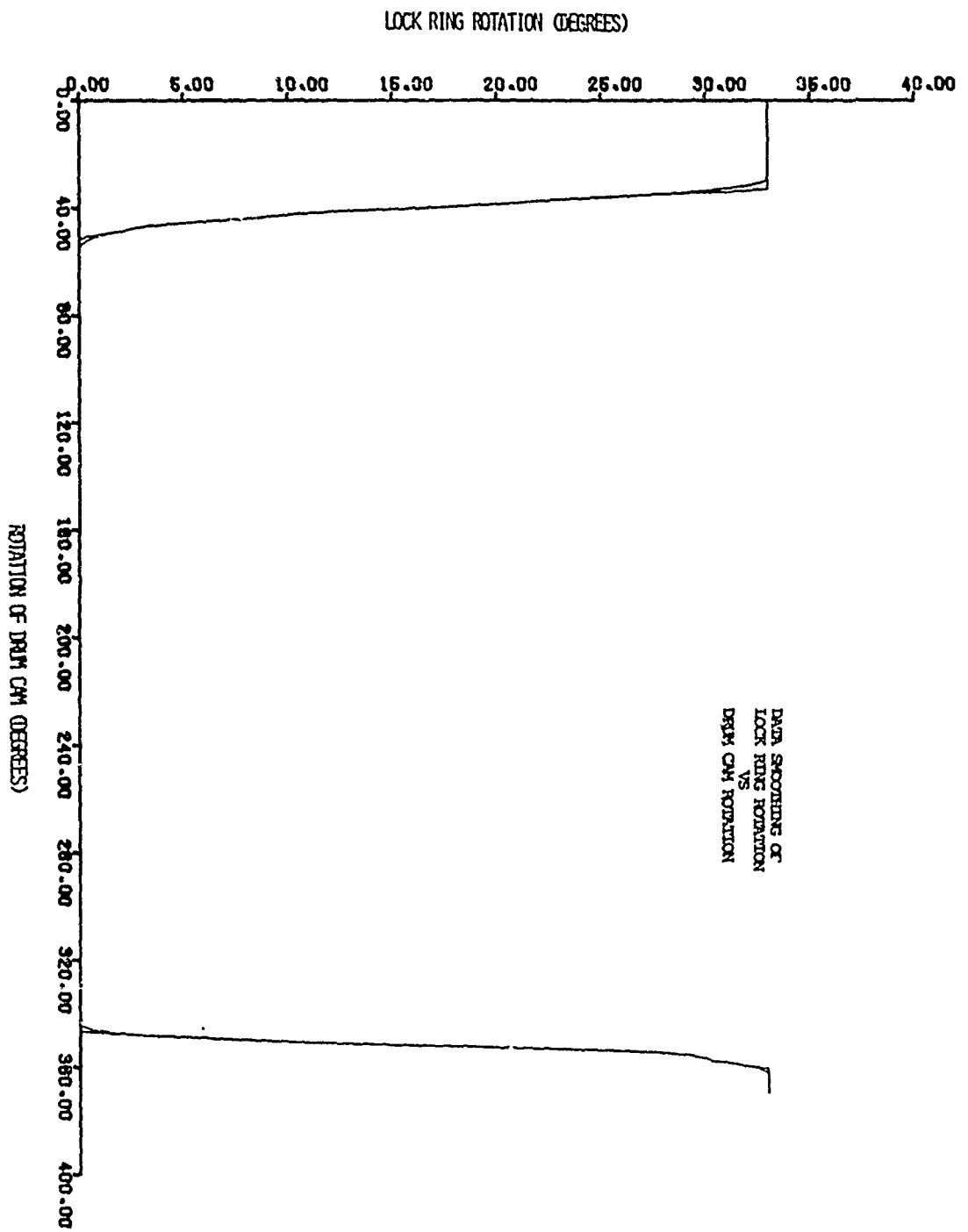


FIGURE 32
SMOOTHED LOCK DATA
51

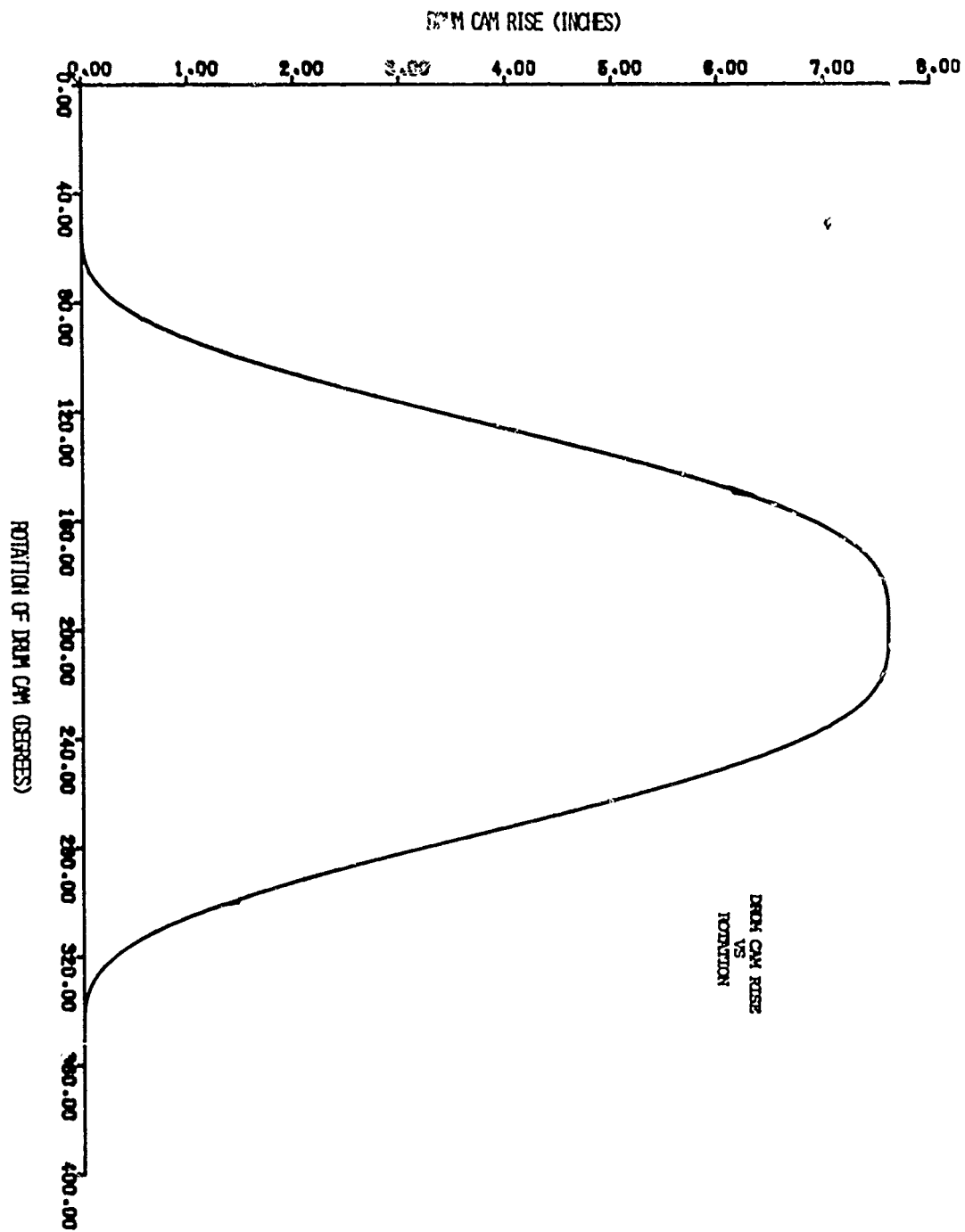
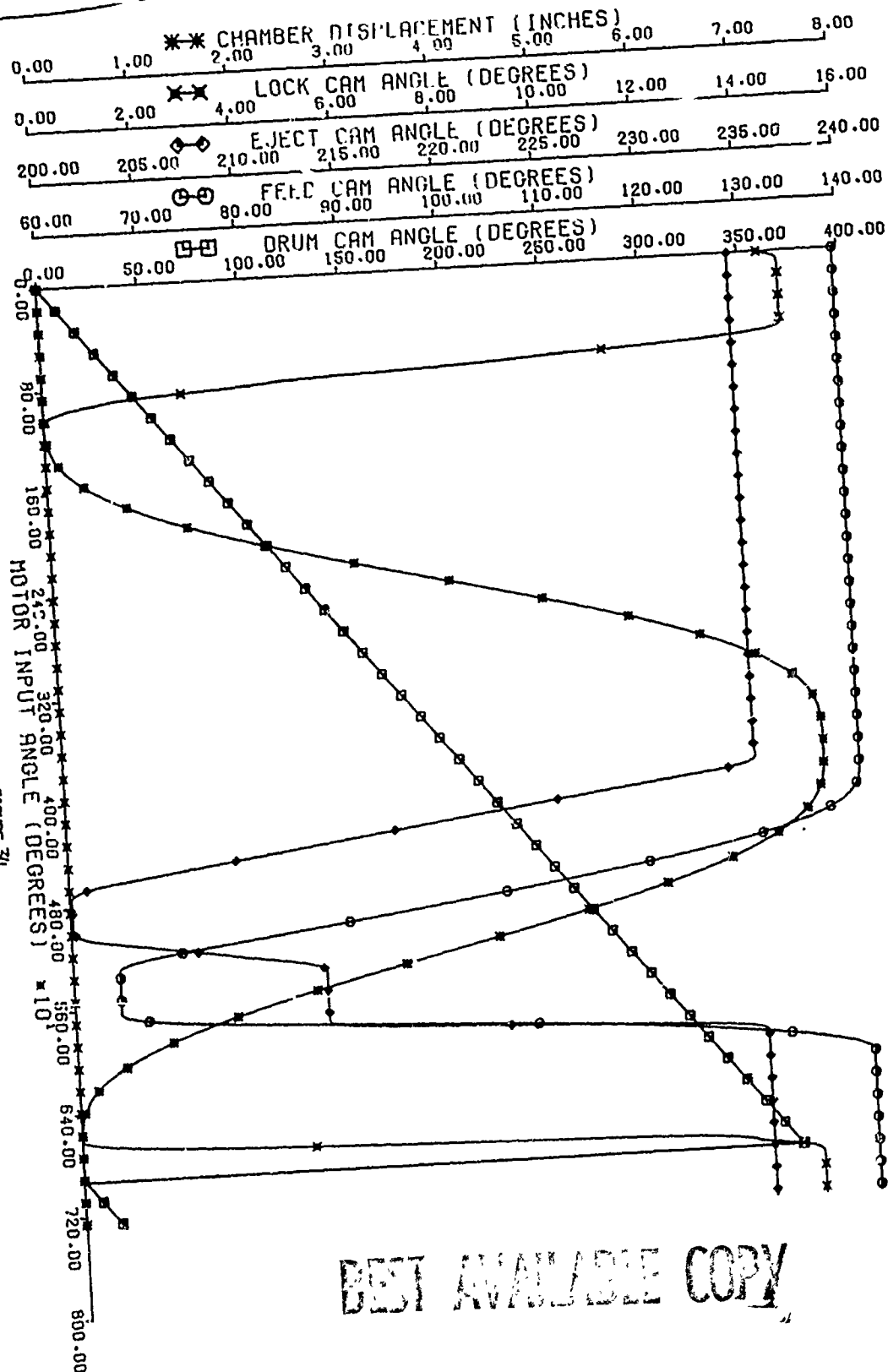


FIGURE 33
DRUM CAM DATA

NEAPON TUNING

56

FIGURE 34



BEST AVAILABLE COPY

6.0 CONCLUSIONS

The three primary objectives of this report have been largely met. The computer programs that comprise the model package have been well documented. The modeling procedure itself has been explained in detail. The operating characteristics of the AMCAWS-30 weapon have been documented. As a bonus, the dynamic model itself seems to work well and the results seem to be similar to the actual weapon.

Figures 27, 28, and 29 are graphical output showing the response of the input drive motor gear over the 0.0 to 2.5 second time range considered. The spikes in the acceleration curve are certainly not present in the actual weapon and might be induced in the interpolation routine or by the highly discreet nature of the various fast acting cams. The model is not "correct" in the purest sense until the source of these spikes are tracked down and the source is either eliminated or justified. The smoothed data line for the acceleration curve represents the more realistic situation.

The computer model package operates at some disadvantage. Since the cancellation of AMCAWS funding in late 1976 there has been understandably little interest or enthusiasm in verifying the model against the actual weapon. As such even the masses and inertias (Table A2-1) are the result of calculations and not measurements. While the calculated and actual values probably do not differ greatly that is a known source of model error. The weapon has not been built up and fired since

this modeling project was started, although a testing program to aid in the model verification was planned.

This report then cannot document an extensive verification, although the position, velocity, and acceleration curves match rough data that could be found from early 1975 gun firings.

Hopefully, the d'Alembert procedure might serve as a basis for modeling efforts for other Army developmental weapons or mechanisms. The procedure is relatively easy to apply and program and the cost is reasonable. The dynamic program in this report was run during prime hours at AVSCOM S&E computers for about fifteen dollars.

REFERENCES

1. Scott, L. AMCAWS-30MM Ammunition Development and Evaluation, Final Report under Contract DAAA25-73-C-043 Hercules Inc., 1 August 1973.
2. Kane, M. R., Rotating Band Torques and Stresses on AMCAWS-30MM Copper Banded Projectiles, Technical Report, Aircraft & Air Defense Weapon's Systems Directorate of Gen. T. Rodman Laboratory, Rock Island Arsenal, Report R-TR-75-022, May 1975.
3. Chace, M. A., Dynamics of Machinery Systems - A Vector/Computer Oriented Approach, Prentice-Hall, 1971.
4. Kass, R. C. and Chace, M. A., 'An Approach to the Simulation of Two-Dimensional Higher Pair Contacts,' Proceedings of the Fourth World Congress on the Theory of Machines & Mechanisms, Newcastle upon Tyne, England, September 1975.
5. Chace, M. A., Published and unpublished Notes presented to University of Michigan M.E. 540 students, Fall 1975.
6. Chace, M. A. and Angell, J. C., Users Guide to DRAM (Dynamic Response of Articulated Machinery), Design Engineering Computer Aids, Department of Mechanical Engineering, University of Michigan, 3rd Edition, April 1975.
7. System/360 Scientific Subroutine Package, Version III, IBM Application Program, Publication GH20-0205-4, Fifth Edition, August 1970.
8. Carnahan, B., Luther, H. A., and Wilkes, J. O., Applied Numerical Methods, John Wiley & Sons, 1969.
9. Rothbart, H. A., Cams, John Wiley & Sons, 1956.
10. Tann, P. W., Cam Design and Manufacture, The Industrial Press, 1965.
11. Merritt, H. E., Gear Engineering, John Wiley & Sons, 1971.

A P P E N D I X 1

FUNCTIONAL RELATIONSHIPS COMPUTER PROGRAM

The Functional Relationships Computer Program (FRCP) specifies, as output, the positional relationships versus the input drive motor angle of the components in the AMCAWS-30 weapon. Since the AMCAWS-30 model is a one degree of freedom system and the degree of freedom is the input drive motor angle, specification of an input angle also specified the position of all the other gun components. Given that there are no part failures (the weapon model uses fantastic materials that cannot fail) these various positional relationships are unchanging.

The FRCP uses the various part geometries, cam paths, and assembly angles to evaluate each part position given the input motor angle. Figure A1-1 is the basic flow chart for the program. The program needs as input the drawing data for the drum cam, the eject and feed cam paths for the face cam and the various offset angles at which the components were assembled. A incremental θ is chosen and the program loops through the six function calls until one complete firing cycle is over. The results of each loop are tabulated.

The program itself is listed in Appendix 3 while the output from the program, in graphical form, is shown in Figures A1-2 thru A1-7. Figures A1-8 thru A1-11 are the unaltered cam drawing data in graphical form and are included here for report completeness.

Figures A1-12 and A1-13 illustrate the basis of program functions FUN43F and FUN53F.

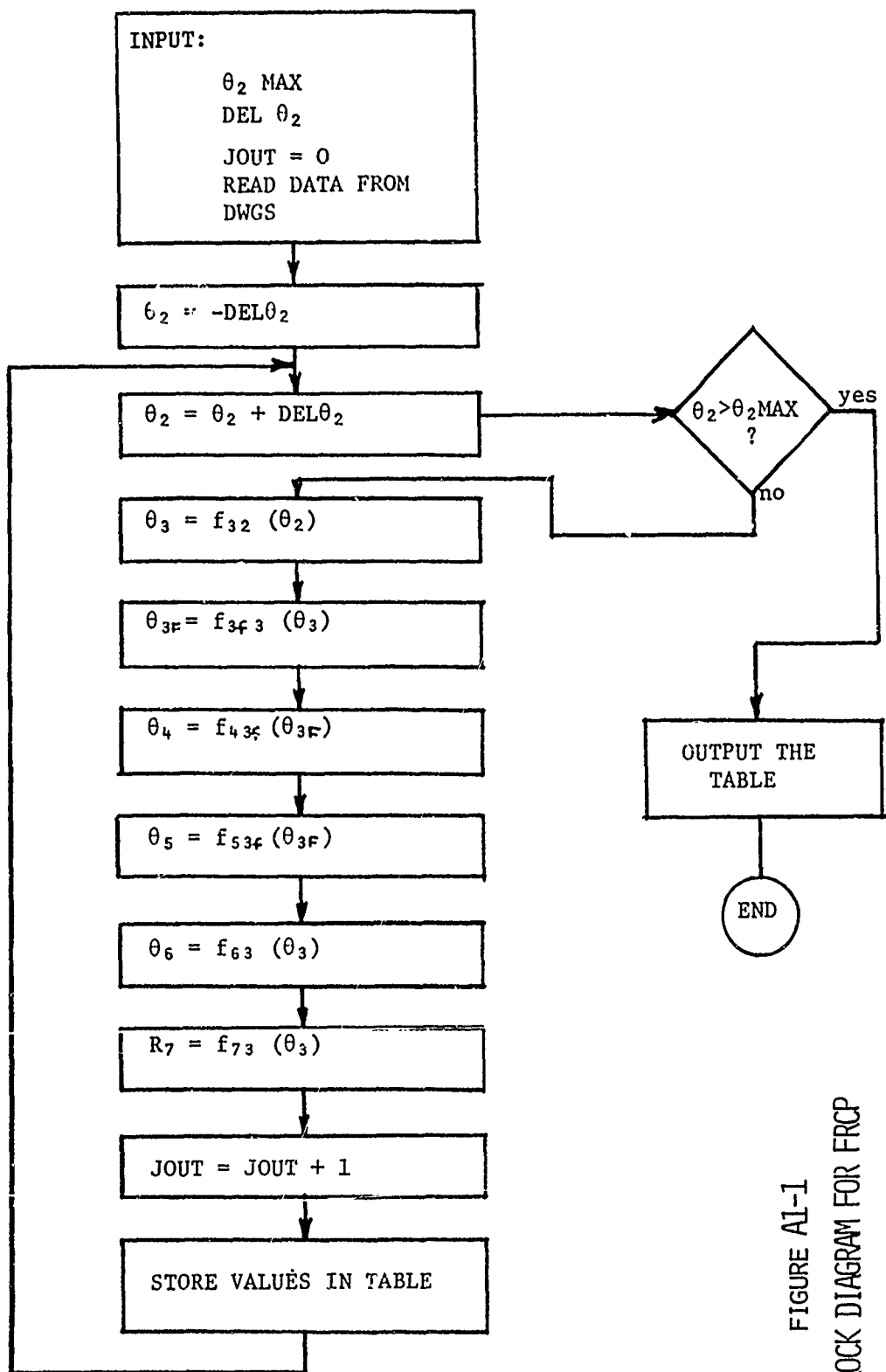


FIGURE AI-1
 BLOCK DIAGRAM FOR FRCP
 AI-2

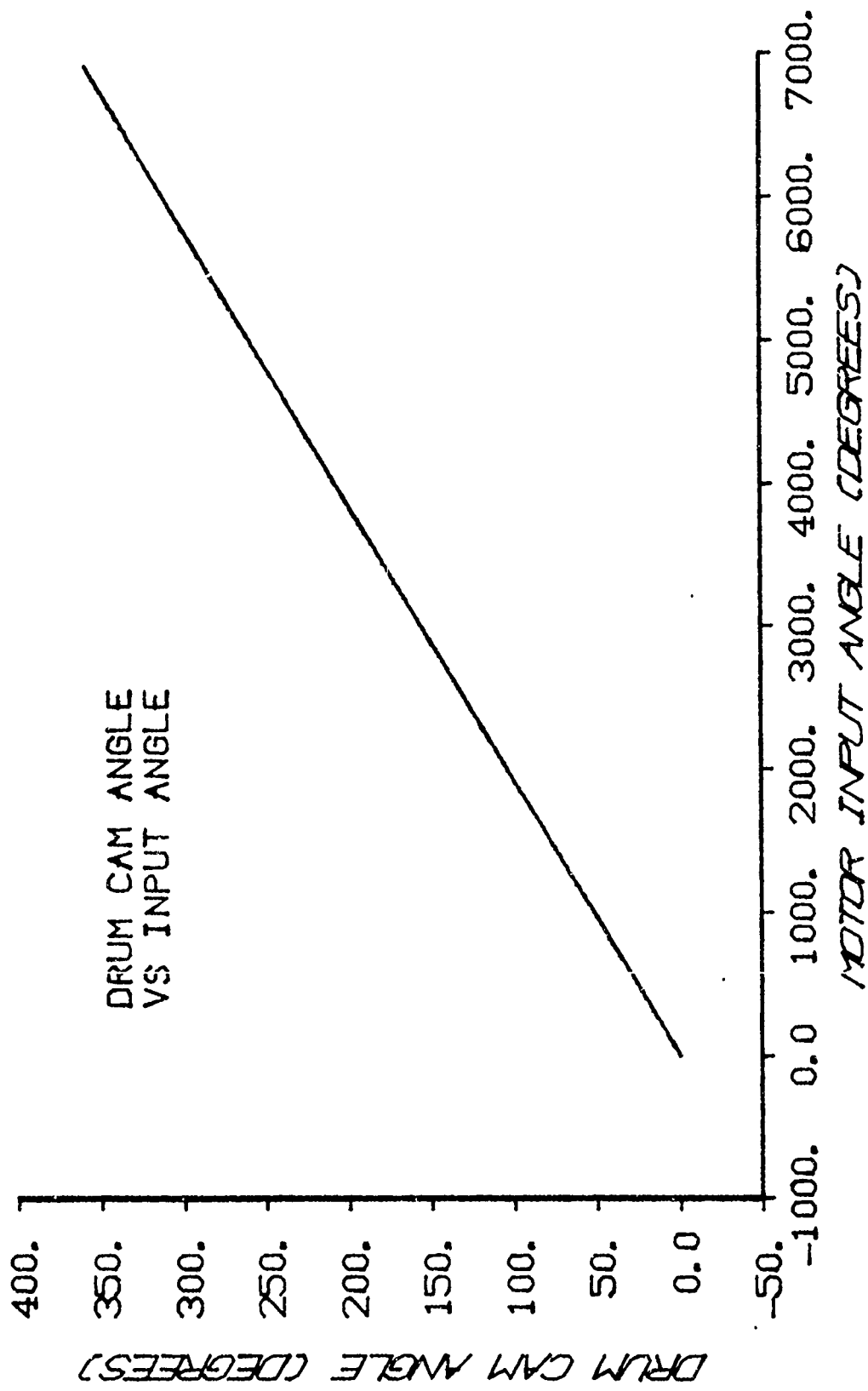


FIGURE A1-2
DRUM CAM ANGLE VS INPUT ANGLE
A1-3

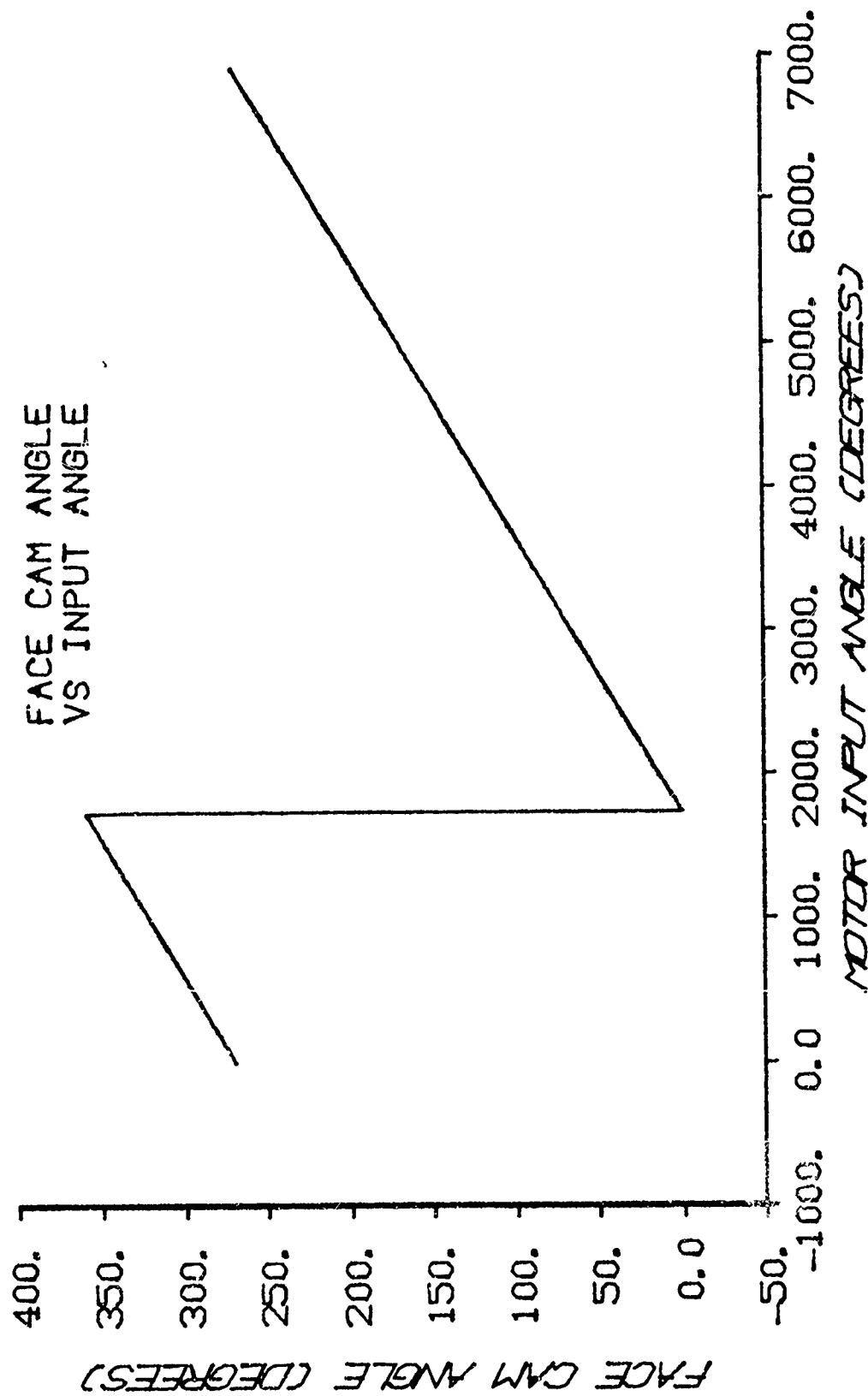


FIGURE A1-3

FACE CAM ANGLE VS INPUT ANGLE

A1-4

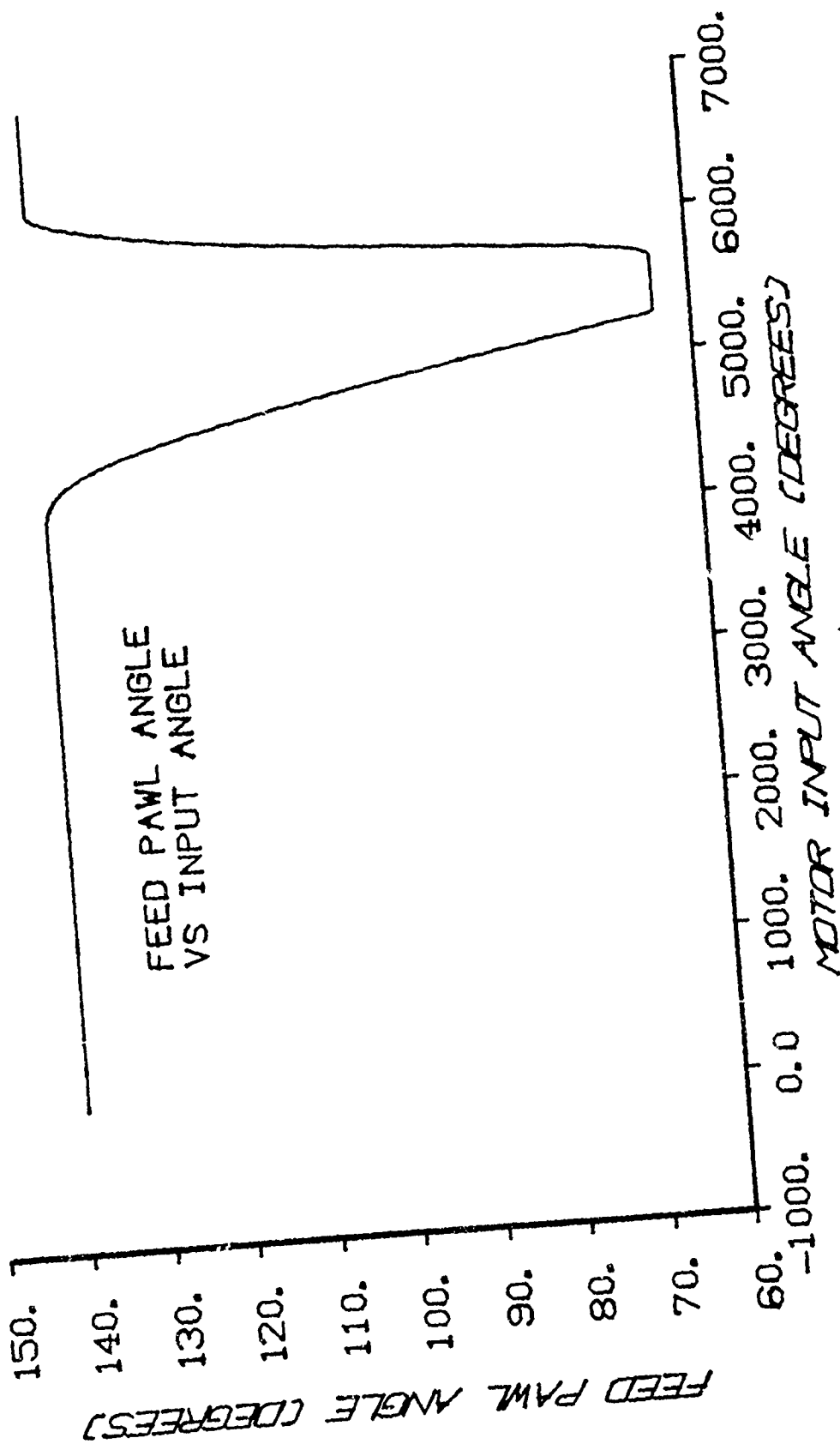


FIGURE A1-4

FEED PAWL ANGLE VS INPUT ANGLE

A1-5

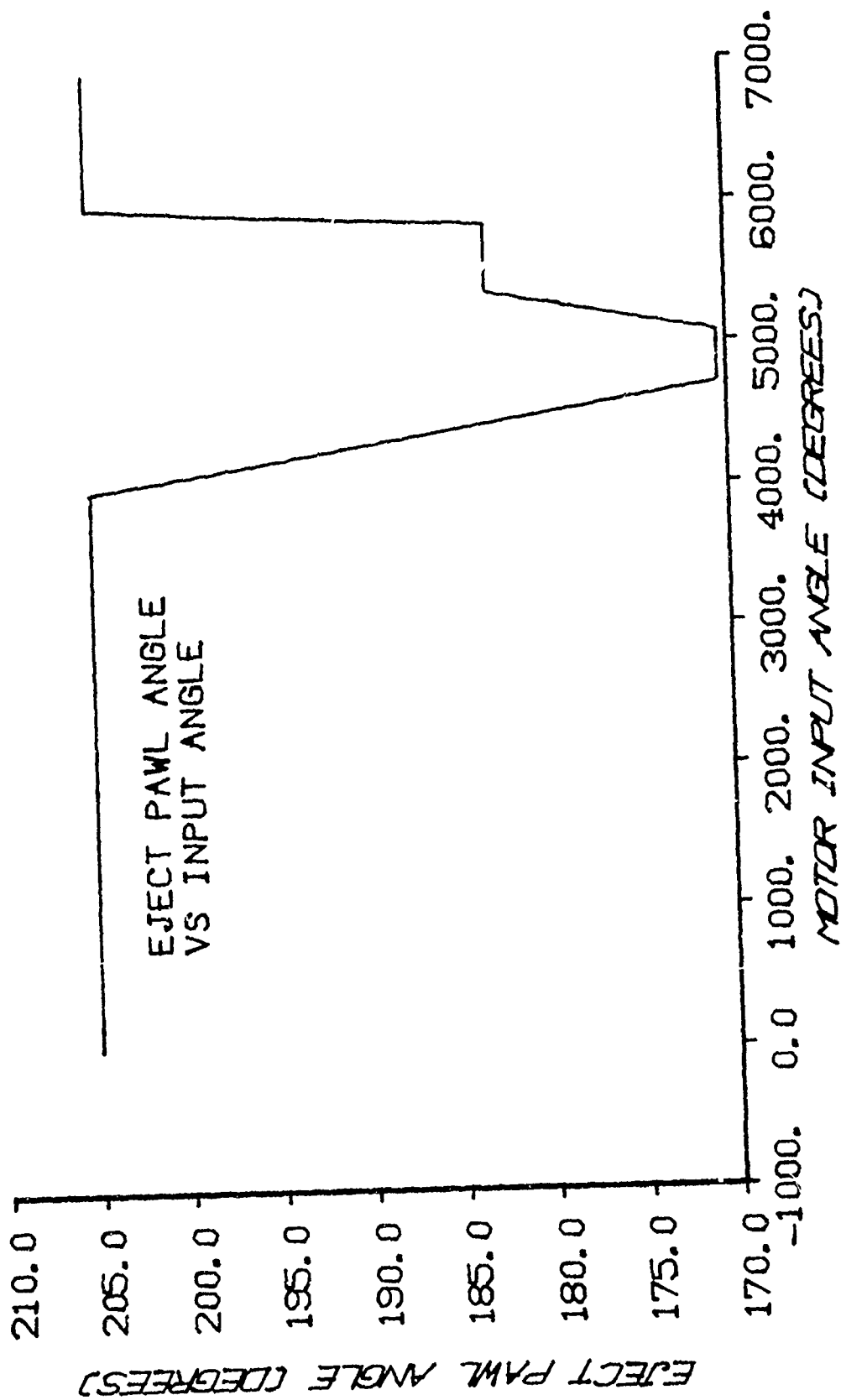


FIGURE A1-5

EJECT PAWL ANGLE VS INPUT ANGLE

A1-6

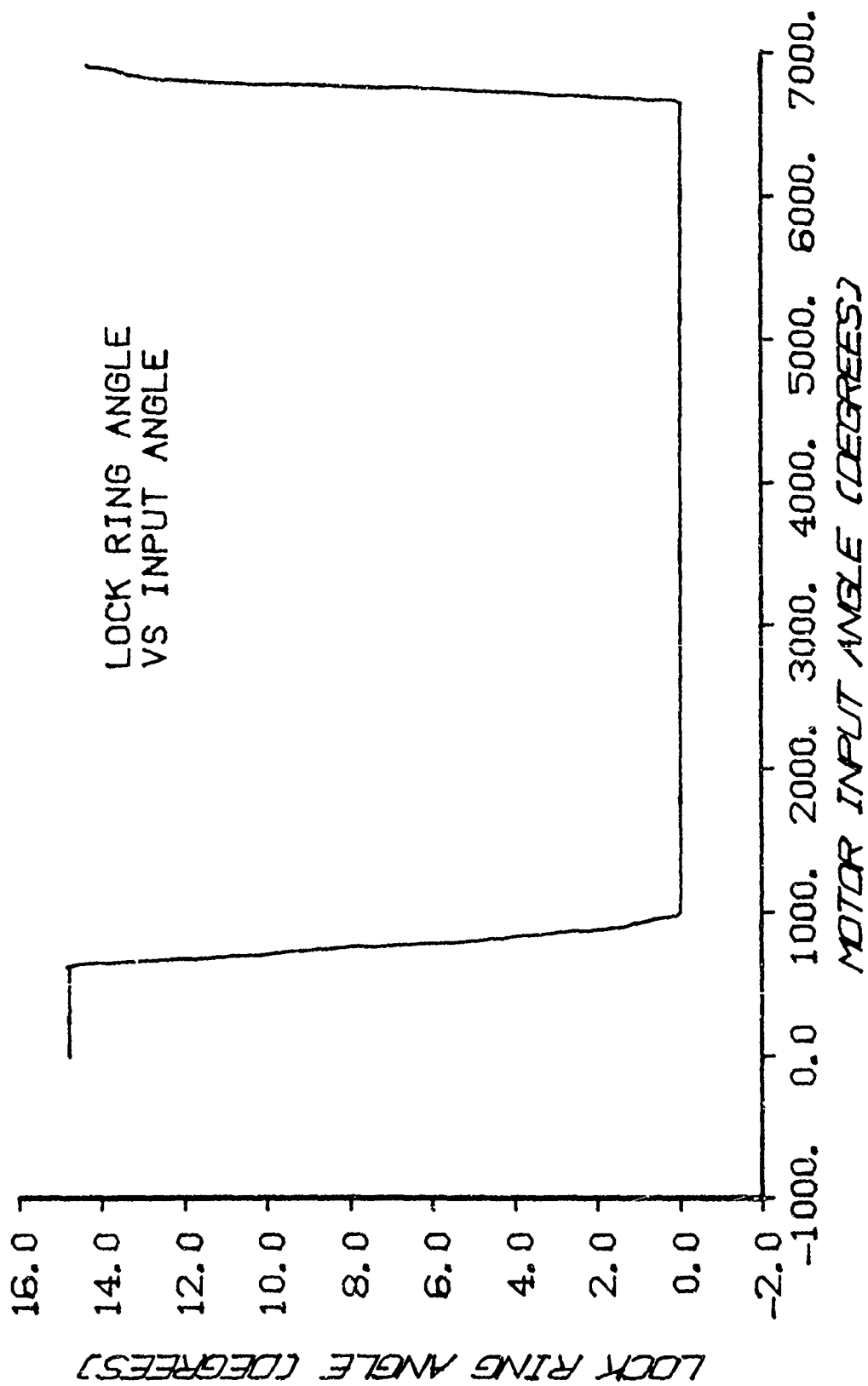


FIGURE A1-6

LOCK RING ANGLE VS INPUT ANGLE

A1-7

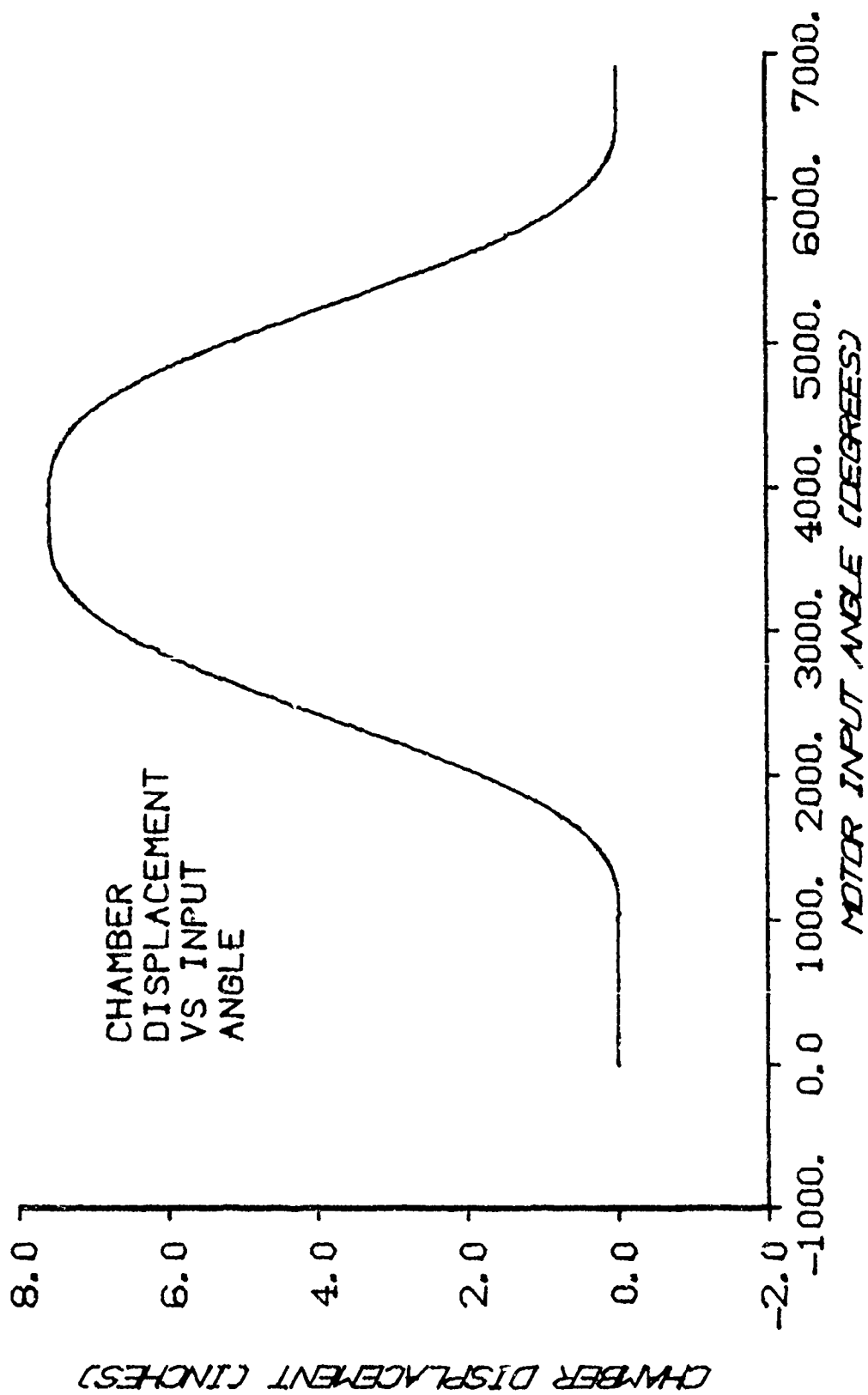


FIGURE AI-7

CHAMBER DISPLACEMENT VS INPUT ANGLE

AI-8

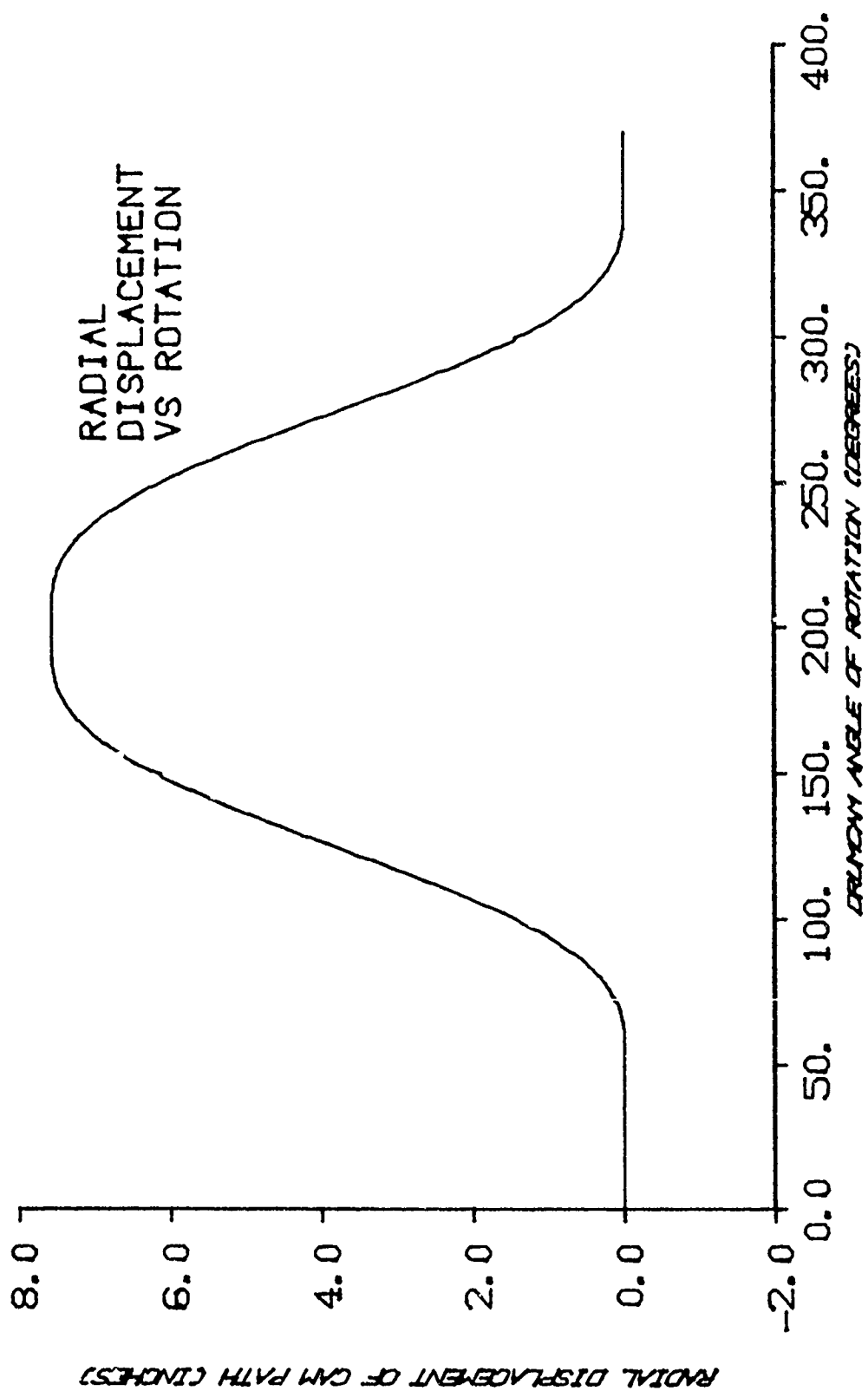


FIGURE A1-8

RADIAL DISPLACEMENT VS ROTATION

A1-9

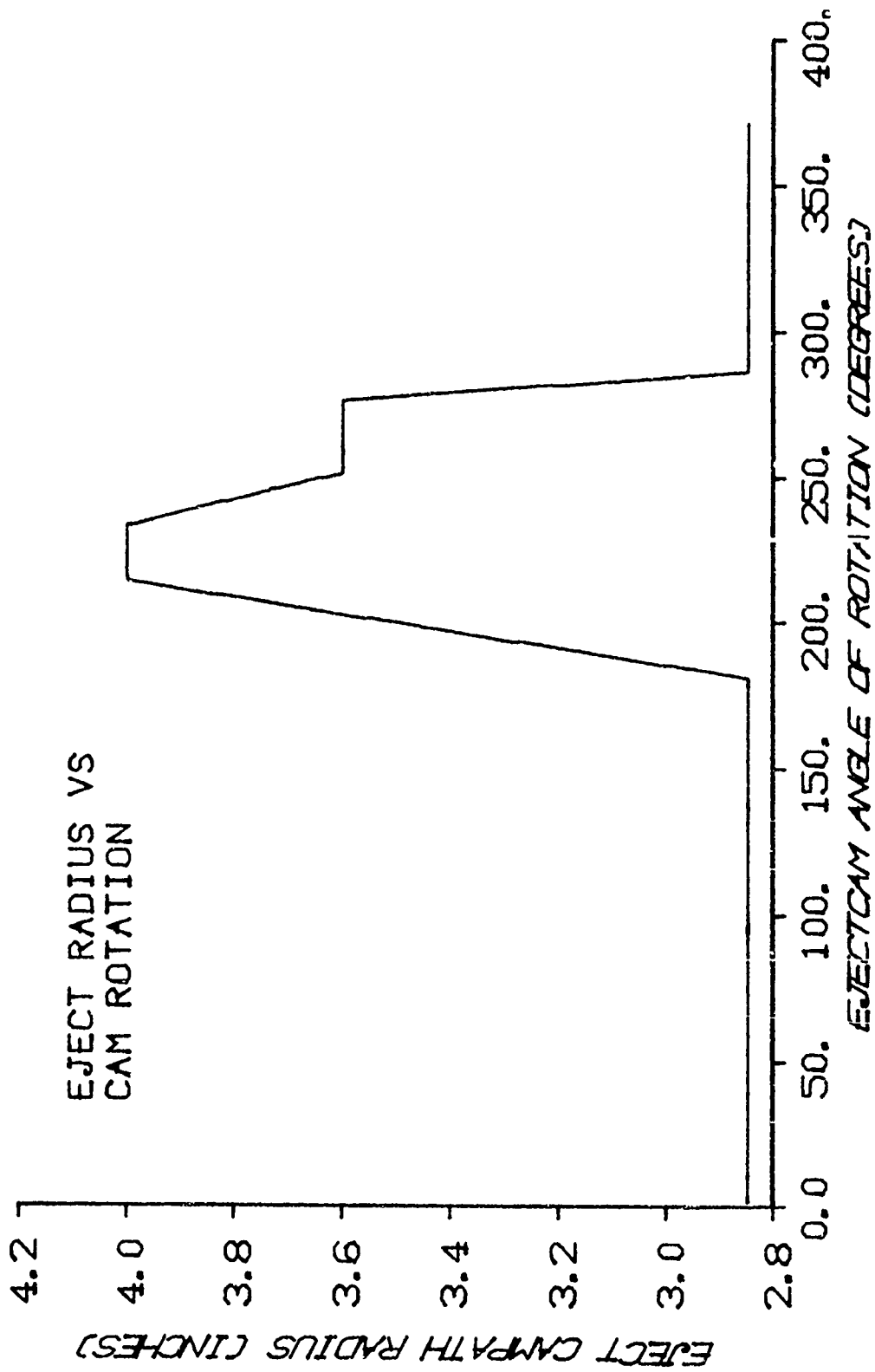


FIGURE A1-9

EJECT RADIUS VS CAM ROTATION

A1-10

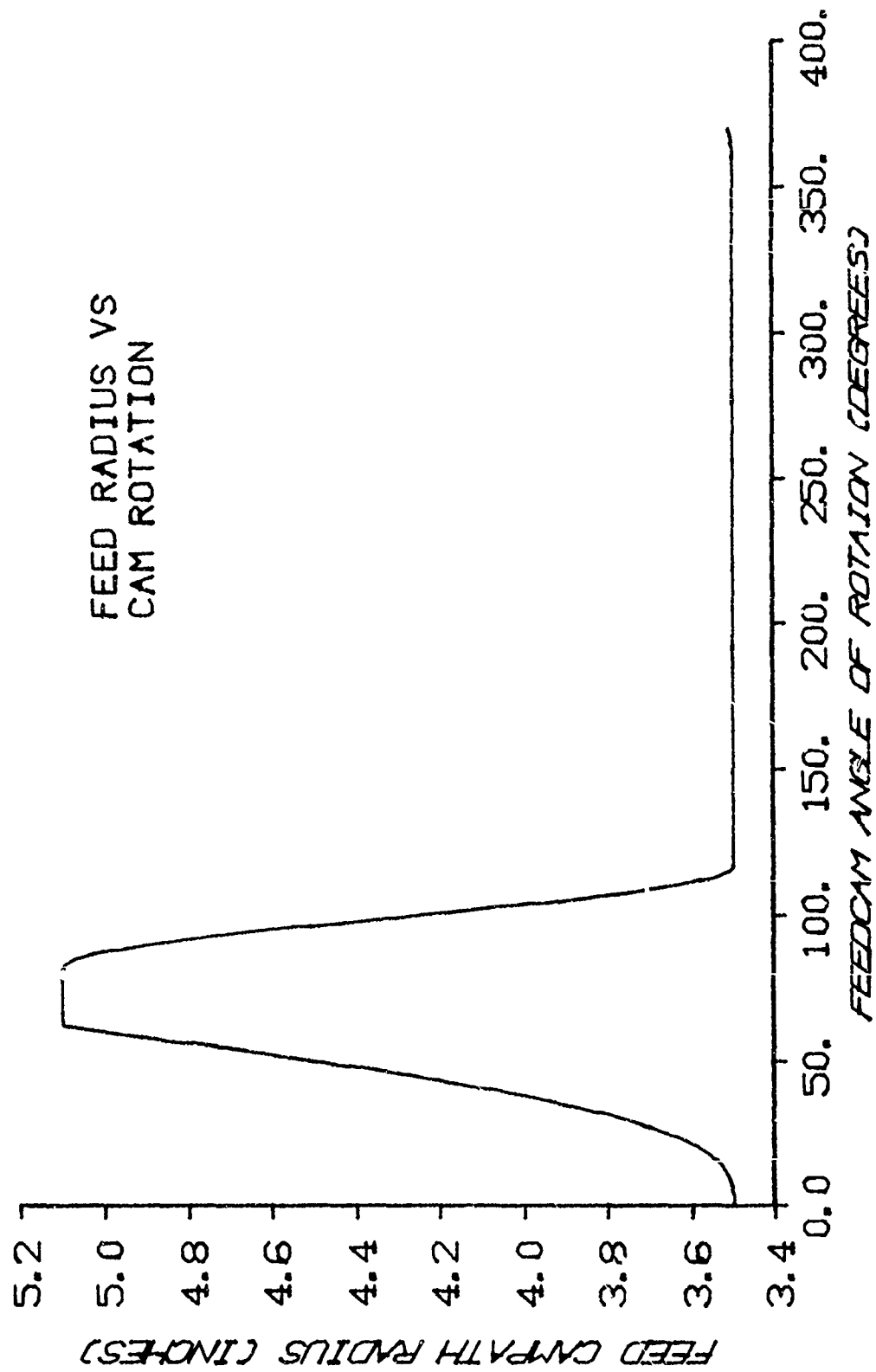


FIGURE A1-10

FEED RADIUS VS CAM ROTATION

A1-11

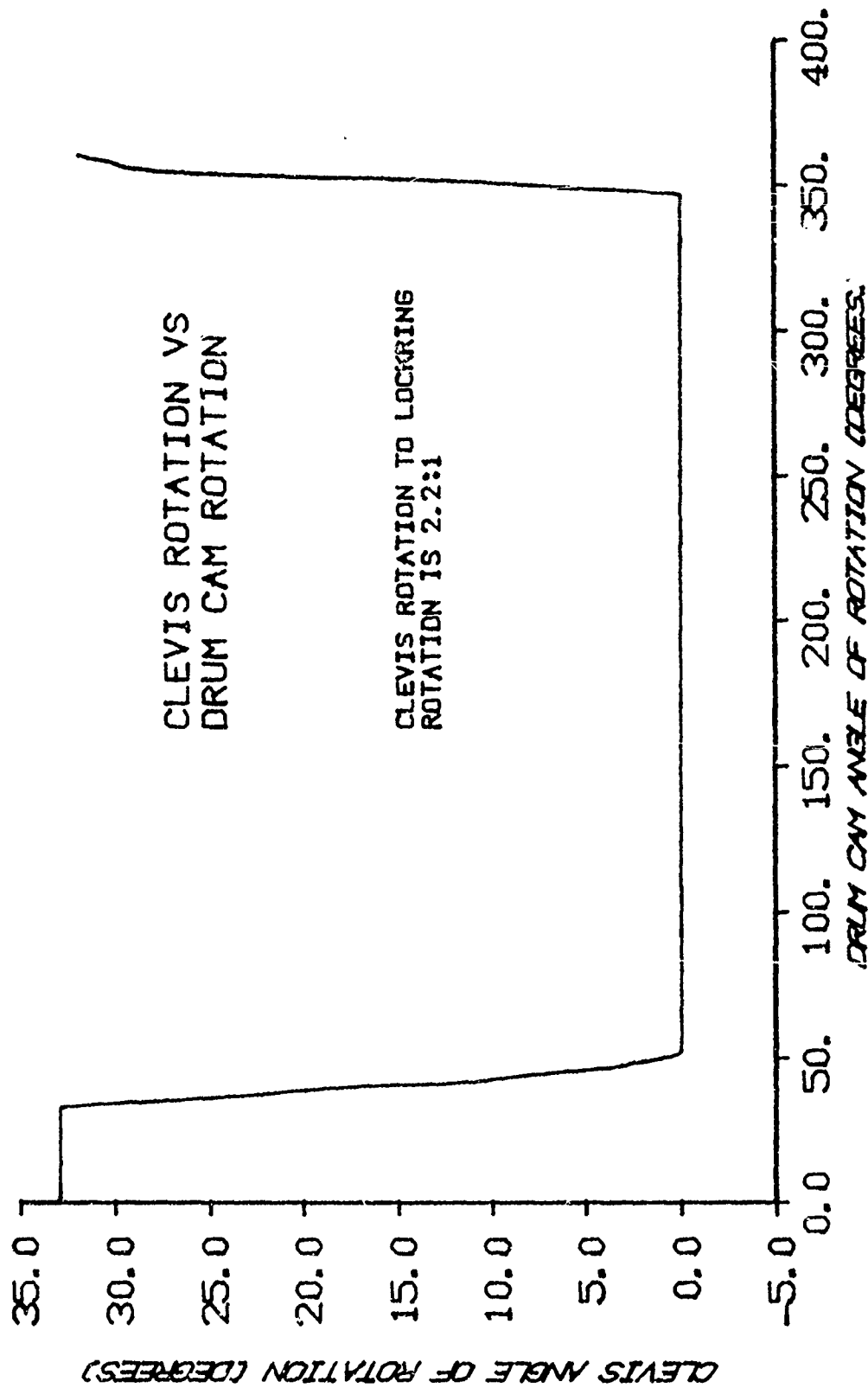


FIGURE A1-11

CLEVIS ROTATION VS DRUM CAM ROTATION

A1-12

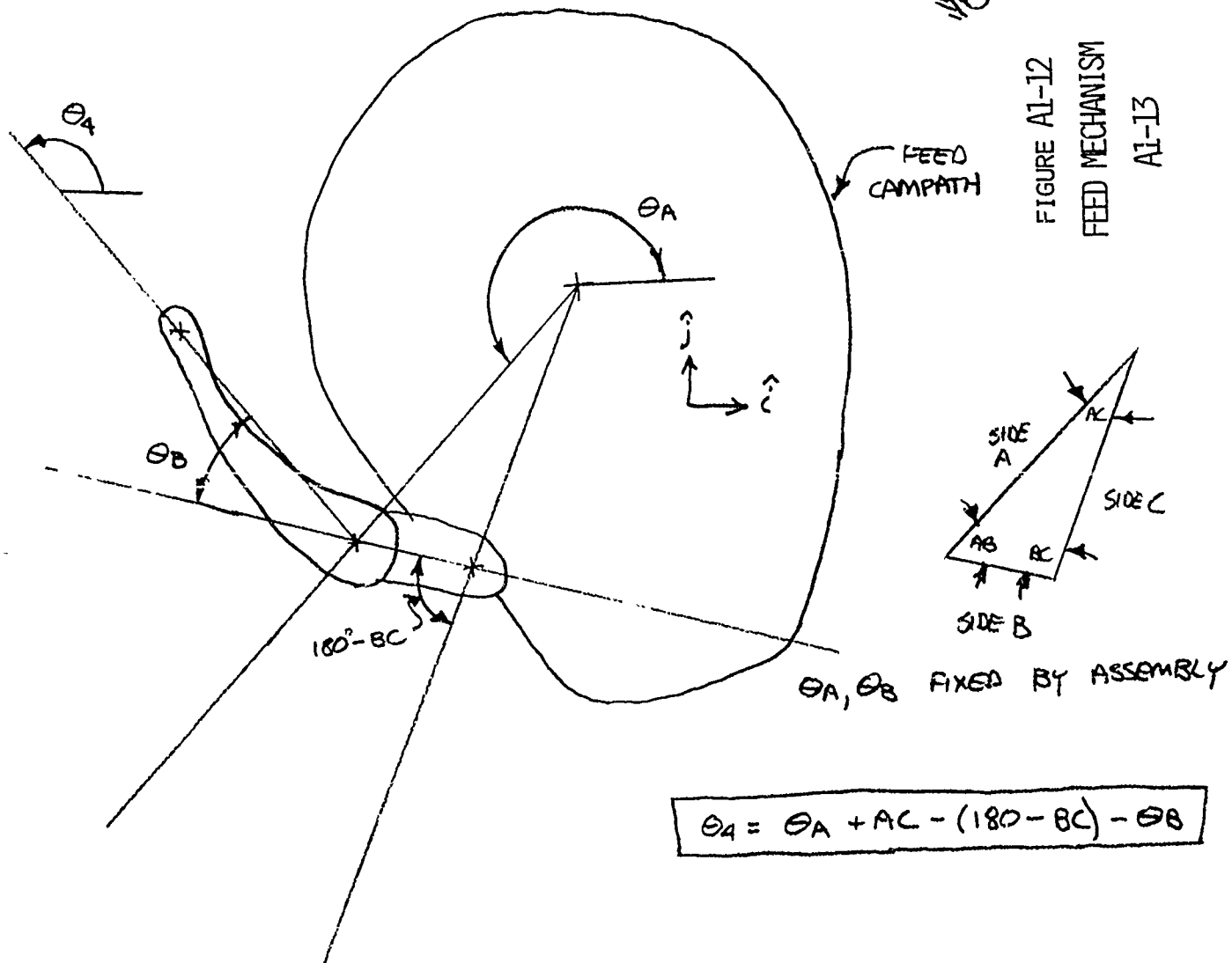
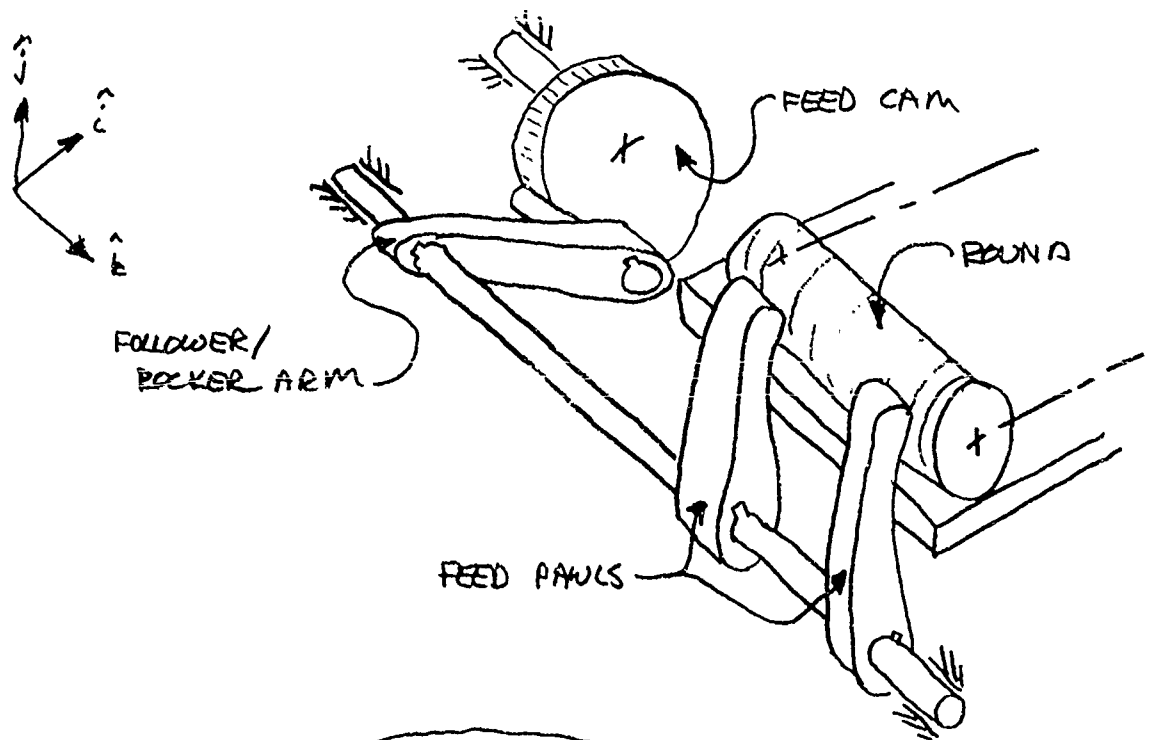
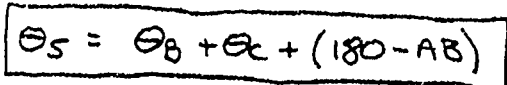


FIGURE A1-12
FEED MECHANISM
A1-13



FIGURE A1-13
EJECT MECHANISM
A1-14



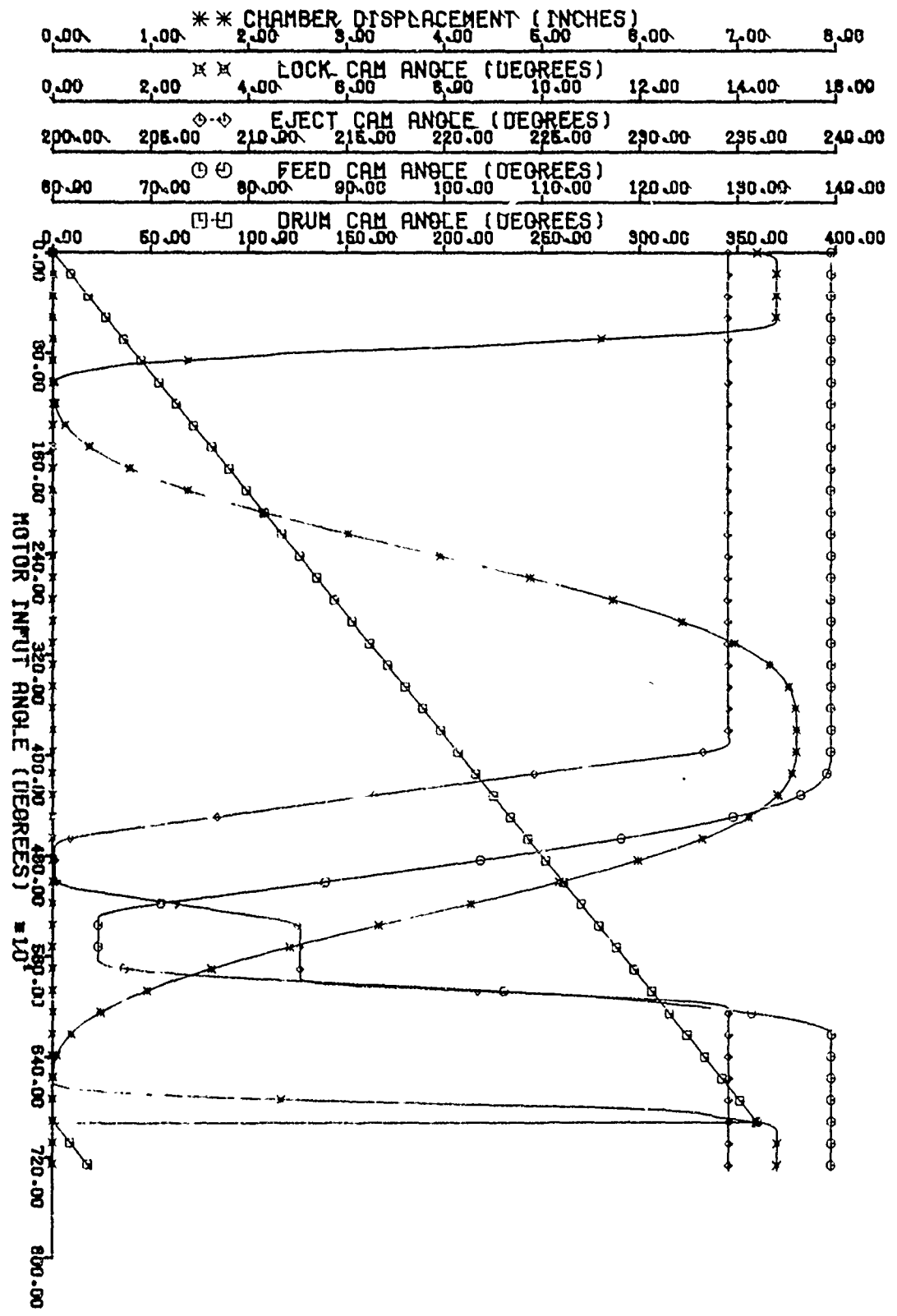


FIGURE AL-14
COMPLETE WEAPON TIMING
AL-15

A P P E N D I X 2

Generalized d'Alembert Force
Procedure and AMCAWS-30
Equation of Motion Development

A2.1 - INTRODUCTION

The systematic derivation of the differential equation of motion for the AMCAWS-30 weapon was accomplished by the application of the generalized d'Alembert force equation

$$\sum_{i=1}^M \vec{F}_i \cdot \frac{\partial \vec{p}_i}{\partial q_j} + \sum_{\ell=1}^L \vec{\lambda}_\ell \cdot \frac{\partial \vec{p}_\ell}{\partial q_j} = 0 \quad (A2.1)$$

where,

M = number of d'Alembert forces in the total system

$\vec{F}$ = the d'Alembert force

$\vec{p}$ = the position vector from a point in ground to the point of application of the d'Alembert force

i = the index of the particular d'Alembert force being considered

q_j = the degree of freedom being considered

$\frac{\partial \vec{p}_i}{\partial q_j}$ = the partial of $\vec{p}_i$ with respect to the degree of freedom

$\vec{\lambda}$ = closed loop chord contact forces

$\vec{P}$ = positional vector spanning the closed loop chord

L = number of independent closed loops

ℓ = loop being considered

j = degree of freedom

Two facts allow a significant simplification of an already simple equation. First, the AMCAWS-30 is a one degree of freedom system. This sets the index $j = 1$. Second, the development of functional relationships describing the response of the major components to the motor input angle, θ_2 , allowed the analysis to proceed with no closed loops (Appendix 1). This sets the index $L=0$. The generalized d'Alembert equation then becomes

$$\sum_{i=1}^M \vec{F}_i \cdot \frac{\partial \vec{p}_i}{\partial (\theta_2)} = 0 \quad (A2.2)$$

The problem at hand is then the cranking out of the $\vec{F}_i$'s and $\vec{p}_i$'s for the six major components involved. The detailed development follows. The black box idealization of Figure A2-4 is somewhat altered in that the reference frames for each component are oriented as they actually are on the weapon. Throughout, the development the $\hat{i}, \hat{j}, \hat{k}$ reference frame holds where $\hat{k}$ is aligned in the direction of projectile travel after a firing, the $\hat{i}$ axis is described by a horizontal line, and $\hat{j}$ corresponds to a vertical line (Figure A2-1). A single dot (i.e. $\dot{\theta}_3$) refers to the derivative of θ_3 with respect to θ_2 (the degree of freedom). Similarly, double dots and primes (i.e. $\ddot{\theta}_3$ and θ_3'') are the second derivatives with respect to time and with respect to θ_2 . The interpolation routines scan the tabular data (coordinate of interest vs θ_2) and returns a local 5th degree polynomial that fits the data in the region of interest. If θ is the coordinate of interest, for any specific θ_2 ,

$$\theta = a_0 + a_1\theta_2 + a_2\theta_2^2 + a_3\theta_2^3 + a_4\theta_2^4 + a_5\theta_2^5 \quad (A2.3)$$

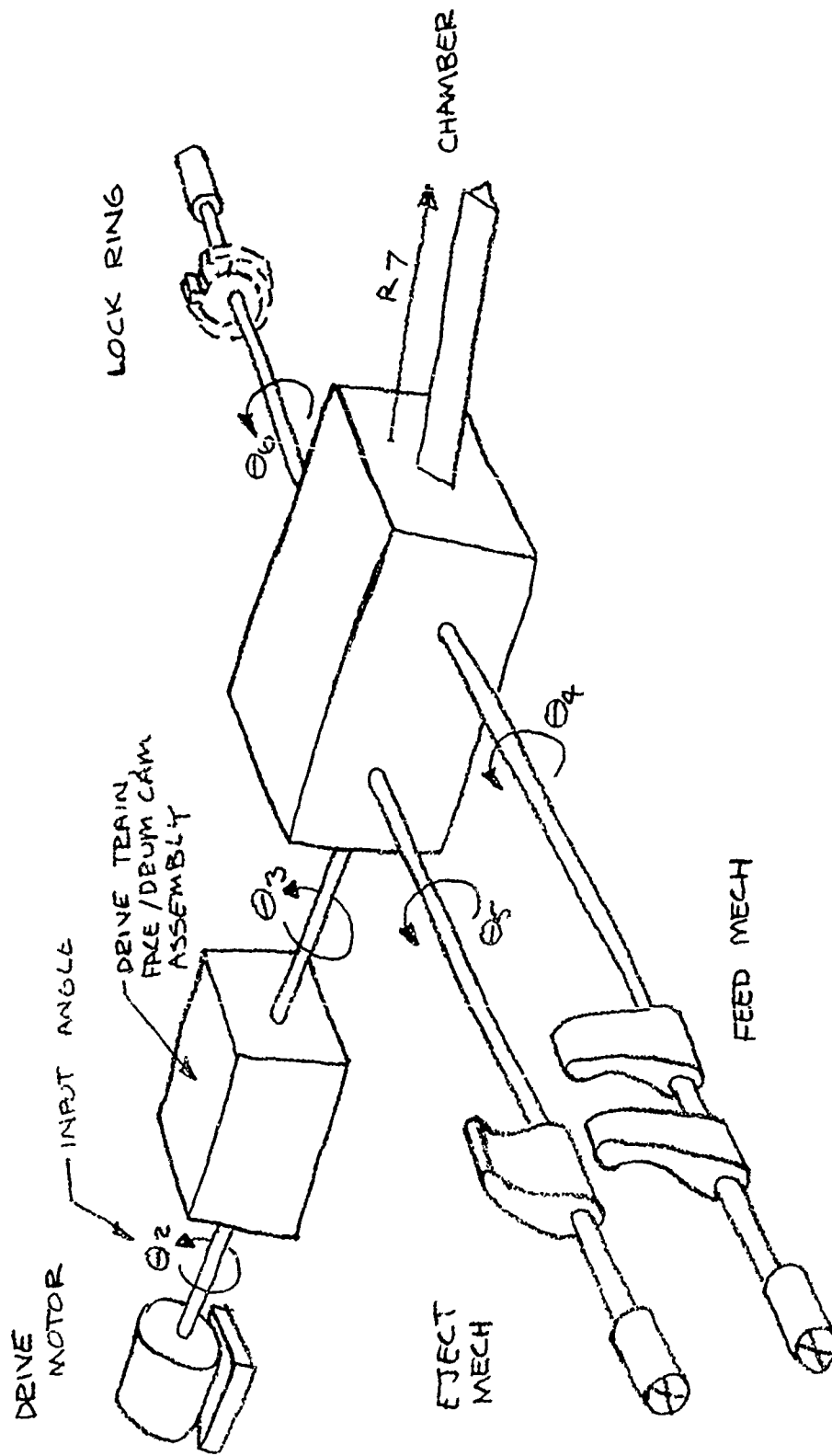
$$\theta' = \frac{\partial \theta}{\partial \theta_2} = a_1 + 2a_2\theta_2 + 3a_3\theta_2^2 + 4a_4\theta_2^3 + 5a_5\theta_2^4 \quad (A2.4)$$

$$\theta'' = \frac{\partial^2 \theta}{\partial \theta_2^2} = 2a_2 + 6a_3\theta_2 + 12a_4\theta_2^2 + 20a_5\theta_2^3 \quad (A2.5)$$

$$\dot{\theta} = \theta' \dot{\theta}_2 \quad (A2.6)$$

$$\ddot{\theta} = \theta' \ddot{\theta}_2 + \theta'' (\dot{\theta}_2)^2 \quad (A2.7)$$

With these relationships the development of the differential equation of motion can proceed by applying the "reduced" d'Alembert equation to each major component and then summing all the terms into a single equation.



BLACK BOX IDEALIZATION OF AMCAWS-30
SYSTEM

FIGURE A2-1

AMCAWS-30 BLACK BOX

A2-3

1.1.1
5/8/76

A-2 - LOCAL COORDINATE 2, DRIVE MOTOR INPUT

The gun parts associated with this coordinate are the input motor (409EH18, Western Gear Motor) and the gear unit transferring torque from the motor to the weapon itself. The parts and reference frame are shown in Figure A2-2.

TERMS:

I_{59} = Mass moment of inertia of the 59 tooth drive gear

I_{120} = Mass moment of inertia of the 120 tooth transfer gear
(including the 16 tooth output gear shaft)

θ_2 = Motor input angle measured as indicated

θ_{120} = Angle of 120 tooth gear measured as indicated

T = Torque drive applied at the 59 tooth gear (a function of $\dot{\theta}_2$)

$\bar{C}_f$ = Frictional losses through the drive train but considered to act on the 59 tooth gear.

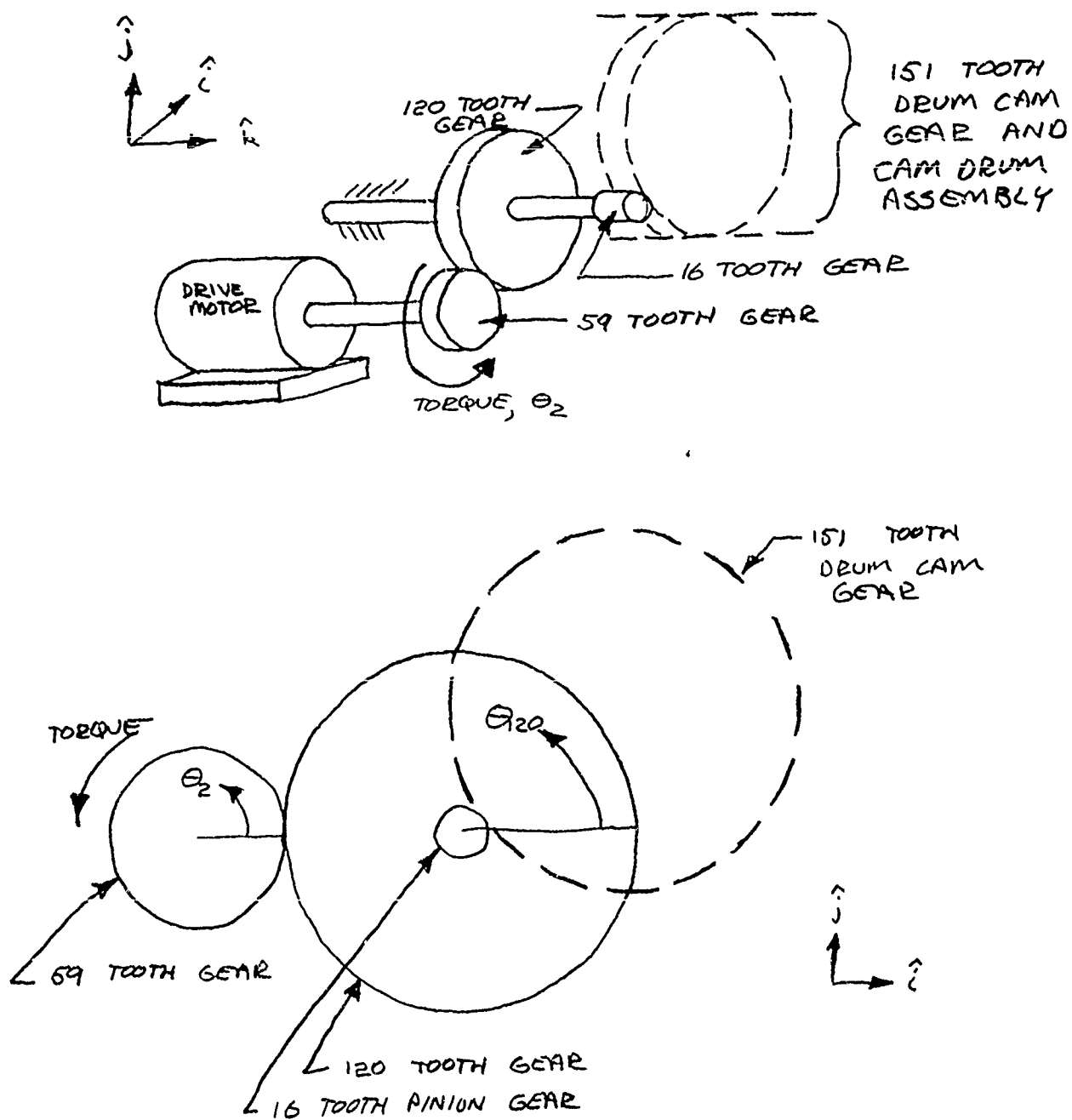


FIGURE A2-2
DRIVE COORDINATES
A2-5

Relationships

$$\theta_2 = \theta_2$$

$$\theta_{120} = (59/120)\theta_2 = -C\theta_2$$

$$\dot{\theta}_{120} = -C\dot{\theta}_2$$

$$\ddot{\theta}_{120} = -C\ddot{\theta}_2$$

$$\vec{C}_f = -C_f \hat{k}$$

Development:

i	F_i	$\vec{p}$	$\frac{\partial \vec{p}_i}{\partial \theta_2}$	$\vec{F}_i \cdot \frac{\partial \vec{p}_i}{\partial \theta_2}$
1	$-I_{59}\ddot{\theta}_2 \hat{k}$	$\theta_2 \hat{k}$	$\hat{k}$	$-I_{59}\ddot{\theta}_2$
2	$-I_{120}\ddot{\theta}_2 \hat{k}$	$\theta_{120} \hat{k}$	$-C\hat{k}$	$C I_{120} \ddot{\theta}_2$
3	$T \hat{k}$	$\theta_2 \hat{k}$	$\hat{k}$	T
4	$-C_f \hat{k}$	$\theta_2 \hat{k}$	$\hat{k}$	$-C_f$

in terms of θ_2 ,

$$\begin{aligned} \sum_{i=1}^4 \vec{F}_i \cdot \frac{\partial \vec{p}_i}{\partial \theta_2} &= \\ &= -I_{59}\ddot{\theta}_2 - C^2 I_{120} \ddot{\theta}_2 + T - C_f \\ &= \ddot{\theta}_2 (-I_{59} - C^2 I_{120}) + T - C_f \end{aligned} \quad (A2.8)$$

A2.3 - LOCAL COORDINATE 3, DRUM/FACE CAMS

The gun parts associated with this coordinate are the drum cam and the face cam. Although in practice they are assembled so that they have no relative motion between them, they are treated separately in keeping with the practice of trying to do the analysis on very primary level so any program revisions necessitated by part changes are minor. The parts and reference frame are shown in Figure A2-3.

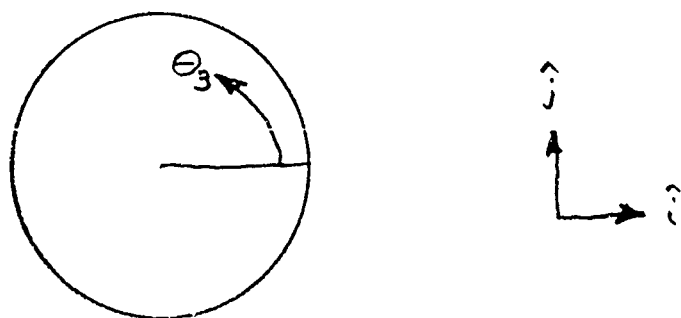
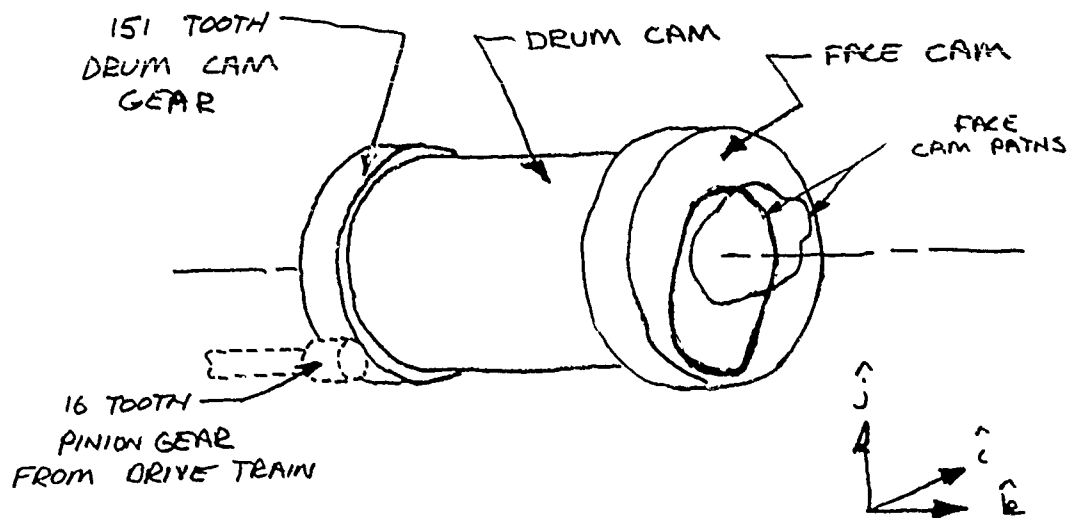


FIGURE A2-3
DRUM/FACE CAM COORDINATES
A2-8

Terms:

IDRUM = mass moment of inertia of the drum cam

IFACE = mass moment of inertia of the face cam

θ_3 = angle made by the zero point of the drum cam with the
i axis, measured as shown.

θ_F = angle made by the zero point of the face cam with the
i axis, measured as shown.

Relationships:

$$\theta_F = \theta_3 + \text{constant angle} = \theta_3 + A$$

$$\dot{\theta}_F = \dot{\theta}_3$$

$$\ddot{\theta}_F = \ddot{\theta}_3$$

$$\theta_3 = a_0 + a_1\theta_2 + a_2\theta_2^2 + a_3\theta_2^3 + a_4\theta_2^4 + a_5\theta_2^5 \text{ for a given } \theta_2$$

Development:

i	$\vec{F}_i$	$\vec{p}_i$	$\frac{\partial \vec{p}_i}{\partial \theta_2}$	$\vec{F}_i \frac{\partial \vec{p}_i}{\partial \theta_2}$
5	$-IDRUM \ddot{\theta}_3 \hat{k}$	$\theta_3 \hat{k}$	$\dot{\theta}_3 \hat{k}$	$-\theta_3 \dot{\theta}_3 IDRUM \ddot{\theta}_3$
6	$-IFACE \ddot{\theta}_F \hat{k}$	$\theta_F \hat{k}$	$\dot{\theta}_F \hat{k}$	$-\theta_F \dot{\theta}_F IFACE \ddot{\theta}_3$

in terms of θ_2

$$\sum_{i=5}^6 \vec{F}_i \cdot \frac{\partial \vec{p}_i}{\partial \theta_2}$$

$$= -\theta_3 \dot{\theta}_3 IDRUM (\dot{\theta}_3 \ddot{\theta}_2 + \dot{\theta}_3 \ddot{\theta}_2^2)$$

$$-\theta_F \dot{\theta}_F IFACE (\dot{\theta}_3 \ddot{\theta}_2 + \dot{\theta}_3 \ddot{\theta}_2^2)$$

$$= \ddot{\theta}_2 [-(\dot{\theta}_3)^2 (IDRUM + IFACE)]$$

$$-\theta_3 \dot{\theta}_3 \ddot{\theta}_2^2 (IDRUM + IFACE)$$

(A2.9)

A2.4 - LOCAL COORDINATE 4, FEED MECHANISM

The gun parts associated with this coordinate are the feed pawls, the feed shaft, and the feed follower which is called a rocker. The parts and reference frame are shown in Figure A2-4.

Terms:

IPAWL = mass moment of inertia of the pawl about the shaft

IROCK = mass moment of inertia of the rocker/follower about the shaft

ISHAFT = mass moment of inertia of the shaft

MPAWL = mass of the pawl

MROCK = mass of the rocker/follower

MAMMO = mass of the ammunition

θ_2 = pawl angle measured as indicated

θ_r = rocker angle measured as indicated

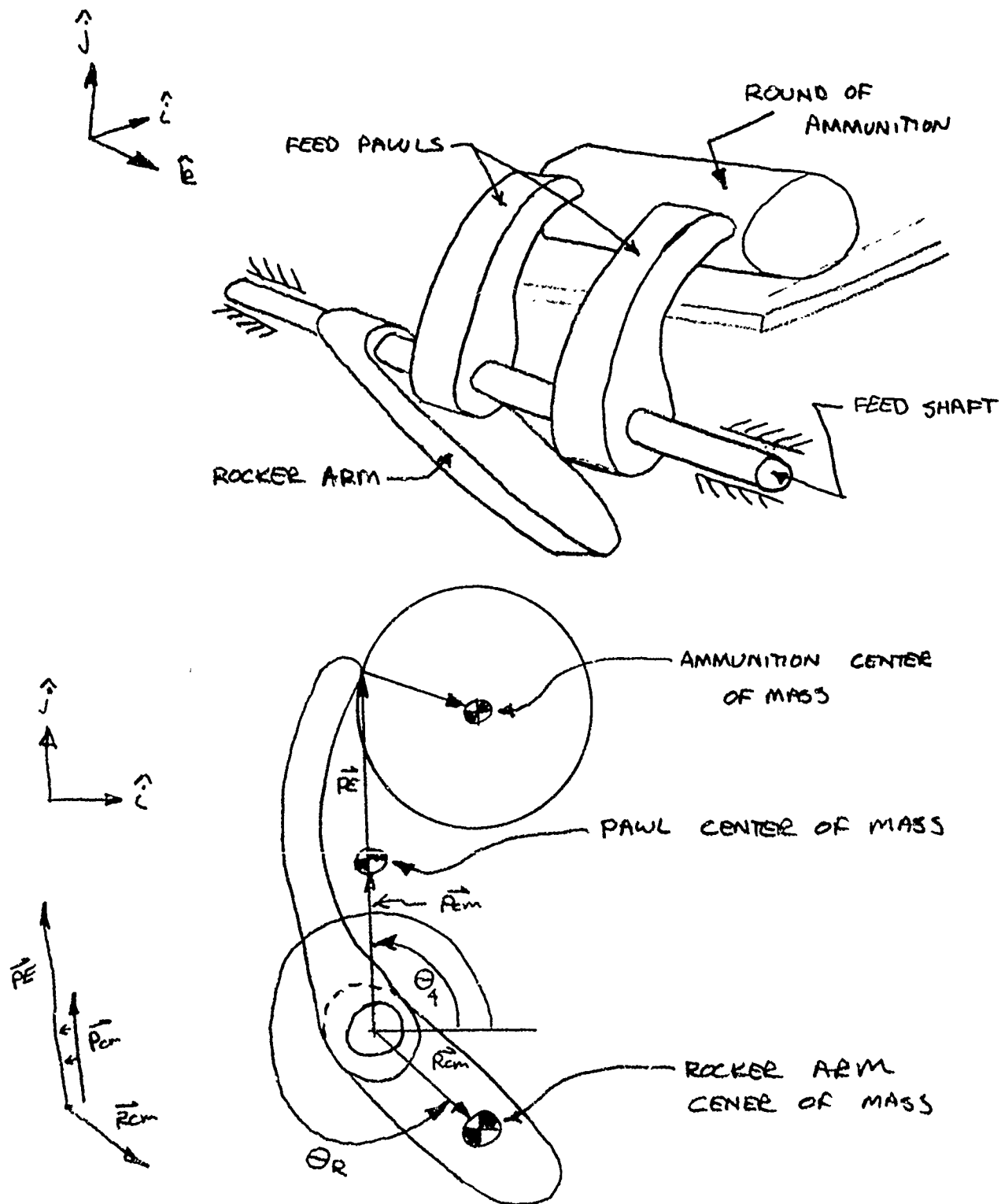


FIGURE A2-4
FEED COORDINATES
A2-11

PCM = Distance from shaft to PAWL center of mass

RCM = Distance from shaft to rocker

PE = Distance from shaft to end of PAWL

$\vec{P}$ = positional vector from ground to pawl center of mass

$\vec{A}$ = positional vector from ground to ammo center of mass

$\vec{R}$ = positional vector from ground to rocker center of mass

T = torque needed to pull ammo belt.

Relationships:

$$\theta_r = \theta_4 + \text{constant angle} = \theta_4 + C$$

$$\dot{\theta}_r = \dot{\theta}_4$$

$$\ddot{\theta}_r = \ddot{\theta}_4$$

$$\vec{P} = \vec{\text{const}1} + \vec{\text{PCM}}$$

$$\vec{A} = \vec{\text{const}2} + \vec{PE} + (\text{DAMMO}/2)\hat{i}$$

$$\vec{R} = \vec{\text{const}3} + \vec{\text{RCM}}$$

Development:

i	$\vec{F}_i$	$\vec{R}_i$	$\frac{\partial p_i}{\partial \theta_2}$	$\vec{F}_i \cdot \frac{\partial p_i}{\partial \theta_2}$
7	$-\text{IPAWL} \ddot{\theta}_4 \hat{k}$	$\theta_4 \hat{k}$	$\theta_4 \hat{k}$	$-\text{IPAWL} \ddot{\theta}_4 \theta_4$
8	$-\text{MPAWL}(\ddot{P} + g\hat{j})$	$\vec{P}$	$\text{PCM} \theta_4 (-\sin \theta_4 \hat{i} + \cos \theta_4 \hat{j})$	$-\text{MPAWL} (\text{PCM})^2 \theta_4 \{ \ddot{\theta}_4 + \cos \theta_4 (g/\text{PCM}) \}$
9	$-\text{IROCK} \ddot{\theta}_r \hat{k}$	$\theta_r \hat{k}$	$\theta_4 \hat{k}$	$-\text{IROCK} \ddot{\theta}_4 \theta_4$
10	$-\text{MROCK}(\ddot{R} + g\hat{j})$	$\vec{R}$	$\text{RCM} \theta_r (-\sin \theta_r \hat{i} + \cos \theta_r \hat{j})$	$-\text{MROCK} (\text{RCM})^2 \theta_r \{ \ddot{\theta}_r + \cos \theta_r (g/\text{RCM}) \}$
11	$-\text{ISHAFT} \ddot{\theta}_4 \hat{k}$	$\theta_4 \hat{k}$	$\theta_4 \hat{k}$	$-\text{ISHAFT} \ddot{\theta}_4 \theta_4$
12	$-\text{MAMMO} \ddot{A}$	$\vec{A}$	$\text{PE} \theta_4 (-\sin \theta_4 \hat{i} + \cos \theta_4 \hat{j})$	$-\text{MAMMO} (\text{PE})^2 \theta_4 \ddot{\theta}_4$
13	$-\text{T} \hat{k}$	$\theta_4 \hat{k}$	$\theta_4 \hat{k}$	$-\text{T} \theta_4$

in terms of θ_2

$$\sum_{i=7}^{13} \vec{F}_i \cdot \frac{\partial \vec{p}_i}{\partial \theta_2}$$

$$\begin{aligned}
 &= \ddot{\theta}_2 \{ -(\dot{\theta}_4)^2 \{ \text{IPAWL} + \text{IROCK} + \text{ISHAFT} + \text{MPAWL}(\text{PCM})^2 + \text{MROCK}(\text{RCM})^2 \\
 &\quad + \text{MAMMO}(\text{PE})^2 \} \\
 &\quad - \dot{\theta}_2^2 (\dot{\theta}_4 \ddot{\theta}_4) \{ \text{IPAWL} + \text{IROCK} + \text{ISHAFT} + \text{MPAWL}(\text{PCM})^2 + \text{MROCK}(\text{RCM})^2 \\
 &\quad + \text{MAMMO}(\text{PE})^2 \} \\
 &\quad - \dot{\theta}_4 \{ \text{MPAWL}(\text{PCM}) g \cos \theta_4 + \text{MROCK}(\text{RCM}) g \cos \theta_4 + T \} \quad (\text{A2.10})
 \end{aligned}$$

NOTE, however that the ammunition is only present during the portion of the cycle during which the ammo is transferred to the chamber for firing. Thus the term

MAMMO = (mass of AMMO) Unit ($\dot{\theta}_4$)

where unit ($\dot{\theta}_4$) = 1 when $\dot{\theta}_4 < 0$, or since $\dot{\theta}_2 > 0$, when $\theta_4 \leq 0$

= 0 when $\dot{\theta}_4 \geq 0$, or since $\dot{\theta}_2 > 0$, when $\theta_4 > 0$

Also, there is currently no ammo belt system yet fabricated so that T is always zero.

A2.5 - LOCAL COORDINATE 5, EJECT MECHANISM

The gun parts associated with this coordinate are the eject pawl, the eject shaft, and the eject cam path fall over which is called a rocker. The parts and reference frame are shown in Figure A2-5.

Terms:

IPAWL = mass moment of inertia of the pawl about the shaft

IROCK = mass moment of inertia of the rocker about the shaft

ISHAFT = mass moment of inertia of the shaft

MPAWL = mass of the eject pawl

MROCK = mass of the rocker

θ_s = pawl angle measured as shown

θ_r = rocker angle measured as shown

PCM = distance from shaft to pawl center of mass

RCM = distance from shaft to rocker center of mass

$\vec{P}$ = positional vector from ground to pawl center of mass

$\vec{R}$ = positional vector from ground to rocker center of mass

Relationships:

$$\theta_r = \theta_s - \text{constant angle} = \theta_s - C$$

$$\dot{\theta}_r = \dot{\theta}_s$$

$$\ddot{\theta}_r = \ddot{\theta}_s$$

$$\vec{P} = \vec{c_{\text{const}}} + \vec{P_{\text{CM}}}$$

$$\vec{R} = \vec{c_{\text{const}}} + \vec{R_{\text{CM}}}$$

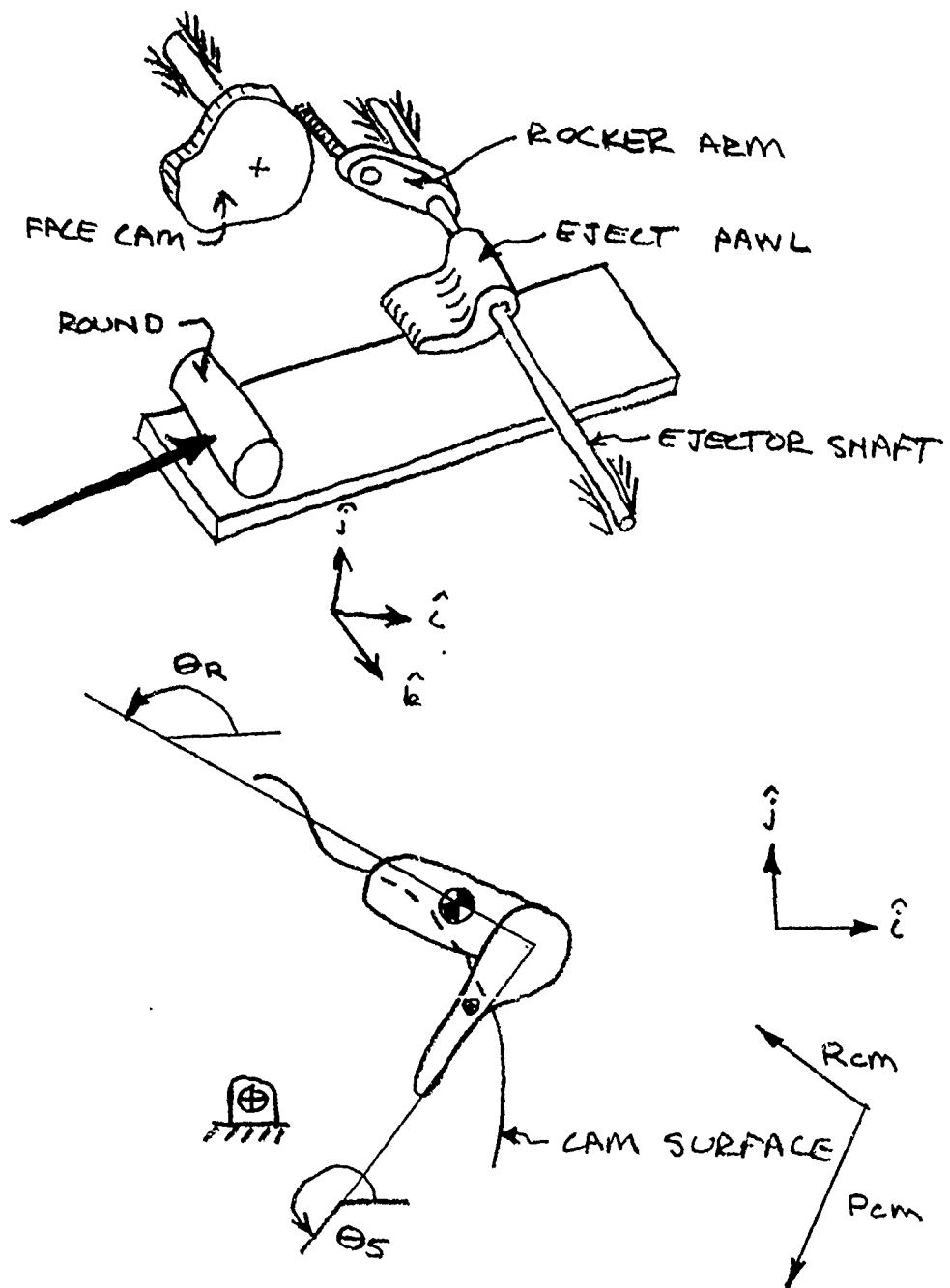


FIGURE A2-5
EJECT COORDINATES
A2-15

Development:

i	$\vec{F}_i$	$\vec{p}_i$	$\frac{\partial \vec{p}_i}{\partial \theta_2}$	$\vec{F}_i \cdot \frac{\partial \vec{p}_i}{\partial \theta_2}$
14	$-IPAWL \ddot{\theta}_5 \hat{k}$	$\theta_5 \hat{k}$	$\theta_5 \hat{k}$	$-IPAWL \ddot{\theta}_5 \theta_5$
15	$-MPAWL (\ddot{\vec{p}} + g \hat{j}) \cdot \vec{p}$		$P_{cm} \dot{\theta}_5 (-\sin \theta_5 \hat{i} + \cos \theta_5 \hat{j})$	
16	$-IROCK \ddot{\theta}_5 \hat{k}$	$\theta_5 \hat{k}$	$\theta_5 \hat{k}$	$-IROCK \ddot{\theta}_5 \theta_5$
17	$-MROCK (\ddot{\vec{R}} + g \hat{j}) \cdot \vec{R}$		$R_{cm} \dot{\theta}_r (-\sin \theta_r \hat{i} + \cos \theta_r \hat{j})$	
18	$-ISHAFT \ddot{\theta}_5 \hat{k}$	$\theta_5 \hat{k}$	$\theta_5 \hat{k}$	$-ISHAFT \ddot{\theta}_5 \theta_5$

$$-MPAWL (P_{cm})^2 \dot{\theta}_5^2 \{ \ddot{\theta}_5 + \cos \theta_5 (g/P_{cm}) \}$$

$$-MROCK (R_{cm})^2 \dot{\theta}_r^2 \{ \ddot{\theta}_r + \cos \theta_r (g/R_{cm}) \}$$

in terms of $\dot{\theta}_2$,

$$\sum_{i=14}^{18} \vec{F}_i \cdot \frac{\partial \vec{p}_i}{\partial \theta_2}$$

$$= -(\dot{\theta}_5)^2 \{ IPAWL + IROCK + ISHAFT + MPAWL (PCM)^2 + MROCK (RCM)^2 \} \ddot{\theta}_2$$

$$-(\dot{\theta}_5 \dot{\theta}_5') \{ IPAWL + IROCK + ISHAFT + MPAWL (PCM)^2 + MROCK (RCM)^2 \} \dot{\theta}_2^2$$

$$-(\dot{\theta}_5) \{ MPAWL (PCM) g \cos \theta_5 + MROCK (RCM) g \cos \theta_r \}$$

(A2.11)

A2.6 - LOCAL COORDINATE 6, LOCK RING

The gun parts associated with this coordinate is the lock ring. The part and reference frame is shown in Figure A2-6.

Terms:

ILOCK = mass moment of inertia of lock ring

T = additional torques acting on the lock ring, including friction

θ_6 = angle from lock ring center to zero point of ring from $\hat{i}$ axis

Relationships:

$$\theta_6 = a_0 + a_1\theta_2 + a_2\theta_2^2 + a_3\theta_2^3 + a_4\theta_2^4 + a_5\theta_2^5 \text{ for given } \theta_2$$

Development:

i	$\vec{F}_i$	$\vec{p}_i$	$\frac{\partial \vec{p}_i}{\partial \theta_2}$	$\vec{F}_i \cdot \frac{\partial \vec{p}_i}{\partial \theta_2}$
19	$-\text{ILOCK} \ddot{\theta}_6 \hat{k}$	$\theta_6 \hat{k}$	$\dot{\theta}_6 \hat{k}$	$-\text{ILOCK} \ddot{\theta}_6 \dot{\theta}_6$
20	$-T \hat{k}$	$\theta_6 \hat{k}$	$\dot{\theta}_6 \hat{k}$	$-T \dot{\theta}_6$

in terms of θ_2

$$\sum_{i=19}^{20} \vec{F}_i \cdot \frac{\partial \vec{p}_i}{\partial \theta_2}$$

$$= \ddot{\theta}_2 (-\text{ILOCK} (\dot{\theta}_6)^2) + \dot{\theta}_2^2 (-\text{ILOCK} \dot{\theta}_6 \ddot{\theta}_6) - T \dot{\theta}_6$$

(A2.12)

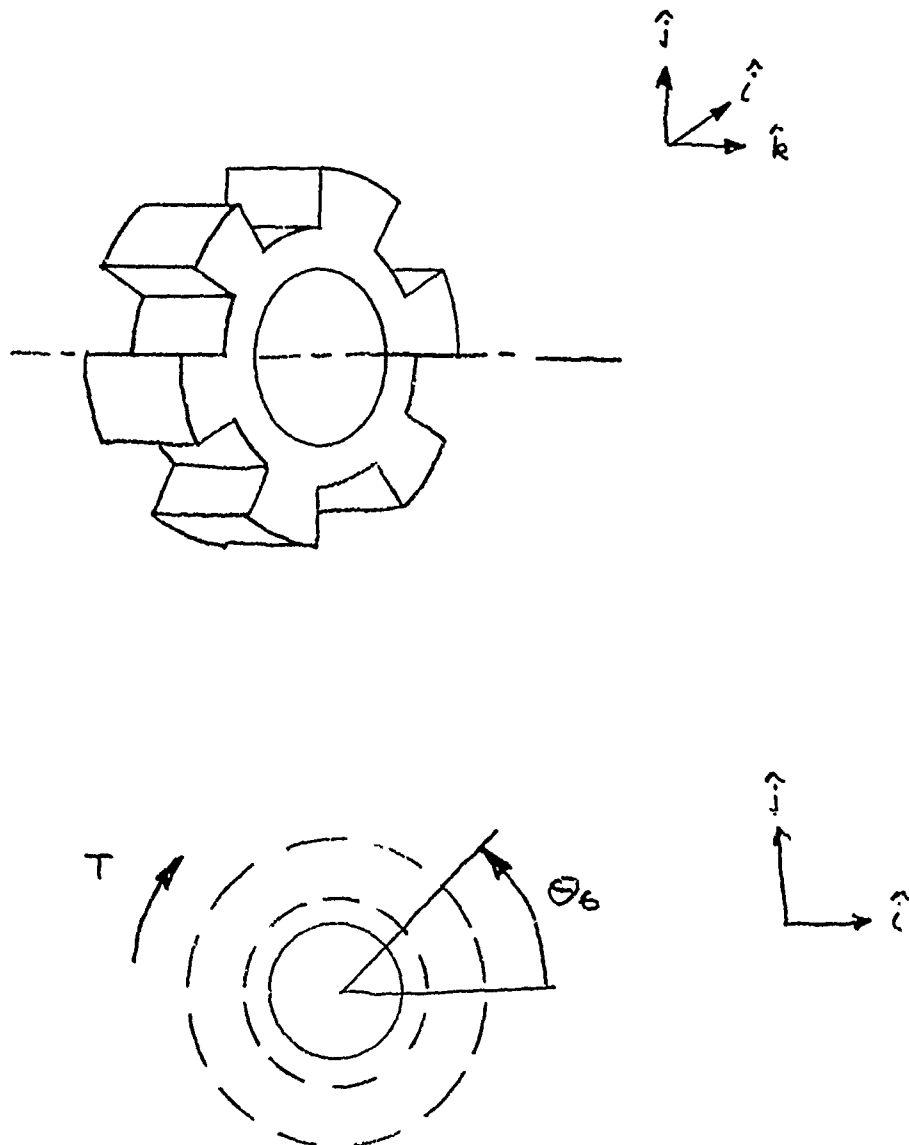


FIGURE A2-6
 LOCK RING COORDINATES
 A2-18

A2.7 - LOCAL COORDINATE 7, CHAMBER

The gun parts associated with this coordinate are the chamber and bolt assemblies. As discussed in Section 2.5, the bolt and chamber translate as a unit only a small distance before the bolt becomes stationary. The actual mass that is translating is the mass of interest. The chamber assembly includes everything shown in Figure 9. The parts and reference frame is shown in Figure A2-7.

Terms:

$\vec{S}$ = vector from ground to fixed point on chamber

Crush = spring force acting on chamber due to round crush up

Sear = spring force acting on chamber during researing of firing
pen spring

$\vec{C}_f$ = friction acting to resist chamber motion

VCHMBR = virtual (actual) translating mass

Relationships:

$$R = a_0 + a_1\theta_2 + a_2\theta_2^2 + a_3\theta_2^3 + a_4\theta_2^4 + a_5\theta_2^5$$

$$\vec{R} = -R\hat{k}$$

$$\vec{S} = \text{const} + \vec{R}$$

$$CRUSH = -(CRUSH) \hat{k}$$

$$SEAR = (SEAR) \hat{k}$$

$$\vec{C}_f = C_f \hat{k} \text{ when } \dot{R} > 0$$

$$-C_f \hat{k} \text{ when } \dot{R} \leq 0$$

$$\ddot{\vec{S}} + \ddot{\vec{R}} = \ddot{\vec{R}}$$

$$\frac{\partial(\vec{S} + \vec{R}_1)}{\partial\theta_2} \quad \frac{\partial R}{\partial\theta_2} = R^1$$

i	$\vec{F}_i$	$\vec{p}_i$	$\frac{\partial p_i}{\partial \theta_2}$	$\vec{F}_i \cdot \frac{\partial \vec{p}_i}{\partial \theta_2}$
21	$-VCHMBR(\ddot{\vec{S}} + \ddot{\vec{R}}_1)$	$\vec{S} + \vec{R}$	$-R' \hat{k}$	$(VCHMBR)R' \ddot{R}$
22	$CRUSH$	$\vec{R}$	$-R' \hat{k}$	$(CRUSH)R'$
23	$SEAR$	$\vec{R}$	$-R' \hat{k}$	$-(SEAR)R'$
24	C_f	$\vec{R}$	$-k' \hat{k}$	$+C_f R' \left(\frac{\dot{R}}{ \dot{R} } \right)$

in terms of θ_2

$$\begin{aligned}
 & \sum_{i=21}^{24} \vec{F}_i \cdot \frac{\partial \vec{p}_i}{\partial \theta_2} \\
 &= VCHMBR R' (\ddot{R}' \dot{\theta}_2 + R'' \dot{\theta}_2^2) + (CRUSH)R' - (SEAR)R' \\
 & \quad + C_f R' (R' \dot{\theta}_2 / \text{ABS}(R' \dot{\theta}_2)) \\
 &= \ddot{\theta}_2 (VCHMBR (R')^2) + \dot{\theta}_2^2 (VCHMBR R' R'') \\
 & \quad + R' (CRUSH - SEAR + C_f (R' \dot{\theta}_2 / \text{ABS}(R' \dot{\theta}_2))) \quad (As.13)
 \end{aligned}$$

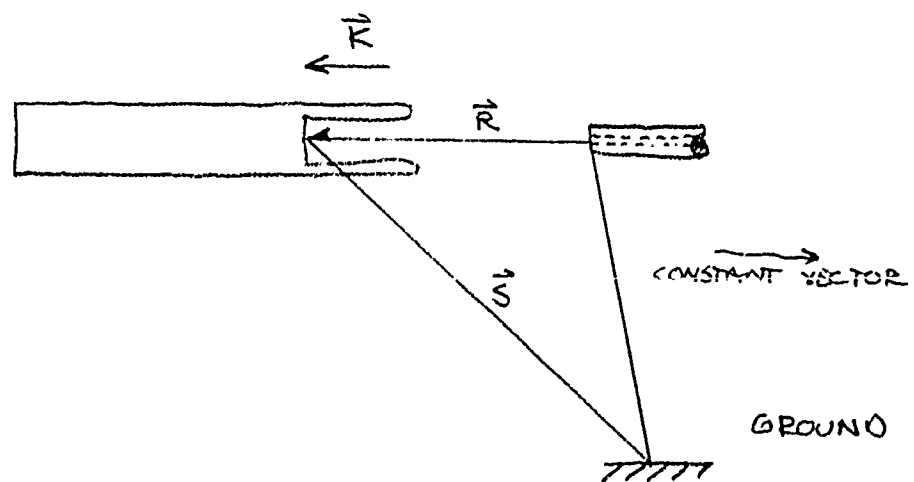
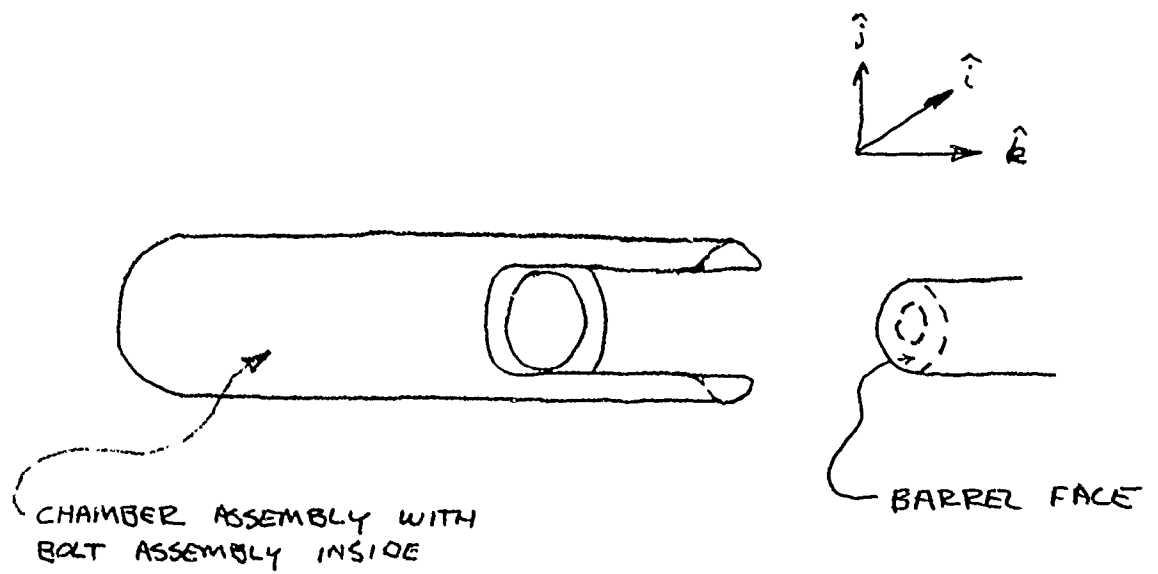


FIGURE A2-7
CHAMBER COORDINATES
A2-21

A2.8 - GENERAL DEVELOPMENT OF A TRANSLATING d'ALEMBERT FORCE

Let the positional vector be PCM and have it acting at angle as shown in the Figure A-8 as always, θ is a function of θ_2

Terms:

$\vec{P}$ = positional vector from ground to the center of mass

θ = angle measured as shown

PCM = magnitude of distance from origin to center of mass

g = acceleration due gravity

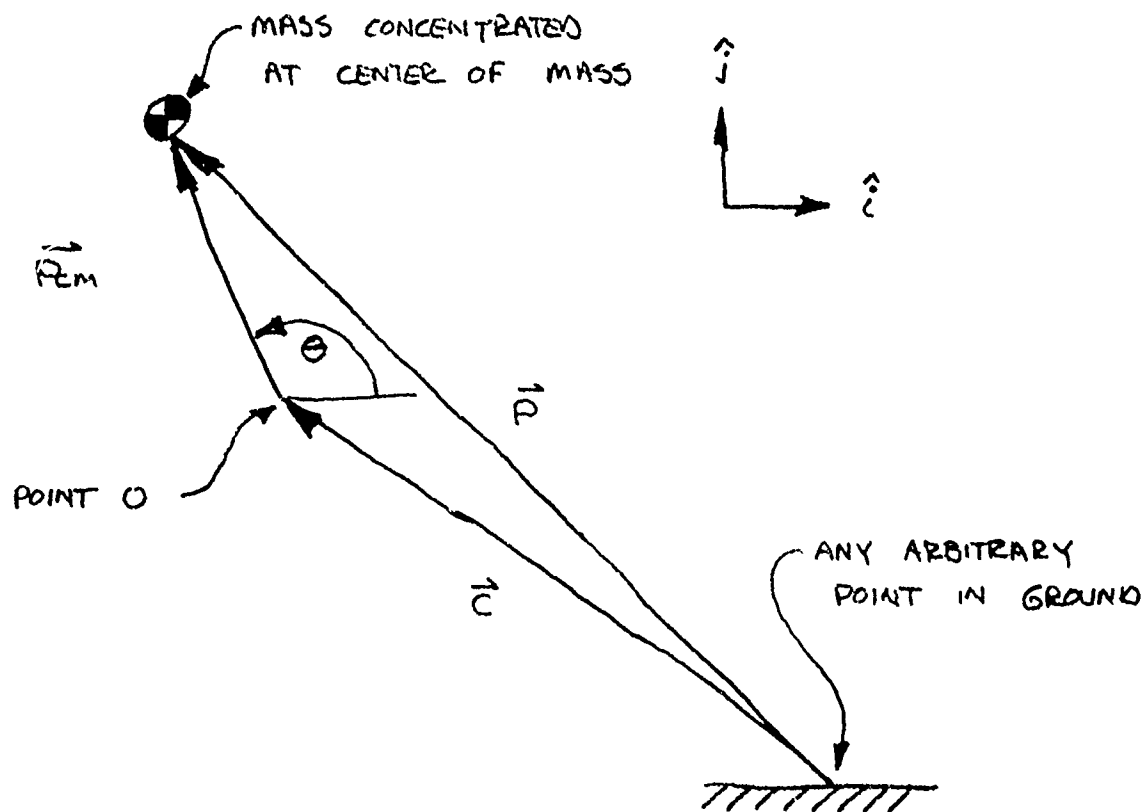
m = mass of part, considered concentrated at center of mass

Relationships:

$$\theta = a + a_1\theta_2 + a_2\theta_2^2 + a_3\theta_2^3 + a_4\theta_2^4 + a_5\theta_2^5 \quad (A2-3)$$

Development:

The only force considered here is the d'Alembert force associated with translation of the center of mass.



NOTES:

$\vec{r}$ IS VECTOR FROM A GROUND POINT TO CM

$\vec{c}$ IS VECTOR FROM THE GROUND POINT TO THE AXIS OF ROTATION FOR THE PART, POINT O

$\vec{r}_{cm}$ IS THE VECTOR FROM O TO THE CM AND THUS HAS FIXED LENGTH

GRAVITY ACTS IN $-\hat{j}$ DIRECTION WITH MAGNITUDE g

FIGURE A2-8
GENERAL TRANSLATING MASS

The positional vector $\vec{P}$ is

$\vec{P} = \vec{C} + \vec{P}_{cm}$, where $\vec{C}$ is a vector from some point in ground to point 0, which is fixed relative to ground.

The second time derivative of the vector $\vec{P}$ (in two dimensions) is

$$\begin{aligned}\ddot{\vec{P}} &= \ddot{\vec{C}} + \ddot{\vec{P}}_{cm} \\ &= (\ddot{P}_{cm}) (\hat{P}_{cm}) + \ddot{\theta} (\hat{k} \times \vec{P}_{cm}) - \dot{\theta}^2 \vec{P}_{cm} \\ &\quad + 2\dot{\theta} (\hat{k} \times (\dot{P}_{cm}) \hat{P}_{cm})\end{aligned}\tag{A2.14}$$

however, the length $P_{cm} = \text{constant}$

$$\text{thus } \dot{P}_{cm} = 0$$

and $\ddot{P}_{cm} = 0$, yielding

$$\ddot{\vec{P}} = \ddot{\theta} (\hat{k} \times \vec{P}_{cm}) - (\dot{\theta})^2 \vec{P}_{cm}\tag{A2.14.a}$$

since

$$\begin{aligned}\vec{P}_{cm} &= P_{cm} (\cos\theta \hat{i} + \sin\theta \hat{j}) \\ (\hat{k} \times \vec{P}_{cm}) &= P_{cm} (-\sin\theta \hat{i} + \cos\theta \hat{j}), \text{ therefore} \\ \ddot{\vec{P}} &= \ddot{\theta} P_{cm} (-\sin\theta \hat{i} + \cos\theta \hat{j}) - \dot{\theta}^2 P_{cm} (\cos\theta \hat{i} + \sin\theta \hat{j}) \\ &= \{(-\sin\theta)(\ddot{\theta})(P_{cm}) - (\dot{\theta}^2)(P_{cm})(\cos\theta)\} \hat{i} \\ &\quad + \{(\cos\theta)(\ddot{\theta})(P_{cm}) - (\dot{\theta}^2)(P_{cm})(\sin\theta)\} \hat{j}\end{aligned}\tag{A2.14.b}$$

$\vec{F}$ for this case is

$$\begin{aligned}\vec{F} &= -M[\ddot{\vec{P}} + g\hat{j}] = \\ &= -MP_{cm} \{(-\sin\theta)\ddot{\theta} - \dot{\theta}^2 \cos\theta\} \hat{i} \\ &\quad + \{(\cos\theta)\ddot{\theta} - \dot{\theta}^2 \sin\theta + \frac{3}{P_{cm}}\} \hat{j}\end{aligned}\tag{A2.15}$$

$$\vec{P} = \vec{C} + P_{cm}^{\rightarrow}, \text{ AND}$$

$$\frac{\partial \vec{P}}{\partial \theta_2} = 0 + \frac{\partial (P_{cm}^{\rightarrow})}{\partial \theta_2}$$

$$\frac{j}{j\theta_2} \{P_{cm}(\cos\theta \hat{i} + \sin\theta \hat{j})\}$$

$$= P_{cm} \frac{d\theta}{d\theta_2} (-\sin\theta \hat{i} + \cos\theta \hat{j})$$

$$= P_{cm} \theta' (-\sin\theta \hat{i} - \cos\theta \hat{j})$$

$$= (P_{cm} \theta' - \sin\theta) \hat{i} + (P_{cm} \theta' + \cos\theta) \hat{j}$$

(A2.16)

$$\text{and } \vec{F} \cdot \frac{d\vec{P}}{d\theta_2}$$

$$= M(P_{cm})^2 \theta' \{ \sin\theta (+\sin\theta) \ddot{\theta} + \sin\theta \dot{\theta}^2 \cos\theta$$

$$+ \cos\theta (\cos\theta) \ddot{\theta} - \cos\theta \dot{\theta}^2 \sin\theta + \cos\theta \frac{g}{P_{cm}} \}$$

$$= -M(P_{cm})^2 \theta' \{ \ddot{\theta} (\sin^2 + \cos^2) + \dot{\theta}^2 (\sin\theta \cos\theta - \sin\theta \cos\theta + \cos\theta \frac{g}{P_{cm}}) \}$$

$$= -M(P_{cm})^2 \theta' \{ \ddot{\theta} + \cos\theta \frac{g}{P_{cm}} \}$$

which in terms of explains as follows

$$= -M(P_{cm})^2 \theta' \{ (\theta' \ddot{\theta}_2 + \theta'' \dot{\theta}_2^2) + (g/P_{cm}) \cos\theta \}$$

$$= \ddot{\theta}_2 \{ -M(P_{cm})^2 (\theta')^2 \} + \dot{\theta}_2^2 \{ -M(P_{cm})^2 \theta' \theta'' \}$$

$$-M(P_{cm}) g \cos\theta \theta'$$

(A2.17)

TABLE OF MASS AND INERTIA

<u>Part Name</u>	<u>Mass</u> <u>(Lb-Sec**2/Ft)</u>	<u>I Mass</u> <u>(Ft-Lb-Sec**2)</u>
59 Gear	.2094	.000949
120 Gear	.4816	.01546
Face Cam	.3525	.04406
Drum Cam	.8540	.0997
Feed Shaft		.000018647
Feed Rocker	.0049232	.00002724
Feed Pawl	.010888	.00032958
Ammunition	.04255	
Eject Shaft		.000016782
Eject Rocker	.0049232	.00002724
Eject Pawl	.017473	.00016703
Lock Ring	.10864	.0020653
Chamber	.68329	

TABLE A2-1

A P P E N D I X A-3

PROGRAM LISTING, FRCP

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MAIN

FORTRAN IV 6 LEVEL 21

C----- ABSTRACT: THIS MAIN PROGRAM IS THE EXECUTIVE WHICH
 C----- CALLS THE VARIOUS ROUTINES. THE OVERALL OBJECTIVE
 C----- OF THE PROGRAM IS TO DEVELOP POSITIONAL RELATIONS
 C----- BETWEEN THE VARIOUS DEPENDENT VARIABLES WHICH
 C----- DETERMINE PART POSITIONS FOR THE VARIOUS WEAPON
 C----- COMPONENTS. THIS PROGRAM ESSENTIALLY MASSAGES
 C----- AVAILABLE DATA (FROM DRAWINGS, ETC.) AND PREPARES
 C----- OUTPUT DATA IN A FORM SUITABLE FOR USE BY THE
 C----- AMCAWS-30 MATHEMATICAL MODEL PROGRAM.
 C-----

C----- PERFORM THE INITIALIZATION NECESSARY FOR PROGRAM
 C-----

C----- CALL INPUT
 C-----

C----- COMPUTE THE VARIOUS RELATIONSHIPS FOR PART POSITIONS
 C-----

C----- CALL CMPUTE(JMAX)
 C-----

C----- PREPARE THE OUTPUT FOR THE AMCAWS-30 MATH PROGRAM
 C-----

C----- CALL OUTPUT(JMAX)
 C-----

C----- CALL PLOTNG(JMAX)
 C-----

C----- STOP
 C----- END

0001

0002

0003

0004

0005

0006

0001 C
C----- ABSTRACT: SUBROUTINE INPUT SETS UP THE VARIABLES
C----- NECESSARY FOR RUNNING THE ANCAWS-30 FUNCTIONAL
C----- RELATIONSHIPS PROGRAM
C

0002 C
0003 COMMON/INPUTS/02MAX,DELO2
0004 COMMON/DWGS1/ETH(1000),FR(1000),NPTSF
0005 COMMON/DWGS2/ETH(1000),ER(1000),NPTSE
0006 COMMON/DWGS3/DTH(1000),DR(1000),NPTSD
0007 COMMON/DWGS4/DLTH(1000),ALTH(1000),NPTSL

0008 C
0009 C----- PREFORM INPUT
0010 C
0011 02MAX=7294.06779
0012 DELO2=02MAX/380.
0013 C

0014 C----- FEEDCAM DATA INPUT FROM FILE 10
0015 C

0016 J=0
0017 100 CONTINUE
0018 C
0019 READ(6,1000,ERR=100,END=200) X,Y
0020 READ(10,1000,ERR=100,END=200) X,Y
0021 READ(10,1000,ERR=100,END=200) Y,Y
0022 J=J+1
0023 IF(X.EQ.380.) NPTSF=J
0024 FTH(J)=X
0025 FR(J)=Y
0026 GO TO 100
0027 200 CONTINUE
0028 C

0029 C----- EJECTCAM DATA INPUT FROM FILE 11
0030 C

0031 J=0
0032 300 CONTINUE
0033 READ(11,1000,ERR=300,END=400) X,Y
0034 J=J+1
0035 IF(X.EQ.380.) NPTSE=J
0036 ETH(J)=X
0037 ERI(J)=Y
0038 GO TO 300
0039 400 CONTINUE
0040 C

0041 C----- DPUNCAM DATA INPUT FROM FILE 12
0042 C

0043 J=0
0044 500 CONTINUE
0045 READ(12,1000,ERR=500,END=600) Y,Y
0046 J=J+1
0047 IF(X.EQ.380.) NPTSD=J
0048 600 CONTINUE
0049 C

```

0032      OTH(J)=X
0033      DR(J)=Y
0034      GO TO 500
0035
600      CONTINUE
C
C----- LOCKCAM DATA INPUT FORM FIL 13
C
J=0
700      CONTINUE
      READ(13,1000,ERR=700,END=800) X,Y
      J=J+1
      IF(X.EQ.380.) NPTSL=J
      OTH(J)=X
      ALTH(J)=Y
      GO TO 700
800      CONTINUE
      RETURN
1000     FORMAT(2F17.4)
      END
0047
  
```

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CMPUTE

FORTRAN IV G LEVEL 21

```

0001      SUBROUTINE CMPUTE(JMAX)
C-----
C----- ABSTRACT: SUBROUTINE CMPUTE MAKES THE FUNCTION
C----- CALLS THAT SET UP THE ROTATION AND DISPLACEMENT
C----- FUNCTIONS.
C
C
C      COMMON/INPUTS/02MAX,DELO2
C      COMMON/OUTVAL/02,03,03F,04,05,06,57,JOUT
C
C      JOUT=0
C      02=DELO2
C----- LOOP FROM 0. TO 02MAX AND CALL FUNCTIONS
C
100      CONTINUE
         02=02+DELO2
         IF(02.GT.02MAX) GO TO 200
         03=FUN32(02)
         03F=FUN3F(03)
         04=FUN43F(03F)
         05=FUN53F(03F)
         06=FUN63(03)
         57=FUN73(03)
         JOUT=JOUT+1
         CALL OUT
         GO TO 100
C
C----- HAVE REACHED 02MAX
C
200      CONTINUE
         JMAX=JOUT
         RETURN
         END
0018
0019
0020
0021

```

FORTRAN IV G LEVEL 21 OUTPUT DATE = 77099 09/20/55 PAGE 0001

```

0001      SUBROUTINE OUTPUT(JMAX)
C----- ABSTRACT: SUBROUTINE OUTPUT PUTS OUT THE ARRAYS
C----- OF POSITIONAL INFORMATION RELATING PART POSITION
C----- AND ROTATIONS TO THE MOTOR INPUT ANGLE.
C
C
C      COMMON/VECTOR/TH2(2001),TH3(2001),TH3F(2001),TH4(2001),
1      TH5(2001),TH6(2001),DISPL7(2001)
C      COMMON/OUTVAL/02,03,03F,04,05,06,57,JOUT
C
C      DO 100 J=1,JMAX
C        WRITE(9,1000) J,TH2(J),TH3(J),TH3F(J)
C        WRITE(9,1000) J,TH4(J),TH5(J),TH6(J),DISPL7(J)
C        WRITE(6,1000) J,TH2(J),TH3(J),TH3F(J)
C        WRITE(6,1000) J,TH4(J),TH5(J),TH6(J),DISPL7(J)
C        WRITE(6,1002)
100      CONTINUE
C
C      DO 200 J=1,JMAX
C        WRITE(1,1001)TH2(J),TH3(J)
C        WRITE(2,1001)TH2(J),TH3F(J)
C        WRITE(3,1001)TH2(J),TH4(J)
C        WRITE(4,1001)TH2(J),TH5(J)
C        WRITE(8,1001)TH2(J),TH6(J)
C        WRITE( 6,1001)TH2(J),DISPL7(J)
C200      CONTINUE
C
C      RETURN
0011      FORMAT( ' ,15,4F16.4)
0012      FORMAT( ' ,2F16.4)
0013      FORMAT( ' )
0014      END
0015
  
```

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OUT1

FORTAN IV 6 LEVEL 21

```

0001      SUBROUTINE OUT1
C----- ABSTRACT: SUBROUTINE OUT1 PAGES RESULTS OF
C----- SUBROUTINE CMPUTE INTO ARRAYS FOR LATER
C----- USE BY THE OUTPUT ROUTINE.
C
C
C
0002      COMMON/VECTOR/TH2(2001),TH3(2001),TH3F(2001),TH4(2001),
1      TH5(2001),TH6(2001),DISPL7(2001)
0003      COMMON/OUTVAL/02,03,03F,04,05,06,07,JOUT
C
C
0004      TH2(JOUT)=02
0005      TH3(JOUT)=03
0006      TH3F(JOUT)=03F
0007      TH4(JOUT)=04
0008      TH5(JOUT)=05
0009      TH6(JOUT)=06
0010      DISPL7(JOUT)=S7
C
C
0011      RETURN
0012      END

```

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FUN32

FORTRAN IV G LEVEL 21

```

0001      C      FUNCTION FUN32 (TH2)
C----- ABSTRACT: FUNCTION FUN32 RETURNS
C----- THE DEPENDENT TH3 VALUE, GIVEN TH2.
C
C      DATA RATIO/.052097/
C
C      TH3=RATIO*TH2
C      TH3=AMOD (TH3,360.000)
C      FUN32=TH3
C
C      RETURN
C      END
0002
0003
0004
0005
0006
0007

```

```

0001      FUNCTION FUN3F3(TH3)
C-----
C----- ABSTRACT: FUNCTION FUN3F3 PROVIDES A FACECAM ANGLE
C----- VS DRUMCAM ANGLE THAT WILL ULTIMATELY
C----- PROVIDE A FACECAM VS MOTOR INPUT ANGLE TABLE
C----- (TH3F VS TH2).
C----- ALL ANGLES IN
C----- DEGREES MEASURED COUNTERCLOCKWISE
C----- FROM 1 DIRECTION LOOKING IN -K DIRECTION
C-----
C
C      TH3F=TH3-90.0*720.
C      TH3F=AMOD(TH3F,360.0000)
C
C      FUN3F3=TH3F
C
C      RETURN
C      END
0002
0003
0004
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0006

```

0001 FUNCTION FUN43F (TH3F)
 C-----
 C----- ABSTRACT: FUNCTION FUN43F WILL PROVIDE
 C----- A FEED PAWL ANGLE VS FACECAM ANGLE THAT
 C----- WILL ULTIMATELY CREATE A FEED PAWL ANGLE
 C----- VS MOTOR INPUT ANGLE. (TH4 VS TH2).
 C----- ALL ANGLES IN
 C----- DEGREES MEASURED COUNTER-CLOCKWISE
 C----- FROM I DIRECTION LOOKING IN -K DIRECTION
 C-----
 C

0002 DIMENSION QDUM(20)
 0003 COMMON/DWGS1/FTH(1000),FR(1000),NPTSF
 0004 DATA A/4.2000/8/1.3480/,THAC/17.2800/
 0005 DATA THCNST/226.0000/,TH3/36.0000/
 C
 C

0006 C----- DETERMINE CURRENT RADIUS USING THCNST,AC,TH3F
 0007 DEG=THCNST*THAC*TH3F
 0008 DEGR=AMOD(DEG,360.0000)
 CALL INTERP(FTH,FR,NPTSF,DEGR,DR,D2R,0,0)
 R=SAINT(NPTSF,FTH,FR,DEGR,5,QDUM)
 C
 C

C----- DETERMINE INTERIOR ANGLES, P IS SIDE C
 C

0009 C=R
 0010 CALL ANGLES(A,B,C,BC,AC,AB)
 0011 THAC=AC
 C
 C

0012 TH4=THCNST*AC-(180.-BC)-TH3
 0013 FUN43F=TH4
 C
 C

0014 RETURN
 0015 END

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FUN73

FORTTRAN IV 6 LEVEL 21

```

0001      FUNCTION FUN73(TH3)
C----- ABSTRACT: FUNCTION FUN73 PROVIDES THE CHAMBER
C----- DISPLACEMENT VS DRUMCAM ANGLE THAT
C----- WILL ULTIMATELY PROVIDE THE CHAMBER
C----- SIDPLACEMENT VS MOTOR INPUT ANGLE
C----- (S7 VS TH2). ALL ANGLES IN
C----- DEGREES MEASURED COUNTER-CLOCKWISE
C----- FROM I DIRECTION LOOKING IN -K DIRECTION
C-----
C
C
C----- DIMENSION QDUM(20)
C----- COMMON/DWG53/DTH(1000),DR(1000),NPTSD
C
C----- DETERMINE DISPL7 KNOWING TH3
C
C----- CALL INTERP(DTH,DR,NPTSD,TH3,R,DR,D2R,0.0)
C----- R=SAINT(NPTSD,DTH,DR,TH3.5,QDUM)
C----- R IS THE DESIRED DISPL7
C
C----- DISPL7=R
C----- FUN73=DISPL7
C
C----- RETURN
C----- END

```

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0008

```

0001      SUBROUTINE ANGLES(A,B,C,AC,AB)
C-----
C----- SUBROUTINE ANGLES ACCEPTS THE 3 SIDES OF ANY TRIANGLE AND CALCULATE
C----- THE INTERNAL ANGLES
C----- A,B,C ARE THE SIDE LENGTHS
C----- AB IS THE ANGLE BETWEEN SIDES A AND B
C----- DETERMINE THE LONGEST SIDE
C-----
      TEST=MAX1(A,B,C)
      IF(TEST.EQ.A) GO TO 100
      IF(TEST.EQ.B) GO TO 200
      IF(TEST.EQ.C) GO TO 300
C----- SHOULD NEVER BE HERE
C-----
      WRITE(6,1000)
      GO TO 100
C-----
100      CONTINUE
      CALL ANGL(A,B,C,BC,AC,AB)
      GO TO 400
200      CONTINUE
      CALL ANGL(B,A,C,AC,BC,AB)
      GO TO 400
300      CONTINUE
      CALL ANGL(C,A,B,AB,BC,AC)
      CONTINUE
      TEST=ABS(AB+AC-BC-180.)
      IF(TEST.LT..1) GO TO 9000
C-----
C----- IF HERE, ALGORITHM HAS FAILED. FOR NOW DO NOTHING
C-----
      WRITE(6,1001)
      GO TO 9000
9000      CONTINUE
      RETURN
1000      FORMAT(' PASSED NO TESTS IN ANGLES')
1001      FORMAT(' INTERIOR ANGLES DO NOT TOTAL TO 180.')
      END

```

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```

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0001          SUBROUTINE ANGL(A,B,C,BC,AC,AB)
C-----      CALCULATE INTERIOR ANGLES OF A TRIANGLE WHEN A IS
C-----      THE LARGEST SIDE AND A,B,C ARE KNOWN
C
C=ARCOS(((B*B+C*C-A*A)/(2.*B*C)))
AC=AR SIN(B* SIN(BC)/A)
AB=AR SIN(C* SIN(BC)/A)
C
BC=BC*57.29578
AC=AC*57.29578
AB=AB*57.29578
      RETURN
      END

```

SUBROUTINE INTERP(XV,YV,NPTS,X,Y,INTER,DYDX,D2YDX2,ISM,IWRAP)

0001

C----- ABSTRACT: SUBROUTINE INTERP SEARCHES THE
C----- XV AND YV VECTORS AND EXTRACTS 6
C----- LOCAL DATA POINTS. THESE ARE PASSED TO
C----- THE POLATE ROUTINE THAT FITS A 5TH
C----- DEGREE POLYNOMIAL TO THEM.
C

0002 C DIMENSION XV(1),YV(1),XPOLY(6),YPOLY(6),COEFF(6)

C
C----- DETERMINE STEP SIZE BETWEEN ADJACENT X(I)
C----- THEN ESTABLISH THE "LOCAL" REGION IN ARRAYS
C

0003 M=5
0004 N=6
0005 XVAL=X
0006 STEP=XV(2)-XV(1)
0007 NSTEP=FIX(XVAL/STEP + .5)
0008 IF(NSTEP.LT.5 .AND. IWRAP.EQ.0) NSTEP=4
0009 IF(NSTEP.LT.5 .AND. IWRAP.EQ.0) GO TO 50
0010 IF((NPTS-2).LT.NSTEP .AND. IWRAP.EQ.0) NSTEP=NPTS-2
0011 IF((NPTS-2).LT.NSTEP .AND. IWRAP.EQ.0) GO TO 50
0012 IF(NSTEP.LT.5) XVAL=XVAL+XV(NPTS)
0013 IF(NSTEP.LT.5) NSTEP=NPTS-NSTEP

C----- SET UP THE 6 ELEMENT ARRAYS TO BE FIT

50 C CONTINUE

0014 BASE=0.0

0015 DO 100 J=1,6

0016 JVAL=NST_P-4+J

0017 XPOLY(J)=XV(JVAL)

0018 YPOLY(J)=YV(JVAL)

0019 XPOLY(J)=BASE + STEP*FLOAT(J)

100 C CONTINUE

0020 OFFSET=XV(NSTEP-3)-XPOLY(1)

0021 XVAL=XVAL-OFFSET

0022 C----- ARRAYS ARE NOW TO BE FIT

C

0023 C CALL POLATE(XPOLY,YPOLY,COEFF)

C----- EVALUATE POLY FOR 0.1,2 DERIVATIVES

C----- AT VALUE XVAL BASED ON IS4

C

0024 P=COEFF(6)

0025 DO 200 J=1,5

0026 I=5-J

0027 P=P+XVAL*COEFF(I+1)

0028 C CONTINUE

C

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```

FORTRAN IV G LEVEL 21      INTERP
0029      IF (ISV.LE.1) GO TO 9999
          C
0030      DO 300 J=1,5
0031      COEFF(J)=J*COEFF(J+1)
0032      CONTINUE
          C
0033      DP=COEFF(5)
0034      DO 400 J=1,4
0035      I=4-J
0036      DP=DP*XVAL*COEFF(I+1)
0037      CONTINUE
          C
0038      DO 500 J=1,4
0039      COEFF(J)=J*COEFF(J+1)
0040      CONTINUE
          C
0041      D2P=COEFF(4)
0042      DO 600 J=1,3
0043      I=3-J
0044      D2P=D2P*XVAL*COEFF(I+1)
0045      CONTINUE
          C
          C
0046      DYDX=DP
0047      D2YDX2=D2P
          C
0048      9999 CONTINUE
          C
0049      YINTER=P
          C
          C
0050      RETURN
0051      END

```

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POLATE

FORTRAN IV 6 LEVEL 21

```

0001 SUBROUTINE POLATE(XV,YV,COEFF)
C----- ABSTRACT: SUBROUTINE POLATE PERFORMS A
C----- POLYNOMIAL REGRESSION ON THE
C----- DATA POINTS IN VECTORS XV,YV AND
C----- RETURNS A COEFFICIENT VECTOR. THE
C----- DEGREE OF THE POLY WILL BE 5.
C
C
0002 DIMENSION XV(1),YV(1),COEFF(1)
0003 DIMENSION FIT(36),FITINV(36),DCOEFF(6),DYPOLY(6)
0004 DOUBLE PRECISION FIT,FITINV,DCOEFF,DYPOLY
C
C----- INITIALIZE FIT MATRIX FOR CURVE FITTING
C
DO 100 I=1,6
FIT(I)=1.
FIT(I,6)=XV(I)
FIT(I,12)=XV(I)**2
FIT(I,18)=XV(I)**3
FIT(I,24)=XV(I)**4
FIT(I,30)=XV(I)**5
DYPOLY(I)=YV(I)
100 CONTINUE
C
C----- ZERO THE INVERSE MATRIX THEN MAKE IT IDENTITY
C
DO 200 I=2,35
FITINV(I)=0.0
200 CONTINUE
C
FITINV(1)=1.
FITINV(8)=1.
FITINV(15)=1.
FITINV(22)=1.
FITINV(29)=1.
FITINV(36)=1.
C----- INVERT THE FIT MATRIX USING GELG
C
CALL DGELG(FITINV,FIT,6,6,1.E-07,ERR)
C----- DETERMINE THE POLY COEFFICIENTS
C
CALL DGMPRD(FITINV,DYPOLY,DCOEFF,6,6,1)
C----- TRANSPOSE DOUBLE PRECISION COEFF TO SINGLE
C
DO 300 I=1,6
COEFF(I)=DCOEFF(I)
300 CONTINUE
C
0025 DO 280 I=1,6
0026 COEFF(I)=DCOEFF(I)
0027
0028 RETURN
0029 END

```

0001 SUBROUTINE GMPRD(A,B,R,N,M,L)
 0002 PURPOSE
 0003 MULTIPLY TWO GENERAL MATRICES TO FORM A RESULTANT GENERAL
 0004 MATRIX

0005 USAGE
 0006 CALL GMPRD(A,B,R,N,M,L)

0007 DESCRIPTION OF PARAMETERS
 0008 A - NAME OF FIRST INPUT MATRIX
 0009 B - NAME OF SECOND INPUT MATRIX
 0010 R - NAME OF OUTPUT MATRIX
 0011 N - NUMBER OF ROWS IN A
 0012 M - NUMBER OF COLUMNS IN A AND ROWS IN B
 0013 L - NUMBER OF COLUMNS IN B

0014 REMARKS

0015 ALL MATRICES MUST BE STORED AS GENERAL MATRICES
 0016 MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX A
 0017 MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX B
 0018 NUMBER OF COLUMNS OF MATRIX A MUST BE EQUAL TO NUMBER OF ROW
 0019 OF MATRIX B

0020 SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
 0021 NONE

0022 METHOD

0023 THE M BY L MATRIX B IS PREMULTIPLIED BY THE N BY M MATRIX A
 0024 AND THE RESULT IS STORED IN THE N BY L MATRIX R.

0025
 0026 SUBROUTINE GMPRD(A,B,R,N,M,L)
 0027
 0028 IMPLICIT REAL*8 (A-H,O-Z)
 0029 DIMENSION A(1),B(1),R(1)
 0030
 0031 IR=0
 0032 IK=M
 0033 DO 10 K=1,L
 0034 IK=IK+M
 0035 DO 10 J=1,N
 0036 IR=IR+1
 0037 JI=J-N
 0038 IB=IK
 0039 R(IR)=0
 0040 DO 10 I=1,M
 0041 JI=JI+N
 0042 IB=IB+1
 0043 10 R(IR)=R(IR)+A(JI)*B(IB)
 0044 RETURN
 0045 END

```

C SUBROUTINE DGMPRD(A,B,R,N,M,L)
C
C PURPOSE
C MULTIPLY TWO GENERAL MATRICES TO FORM A RESULTANT GENERAL
C MATRIX
C
C USAGE
C CALL GMPRD(A,B,R,N,M,L)
C
C DESCRIPTION OF PARAMETERS
C A - NAME OF FIRST INPUT MATRIX
C B - NAME OF SECOND INPUT MATRIX
C R - NAME OF OUTPUT MATRIX
C N - NUMBER OF ROWS IN A
C M - NUMBER OF COLUMNS IN A AND ROWS IN B
C L - NUMBER OF COLUMNS IN B
C
C REMARKS
C ALL MATRICES MUST BE STORED AS GENERAL MATRICES
C MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX A
C MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX B
C NUMBER OF COLUMNS OF MATRIX A MUST BE EQUAL TO NUMBER OF ROW
C OF MATRIX B

```

```

SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
NONE
METHOD
THE M BY L MATRIX B IS PREMULTIPLIED BY THE N BY M MATRIX A
AND THE RESULT IS STORED IN THE N BY L MATRIX R.

```

```

0001 SUBROUTINE DGMPRD(A,B,R,N,M,L)
0002 IMPLICIT REAL*8 (A-H,O-Z)
0003 DIMENSION A(1),B(1),R(1)
0004 IR=0
0005 IK=-M
0006 DO 10 K=1,L
0007 IK=IK+M
0008 DO 20 J=1,N
0009 IR=IR+1
0010 JI=J-N
0011 IB=IK
0012 R(IR)=0.000
0013 DO 30 I=1,M
0014 JI=JI-N
0015 IB=IB+1
0016 R(IR)=R(IR)+A(JI)*B(IB)
0017 CONTINUE
0018 30 CONTINUE
0019 20 CONTINUE
0020 10 RETURN

```

SUBROUTINE DGELG(R,A,M,N,EPS,IER)
 PURPOSE
 TO SOLVE A GENERAL SYSTEM OF SIMULTANEOUS LINEAR EQUATIONS.

USAGE
 CALL DGELG(R,A,M,N,EPS,IER)

DESCRIPTION OF PARAMETERS
 R - DOUBLE PRECISION M BY N RIGHT HAND SIDE MATRIX
 (DESTROYED). ON RETURN R CONTAINS THE SOLUTIONS
 OF THE EQUATIONS.
 A - DOUBLE PRECISION M BY M COEFFICIENT MATRIX
 (DESTROYED).
 M - THE NUMBER OF EQUATIONS IN THE SYSTEM.
 N - THE NUMBER OF RIGHT HAND SIDE VECTORS.
 EPS - SINGLE PRECISION INPUT CONSTANT WHICH IS USED AS
 RELATIVE TOLERANCE FOR TEST ON LOSS OF
 SIGNIFICANCE.
 IER - RESULTING ERROR PARAMETER CODED AS FOLLOWS
 IER=0 - NO ERROR.
 IER=-1 - NO RESULT BECAUSE OF M LESS THAN 1 OR
 PIVOT ELEMENT AT ANY ELIMINATION STEP
 EQUAL TO 0.
 IER=K - WARNING DUE TO POSSIBLE LOSS OF SIGNIFI-
 CANCE INDICATED AT ELIMINATION STEP K+1,
 WHERE PIVOT ELEMENT WAS LESS THAN OR
 EQUAL TO THE INTERNAL TOLERANCE EPS TIMES
 ABSOLUTELY GREATEST ELEMENT OF MATRIX A.

REMARKS
 INPUT MATRICES R AND A ARE ASSUMED TO BE STORED COLUMNWISE
 IN M*N RESP. M*M SUCCESSIVE STORAGE LOCATIONS. ON RETURN
 SOLUTION MATRIX R IS STORED COLUMNWISE TOO.
 THE PROCEDURE GIVES RESULTS IF THE NUMBER OF EQUATIONS M IS
 GREATER THAN 0 AND PIVOT ELEMENTS AT ALL ELIMINATION STEPS
 ARE DIFFERENT FROM 0. HOWEVER WARNING IER=K - IF GIVEN -
 INDICATES POSSIBLE LOSS OF SIGNIFICANCE. IN CASE OF A WELL
 SCALED MATRIX A AND APPROPRIATE TOLERANCE EPS, IER=K MAY BE
 INTERPRETED THAT MATRIX A HAS THE RANK K. NO WARNING IS
 GIVEN IN CASE M=1.

SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
 NONE
 METHOD
 SOLUTION IS DONE BY MEANS OF GAUSS-ELIMINATION WITH
 COMPLETE PIVOTING.

SUBROUTINE DGELG(R,A,M,N,EPS,IER)

09/20/55

DATE = 77099

DGELG

FORTRAN IV G LEVEL 21

```

0002      C
0003      DIMENSION A(1),R(1)
0004      DOUBLE PRECISION R,A,PIV,TB,TOL,PIVI
          IF(1/23,23,1)
0005      C
0006      C
0007      SEARCH FOR GREATEST ELEMENT IN MATRIX A
0008      1 IER=0
0009      PIV=0.00
0010      MM=MM
0011      NM=NM
0012      DO 3 L=1,MM
0013      TB=DABS(A(L))
0014      IF(TB-PIV)3,3,2
0015      2 PIV=TB
          1=L
          3 CONTINUE
          TOL=EPS*PIV
          A(I) IS PIVOT ELEMENT. PIV CONTAINS THE ABSOLUTE VALUE OF A(I).
0016      C
0017      C
0018      START ELIMINATION LOOP
0019      LST=1
0020      DO 17 K=1,M
0021      C
0022      TEST ON SINGULARITY
0023      IF(PIV/23,23,4)
0024      4 IF(1/17,5,7)
0025      5 IF(PIV-TOL)6,6,7
0026      6 IER=K-1
0027      7 PIVI=1.00/A(I)
0028      J=(I-1)/M
0029      I=I-J*M-K
0030      J=J+1-K
          I*K IS ROW-INDEX, J*K COLUMN-INDEX OF PIVOT ELEMENT
0031      C
0032      C
0033      PIVOT ROW REDUCTION AND ROW INTERCHANGE IN RIGHT HAND SIDE R
0034      DO 8 L=K,N,M
0035      LL=L+1
0036      TB=PIVI*R(LL)
0037      R(LL)=R(LL)
0038      8 R(LL)=TB
0039      C
0040      C
0041      IS ELIMINATION TERMINATED
0042      IF(K=M)9,10,18
0043      C
0044      C
0045      COLUMN INTERCHANGE IN MATRIX A
0046      9 LEND=LST+M-K
0047      IF(J)12,12,10
0048      10 11=J*M
0049      DO 11 L=LST,LEND
0050      TB=A(L)
0051      LL=L+1
0052      A(LL)=A(LL)

```

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DGELG

FORTRAN IV G LEVEL 21

```

0039      11 A(LL)=TB
      C
      C      ROW INTERCHANGE AND PIVOT ROW REDUCTION IN MATRIX A
0040      12 DO 13 L=LST,MM,M
0041          LL=L+1
0042          TB=PIV(A(LL))
0043          A(LL)=A(L)
0044      13 A(L)=TB
      C
      C      SAVE COLUMN INTERCHANGE INFORMATION
      C      A(LST)=J
      C
      C      ELEMENT REDUCTION AND NEXT PIVOT SEARCH
      C      PIV=0.00
      C      LST=LST+1
      C      J=0
0046      DO 16 I=LST,LEND
0047          PIV=A(I)
0048          PIV=A(I)
0049          PIV=A(I)
0050          PIV=A(I)
0051          PIV=A(I)
0052          J=J+1
0053      DO 15 L=IST,MM,M
0054          LL=L-J
0055          A(L)=A(L)+PIV*A(LL)
0056          TB=OABS(A(L))
0057          IF(TB=PIV) 15,15,14
0058      14 PIV=TB
0059      I=L
0060      DO 16 L=K,NN,M
0061          LL=L+J
0062          R(LL)=R(LL)+PIV*R(L)
0063      17 LST=LST+M
0064      END OF ELIMINATION LOOP
      C
      C
      C      BACK SUBSTITUTION AND BACK INTERCHANGE
0065      18 IF(M=1) 23,22,19
0066      19 IST=K+M
0067          LST=M+1
0068          DO 21 I=2,M
0069              I=LST-I
0070              IST=IST-LST
0071              L=IST-M
0072              L=A(L)*.500
0073              DO 21 J=I,NN,M
0074                  TB=R(J)
0075                  LL=J
0076              DO 20 K=IST,MM,M
0077                  LL=LL+1
0078              TB=TB-A(K)*R(LL)
0079              K=J+L
0080              R(J)=R(K)
0081      21 R(K)=TB

```

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DGELG

FORTRAN IV G LEVEL 21

0082 22 RETURN

C

C

ERROR RETURN

23 IER=-1

RETURN

END

0083

0084

0085

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FORTAN IV G LEVEL 21

PLOTNG

SUBROUTINE PLOTNG(JMAX)

0001

C

```

0002      DIMENSION IBUF(1000)
0003      COMMON/VECTOR/TH2(2001),TH3(2001),TH3F(2001),TH4(2001),
          1      TH5(2001),TH6(2001),DISPL7(2001)

```

C

```

0004      CALL PLOTS(IBUF,1000,14)
0005      CALL FACTOR(1,0)
0006      CALL PLOT(15,0,-36,0,-3)
0007      CALL PLOT(2,0,2,5,-3)
0008      CALL SCALE(TH2,10,JMAX,1)
0009      CALL SCALE( TH3,8,0,JMAX,1)
0010      CALL SCALE( TH4,8,0,JMAX,1)
0011      CALL SCALE( TH5,8,0,JMAX,1)
0012      CALL SCALE( TH6,8,0,JMAX,1)
0013      CALL SCALE( DISPL7,8,0,JMAX,1)

```

C

```

0014      IF JMAX=1
0015      ID=IF+1

```

C

```

0016      CALL AXIS(0,0,0,0,27,MOTOR INPUT ANGLE (DEGREES),-27,10,0,0,0,
          1      TH2(IF),TH2(ID))
0017      CALL AXIS( 0,0,0,0,24,HORUM CAM ANGLE (DEGREES),+24,
          1      8,90,TH3(IF),TH3(ID))
          CALL NEWPEN(2)
0018      CALL LINE(TH2,TH3,JMAX,1,0,0)
0019      CALL NEWPEN(1)
0020      CALL PLOT(15,0,0,0,-3)
0021

```

C

```

0022      CALL AXIS(0,0,0,0,27,MOTOR INPUT ANGLE (DEGREES),-27,10,0,0,0,
          1      TH2(IF),TH2(ID))
0023      CALL AXIS( 0,0,0,0,24,HFEED CAM ANGLE (DEGREES),+24,
          1      8,90,TH4(IF),TH4(ID))
          CALL NEWPEN(2)
0024      CALL LINE(TH2,TH4,JMAX,1,0,1)
0025      CALL NEWPEN(1)
0026      CALL PLOT(15,0,0,0,-3)
0027

```

C

```

0028      CALL AXIS(0,0,0,0,27,MOTOR INPUT ANGLE (DEGREES),-27,10,0,0,0,
          1      TH2(IF),TH2(ID))
0029      CALL AXIS( 0,0,0,0,25,SHEJECT CAM ANGLE (DEGREES),+25,
          1      8,90,TH5(IF),TH5(ID))
          CALL NEWPEN(2)
0030      CALL LINE(TH2,TH5,JMAX,1,0,5)
0031      CALL NEWPEN(1)
0032      CALL PLOT(15,0,0,0,-3)
0033

```

C

```

0034      CALL AXIS(0,0,0,0,27,MOTOR INPUT ANGLE (DEGREES),-27,10,0,0,0,
          1      TH2(IF),TH2(ID))
0035      CALL AXIS( 0,0,0,0,24,HLOCK CAM ANGLE (DEGREES),+24,
          1      8,90,TH6(IF),TH6(ID))
          CALL NEWPEN(2)
0036

```

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PLOTNG

FORTPAN IV G LEVEL 21

```

0037 CALL LINE (TH2, TH6, JMAX, 1.0, 10)
0038 CALL NEWPEN(1)
0039 CALL PLOT (15.0, 0.0, -3)

C
0040 CALL AXIS (0.0, 0.0, 0.27, H MOTOR INPUT ANGLE (DEGREES), -27, 10.0, 0.0,
0041 TH2 (IF), TH2 (ID))
0042 CALL AXIS (0.0, 0.0, 0.29, H CHAMBER DISPLACEMENT (INCHES), -29,
0043 8.90, -DISPL7 (IF), -DISPL7 (ID))
0044 CALL NEWPEN(2)
0045 CALL LINE (TH2, DISPL7, JMAX, 1.0, 11)
0046 CALL NEWPEN(1)
0047 CALL PLOT (20.0, 0.0, -3)

C
0048 CALL AXIS (0.0, 0.0, 0.27, H MOTOR INPUT ANGLE (DEGREES), -27, 10.0, 0.0,
0049 TH2 (IF), TH2 (ID))
0050 CALL AXIS (0.0, 0.0, 0.24, H ORUM CAM ANGLE (DEGREES), -24,
0051 8.90, -TH3 (IF), -TH3 (ID))
0052 CALL AXIS (-0.5, 0.0, 0.24, H FEED CAM ANGLE (DEGREES), -24,
0053 8.90, -TH4 (IF), -TH4 (ID))
0054 CALL AXIS (-1.0, 0.0, 0.25, H EJECT CAM ANGLE (DEGREES), -25,
0055 8.90, -TH5 (IF), -TH5 (ID))
0056 CALL AXIS (-1.5, 0.0, 0.24, H LOCK CAM ANGLE (DEGREES), -24,
0057 8.90, -TH6 (IF), -TH6 (ID))
0058 CALL AXIS (-2.0, 0.0, 0.29, H CHAMBER DISPLACEMENT (INCHES), -29,
0059 8.90, -DISPL7 (IF), -DISPL7 (ID))
0060 CALL NEWPEN(2)
0061 CALL LINE (TH2, TH6, JMAX, 1.0, 10)
0062 CALL LINE (TH2, TH5, JMAX, 1.0, 5)
0063 CALL LINE (TH2, TH4, JMAX, 1.0, 1)
0064 CALL LINE (TH2, TH3, JMAX, 1.0, 0)
0065 BASEX = -32
0066 BASEY = 1.5
0067 BASEY = BASEY + 0.25
0068 CALL SYMBOL (BASEX, BASEY, 140.0, 90.0, -1)
0069 CALL SYMBOL (BASEX, BASEY, 140.0, 90.0, -2)
0070 CALL SYMBOL (BASEX, -5, BASEY, 140.0, 90.0, -1)
0071 CALL SYM 10L (BASEX, -5, BASEY, 140.0, 90.0, -2)
0072 CALL SYMBOL (BASEX, -1.0, BASEY, 140.0, 90.0, -1)
0073 CALL SYMBOL (BASEX, -1.0, BASEY, 140.0, 90.0, -2)
0074 CALL SYMBOL (BASEX, -1.5, BASEY, 140.0, 90.0, -1)
0075 CALL SYMBOL (BASEX, -1.5, BASEY, 140.0, 90.0, -2)
0076 CALL SYMBOL (BASEX, -2.0, BASEY, 140.0, 90.0, -1)
0077 CALL SYMBOL (BASEX, -2.0, BASEY, 140.0, 90.0, -2)

C
0078 CALL PLOT (20.0, 0.0, 999)
0079 RETURN
0080 END

```

3	THZ THA	TH3 TH5	TH3F TH6	DISC 7
1	0.0	0.0	270.0000	0.0
1	139.5305	234.5235	14.3942	
2	19.1942	1.0000	271.0000	0.0
2	139.5305	234.5235	14.6095	
3	38.3898	2.0000	272.0000	0.0
3	139.5305	234.5235	14.7360	
4	57.5847	3.0000	273.0000	0.0
4	139.5305	234.5235	14.7900	
5	76.7796	4.0000	274.0000	0.0
5	139.5305	234.5235	14.3010	
6	95.9745	5.0000	274.9998	0.0
6	139.5305	234.5235	14.7982	
7	115.1694	6.0000	275.9998	0.0
7	139.5305	234.5235	14.7982	
8	134.3643	7.0000	276.9998	0.0
8	139.5305	234.5235	14.7982	
9	153.5592	8.0000	277.9998	0.0
9	139.5305	234.5235	14.7982	
10	172.7541	9.0000	278.9998	0.0
10	139.5305	234.5235	14.7982	
11	191.9490	10.0000	279.9998	0.0
11	139.5305	234.5235	14.7982	
12	211.1439	11.0000	280.9998	0.0
12	139.5305	234.5235	14.7982	
13	230.3388	12.0000	281.9998	0.0
13	139.5305	234.5235	14.7982	
14	249.5337	13.0000	282.9998	0.0
14	139.5305	234.5235	14.7982	
15	268.7285	13.9999	283.9998	0.0
15	139.5305	234.5235	14.7982	
16	287.9233	14.9999	284.9998	0.0
16	139.5305	234.5235	14.7982	
17	307.1182	15.9999	285.9998	0.0
17	139.5305	234.5235	14.7982	
18	326.3130	16.9999	286.9998	0.0
18	139.5305	234.5235	14.7982	
19	345.5078	17.9999	287.9998	0.0
19	139.5305	234.5235	14.7982	
20	364.7026	18.9999	288.9998	0.0
20	139.5305	234.5235	14.7982	

21	383.8975	19.9999	289.9998	0.0
21	139.5305	234.5235	14.7982	
22	403.0923	20.9999	290.9998	0.0
22	139.5305	234.5235	14.7982	
23	422.2871	21.9999	291.9998	0.0
23	139.5305	234.5235	14.7982	
24	441.4819	22.9999	292.9998	0.0
24	139.5305	234.5235	14.7982	
25	460.6768	23.9999	293.9998	0.0
25	139.5305	234.5235	14.7982	
26	479.8716	24.9999	294.9998	0.0
26	139.5305	234.5235	14.7982	
27	499.0664	25.9998	295.9998	0.0
27	139.5305	234.5235	14.7982	
28	518.2612	26.9998	296.9998	0.0
28	139.5305	234.5235	14.7982	
29	537.4561	27.9998	297.9998	0.0
29	139.5305	234.5235	14.7982	
30	556.6509	28.9998	298.9998	0.0
30	139.5305	234.5235	14.7982	
31	575.8457	29.9998	299.9998	0.0
31	139.5305	234.5235	14.7982	
32	595.0405	30.9998	300.9998	0.0
32	139.5305	234.5235	14.5286	
33	614.2354	31.9998	301.9998	0.0
33	139.5305	234.5235	14.1811	
34	633.4302	32.9998	302.9998	0.0
34	139.5305	234.5235	13.6326	
35	652.6250	33.9998	303.9998	0.0
35	139.5305	234.5235	13.0261	
36	671.8198	34.9998	304.9998	0.0
36	139.5305	234.5235	12.2045	
37	691.0146	35.9998	305.9998	0.0
37	139.5305	234.5235	11.2110	
38	710.2095	36.9998	306.9998	0.0
38	139.5305	234.5235	10.1291	
39	729.4043	37.9998	307.9998	0.0
39	139.5305	234.5235	9.4172	
40	748.5991	38.9998	308.9998	0.0
40	139.5305	234.5235	8.5517	

41	767.7939	39.9998	309.9998	0.0
41	139.5305	234.5235	7.3831	
42	786.9888	40.9997	310.9995	0.0
42	139.5305	234.5235	5.8300	
43	806.1836	41.9997	311.9995	0.0
43	139.5305	234.5235	4.7895	
44	825.3784	42.9997	312.9995	0.0
44	139.5305	234.5235	4.2506	
45	844.5732	43.9997	313.9995	0.0
45	139.5305	234.5235	3.5876	
46	863.7681	44.9997	314.9995	0.0
46	139.5305	234.5235	2.7729	
47	882.9629	45.9997	315.9995	0.0
47	139.5305	234.5235	1.8850	
48	902.1577	46.9997	316.9995	0.0
48	139.5305	234.5235	1.3454	
49	921.3525	47.9997	317.9995	0.0
49	139.5305	234.5235	1.1152	
50	940.5474	48.9997	318.9995	0.0
50	139.5305	234.5235	0.8032	
51	959.7422	49.9997	319.9995	0.0
51	139.5305	234.5235	0.5298	
52	978.9370	50.9997	320.9995	0.0
52	139.5305	234.5235	0.3267	
53	998.1318	51.9997	321.9995	0.0000
53	139.5305	234.5235	0.1834	
54	1017.3267	52.9996	322.9995	-0.0000
54	139.5305	234.5235	0.0896	
55	1036.5215	53.9996	323.9995	0.0001
55	139.5305	234.5235	0.0347	
56	1055.7163	54.9996	324.9995	0.0004
56	139.5305	234.5235	0.0085	
57	1074.9111	55.9996	325.9995	0.0010
57	139.5305	234.5235	0.0004	
58	1094.1060	56.9996	326.9995	0.0020
58	139.5305	234.5235	-0.0000	
59	1113.3008	57.9996	327.9995	0.0035
59	139.5305	234.5235	-0.0000	
60	1132.4956	58.9996	328.9995	0.0056
60	139.5305	234.5235	-0.0000	

61	1151.6904	59.9996	329.9995	0.0083
61	139.5305	234.5235	0.0	
62	1170.8853	60.9996	330.9995	0.0119
62	139.5305	234.5235	0.0	
63	1190.7801	61.9996	331.9995	0.0162
63	139.5305	234.5235	0.0	
64	1209.2749	62.9996	332.9995	0.0216
64	139.5305	234.5235	0.0	
65	1228.4697	63.9996	333.9995	0.0280
65	139.5305	234.5235	0.0	
66	1247.6646	64.9996	334.9995	0.0355
66	139.5305	234.5235	0.0	
67	1266.8594	65.9996	335.9995	0.0442
67	139.5305	234.5235	0.0	
68	1286.0542	66.9996	336.9995	0.0542
68	139.5305	234.5235	0.0	
69	1305.2490	67.9995	337.9995	0.0656
69	139.5305	234.5235	0.0	
70	1324.4438	68.9995	338.9995	0.0784
70	139.5305	234.5235	0.0	
71	1343.6387	69.9995	339.9995	0.0928
71	139.5305	234.5235	0.0	
72	1362.8335	70.9995	340.9995	0.1088
72	139.5305	234.5235	0.0	
73	1382.0283	71.9995	341.9995	0.1264
73	139.5305	234.5235	0.0	
74	1401.2231	72.9995	342.9995	0.1457
74	139.5305	234.5235	0.0	
75	1420.4180	73.9995	343.9993	0.1669
75	139.5305	234.5235	0.0	
76	1439.6128	74.9995	344.9993	0.1899
76	139.5305	234.5235	0.0	
77	1458.8076	75.9995	345.9993	0.2148
77	139.5305	234.5235	0.0	
78	1478.0024	76.9995	346.9993	0.2417
78	139.5305	234.5235	0.0	
79	1497.1973	77.9995	347.9993	0.2705
79	139.5305	234.5235	0.0	
80	1516.3921	78.9995	348.9993	0.3015
80	139.5305	234.5235	0.0	

81	1535.5869	79.9995	349.9993	0.3345
81	139.5305	234.5235	0.0	
82	1554.7817	80.9995	350.9993	0.3696
82	139.5305	234.5235	0.0	
83	1573.9766	81.9995	351.9993	0.4069
83	139.5305	234.5235	0.0	
84	1593.1714	82.9994	352.9993	0.4464
84	139.5305	234.5235	0.0	
85	1612.3662	83.9994	353.9993	0.4881
85	139.5305	234.5235	0.0	
86	1631.5610	84.9994	354.9993	0.5321
86	139.5305	234.5235	0.0	
87	1650.7559	85.9994	355.9993	0.5682
87	139.5305	234.5235	0.0	
88	1669.9507	86.9994	356.9993	0.6367
88	139.5305	234.5235	0.0	
89	1689.1455	87.9994	357.9993	0.6774
89	139.5305	234.5235	0.0	
90	1708.3403	88.9994	358.9993	0.7304
90	139.5305	234.5235	0.0	
91	1727.5352	89.9994	359.9993	0.7856
91	139.5305	234.5235	0.0	
92	1746.7300	90.9994	360.9993	0.8431
92	139.5305	234.5235	0.0	
93	1765.9248	91.9994	361.9993	0.9029
93	139.5305	234.5235	0.0	
94	1785.1196	92.9994	362.9993	0.9649
94	139.5305	234.5235	0.0	
95	1804.3145	93.9994	363.9993	1.0292
95	139.5305	234.5235	0.0	
96	1823.5093	94.9993	364.9993	1.0956
96	139.5305	234.5235	0.0	
97	1842.7041	95.9993	365.9993	1.1642
97	139.5305	234.5235	0.0	
98	1861.8989	96.9993	366.9993	1.2350
98	139.5305	234.5235	0.0	
99	1881.0937	97.9993	367.9993	1.3077
99	139.5305	234.5235	0.0	
100	1900.2886	98.9993	368.9993	1.3827
100	139.5305	234.5235	0.0	

101	1919.4834	99.9993	9.9993	1.4596
101	139.5305	234.5235	0.0	
102	1938.6782	100.9993	10.9993	1.5386
102	139.5305	234.5235	0.0	
103	1957.8730	101.9993	11.9993	1.6194
103	139.5305	234.5235	0.0	
104	1977.0679	102.9993	12.9993	1.7022
104	139.5305	234.5235	0.0	
105	1996.2627	103.9993	13.9993	1.7868
105	139.5305	234.5235	0.0	
106	2015.4575	104.9993	14.9993	1.8731
106	139.5305	234.5235	0.0	
107	2034.6523	105.9993	15.9993	1.9612
107	139.5305	234.5235	0.0	
108	2053.8472	106.9993	16.9993	2.0508
108	139.5305	234.5235	0.0	
109	2073.0420	107.9993	17.9990	2.1421
109	139.5305	234.5235	0.0	
110	2092.2368	108.9993	18.9990	2.2348
110	139.5305	234.5235	0.0	
111	2111.4316	109.9992	19.9990	2.3289
111	139.5305	234.5235	0.0	
112	2130.6265	110.9992	20.9990	2.4244
112	139.5305	234.5235	0.0	
113	2149.8213	111.9992	21.9990	2.5211
113	139.5305	234.5235	0.0	
114	2169.0161	112.9992	22.9990	2.6190
114	139.5305	234.5235	0.0	
115	2188.2109	113.9992	23.9990	2.7180
115	139.5305	234.5235	0.0	
116	2207.4058	114.9992	24.9990	2.8180
116	139.5305	234.5235	0.0	
117	2226.6006	115.9992	25.9990	2.9189
117	139.5305	234.5235	0.0	
118	2245.7954	116.9992	26.9990	3.0206
118	139.5305	234.5235	0.0	
119	2264.9902	117.9992	27.9990	3.1230
119	139.5305	234.5235	0.0	
120	2284.1851	118.9992	28.9990	3.2261
120	139.5305	234.5235	0.0	

121	2303.3799	119.9992	29.9990	3.3297
121	139.5305	234.5235	0.0	
122	2322.5747	120.9992	30.9990	3.4337
122	139.5305	234.5235	0.0	
123	2341.7695	121.9991	31.9990	3.5381
123	139.5305	234.5235	0.0	
124	2360.9644	122.9991	32.9990	3.6427
124	139.5305	234.5235	0.0	
125	2380.1592	123.9991	33.9990	3.7475
125	139.5305	234.5235	0.0	
126	2399.3540	124.9991	34.9990	3.8523
126	139.5305	234.5235	0.0	
127	2418.5488	125.9991	35.9990	3.9571
127	139.5305	234.5235	0.0	
128	2437.7437	126.9991	36.9990	4.0617
128	139.5305	234.5235	0.0	
129	2456.9385	127.9991	37.9990	4.1661
129	139.5305	234.5235	0.0	
130	2476.1333	128.9991	38.9990	4.2701
130	139.5305	234.5235	0.0	
131	2495.3281	129.9991	39.9990	4.3737
131	139.5305	234.5235	0.0	
132	2514.5229	130.9991	40.9990	4.4768
132	139.5305	234.5235	0.0	
133	2533.7178	131.9991	41.9990	4.5792
133	139.5305	234.5235	0.0	
134	2552.9126	132.9991	42.9990	4.6809
134	139.5305	234.5235	0.0	
135	2572.1074	133.9991	43.9990	4.7818
135	139.5305	234.5235	0.0	
136	2591.3022	134.9991	44.9990	4.8818
136	139.5305	234.5235	0.0	
137	2610.4971	135.9991	45.9990	4.9808
137	139.5305	234.5235	0.0	
138	2629.6919	136.9990	46.9990	5.0787
138	139.5305	234.5235	0.0	
139	2648.8867	137.9990	47.9990	5.1754
139	139.5305	234.5235	0.0	
140	2668.0815	138.9990	48.9990	5.2709
140	139.5305	234.5235	0.0	

141	2687.2764	139.9990	49.9990	5.3650
141	139.5305	234.5235	0.0	
142	2706.4712	140.9990	50.9988	5.4577
142	139.5305	234.5235	0.0	
143	2725.6660	141.9990	51.9988	5.5490
143	139.5305	234.5235	0.0	
144	2744.8608	142.9990	52.9988	5.6386
144	139.5305	234.5235	0.0	
145	2764.0557	143.9990	53.9988	5.7267
145	139.5305	234.5235	0.0	
146	2783.2505	144.9990	54.9988	5.8130
146	139.5305	234.5235	0.0	
147	2802.4453	145.9990	55.9988	5.8976
147	139.5305	234.5235	0.0	
148	2821.6401	146.9990	56.9988	5.9804
148	139.5305	234.5235	0.0	
149	2840.8350	147.9990	57.9988	6.0612
149	139.5305	234.5235	0.0	
150	2860.0298	148.9989	58.9988	6.1402
150	139.5305	234.5235	0.0	
151	2879.2246	149.9989	59.9988	6.2172
151	139.5305	234.5235	0.0	
152	2898.4194	150.9989	60.9988	6.2921
152	139.5305	234.5235	0.0	
153	2917.6143	151.9989	61.9988	6.3649
153	139.5305	234.5235	0.0	
154	2936.8091	152.9989	62.9988	6.4357
154	139.5305	234.5235	0.0	
155	2956.0039	153.9989	63.9988	6.5043
155	139.5305	234.5235	0.0	
156	2975.1987	154.9989	64.9988	6.5707
156	139.5305	234.5235	0.0	
157	2994.3936	155.9989	65.9988	6.6350
157	139.5305	234.5235	0.0	
158	3013.5884	156.9989	66.9988	6.6970
158	139.5305	234.5235	0.0	
159	3032.7832	157.9989	67.9988	6.7568
159	139.5305	234.5235	0.0	
160	3051.9780	158.9989	68.9988	6.8143
160	139.5305	234.5235	0.0	

161	3071.1729	159.9989	69.9988	6.8695
161	139.5305	234.5235	0.0	
162	3090.3677	160.9989	70.9988	6.9225
162	139.5305	234.5235	0.0	
163	3109.5625	161.9989	71.9988	6.9732
163	139.5305	234.5235	0.0	
164	3128.7573	162.9989	72.9988	7.0217
164	139.5305	234.5235	0.0	
165	3147.9521	163.9988	73.9988	7.0678
165	139.5305	234.5235	0.0	
166	3167.1470	164.9988	74.9988	7.1118
166	139.5305	234.5235	0.0	
167	3186.3418	165.9988	75.9988	7.1536
167	139.5305	234.5235	0.0	
168	3205.5366	166.9988	76.9988	7.1931
168	139.5305	234.5235	0.0	
169	3224.7314	167.9988	77.9988	7.2304
169	139.5305	234.5235	0.0	
170	3243.9263	168.9988	78.9988	7.2655
170	139.5305	234.5235	0.0	
171	3263.1211	169.9988	79.9988	7.2935
171	139.5305	234.5235	0.0	
172	3282.3159	170.9988	80.9988	7.3294
172	139.5305	234.5235	0.0	
173	3301.5107	171.9988	81.9988	7.3583
173	139.5305	234.5235	0.0	
174	3320.7056	172.9988	82.9988	7.3852
174	139.5305	234.5235	0.0	
175	3339.9004	173.9988	83.9985	7.4101
175	139.5305	234.5235	0.0	
176	3359.0952	174.9988	84.9985	7.4331
176	139.5305	234.5235	0.0	
177	3378.2900	175.9988	85.9985	7.4542
177	139.5305	234.5235	0.0	
178	3397.4849	176.9987	86.9985	7.4735
178	139.5305	234.5235	0.0	
179	3416.6797	177.9987	87.9985	7.4912
179	139.5305	234.5235	0.0	
180	3435.8745	178.9987	88.9985	7.5072
180	139.5305	234.5235	0.0	

181	3455.0693	179.9987	89.9985	7.5216
181	139.5305	234.5235	0.0	
182	3474.2642	180.9987	90.9985	7.5344
182	139.5305	234.5235	0.0	
183	3493.4590	181.9987	91.9985	7.5458
183	139.5305	234.5235	0.0	
184	3512.6538	182.9987	92.9985	7.5558
184	139.5305	234.5235	0.0	
185	3531.8486	183.9987	93.9985	7.5645
185	139.5305	234.5235	0.0	
186	3551.0435	184.9987	94.9985	7.5720
186	139.5305	234.5235	0.0	
187	3570.2383	185.9987	95.9985	7.5784
187	139.5305	234.5235	0.0	
188	3589.4331	186.9987	96.9985	7.5837
188	139.5305	234.5235	0.0	
189	3608.6279	187.9987	97.9985	7.5881
189	139.5305	234.5235	0.0	
190	3627.8228	188.9987	98.9985	7.5916
190	139.5305	234.5235	0.0	
191	3647.0176	189.9987	99.9985	7.5944
191	139.5305	234.5235	0.0	
192	3666.2124	190.9986	100.9985	7.5964
192	139.5305	234.5235	0.0	
193	3685.4072	191.9986	101.9985	7.5979
193	139.5305	234.5235	0.0	
194	3704.6021	192.9985	102.9985	7.5989
194	139.5305	234.5235	0.0	
195	3723.7969	193.9986	103.9985	7.5995
195	139.5305	234.5235	0.0	
196	3742.9917	194.9985	104.9985	7.5998
196	139.5305	234.5235	0.0	
197	3762.1865	195.9986	105.9985	7.6000
197	139.5305	234.5235	0.0	
198	3781.3813	196.9986	106.9985	7.6000
198	139.5305	234.5235	0.0	
199	3800.5762	197.9986	107.9985	7.6000
199	139.5305	234.5235	0.0	
200	3819.7710	198.9986	108.9985	7.6000
200	139.5305	234.5235	0.0	

201	3838.9658	199.9986	109.9985	7.6000
201	139.5305	234.5250	0.0	
202	3858.1606	200.9986	110.9985	7.6000
202	139.5305	234.5568	0.0	
203	3877.3555	201.9986	111.9985	7.6000
203	139.5305	234.5961	0.0	
204	3896.5503	202.9986	112.9985	7.6000
204	139.5305	234.5902	0.0	
205	3915.7451	203.9986	113.9985	7.5999
205	139.5305	234.4985	0.0	
206	3934.9399	204.9986	114.9985	7.5996
206	139.5305	234.2677	0.0	
207	3954.1348	205.9985	115.9985	7.5950
207	139.5305	233.8559	0.0	
208	3973.3296	206.9985	116.9985	7.5980
208	139.5028	233.2100	0.0	
209	3992.5244	207.9985	117.9983	7.5965
209	139.5316	232.4967	0.0	
210	4011.7192	208.9985	118.9983	7.5944
210	139.5232	231.3046	0.0	
211	4030.9141	209.9985	119.9983	7.5917
211	139.5116	230.3269	0.0	
212	4050.1089	210.9985	120.9983	7.5881
212	139.4915	229.3552	0.0	
213	4069.3037	211.9985	121.9983	7.5838
213	139.4573	228.3960	0.0	
214	4088.4985	212.9985	122.9983	7.5784
214	139.4059	227.4440	0.0	
215	4107.6914	213.9984	123.9983	7.5720
215	139.3391	226.4972	0.0	
216	4126.8828	214.9982	124.9980	7.5645
216	139.2863	225.5599	0.0	
217	4146.0742	215.9980	125.9978	7.5558
217	139.1228	224.6259	0.0	
218	4165.2656	216.9978	126.9978	7.5458
218	138.9798	223.6995	0.0	
219	4184.4570	217.9976	127.9976	7.5344
219	138.8020	222.7788	0.0	
220	4203.6484	218.9975	128.9973	7.5216
220	138.5919	221.8588	0.0	

221	4222.8398	219.9973	129.9971	7.5072
221	138.3427	220.9470	0.0	
222	4242.0312	220.9971	130.9971	7.4912
222	138.0497	220.0384	0.0	
223	4261.2227	221.9969	131.9968	7.4737
223	137.7166	219.1297	0.0	
224	4280.4141	222.9967	132.9966	7.4544
224	137.3385	218.2278	0.0	
225	4299.6055	223.9965	133.9963	7.4332
225	136.9101	217.3279	0.0	
226	4318.7969	224.9963	134.9963	7.4102
226	136.4313	216.4275	0.0	
227	4337.9883	225.9962	135.9961	7.3853
227	135.8969	215.5325	0.0	
228	4357.1797	226.9960	136.9958	7.3584
228	135.3101	214.6384	0.0	
229	4376.3711	227.9958	137.9956	7.3296
229	134.6627	213.7442	0.0	
230	4395.5625	228.9956	138.9954	7.2986
230	133.9579	212.8537	0.0	
231	4414.7539	229.9954	139.9954	7.2657
231	133.1897	211.9629	0.0	
232	4433.9453	230.9952	140.9951	7.2306
232	132.3665	211.0723	0.0	
233	4453.1367	231.9950	141.9949	7.1933
233	131.4797	210.1842	0.0	
234	4472.3281	232.9949	142.9946	7.1538
234	130.5319	209.2955	0.0	
235	4491.5195	233.9947	143.9946	7.1121
235	129.5215	208.4057	0.0	
236	4510.7109	234.9945	144.9944	7.0681
236	128.4409	207.5182	0.0	
237	4529.9023	235.9943	145.9941	7.0321
237	127.3330	206.6296	0.0	
238	4549.0937	236.9941	146.9939	6.9637
238	126.1563	205.7392	0.0	
239	4568.2852	237.9939	147.9939	6.9228
239	124.9257	204.8502	0.0	
240	4587.4766	238.9937	148.9937	6.8700
240	123.6446	203.9603	0.0	

241	4606.6680	239.9936	149.9934	6.8148
241	122.3155	203.0680	0.0	
242	4625.8594	240.9934	150.9932	6.7573
242	120.9423	202.1837	0.0	
243	4645.0508	241.9932	151.9932	6.6975
243	119.5255	201.4463	0.0	
244	4664.2422	242.9930	152.9929	6.6355
244	118.0711	200.8886	0.0	
245	4683.4336	243.9928	153.9927	6.5713
245	116.5822	200.4997	0.0	
246	4702.6250	244.9926	154.9924	6.5049
246	115.0579	200.2543	0.0	
247	4721.8164	245.9924	155.9924	6.4363
247	113.5061	200.1377	0.0	
248	4741.0078	246.9923	156.9922	6.3656
248	111.9236	200.1033	0.0	
249	4760.1982	247.9921	157.9919	6.2928
249	110.3203	200.1064	0.0	
250	4779.3906	248.9919	158.9917	6.2178
250	108.6890	200.1064	0.0	
251	4798.5820	249.9917	159.9917	6.1409
251	107.0389	200.1064	0.0	
252	4817.7734	250.9915	160.9915	6.0620
252	105.3699	200.1064	0.0	
253	4836.9648	251.9913	161.9912	5.9812
253	103.6813	200.1064	0.0	
254	4856.1562	252.9911	162.9910	5.8984
254	101.9794	200.1064	0.0	
255	4875.3477	253.9910	163.9910	5.8139
255	100.2570	200.1064	0.0	
256	4894.5391	254.9908	164.9907	5.7276
256	98.5234	200.1064	0.0	
257	4913.7305	255.9906	165.9905	5.6395
257	96.7759	200.1064	0.0	
258	4932.9219	256.9902	166.9902	5.5500
258	95.0133	200.1064	0.0	
259	4952.1133	257.9900	167.9900	5.4587
259	93.2414	200.1064	0.0	
260	4971.3047	258.9900	168.9900	5.3660
260	91.4528	200.1063	0.0	

261	4990.4961	259.9897	169.9897	5.2720
261	89.6535	200.1284	0.0	
262	5009.6875	260.9895	170.9895	5.1765
262	87.8446	200.2124	0.0	
263	5028.8789	261.9893	171.9893	5.0798
263	86.0213	200.3982	0.0	
264	5048.0703	262.9893	172.9893	4.9820
264	84.1819	200.7399	0.0	
265	5067.2617	263.9890	173.9890	4.8830
265	82.3352	201.3044	0.0	
266	5086.4531	264.9888	174.9888	4.7830
266	80.4689	202.0998	0.0	
267	5105.6445	265.9885	175.9885	4.6822
267	78.5987	202.9447	0.0	
268	5124.8359	266.9885	176.9885	4.5805
268	76.6982	203.7921	0.0	
269	5144.0273	267.9883	177.9883	4.4781
269	74.8002	204.6341	0.0	
270	5163.2187	268.9880	178.9880	4.3750
270	72.8669	205.4664	0.0	
271	5182.4102	269.9878	179.9878	4.2715
271	71.0146	206.2906	0.0	
272	5201.6016	270.9878	180.9878	4.1675
272	69.3373	207.1070	0.0	
273	5220.7930	271.9875	181.9875	4.0631
273	67.8501	207.9187	0.0	
274	5239.9844	272.9873	182.9873	3.9585
274	66.5800	208.5444	0.0	
275	5259.1758	273.9871	183.9871	3.8538
275	65.5714	209.4997	0.0	
276	5278.3672	274.9871	184.9871	3.7490
276	64.8955	210.3047	0.0	
277	5297.5586	275.9868	185.9868	3.6442
277	64.6406	211.0939	0.0	
278	5316.7500	276.9866	186.9866	3.5396
278	64.6398	211.7946	0.0	
279	5335.9414	277.9863	187.9863	3.4352
279	64.6398	212.2542	0.0	
280	5355.1328	278.9863	188.9863	3.3312
280	64.6398	212.5116	0.0	

281	5374.3242	279.9861	189.9861	3.2276
281	64.6398	212.6365	0.0	
282	5393.5156	280.9858	190.9858	3.1246
282	64.6398	212.6724	0.0	
283	5412.7070	281.9856	191.9856	3.0222
283	64.6398	212.6655	0.0	
284	5431.8984	282.9854	192.9854	2.9205
284	64.6398	212.6483	0.0	
285	5451.0898	283.9854	193.9854	2.8196
285	64.6398	212.6467	0.0	
286	5470.2812	284.9851	194.9851	2.7196
286	64.6398	212.6466	0.0	
287	5489.4727	285.9849	195.9849	2.6206
287	64.6398	212.6466	0.0	
288	5508.6641	286.9846	196.9846	2.5227
288	64.6398	212.6466	0.0	
289	5527.8555	287.9846	197.9846	2.4260
289	64.6398	212.6466	0.0	
290	5547.0469	288.9844	198.9844	2.3305
290	64.6398	212.6466	0.0	
291	5566.2383	289.9841	199.9841	2.2364
291	64.6398	212.6466	0.0	
292	5585.4297	290.9839	200.9839	2.1437
292	64.6402	212.6466	0.0	
293	5604.6211	291.9839	201.9839	2.0524
293	64.5996	212.6466	0.0	
294	5623.8125	292.9836	202.9836	1.9628
294	64.5598	212.6466	0.0	
295	5643.0039	293.9834	203.9834	1.8746
295	64.6526	212.6466	0.0	
296	5662.1953	294.9832	204.9832	1.7883
296	65.0370	212.6466	0.0	
297	5681.3867	295.9832	205.9832	1.7037
297	65.9085	212.6466	0.0	
298	5700.5781	296.9829	206.9829	1.6209
298	67.3202	212.6466	0.0	
299	5719.7695	297.9827	207.9827	1.5401
299	69.3806	212.6466	0.0	
300	5738.9609	298.9824	208.9824	1.4611
300	72.1793	212.6469	0.0	

301	5758.1523	299.9824	209.9824	1.3841
301	75.7725	212.6385	0.0	
302	5777.3437	300.9822	210.9822	1.3091
302	80.1422	212.6831	0.0	
303	5796.5352	301.9819	211.9819	1.2363
303	85.1705	212.9945	0.0	
304	5815.7266	302.9817	212.9817	1.1655
304	90.6074	213.8466	0.0	
305	5834.9180	303.9817	213.9817	1.0968
305	96.1208	215.6764	0.0	
306	5854.1094	304.9814	214.9814	1.0304
306	101.3765	218.5575	0.0	
307	5873.3008	305.9812	215.9812	0.9661
307	106.1510	221.7124	0.0	
308	5892.4922	306.9810	216.9810	0.9041
308	110.3696	224.7781	0.0	
309	5911.6836	307.9810	217.9810	0.8442
309	114.0807	227.6341	0.0	
310	5930.8750	308.9807	218.9807	0.7867
310	117.3700	230.2688	0.0	
311	5950.0664	309.9805	219.9805	0.7315
311	120.3149	232.5148	0.0	
312	5969.2578	310.9802	220.9802	0.6784
312	122.9725	233.7642	0.0	
313	5988.4492	311.9800	221.9800	0.6277
313	125.3846	234.3376	0.0	
314	6007.6406	312.9800	222.9800	0.5791
314	127.5831	234.5210	0.0	
315	6026.8320	313.9797	223.9797	0.5330
315	129.5758	234.5263	0.0	
316	6046.0234	314.9795	224.9795	0.4890
316	131.3932	234.5236	0.0	
317	6065.2148	315.9792	225.9792	0.4472
317	133.0281	234.5235	0.0	
318	6084.4062	316.9792	226.9792	0.4077
318	134.4976	234.5235	0.0	
319	6103.5977	317.9790	227.9790	0.3704
319	135.7935	234.5235	0.0	
320	6122.7891	318.9788	228.9788	0.3352
320	136.9149	234.5235	0.0	

321	6141.9805	319.9785	229.9785	0.3022
321	137.8559	234.5235	0.0	
322	6161.1719	320.9785	230.9785	0.2712
322	138.6050	234.5235	0.0	
323	6180.3633	321.9783	231.9783	0.2423
323	139.1650	234.5235	0.0	
324	6199.5547	322.9780	232.9780	0.2154
324	139.4117	234.5235	0.0	
325	6218.7461	323.9778	233.9778	0.1904
325	139.5848	234.5235	0.0	
326	6237.9375	324.9778	234.9778	0.1674
326	139.5735	234.5235	0.0	
327	6257.1289	325.9775	235.9775	0.1463
327	139.5335	234.5235	0.0	
328	6276.3203	326.9773	236.9773	0.1268
328	139.5305	234.5235	0.0	
329	6295.5111	327.9771	237.9771	0.1092
329	139.5305	234.5235	0.0	
330	6314.7031	328.9771	238.9771	0.0931
330	139.5305	234.5235	0.0	
331	6333.8945	329.9768	239.9768	0.0787
331	139.5305	234.5235	0.0	
332	6353.0859	330.9766	240.9766	0.0659
332	139.5305	234.5235	0.0	
333	6372.2773	331.9763	241.9763	0.0545
333	139.5305	234.5235	0.0	
334	6391.4687	332.9763	242.9763	0.0444
334	139.5305	234.5235	0.0	
335	6410.6602	333.9761	243.9761	0.0357
335	139.5305	234.5235	0.0	
336	6429.8516	334.9758	244.9758	0.0282
336	139.5305	234.5235	0.0	
337	6449.0430	335.9756	245.9756	0.0217
337	139.5305	234.5235	0.0	
338	6468.2344	336.9753	246.9753	0.0163
338	139.5305	234.5235	0.0	
339	6487.4258	337.9753	247.9753	0.0120
339	139.5305	234.5235	0.0	
340	6506.6172	338.9751	248.9751	0.0085
340	139.5305	234.5235	0.0	

341	6525.8086	339.9749	249.9749	0.0057
341	139.5305	234.5235	0.0	
342	6545.0000	340.9746	250.9746	0.0036
342	139.5305	234.5235	0.0	
343	6564.1914	341.9746	251.9746	0.0021
343	139.5305	234.5235	0.0	
344	6583.3828	342.9744	252.9744	0.0011
344	139.5305	234.5235	0.0001	
345	6602.5742	343.9741	253.9741	0.0005
345	139.5305	234.5235	-0.0003	
346	6621.7656	344.9739	254.9739	0.0002
346	139.5305	234.5235	0.0414	
347	6640.9570	345.9739	255.9739	0.0000
347	139.5305	234.5235	0.2038	
348	6660.1484	346.9736	256.9736	-0.0000
348	139.5305	234.5235	0.5401	
349	6679.3398	347.9734	257.9734	0.0000
349	139.5305	234.5235	1.1025	
350	6698.5312	348.9731	258.9731	0.0
350	139.5305	234.5235	1.9437	
351	6717.7227	349.9731	259.9731	0.0
351	139.5305	234.5235	3.1164	
352	6736.9141	350.9729	260.9729	0.0
352	139.5305	234.5235	4.6724	
353	6756.1055	351.9727	261.9727	0.0
353	139.5305	234.5235	6.6673	
354	6775.2969	352.9724	262.9724	0.0
354	139.5305	234.5235	8.9048	
355	6794.4883	353.9724	263.9724	0.0
355	139.5305	234.5235	11.1576	
356	6813.6797	354.9722	264.9722	0.0
356	139.5305	234.5235	12.5313	
357	6832.8711	355.9719	265.9719	0.0
357	139.5305	234.5235	13.1030	
358	6852.0625	356.9717	266.9717	0.0
358	139.5305	234.5235	13.4463	
359	6871.2539	357.9717	267.9717	0.0
359	139.5305	234.5235	13.5824	
360	6890.4453	358.9714	268.9714	0.0
360	139.5305	234.5235	14.0092	

361	6909.6367	359.9712	269.9712	0.0
361	139.5305	234.5235	14.3732	
362	6928.8281	0.9709	270.9709	0.0
362	139.5305	234.5235	14.6046	
363	6948.0195	1.9709	271.9709	0.0
363	139.5305	234.5235	14.7334	
364	6967.2109	2.9707	272.9707	0.0
364	139.5305	234.5235	14.7892	
365	6986.4023	3.9705	273.9705	0.0
365	139.5305	234.5235	14.8010	
366	7005.5937	4.9702	274.9702	0.0
366	139.5305	234.5235	14.7983	
367	7024.7852	5.9700	275.9700	0.0
367	139.5305	234.5235	14.7982	
368	7043.9766	6.9700	276.9700	0.0
368	139.5305	234.5235	14.7982	
369	7063.1680	7.9697	277.9697	0.0
369	139.5305	234.5235	14.7982	
370	7082.3594	8.9695	278.9695	0.0
370	139.5305	234.5235	14.7982	
371	7101.5500	9.9692	279.9692	0.0
371	139.5305	234.5235	14.7982	
372	7120.7422	10.9692	280.9692	0.0
372	139.5305	234.5235	14.7982	
373	7139.9336	11.9690	281.9690	0.0
373	139.5305	234.5235	14.7982	
374	7159.1250	12.9688	282.9687	0.0
374	139.5305	234.5235	14.7982	
375	7178.3164	13.9685	283.9685	0.0
375	139.5305	234.5235	14.7982	
376	7197.5078	14.9685	284.9685	0.0
376	139.5305	234.5235	14.7982	
377	7216.6992	15.9683	285.9683	0.0
377	139.5305	234.5235	14.7982	
378	7235.8906	16.9680	286.9680	0.0
378	139.5305	234.5235	14.7982	
379	7255.0820	17.9678	287.9678	0.0
379	139.5305	234.5235	14.7982	
380	7274.2734	18.9678	288.9678	0.0
380	139.5305	234.5235	14.7982	

A P P E N D I X A-4

PROGRAM LISTING, DYNAMIC MODEL

06/14/24

DATE = 77104

MAIN

FORTRAN IV G LEVEL 21

```
0001      C      DIMENSION DUM2(6),DUM3(6),DUM4(6),DUM5(6),DUM6(6),DUM7(6)
          C
          C----- THIS IS THE MAIN PROGRAM EXECUTIVE
          C
          C      CALL INPUT
          C
          C      CALL DATAIN
          C
          C      CALL CMPUTE
          C
          C      CALL TBLOUT(10,DJM2,DUM3,DUM4,DUM5,DUM6,DUM7,X1,X2,X3)
          C
          C      STOP
          C      END
```

```
00000010
00000020
00000030
00000040
00000050
00000060
00000070
00000080
00000090
00000100
00000110
00000120
00000130
00000140
00000150
```

FORTRAN IV 6 LEVEL 21 INPUT DATE = 77104 06/14/24

```

0001      SUBROUTINE INPUT                                0000160
C----- ABSTRACT: SUBROUTINE INPUT PREFORMS AS THE CALLING ROUTINE F00000170
C----- THE WEAPON INIT                                00000180
C-----                                00000190
C                                00000200
C                                00000210
C                                00000220
0002      COMMON/TIME/TINIT,TFINAL,TNOW,TOUT,TSTEP,TNEXT 00000230
0003      COMMON/ANGLE2/TH2,DT*2,DT2TH2                00000240
0004      COMMON/SWITCH/IACI                             00000250
C-----                                00000260
C-----                                00000270
C-----                                00000280
C----- COMMON TIMES                                00000290
C TINIT REAL INITIAL TIME FOR INTEGRATION (SECONDS) 00000300
C TFINAL REAL FINAL AND TERMINATING TIME FOR INTEGRATION (SECONDS) 00000310
C TNOW REAL TIME TO WHICH THE INTEGRATION HAS PROGRESSED (SECONDS) 00000320
C TOUT REAL TIME STEP THAT MUST BE EXCEEDED TO GET AN OUTPUT 00000330
C TSTEP REAL INITIAL TIME STEP SIZE TO START INTEGRATION (SECONDS) 00000340
C TNEXT REAL ABSOLUTE TIME FOR NEXT OUTPUT STEP. TNEXT=TNEXT1+TSTEP 00000350
C----- COMMON ANGLE2                                00000360
C TH2X7L REAL ROTATION OF INPUT MOTOR GEAR (DEGREES) 00000370
C DT*2 REAL FIRST TIME DERIVATIVE OF TH2 (DEG/SEC) 00000380
C DT2TH2 REAL SECOND TIME DERIVATIVE OF TH2 (DEG/SEC**2) 00000390
C----- COMMON SWITCH                                00000400
C IACI INTEGER INTERACTIVE INPUT SWITCH. 2 IS INTERACTIVE. 0 IS 00000410
C-----                                00000420
C----- ASK USER IF HE WANTS DEFAULT VALUES OF TH2 TO INPUT INTER0000430
C----- SET INTERACTIVE SWITCH (IACI) ACCORDINGLY 00000440
C-----                                00000450
C----- FOR AVSCOM, FORGET ABOUT INTERACTIVE WORK 00000460
C-----                                00000470
C-----                                00000480
C-----                                00000490
C-----                                00000500
C-----                                00000510
C-----                                00000520
C-----                                00000530
C-----                                00000540
C-----                                00000550
C-----                                00000560
C-----                                00000570
C-----                                00000580
C-----                                00000590
C-----                                00000600
C-----                                00000610
C-----                                00000620
C-----                                00000630
C-----                                00000640
C-----                                00000650
C-----                                00000660
C-----                                00000670
C-----                                00000680

TH2=0.
DT*2=0.
DT2TH2=0.
TINIT=0.
TFINAL=2.5
TNOW=0.
TOUT=.01
TSTEP=.01
IACI=0
CONTINUE
9000      TNEXT=0.0

C----- UPDATE ALL THE OTHER ANGLE COMMONS AND DISPL COMMON
C-----
C----- CALL UPDATE
C-----
C----- INITIALIZATION IS COMPLETED
C-----

```

```
FORTRAN IV G LEVEL 21      INPUT      DATE = 77104      06/14/74      00000690
0016      RETURN      00000700
0017      1000  FORMAT(1) ENTER 1 IF YOU WISH DEFAULT VALUES,/.      00000710
      2  'ENTER 2 IF YOU WISH TO SPECIFY INITIAL CONDITIONS,/.      00000720
      3  'THEN HIT RETURN'      00000730
0018      1001  FORMAT(11)      00000740
0019      END
```


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DATIN

FORTRAN IV G LEVEL 21

```

0018      GO TO 100
0019      C
0020      CONTINUE
0021      VP152=J
0022      300 CONTINUE
0023      READ(2,1000,END=400,ERR=900) J,RPM(J),TRPM(J)
0024      TRPM(J)=TRPM(J)/12.0
0025      WRITE(6,200)J,RPM(J),TRPM(J)
0026      GO TO 300
0027      C
0028      400 CONTINUE
0029      NP1TG=J
0030      C
0031      C----- DATA IS NOW IN PROPER COMMONS
0032      C----- ERROR HANDLER IF NECESSARY
0033      C
0034      GO TO 9999
0035      900 CONTINUE
0036      WRITE(6,1001) J
0037      9999 CONTINUE
0038      C
0039      RETURN
0040      1001 FORMAT(' UNIT READ ERROR. UNIT 1 OR 2. J=',I5)
0041      END

```

00001280
00001290
00001300
00001310
00001320
00001330
00001340
00001350
00001360
00001370
00001380
00001390
00001400
00001410
00001420
00001430
00001440
00001450
00001460
00001470
00001480
00001490
00001500
00001510
00001520
00001530
00001540

```

0001 SUBROUTINE CPMUTE
C----- ABS(RACT) SUBROUTINE CPMUTE HANDLES THE NUMERICAL
C----- INTEGRATION BY A CALL TO THE IBM-SSP SUBROUTINE
C----- MPCG CHANGING PREDICTOR-CORRECTOR, MODIFIED)
C----- CPMUTE SETS UP THE PARAMETERS USED IN THE CALLING
C----- ARRAYS AND THEN HANDLES CONTROL OF THE PROGRAM TO
C----- MPCG. MPCG REQUIRES TWO PROGRAMMER SUPPLIED
C----- ROUTINES CALLED FCT AND OUTP
C
COMMON/TIMES/TINIT,TFINAL,TNOW,TOUT,TSTEP,TNEXT
COMMON/ANGLE2/TH2,DTH2,DST+2
DIMENSION Y(2),DERV(2),PRNT(5),AUX(16,**)
EXTERNAL FCT,OUTP
C-----
C----- VARIABLE TYPE DESCRIPTION
C-----
C----- COMMON TIMES
C TINIT REAL INITIAL TIME FOR INTEGRATION (SECONDS)
C TFINAL REAL FINAL AND TERMINATING TIME FOR INTEGRATION (SECOND)0001730
C TNOW REAL TIME TO WHICH THE INTEGRATION HAS PROGRESSED (SEC)0001750
C TOUT REAL TIME STEP THAT MUST BE EXCEEDED TO GET AN OUTPUT 00001760
C TSTEP REAL INITIAL TIME STEP SIZE TO START INTEGRATION (SEC)0001770
C TNEXT REAL ABSOLUTE TIME FOR NEXT OUTPUT STEP. TNEXT=TNEXT+TSTEP 00001780
C----- COMMON ANGLE2
C TH2 REAL ROTATION OF INPUT MOTOR GEAR (DEGREES) 00001790
C DTH2 REAL FIRST TIME DERIVATIVE OF TH2 (DEG/SEC) 00001810
C DST+2 REAL SECOND TIME DERIVATIVE OF TH2 (DEG/SEC**2) 00001820
C
C Y(1) REAL INITIAL ANGLE OF INPUT MOTOR (DEGREES) 00001830
C Y(2) REAL INITIAL ANGULAR VELOCITY OF INPUT MOTOR (DEG/SEC)0001840
C DERV(1) REAL ERROR WEIGHT FACTOR FOR INTEGRATING ROUTINE 00001850
C DERV(2) REAL ERROR WEIGHT FACTOR FOR INTEGRATING ROUTINE 00001860
C PRNT(1) REAL INITIAL TIME SUPPLIED TO MPCG ROUTINE, LIMIT (SEC)0001870
C PRNT(2) REAL FINAL TIME GIVEN TO MPCG, *TFINAL (SECONDS) 00001880
C PRNT(3) REAL OUTPUT OCCURS EVERY PRMT(3) SECONDS 00001890
C PRMT(4) REAL ABSOLUTE ERROR UPON WHICH INTEGRATING TIME STEP 10001900
C PRMT(5) REAL UNUSED HERE. CAN BE USED OUT OF OUTPUT ROUTINE 00001910
C AUX(16,**) REAL SWITCH VECTOR USED IN MPCG 00001920
C NDIM INTEGER NUMBER OF ELEMENTS IN DERY VECTOR 00001930
C-----
C----- SET UP THE PRMT VECTOR, PRMT(5) IS SET INTERNALLY
C
PRMT(1)=TINIT
PRMT(2)=TFINAL
PRMT(3)=TSTEP
PRMT(4)=40.
C
C----- SET UP THE DELTIMED DERY VECTOR. NOTE THAT THE
C----- SIZE OF THE DERY ELEMENTS MUST BE 1.
C
DERV(1)=.5
0001550
0001560
0001570
0001580
0001590
0001600
0001610
0001620
0001630
0001640
0001650
0001660
0001670
0001680
0001690
0001700
0001710
0001720
0001730
0001750
0001760
0001770
0001780
0001790
0001800
0001810
0001820
0001830
0001840
0001850
0001860
0001870
0001880
0001890
0001900
0001910
0001920
0001930
0001940
0001950
0001960
0001970
0001980
0001990
0002000
0002010
0002020
0002030
0002040
0002050
0002060
0002070

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CMPUTE

FORTRAN IV G LEVEL 21

```

0011      C      JERY(2)=.5
C----- SET UP THE Y VECTOR WITH THE ANGLE2 INITIAL
C----- CONDITIONS
C
0012      C      Y(1)=TH2
0013      C      Y(2)=DTH2
C----- DIMENSION OF THE PROBLEM IS 2
C
0014      C      NDI=2
C----- ARGUMENT LIST IS NOW COMPLETE. GIVE CONTROL
C----- OF THE NUMERICAL INTEGRATION PROCEDURE TO
C----- IBM-SS SUBROUTINE HPCG
C
0015      C      CALL HPCGIPRAT,Y,JERY,NDI,IMLF,FCT,OUTP,AJX)
C
0016      C      RETURN
0017      C      END
00002080
00002090
00002100
00002110
00002120
00002130
00002140
00002150
00002160
00002170
00002180
00002190
00002200
00002210
00002220
00002230
00002240
00002250
00002260
00002270
00002280

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DATE = 77104

MAIN

FORTRAN IV 3 LEVEL 21

```

C SUBROUTINE HPCG(PRMT,Y,DERY,NDIM,IMLF,FCT,OUTP,AUX)
C
C PURPOSE
C TO SOLVE A SYSTEM OF FIRST ORDER ORDINARY GENERAL
C DIFFERENTIAL EQUATIONS WITH GIVEN INITIAL VALUES.
C
C USAGE
C CALL HPCG (PRMT,Y,DERY,NDIM,IMLF,FCT,OUTP,AUX)
C PARAMETERS FCT AND OUTP REQUIRE AN EXTERNAL STATEMENT.
C
C DESCRIPTION OF PARAMETERS
C PRMT - AN INPUT AND OUTPUT VECTOR WITH DIMENSION GREATER
C OR EQUAL TO 5, WHICH SPECIFIES THE PARAMETERS OF
C THE INTERVAL AND OF ACCURACY AND WHICH SERVES FOR
C COMMUNICATION BETWEEN OUTPUT SUBROUTINE (FURNISHED
C BY THE USER) AND SUBROUTINE HPCG. EXCEPT PRMT(5)
C THE COMPONENTS ARE NOT DESTROYED BY SUBROUTINE
C HPCG AND THEY ARE
C PRMT(1)- LOWER BOUND OF THE INTERVAL (INPUT),
C PRMT(2)- UPPER BOUND OF THE INTERVAL (INPUT),
C PRMT(3)- INITIAL INCREMENT OF THE INDEPENDENT VARIABLE
C (INPUT),
C PRMT(4)- UPPER ERROR BOUND (INPUT). IF ABSOLUTE ERROR IS
C GREATER THAN PRMT(4), INCREMENT GETS HALVED.
C IF INCREMENT IS LESS THAN PRMT(3) AND ABSOLUTE
C ERROR LESS THAN PRMT(4)/50, INCREMENT GETS DOUBLED.
C THE USER MAY CHANGE PRMT(4) BY MEANS OF HIS
C OUTPUT SUBROUTINE.
C PRMT(5)- NO INPUT PARAMETER. SUBROUTINE HPCG INITIALIZES
C PRMT(5)=0. IF THE USER WANTS TO TERMINATE
C SUBROUTINE HPCG AT ANY OUTPUT POINT, HE HAS TO
C CHANGE PRMT(5) TO NON-ZERO BY MEANS OF SUBROUTINE
C OUTP. FURTHER COMPONENTS OF VECTOR PRMT ARE
C FEASIBLE IF ITS DIMENSION IS DEFINED GREATER
C THAN 5. HOWEVER SUBROUTINE HPCG DOES NOT REQUIRE
C AND CHANGE THEM. NEVERTHELESS THEY MAY BE USEFUL
C FOR HANDLING RESULT VALUES TO THE MAIN PROGRAM
C (CALLING HPCG) WHICH ARE OBTAINED BY SPECIAL
C MANIPULATIONS WITH OUTPUT DATA IN SUBROUTINE OUTP.
C
C Y - INPUT VECTOR OF INITIAL VALUES. (DESTROYED)
C LATERON Y IS THE RESULTING VECTOR OF DEPENDENT
C VARIABLES COMPUTED AT INTERMEDIATE POINTS X.
C
C DERY - INPUT VECTOR OF ERROR HEIGHTS. (DESTROYED)
C THE SUM OF ITS COMPONENTS MUST BE EQUAL TO 1.
C LATERON DERY IS THE VECTOR OF DERIVATIVES, WHICH
C BELONGS TO FUNCTION VALUES Y AT A POINT X.
C
C NDIM - AN INPUT VALUE, WHICH SPECIFIES THE NUMBER OF
C EQUATIONS IN THE SYSTEM.
C
C IMLF - AN OUTPUT VALUE, WHICH SPECIFIES THE NUMBER OF
C BISECTIONS OF THE INITIAL INCREMENT. IF IMLF GETS
C GREATER THAN 10, SUBROUTINE HPCG RETURNS WITH
C ERROR MESSAGE IMLF=11 INTO MAIN PROGRAM.
C ERROR MESSAGE IMLF=12 OR IMLF=13 APPEARS IN CASE

```

```

00002290
00002300
00002310
00002320
00002330
00002340
00002350
00002360
00002370
00002380
00002390
00002400
00002410
00002420
00002430
00002440
00002450
00002460
00002470
00002480
00002490
00002500
00002510
00002520
00002530
00002540
00002550
00002560
00002570
00002580
00002590
00002600
00002610
00002620
00002630
00002640
00002650
00002660
00002670
00002680
00002690
00002700
00002710
00002720
00002730
00002740
00002750
00002760
00002770
00002780
00002790
00002800
00002810

```

0001

0002	00003330	DIMENSION PRMT(1),Y(1),DERY(1),AUX(16,1)	
0003	00003330	Y=1	
0004	00003370	IMLF=0	
0005	00003380	X=PRMT(1)	
0006	00003390	Y=PRMT(3)	
0007	00003400	PRMT(5)=0.	
0008	00003410	DO 1 I=1,NDIM	
0009	00003420	AUX(16,I)=0.	
0010	00003430	AUX(15,I)=DERY(I)	
0011	00003440	AUX(1,I)=Y(I)	
0012	00003450	1 IF (Y=PRMT(2)-X) 3,2,4	
	00003460		
	00003470		
	00003480	ERRQR RETURNS	
0013	00003490	2 IMLF=12	
0014	00003500	GOTO 4	
0015	00003510	3 IMLF=13	
	00003520		
0016	00003530	C COMPUTATION OF DERY FOR STARTING VALUES	
	00003540	4 CALL FCT(X,Y,DERY)	
	00003550		
	00003560	C RECORDING OF STARTING VALUES	
0017	00003570	CALL OUTP(X,Y,DERY,IMLF,NDIM,PRMT)	
0018	00003580	IF (PRMT(5)) 6,5,6	
0019	00003590	5 IF (IMLF) 7,7,5	
0020	00003600	6 RETURN	
0021	00003610	7 DO 8 I=1,NDIM	
0022	00003620	9 AUX(8,I)=DERY(I)	
	00003630		
0023	00003640	C COMPUTATION OF AUX(2,I)	
0024	00003650	IS=1	
	00003660	GOTO 100	
0025	00003670		
0026	00003680	9 X=X+H	
0027	00003690	DO 10 I=1,NDIM	
	00003700	10 AUX(2,I)=Y(I)	
	00003710		
0028	00003720	C INCREMENT H IS TESTED BY MEANS OF BISECTION	
0029	00003730	11 IMLF=IMLF+1	
0030	00003740	X=X-H	
0031	00003750	DO 12 I=1,NDIM	
0032	00003760	12 AUX(4,I)=AUX(2,I)	
0033	00003770	H=.5*H	
0034	00003780	Y=1	
0035	00003790	IS=2	
	00003800	GOTO 100	
	00003810		
0036	00003820	C 13 X=X+H	
0037	00003830	CALL FCT(X,Y,DERY)	
0038	00003840	Y=2	
0039	00003850	DO 14 I=1,NDIM	
0040	00003860	AUX(2,I)=Y(I)	
0041	00003870	14 AUX(9,I)=DERY(I)	
0042	00003880	IS=3	

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```

0043      GOTO 100
C
0044      COMPUTATION OF TEST VALUE DELT
0045      15 DELT=0.
0046      DO 16 I=1,NDIM
0047      16 DELT=DELTAUX(I,1)*ABS(Y(I)-AUX(I,1))
0048      DELT=.06666667*DELT
0049      IF (DELT-PRMT(4))19,19,17
0050      17 IF (IMLF-10)11,18,18
C
0051      18 IMLF=11
0052      X=X+H
0053      GOTO 4
C
0054      19 X=X+H
0055      CALL FCT(X,Y,DERY)
0056      DO 20 I=1,NDIM
0057      20 AUX(I,1)=DERY(I)
0058      N=3
0059      ISW=4
0060      GOTO 100
C
0061      21 N=1
0062      X=X+H
0063      CALL FCT(X,Y,DERY)
0064      X=PRMT(1)
0065      DO 22 I=1,NDIM
0066      22 AUX(I,1)=DERY(I)
0067      220 Y(I)=AUX(I,1)+H*(.375*AUX(8,I)+.7916667*AUX(9,I)
0068      1-.2083333*AUX(10,I)+.04166667*DERY(I))
0069      N=N+1
0070      CALL FCT(X,Y,DERY)
0071      CALL OUTP(X,Y,DERY,IMLF,NDIM,PRMT)
0072      IF (PRMT(5))6,24,6
0073      24 IF (N-4)25,200,200
0074      25 DO 26 I=1,NDIM
0075      26 AUX(N,I)=Y(I)
0076      AUX(N+7,I)=DERY(I)
0077      IF (N-3)27,29,200
C
0078      27 DO 29 I=1,NDIM
0079      29 DELT=AUX(9,I)+AUX(9,I)
0080      DELT=DELT*DELT
0081      28 Y(I)=AUX(1,I)+.33333333*(AUX(9,I)+DELT*AUX(10,I))
0082      GOTO 23
C
0083      29 DO 30 I=1,NDIM
0084      30 DELT=AUX(9,I)+AUX(10,I)
0085      DELT=DELT*DELT

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```

0086      30 Y(I)=AUX(I,I)+.375*H*(AUX(8,I)+DELTA*AUX(11,I))
0087      GOTO 23
C
C      THE FOLLOWING PART OF SUBROUTINE HPCG COMPUTES BY MEANS OF
C      RUNGE-KUTTA METHOD STARTING VALUES FOR THE NOT SELF-STARTING
C      PREDICTOR-CORRECTOR METHOD.
0088      100 DO 101 I=1,NDIM
0089          Z=H*AUX(N+7,I)
0090          AUX(5,I)=Z
0091      101 Y(I)=AUX(N,I)+.4*Z
C      Z IS AN AUXILIARY STORAGE LOCATION
C
C      Z=X+.4*H
0092      CALL FCT(Z,Y,DERY)
0093      DO 102 I=1,NDIM
0094          Z=H*DERY(I)
0095          AUX(6,I)=Z
0096      102 Y(I)=AUX(N,I)+.2969776*AUX(5,I)+.1587596*Z
C
C      Z=X+.4557372*H
0098      CALL FCT(Z,Y,DERY)
0099      DO 103 I=1,NDIM
0100          Z=H*DERY(I)
0101          AUX(7,I)=Z
0102      103 Y(I)=AUX(N,I)+.218100*AUX(5,I)+.3.050955*AUX(6,I)+.832855*Z
C
C      Z=X+H
0104      CALL FCT(Z,Y,DERY)
0105      DO 104 I=1,NDIM
0106          104 Y(I)=AUX(N,I)+.1747603*AUX(5,I)+.5514807*AUX(6,I)
0107          1.205535*AUX(7,I)+.1711848*H*DERY(I)
0108      GOTO(9,13,15,21),ISM
C
C      POSSIBLE BREAK-POINT FOR LINKAGE
C
C      STARTING VALUES ARE COMPUTED.
C      NOW START HANNINGS MODIFIED PREDICTOR-CORRECTOR METHOD.
0109      200 ISTEP=3
0110      201 IF(N-8)204,202,204
C
C      N=8 CAUSES THE ROWS OF AUX TO CHANGE THEIR STORAGE LOCATIONS
0111      202 DO 203 N=2,7
0112          DO 203 I=1,NDIM
0113              AUX(N-1,I)=AJX(N,I)
0114              AUX(N+6,I)=AJX(N+7,I)
0115          N=7
C
C      N LESS THAN 8 CAUSES N+1 TO GET N
0116      204 N=N+1
C
C      COMPUTATION OF NEXT VECTOR Y
0117      DO 205 I=1,NDIM
0118          AUX(N+1,I)=Y(I)

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```

0119 205 AUX(N+6,I)=DERY(I)
0120 X=X+H
0121 ISTEP=ISTEP+1
0122 DO 207 I=1,NJIM
0123 ODELTA=AUX(N+4,I)+1.333333*H*(AUX(N+6,I)+AUX(N+5,I)-AUX(N+5,I)+
      1AUX(N+4,I)+AUX(N+4,I))
0124 Y(I)=DELTA-.9256198*AUX(15,I)
0125 207 AUX(16,I)=DELTA
      C PREDICTOR IS NOW GENERATED IN ROW 16 OF AUX, MODIFIED PREDICTOR
      C IS GENERATED IN Y. DELTA MEANS AN AUXILIARY STORAGE.
      C
0126 CALL FCT(X,Y,DERY)
      C DERIVATIVE OF MODIFIED PREDICTOR IS GENERATED IN DERY
      C
0127 DO 208 I=1,NJIM
0128 ODELTA=.125*(9.*AUX(N+1,I)-AUX(N+3,I)+3.*H*(DERY(I)+AUX(N+3,I)+
      1AUX(N+6,I)-AUX(N+5,I)))
0129 X(16,I)=AUX(16,I)-DELTA
0130 Y(I)=DELTA+.07438017*AUX(16,I)
      C
0131 TEST WHETHER H MUST BE HALVED OR DOUBLED
0132 DELTA=0.
0133 DO 209 I=1,NJIM
0134 DELTA=DELTA+AUX(15,I)*ABS(AUX(16,I))
      IF(DELTA-PRMT(4))210,222,222
      C
0135 H MUST NOT BE HALVED. THAT MEANS Y(I) ARE GOOD.
0136 CALL FCT(X,Y,DERY)
0137 CALL OUTP(X,Y,DERY,IMLF,NDIM,PRMT)
0138 IF(PRMT(5))212,211,212
0139 IF(IMLF-11)213,212,212
0140 RETURN
0141 213 IF(H*(X-PRMT(2)))214,212,212
0142 214 IF(ABS(X-PRMT(2))-.1*ABS(H))212,215,215
      215 IF(DELTA-.02*PRMT(4))216,216,201
      C
0143 H COULD BE DOUBLED IF ALL NECESSARY PRECEDING VALUES ARE
      C AVAILABLE
0144 216 IF(IMLF)201,201,217
0145 217 IF(4-7)201,218,218
0146 218 IF(ISTEP-4)201,219,219
0147 219 IMOD=1STEP/2
0148 IF(ISTEP-IMOD-1)201,220,201
0149 220 H=H*H
      IMLF=IMLF-1
      ISTEP=0
0150 DO 221 I=1,NJIM
0151 AUX(N+1,I)=AUX(N+2,I)
0152 AUX(N+2,I)=AUX(N+4,I)
0153 AUX(N+3,I)=AUX(N+6,I)
0154 AUX(N+5,I)=AUX(N+5,I)
0155 AUX(N+6,I)=AUX(N+3,I)
0156
00004940
00004950
00004960
00004970
00004980
00004990
00005000
00005010
00005020
00005030
00005040
00005050
00005060
00005070
00005080
00005090
00005100
00005110
00005120
00005130
00005140
00005150
00005160
00005170
00005180
00005190
00005200
00005210
00005220
00005230
00005240
00005250
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00005270
00005280
00005290
00005300
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00005370
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00005400
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00005460

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00054700
00054800
00054900
00055000
00055100
00055200
00055300
00055400
00055500
00055600
00055700
00055800
00055900
00056000
00056100
00056200
00056300
00056400
00056500
00056600
00056700
00056800
00056900
00057000
00057100
00057200
00057300
00057400
00057500
00057600
00057700
00057800
00057900
00058000
00058100
00058200
00058300
00058400

AUX(N+4,I)=AUX(N+1,I)
DELTAUX(N+6,I)+AUX(N+5,I)
DELT=DELT+DELT
2210AUX(16,I)=8.962963*(Y(I)-AUX(N-3,I))-3.361111*H*(OERY(I)+DELT
1+AUX(N+4,I))
GOTO 201

C
C
C
I MUST BE HALVED
222 IHLF=IHLF+1
IF(IHLF-10)223,223,210
223 H=.5*H
ISTEP=0
DO 224 I=1,NDIM
OY(I)=.00390625*(80.*AUX(N-1,I)+135.*AUX(N-2,I)+40.*AUX(N-3,I)+
1AUX(N-4,I))-11.71875*(AUX(N-5,I)-6.*AUX(N+5,I))-AUX(N+4,I))*H
0AUX(N-4,I)=.00390625*(12.*AUX(N-1,I)+135.*AUX(N-2,I)+
1108.*AUX(N-3,I)+AUX(N+4,I))-12.234375*(AUX(N-6,I)+18.*AUX(N+5,I)-
29.*AUX(N+4,I))*H
AUX(N-3,I)=AUX(N-2,I)
AUX(N+4,I)=AUX(N+5,I)
X=X-H
DELT=X-(H+H)
CALL FCT(DELT,Y,DERY)
DO 225 I=1,NDIM
AUX(N-2,I)=Y(I)
AUX(N+5,I)=DERY(I)
225 Y(I)=AUX(N-4,I)
DELT=DELT-(H+H)
CALL FCT(DELT,Y,DERY)
DO 226 I=1,NDIM
DELT=AUX(N+5,I)+AUX(N+4,I)
DELT=DELT+DELT
0AUX(16,I)=8.962963*(AUX(N-1,I)-Y(I))-3.361111*H*(AUX(N+6,I)+DELT
1+OERY(I))
226 AUX(N+3,I)=DERY(I)
GOTO 206

END
00058500
00058600
00058700
00058800
00058900
00059000
00059100
00059200
00059300
00059400
00059500
00059600
00059700
00059800
00059900

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FCT

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```

0014      IF (ALL.LI.ALLMIN) ALLMIN=ALL
C----- REPLACE INTO VECTOR DERY
C
0015      DERY(1)=DTH2
0016      DERY(2)=DTH2
C
C
0017      RETURN
0018      1000 FORMAT(1, ZERO ALL OUT OF FCT,/,
2          'OCCURED WHEN',F16.4,',DTH2',F16.4,',DTH2',/,
3          'F16.4',DTH2',/, ZERO ALL IS REPLACED BY ',F16.4)
0019      END

```

00006380
00006390
00006400
00006410
00006420
00006430
00006440
00006450
00006460
00006470
00006480
00006490
00006500

[illegible]

```

00001 SUBROUTINE CCEF2(IH2,JUH2,AL2,AR2)
C
C      00006970
C      00006980
C      00006990
C      00007000
C      00007010
C      00007020
C      00007030
C      00007040
C      00007050
C      00007060
C      00007070
C      00007080
C      00007090
C      00007100
C      00007110
C      00007120
C      00007130
C      00007140
C      00007150
C      00007160
C      00007170
C      00007180
C      00007190
C      00007200
C      00007210
C      00007220
C      00007230
C      00007240
C      00007250
C      00007260
C      00007270
C      00007280
C      00007290
C      00007300
C      00007310
C      00007320
C      00007330
C
C-----
C      COMMON MTRQ          VECTOR OF RPM VALUES FOR INPUT MOTOR (DEG/SEC)
C      RPM(1000)           REAL
C      TRPM(1000)          REAL
C      NPITQ               VECTOR OF TORQUES CORRES. TO RPM VECTOR (FT-LBS)
C                          INTEGER POINTS IN RPM-TRPM TORQUE/SPEED CURVE VECTORS
C
C      AL2                 COEFF OF 2ND DERIV. FOR INPUT MOTOR COMPOMENTS
C      AR2                 1ST DERIV. AND CONSTANTS VALUE FOR INPUT MOTOR COMPOMENTS
C      IS9                 INERTIA MOMENT OF 59TH GEAR (FT-LB-SEC**2)
C      I120                INERTIA MOMENT OF 120 TH IDLER GEAR (FT-LB-SEC**2)
C      TORQUE              REAL
C      IH2                 TORQUE AT JH2 INTERPOLATED FROM RPM-TRPM CURVE
C      DH2                 INPUT MOTOR ANGLE AT TIME T (DEGREES)
C      DTH2                REAL
C                        ANGULAR VELOCITY OF MOTOR INPUT ANGLE AT TIME T
C----- NOTE THAT IH2,DH2,JDH2 ARE ONLY LOGIC TO FCT,VALUES,COEFF# SUBS-----
C      00006970
C      00006980
C      00006990
C      00007000
C      00007010
C      00007020
C      00007030
C      00007040
C      00007050
C      00007060
C      00007070
C      00007080
C      00007090
C      00007100
C      00007110
C      00007120
C      00007130
C      00007140
C      00007150
C      00007160
C      00007170
C      00007180
C      00007190
C      00007200
C      00007210
C      00007220
C      00007230
C      00007240
C      00007250
C      00007260
C      00007270
C      00007280
C      00007290
C      00007300
C      00007310
C      00007320
C      00007330
C
C----- COMPUTE AL2,AR2
C
C      AL2=-(I59+I120*RATIO**2)
C      CALL INTER(RPM,TRPM,NPITQ,DH2/6.,TORQUE,DUM1,DUM2,1,0)
C      AR2=TORQUE - .1*TORQUE
C
C      RETURN
C      END

```

```

0001 SUBROUTINE COEF3(TM2,UTM2,AL3,AR3)
C
C
C
C
C
COMMON/DRUM3/DTM3(1000)
COMMON/MOTOR2/AMT2(1000),NPTS2
COMMON/UPDTE3/TM3,DITH3,D2TM3
REAL IDRUM(.0997/.IFACE/.04406/)
C-----
C VARIABLE TYPE DESCRIPTION
C TM2 REAL INPUT MOTOR ANGLE AT TIME T (DEGREES)
C DTH2 REAL ANGULAR VELOCITY OF MOTOR INPUT ANGLE AT TIME T
C----- NOTE THAT TM2,DTH2,D2TM2 ARE ONLY LOCAL OO FCT,VALUES,COEFFS,SUBS0007480
C AL3 REAL COEFF. OF 2ND DERIV. FOR DRUM/FACE CAM COMPONENTS0007500
C----- COMMON MOTOR2
C AMT2(1000) REAL VECTOR OF SUCCESSIVE INPUT MOTOR POSITIONS (DEG)
C NPTS2 INTEGER POINTS IN AMT2,DRUM3,FACE3F,FEED*,EJECT5,LOCK6,00007530
C----- COMMON DRUM3
C DTH3(1000) REAL VECTOR OF DRUM POSITIONS FOR CORRECTING DRUM0007560
C
C IORJM REAL INERTIA MOMENT OF DRUM CAM (FT-LB-SEC**2)
C IFACE REAL INERTIA MOMENT OF THE FACE CAM (FT-LB-SEC**2)
C SUM REAL SUM OF FACE AND DRUM MOMENTS OF INERTIA (FT-LB-SE0007590
C-----
C CALL INTERP(AMT2,DTM3,NPTS2,AMT2,DTM3,D2TM3,.02TM3,.3,00007630
C
C )
C
C SUM=IDRUM*IFACE
C AL3=(-DITH3**2)*SUM
C AR3= -(DTH2**2)*(DITH3*D2TM3*SUM)
C
C RETURN
END
0007340
0007350
0007360
0007370
0007380
0007390
0007400
0007410
0007420
0007430
0007440
0007450
0007460
0007470
0007480
0007490
0007500
0007510
0007520
0007530
0007540
0007550
0007560
0007570
0007580
0007590
0007600
0007610
0007620
0007630
0007640
0007650
0007660
0007670
0007680
0007690
0007700
0007710
0007720
0007730

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COEF4

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SUBROUTINE COEF4 (TH2, DTH2, AL4, AR4)

0001

```

C
C
C
C
C
C
COMMON/FEED4/FTM4(1000)
COMMON/MOTOR2/AMTR2(1000),NPTS2
COMMON/UPOTE4/TH4,DTH4,D2TH4
REAL ISHFT/.000186477,IROCK/.00002724/.1PAWL/.00032958/
REAL MAMMO/.04255/MROCK/.0049232/MPAWL/.010888/
REAL THCNST/215./5RAV/32.2/RCH/.08333/PE/.3000/
DATA PCM/.16670/
0002
0003
0004
0005
0006
0007
0008

```

```

C-----
C VARIABLE TYPE DESCRIPTION
C-----
C----- COMMON EJECTS
C FTH4 REAL
C----- COMMON MOTOR2
C AMTR2(1000) REAL
C NPTS2 INTEGER
C-----
C TH2 REAL INPUT MOTOR ANGLE AT TIME T (DEGREES)
C DTH2 REAL ANGULAR VELOCITY OF MOTOR INPUT ANGLE AT TIME T (00007970
C----- NOTE THAT TH2,DTH2 ARE ONLY LOCAL 00 FCT-VALUES,COEFF# SUBS00007980
C AL4 REAL CONSTANTS & 1ST DER VALUES FOR DRUM/FACE C&M COMP00007990
C AR4 REAL CONSTANTS & 1ST DER VALUES FOR COMPONENTS OF FEED00008000
C ISHFT REAL INERTIA MOMENT OF FEED SHAFT (FT-LB-SEC**2)
C IROCK REAL INERTIA MOMENT OF ROCKER PAWL (FT-LB-SEC**2)
C IPAWL REAL INERTIA MOMENT OF FEED PAWL (FT-LB-SEC**2)
C AMMO REAL MASS OF THE AMMO ROUND (LB-SEC**2/FT)
C MROCK REAL MASS OF THE ROCKER ARM (LB-SEC**2/FT)
C MPAWL REAL MASS OF THE FEED PAWL (LB-SEC**2/FT)
C THCNST REAL THE CONSTANT ANGLE BETWEEN FEED PAWL AND ROCKER A
C GRAV REAL ACCELERATION DUE GRAVITY (FT/SEC**2)
C RCH REAL LENGTH FROM 5' FT CENTER TO ROCKER MASS CENTER (F00008090
C PCW REAL LENGTH FROM 4' SHAFT CENTER TO PAWL MASS CENTER (FT)00008100
C PE REAL LENGTH FROM 3' SHAFT CENTER TO PAWL END (FT)
C C4 REAL COSINE OF FEED PAWL ANGLE
C C4C REAL COSINE OF ROCKER ARM ANGLE
0009
C ARG1 REAL
C ARG2 REAL
C-----

```

```

C
C
C
C
C
C
CALL INTERP(AMTR2,FTM4,NPTS2,AMMO(TH2,6910.17),TH4,DTH4,D2TH4,3,00008200
1
C
C
C=C3S,TH4/57.2957795)
C=C3S(TH4/57.2957795+THCNST/57.2957795)
0011
0012

```

RETURN
END

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COEFS

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```
0013      C      C      AR5=- (01M2**2*011HS*21HS) * (IPAWL+MPAWL*PCW**2+IROCK+
      C      C      1      MROCK**PCW**2+ISHF1)
      C      C      2      -GRAVE011HS* (PCW*MPAWL*CS+RCW*YROCK<*CSC)
0014      C      C      RETURN
0015      C      C      END
```

0008960
0008970
0008980
0008990
0009000
0009010
0009020
0009030
0009040
0009050

```

0001 SUBROUTINE COEF6(TH2,DTH2,AL6,AR6)
C
C C
C C
C C
C C
      REAL ILOCK*,0020653/
COMMON/LOCK6/ALTH6(1000)
COMMON/MOTOR2/AMTH2(1000),NPTS2
COMMON/UPDT6/TM6,DTH6,D2TM6
C
C-----
C VARIABLE TYPE DESCRIPTION
C----- COMMON LOCK6
C--- ALTH6(1000) REAL VECTOR OF LOCKT POSITIONS FOR CORRESPONDING AMTH2
C--- COMMON MOTOR2
C AMTH2(1000) REAL VECTOR OF SUCCESSIVE INPUT MOTOR POSITIONS (DEG)
C NPTS2 INTEGER POINTS IN AMTH2, DRUM3*FACE3F,FEED4,EJECT5,LOCK6,DOOR9230
C
C IM2 REAL INPUT MOTOR ANGLE AT TIME T (DEGREES)
C DT+2 REAL ANGULAR VELOCITY OF MOTOR INPUT ANGLE AT TIME T (00009260)
C----- NOTE THAT T+2,DTH2,D2TH2 ARE ONLY LOCAL TO FC1,VALUES,COEFF# SUBS,0009270
C-----
C C
C CALL INTERP(AMTH2,ALTH6,NPTS2,AMO3(TM2,6910.17),TM6,DT+ ,D2TM6,3,000009310
      )
C
C C
      ALB=-(DTH6**2)*ILOCK
      ARG=-((DTH2**2)*(DTH6*D2TH6*ILOCK))-DTH6*TDR(ARG1,ARG2)
C
C C
      RETURN
      END
0009
0010

```

```

0001      SUBROUTINE COEFF7(TH2,DTH2,AL7,AR7)
C
C
C
C
COMMON/DISP7/RAD7(1000)
COMMON/MOTOR2/AMT2(1000),NPTS2
COMMON/UPDET7/R7,DRT,D2R7
DATA CFRIC7/.9/
C-----
C  VARIABLE      TYPE      DESCRIPTION
C-----
C----- COMMON DISP7
C RAD7(1000) REAL
C----- COMMON MOTOR2
C AMT2(1000) REAL VECTOR OF CHAMBER DISPLACEMENTS COR. TO AMT2 (FT00009540
C NPTS2 INTEGER POINTS IN AMT2,DRUM3,FACR3F,FEED,EJECTS,LOCK6,000009570
C TH2 REAL INPUT MOTOR ANGLE AT TIME T (DEGREES)
C DT2 REAL ANGULAR VELOCITY OF MOTOR INPUT ANGLE AT TIME T (00009580
C DT2 NOTE THAT TH2,DT2 ARE ONLY LOCAL TO FCT,VALUES,COEFF# SUBS00009590
C----- COEFF OF 2ND DERIVATIVE FOR COMPONENTS OF CHAMBER00009600
C AL7 REAL CONSTANTS & 1ST DER VALUES FOR COMPONENTS OF CHAM00009610
C AR7 REAL TRANSLATING MASS ASSOCIATED WITH CHAMBER MOTION (00009620
C VCHMBR REAL
C-----
C
C
C CALL INTERP(AMT2,RAD7,NPTS2,AMOD(TH2,5910.17),R7,DRT,D2R7,3,0)
CALL CHAMBR(CRUS1,SEAR,VCHMBR)
C
C
C AL7=(DRT**2)*VCHMBR
AR7=(DTH2**2)*VCHMBR*DRT*D2R7 + DRT*(CRUSH-SEAR)
IF(DRT.NE.0.) AR7=AR7*CFRIC7*(DRT/ABS(DRT))
C
C RETURN
C END
0006
0007
0008
0009
0010
0011
0012

```


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0012	CALL UPDATE			
	C-----			00010300
	C-----			00010310
	C-----			00010320
	C-----			00010330
0013	CALL OUTPUT			00010340
	C			00010350
	C			00010360
0014	RETURN			00010370
0015	END			00010380

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OUTPUT

```

0001      SUBROUTINE OUTPUT
0002      C
0003      COMMON/TIME/TINIT,TFINAL,TNOW,TOUT,TSTEP,TNEXT
0004      COMMON/ANGLE2/TH2,DTM2,DTM2-TNOW
      DATA ITHRU/0/

0005      IF (ITHRU.GT.5) GO TO 25
0006      WRITE( 6,999)
0007      FORMAT('1',///)
0008      ITHRU=10
0009      25 CONTINUE
0010      WRITE( 6,1000) TH2,DTM2,DTM2-TNOW
0011      WRITE(12,1000) TH2,DTM2,DTM2-TNOW
      FORMAT('1',F20.5)

0012      WRITE(13,1234) TNOW,TH2
0013      WRITE(14,1234) TNOW,DTM2
0014      WRITE(15,1234) TNOW,DTM2
0015      FORMAT(2F16.4)
0016      1234 FORMAT('1',F20.5)

0017      RETURN
0018      END

```

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ANGLES

FORTRAN IV G LEVEL 21

```

0001      C      SUBROUTINE ANGLES(A,B,C,BC,AC,AB)
C-----
C----- SUBROUTINE ANGLES ACCEPTS THE 3 SIDES OF ANY TRIANGLE AND
C----- THE INTERVAL ANGLES
C----- A,B,C ARE THE SIDE LENGTHS
C----- AB IS THE ANGLE BETWEEN SIDES A AND B
C----- DETERMINE THE LONGEST SIDE
C
      TEST=MAX1(A,B,C)
      IF(TEST.EQ.A) GO TO 100
      IF(TEST.EQ.B) GO TO 200
      IF(TEST.EQ.C) GO TO 300
C----- SHOULD NEVER BE HERE
C
      WRITE(6,1000)
      GO TO 100
C
100  CONTINUE
      CALL ANGL(A,B,C,BC,AC,AB)
      GO TO 400
200  CONTINUE
      CALL ANGL(B,A,C,AC,BC,AB)
      GO TO 400
300  CONTINUE
      CALL ANGL(C,A,B,AB,BC,AC)
      GO TO 400
400  CONTINUE
      TEST=ABS(AB*AC+BC-180.)
      IF(TEST.LT.1) GO TO 9000
C----- IF HERE, ALGORITHM HAS FAILED. FOR NOW DO NOTHING
C
      WRITE(6,1001)
      GO TO 9000
9000 CONTINUE
      RETURN
1000 FORMAT(' PASSED NO TESTS IN ANGLES')
1001 FORMAT(' INTERIOR ANGLES DO NOT TOTAL TO 180.')
      END

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0021
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0023
0024
0025

00010700
00010710
00010720
00010730
00010740
00010750
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00010770
00010780
00010790
00010800
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00010900
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00010930
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00010970
00010980
00010990
00011000
00011010
00011020
00011030
00011040
00011050
00011060
00011070
00011080
00011090

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ANGL

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```

0001      SUBROUTINE ANGL(A,B,C,BC,AC,AB)
C-----
C-----  CALCULATE INTERIOR ANGLES OF A TRIANGLE WHEN A IS
C-----  THE LARGEST SIDE AND A,B,C ARE KNOWN
C
      BC=ARCOS(((B*B+C*C-A*A)/2*B*C))
      AC=ARSIN(B*5IN(BC)/A)
      AB=ARSIN(C*5IN(BC)/A)
C
C
C      AB=AB*57.2957795
      AC=AC*57.2957795
      BC=BC*57.2957795
C
      RETURN
      END
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0009

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00011100
00011110
00011120
00011130
00011140
00011150
00011160
00011170
00011180
00011190
00011200
00011210
00011220
00011230
00011240
00011250
00011260

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T04

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FUNCTION TOR(X,Y)

00011270
00011280
00011290
00011300
00011310
00011320
00011330
00011340
00011350
00011360

C
C
C
C
C
C

TOR=0.0

RETURN
END

0001
0002
0003
0004

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UNIT

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0001370
0001380
0001390
0001400
0001410
0001420
0001430
0001440
0001450
0001460
0001470
0001480

FUNCTION UNIT(X)

0001

C
C
C
C
C

UNIT=1.0
IF(X.LE.0.0) UNIT=0.0

0002
0003

C
C

RETURN
END

0004
0005

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UPDATE

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```

0001      SUBROUTINE UPDATE
C
C----- ABSTRACT: SUBROUTINE UPDATE IS THE EXECUTIVE WHICH
C----- CAUSES DETERMINATION OF PART POSITIONS, VELOCITIES,
C----- ACCELERATIONS, AND FORCES FOR THE MAJOR MODELED
C----- COMPONENTS. EACH MAJOR SUB-ASSEMBLY IS UPDATED
C----- BY AN INDIVIDUAL SUBROUTINE AND A LARGE TABLE IS GENERATED
C----- IS THE TIME HISTORY AND UPDATED VALUES FOR THE COMPONENTS OF
C----- INTEREST.
C
C      DIMENSION VEC3(6), VEC4(6), VEC5(6), VEC6(6), VEC7(6)
C      COMMON/ANGLE2/TH2, DTH2, D2TH2
C      DATA ITHRU/0/
C-----
C      VARIABLE TYPE DESCRIPTION
C----- COMMON ANGLE2
C TH2 REAL ROTATION OF INPUT MOTOR GEAR (DEGREES)
C DTH2 REAL FIRST TIME DERIVATIVE OF TH2 (DEG/SEC)
C D2TH2 REAL SECOND TIME DERIVATIVE OF TH2 (DEG/SEC**2)
C
C      VEC3(1) REAL ROTATION OF THE DRUM CAM (DEG)
C      VEC3(2) REAL ANG VELOCITY OF DRUM CAM (DEG/SEC)
C      VEC3(3) REAL ANG ACC OF DRUM CAM (DEG/SEC**2)
C      VEC3(4) REAL TORQUE ACTING ON DRUM CAM
C      VEC4(1) REAL ROTATION OF THE FEED PAWL (DEG)
C      VEC4(2) REAL ANG VELOCITY OF FEED PAWL (DEG/SEC)
C      VEC4(3) REAL ANG ACC OF FEED PAWL (DEG/SEC**2)
C      VEC4(4) REAL FORCE ACCELERATING AMMO
C      VEC4(5) REAL TORQUE ACTING ON FEED ABOUT SHAFT
C      VEC4(6) REAL FORCE ACTING ON ROLLER BEARING
C      VEC5(1) REAL ROTATION OF THE EJECT PAWL (DEG)
C      VEC5(2) REAL ANG VELOCITY OF EJECT PAWL (DEG/SEC)
C      VEC5(3) REAL ANG ACC OF EJECT PAWL (DEG/SEC**2)
C      VEC5(4) REAL TORQUE ACTING ON EJECT ABOUT SHAFT
C      VEC5(5) REAL FORCE ACTING ON ROLLER BEARING
C      VEC6(1) REAL ROTATION OF THE LOCK CAM (DEG)
C      VEC6(2) REAL ANG VELOCITY OF LOCK CAM (DEG/SEC)
C      VEC6(3) REAL ANG ACC OF LOCK CAM (DEG/SEC**2)
C      VEC6(4) REAL TORQUE ACTING ON LOCK CAM
C      VEC6(5) REAL FORCE ON THE ACTUATOR GEAR SET
C      VEC6(6) REAL
C
C      CONTINUE
C      VEC7(1) REAL DISPLACEMENT OF THE CHAMBER (IN)
C      VEC7(2) REAL VELOCITY OF CHAMBER (IN/SEC)
C      VEC7(3) REAL ACC OF CHAMBER (IN/SEC**2)
C      VEC7(4) REAL CRJSH FORCE EXERTED BY ROUND (LBS)
C      VEC7(5) REAL SEAM FORCE DUE RE-SEARING (LBS)
C      VEC7(6) REAL FORCE ON THE CHAMBER TO DRUM CAM STUD (LBS)
C-----
C----- FILL OUT POSSIBLE UNUSED VECTOR LOCATIONS
C-----
0002
0003
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0005

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UPDATE

FORTRAN IV 6 LEVEL 21

```

0006      C
0007      IF (ITHRU.GT.5) GO TO 200
0008      DO 100 J=5,6
0009      VEC3(J)=99999.9
0010      VEC4(J)=99999.9
0011      VEC5(J)=99999.9
0012      VEC6(J)=99999.9
0013      VEC7(J)=99999.9
0014      CONTINUE
0015      100 ITHRU=10
0016      CONTINUE
0017      CALL UPDT3(TH2,DTM2,D2TM2,VEC3)
0018      CALL UPDT4(TH2,DTM2,D2TM2,VEC4)
0019      CALL UPDT5(TH2,DTM2,D2TM2,VEC5)
0020      CALL UPDT6(TH2,DTM2,D2TM2,VEC6)
0021      CALL UPDT7(TH2,DTM2,D2TM2,VEC7)
0022      C
0023      C----- GENERATE THE OUTPUT TABLE
0024      CALL TBLOUT(1,VEC2,VEC3,VEC4,VEC5,VEC6,VEC7,TH2,DTM2,D2TM2)
0025      C
0026      RETURN
0027      END

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00012020
00012030
00012040
00012050
00012060
00012070
00012080
00012090
00012100
00012110
00012120
00012130
00012140
00012150
00012160
00012170
00012180
00012190
00012200
00012210
00012220
00012230
00012240
00012250
00012260

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0001      SUBROUTINE UPDT4(TH2,DTH2,D2TH2,VFC)
0002      C----- ABSTRACT: UPDT4 UPDATES SOME OF THE FEED PARAMETERS
0003      C----- THE PARAMETERS ARE SHOWN IN THE VARIABLE LIST.
0004      C----- DIMENSION VEC(1)
0005      COMMON/UPDT4/TH4,DTH4,D2TH4
0006      REAL IPAWL/.00032958/,IROCK/.0000724/,ISHFT/.000018647/
      REAL HAMMO/.04255/,RE/.166667/,PE/.3000/
      DATA DG2RAD/.0174533/

      C-----
      C VARIABLE TYPE DESCRIPTION
      C-----
      C----- COMMON UPDT4
      C TH4 REAL ROTATION OF FEED PAWL (DEG)
      C DTH4 REAL DERIVATIVE WRT T2 OF TH4
      C D2TH4 REAL SECOND DER WRT T2 OF TH4

      C TH2 REAL ROTATION OF INPUT MOTOR GEAR (DEGREES)
      C DTH2 REAL FIRST TIME DERIVATIVE OF TH2 (DEG/SEC)
      C D2TH2 REAL SECOND TIME DERIVATIVE OF TH2 (DEG/SEC**2)
      C VEC(1) REAL ROTATION OF THE FEED PAWL (DEG)
      C (2) REAL ANG VELOCITY OF FEED PAWL (DEG/SEC)
      C (3) REAL ANG ACC OF FEED PAWL (DEG/SEC**2)
      C (4) REAL FORCE ACCELERATING AMMO
      C (5) REAL TORQUE ACTING ON FEED ABOUT SHAFT
      C (6) REAL FORCE ACTING ON ROLLER BEARING
      C ISHFT REAL INERTIA MOMENT OF FEED SHAFT (FT-LB-SEC**2)
      C IROCK REAL INERTIA MOMENT OF ROCKER PAWL (FT-LB-SEC**2)
      C IPAWL REAL INERTIA MOMENT OF FEED PAWL (FT-LB-SEC**2)
      C AMMO REAL MASS OF THE AMMO ROUND (LB-SEC**2/FT)
      C MRGCK REAL MASS OF THE ROCKER ARM (LB-SEC**2/FT)
      C MPAWL REAL MASS OF THE FEED PAWL (LB-SEC**2/FT)
      C PE REAL LENGTH TO ROCKER END (FT)
      C DTH2 REAL LENGTH TO PAWL END (FT)
      C DG2RAD REAL CONVERTS DEGREES TO RADIANS
      C IDRUM REAL INERTIA MOMENT OF DRUM CAM (FT-LB-SEC**2)
      C IFACE REAL INERTIA MOMENT OF THE FACE CAM (FT-LB-SEC**2)

      C ITOTAL REAL SUM OF FACE AND DRUM MOMENTS OF INERTIA (FT-LB-SEC**2)

      C-----
      C----- OBTAIN THE VEC PARAMETERS
      C-----
      VEC(1)=TH4
      VEC(2)=DTH4*DTH2
      VEC(3)=DTH4*D2TH2 + D2TH4*(DTH2**2)
      VEC(4)=VEC(3)*DG2RAD*PE*HAMMO*UNIT(-DTH4)
      VEC(5)=VEC(4)*PE + ITOTAL*VEC(3)*DG2RAD
      VEC(6)=VEC(5)/RE
      RETURN
      END

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[illegible]


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0001 SUBROUTINE UPDT7(TH2,DTH2,D02TH2,VFC)
C----- ABSTRACT: SUBROUTINE UPDT7 UPDATES SOME OF THE CHAMBER
C----- PARAMETERS. THE PARAMETERS ARE SHOWN IN THE
C----- VARIABLE LIST.
C
C DIMENSION VEC(1)
COMMON/UPDT7/R7,DR7,D2R7
C-----
C VARIABLE TYPE DESCRIPTION
C-----
C----- COMMON UPDT7
C R7 REAL DISPLACEMENT OF CHAMBER (IN)
C DR7 REAL DERIVATIVE WRT TH2 OF R7
C D2R7 REAL SECOND DER WRT TH2 OF R7
C
C CRUSH REAL CRUSH FORCE EXERTED BY ROUND (LBS)
C MBOLT REAL WEIGHT OF THE BOLT ASSY (LBS)
C VMASS REAL THE ACTUAL TRANSLATING MASS
C RESEAR REAL SEAR FORCE DUE TO RE-SEARING (LBS)
C TH2 REAL ROTATION OF INPUT MOTOR GEAR (DEGREES)
C DTH2 REAL FIRST TIME DERIVATIVE OF TH2 (DEG/SEC)
C D2TH2 REAL SECOND TIME DERIVATIVE OF TH2 (DEG/SEC**2)
C VEC(1) REAL DISPLACEMENT OF THE CHAMBER (IN)
C (2) REAL VELOCITY OF CHAMBER(IN/SEC)
C (3) REAL ACC OF CHAMBER(IN/SEC**2)
C (4) REAL CRUSH FORCE EXERTED BY ROUND (LBS)
C (5) REAL SEAR FORCE DUE TO RE-SEARING (LBS)
C (6) REAL FORCE ON THE CHAMBER TO DRUM CAM STUD (LBS)
C D02RAD REAL CONVERTS DEGREES TO RADIANS
C ROUND REAL NOMINAL UNCUSHED LENGTH OF THE ROUND
C-----
C CONTINUE
C HDSP REAL NOMINAL HEADSPACE OF THE WEAPON (FT)
C CRATE REAL CRUSH SPRING RATE (LBS/FT)
C SPRATE REAL SEAR SPRING RATE (LBS/FT)
C SPRE REAL SEAR SPRING PRELOAD (LBS)
C-----
C----- OBTAIN VEC PARAMETERS
C-----
C VEC(1)=R7*12.0
C VEC(2)=DR7*DTH2*12.0
C VEC(3)=DR7*D2TH2 + D2R7*(DTH2**2)
C-----
C----- GET ALL THE CURRENT CHAMBER INFORMATION
C-----
C CALL CHAMBR(CRUSH,RESEAR,VMASS)
C VEC(4)=CRUSH
C VEC(5)=RESEAR
C VEC(6)=VEC(3)*VMASS
C VEC(3)=VEC(3)*12.0
C-----
C RETURN
C END
0004
0005
0006
0007
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0010
0011
0012
0013
0014
000142220
000142300
000142400
000142500
000142600
000142700
000142800
000142900
000143000
000143100
000143200
000143300
000143400
000143500
000143600
000143700
000143800
000143900
000144000
000144100
000144200
000144300
000144400
000144500
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000146500
000146600
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000147400

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CHAMBR

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0001 SUBROUTINE CHAMBR(CRUSH,RESEAR,VMASS) 00014750
C----- ABSTRACT: SUBROUTINE CHAMBR DETERMINES THE POSITION OF THE 00014760
C----- CHAMBER AND CALCULATES THE CRUSH UP AND RESEARING FORCES 00014770
C----- THAT MIGHT BE ACTING ON THE CHAMBER. THE ACTUAL TRANSLATING 00014780
C----- MASS IS ALSO DETERMINED. 00014790
C----- 00014800
C COMMON/UPDTET/R7,DR7,D2R7 00014810
C COMMOV/UPDTET/TH3,DT3,D2TH3 00014820
C REAL MCHMBR/.6211,MBOLT/.2795/ 00014830
C DATA CRATE/280800./,SRATE/84.0/,SPRE/33.0/ 00014840
C DATA ROUND/.52625/,HDSP/.52417/ 00014850
C 00014860
C 00014870
C 00014880
C 10 CONTINUE 00014890
C 00014900
C----- CRUSHUP ON ROUND OCCURS ONLY WHEN TH3 IS -NOT- IN 33-250 00014910
C----- DEGREE RANGE OF DRUM CAM ROTATION. 00014920
C 00014930
C IF (TH3.GT.33. .AND. TH3.LT.250.) GO TO 100 00014940
C CRUSH=(ROUND-(R7+HDSP))*CRATE 00014950
C GO TO 200 00014960
C 100 CONTINUE 00014970
C 00014980
C CRUSH=0.0 00014990
C 200 CONTINUE 00015000
C 00015010
C----- RE-SEAR FORCE WILL ONLY OCCUR WHEN TH3 -IS- IN THE 00015020
C----- 150-250 DEGREE PORTION OF DRUM CAM ROTATION. 00015030
C 00015040
C IF (.NOT. (TH3.GT.150. .AND. TH3.LT.250.)) GO TO 300 00015050
C 00015060
C----- RE-SEARING OCCURS ONLY DURING THE LAST INCH OF CHAMBER 00015070
C----- MOTION, FROM R7=6.6 TO R7=7.6, .550 TO .633333 FT 00015080
C 00015090
C IF (R7.LT..550) GO TO 300 00015100
C RESEAR=SPRE*SRATE*(R7-.550) 00015110
C GO TO 400 00015120
C 300 CONTINUE 00015130
C RESEAR=0.0 00015140
C 400 CONTINUE 00015150
C 00015160
C----- NOW DETERMINE THE VIRTUAL MASS OF THE TRANSLATING CHAMBER. 00015170
C----- THE BOLT ONLY TRAVELS ABOUT 1/2 INCH WITH THE CHAMBER 00015180
C----- WHEN R7 IS LESS THAN .5 INCH, .0417 FT 00015190
C 00015200
C IF (R7.GT..0417) GO TO 500 00015210
C VMASS=MCHMBR*MBOLT 00015220
C GO TO 600 00015230
C 500 CONTINUE 00015240
C VMASS=MCHMBR 00015250
C 600 CONTINUE 00015260
C RETURN 00015270
C END

```

```

0001 SUBROUTINE TBLOUT(IVAL,VEC2,VEC3,VEC4,VFC5,VEC6,VEC7,TH2,DTH2,
1 D2TH2)
C
C
C
0002 DIMENSION VEC2(1),VEC3(1),VEC4(1),VEC5(1),VEC6(1),VEC7(1)
0003 DIMENSION V3(300,6),V4(300,6),V5(300,6),V6(300,6),V7(300,6)
0004 REAL TIME(300),ROT(300),J2MT(300)
0005 COMMON/TIMES/TINT1,TFINAL,TNO,J2J1,ISTEP,NEXT
0006 DATA J2/J2/
C
C-----
C VARIABLE TYPE DESCRIPTION
C IVAL INTEGER IVAL,5 THEN ADD TO TABLE,GT.5 THEN OUTPUT TABLE
C TH2 REAL ROTATION OF INPUT MOTOR GEAR (DEGREES)
C DTH2 REAL FIRST TIME DERIVATIVE OF TH2 (DEG/SEC)
C D2TH2 REAL SECOND TIME DERIVATIVE OF TH2 (DEG/SEC**2)
C 3(2) REAL ANG VELOCITY OF DRUM CAM (DEG/SEC)
C 3(3) REAL ANG ACC OF DRUM CAM (DEG/SEC**2)
C 3(4) REAL TORQUE ACTING ON DRUM CAM (FT-LBS)
C VEC4(1) REAL ROTATION OF THE FEED PAWL (DEG)
C 4(2) REAL ANG VELOCITY OF FEED PAWL (DEG/SEC)
C 4(3) REAL ANG ACC OF FEED PAWL (DEG/SEC**2)
C 4(4) REAL FORCE ACCELERATING AWMO
C 4(5) REAL TORQUE ACTING ON FEED ABOUT SHAFT
C 4(6) REAL FORCE ACTING ON ROLLER BEARING
C VEC5(1) REAL ROTATION OF THE EJECT PAWL (DEG)
C 5(2) REAL ANG VELOCITY OF EJECT PAWL (DEG/SEC)
C 5(3) REAL ANG ACC OF EJECT PAWL (DEG/SEC**2)
C 5(4) REAL TORQUE ACTING ON EJECT ABOUT SHAFT
C 5(5) REAL TORQUE ACTING ON ROLLER BEARING
C VEC6(1) REAL ROTATION OF THE LOCK CAM (DEG)
C 6(2) REAL ANG VELOCITY OF LOCK CAM (DEG/SEC)
C 6(3) REAL ANG ACC OF LOCK CAM (DEG/SEC**2)
C 6(4) REAL TORQUE ACTING ON LOCK CAM
C 6(5) REAL FORCE ON THE ACTUATOR GEAR SET
C CONTINUE
C VEC7(1) REAL DISPLACEMENT OF THE CHAMBER (IN)
C 7(2) REAL VELOCITY OF CHAMBER (IN/SEC)
C 7(3) REAL ACC OF CHAMBER (IN/SEC**2)
C 7(4) REAL CRUSH FORCE EXERTED BY ROJUN (LBS)
C 7(5) REAL SEAR FORCE DUE TO SEARINGS (LBS)
C 7(6) REAL FORCE ON THE CHAMBER TO DRUM CAM STUD (LBS)
C-----
C
C IF IFINAL.GT.10) GO TO 200
C J=J+1
C DO 100 M=1,6
0007 V3(J,M)=VEC3(M)
0008 V4(J,M)=VEC4(M)
0009 V5(J,M)=VEC5(M)
0010 V6(J,M)=VEC6(M)
0011 V7(J,M)=VEC7(M)
0012
0013
0014

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TBLOUT

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0015      V7(J,M)=VEC7(M)
0016      CONTINUE
0017      TIME(J)=NOW
0018      MOT(J)=TH2
0019      DMOT(J)=DMT2
0020      DMCL(J)=DMT42

C----- IS TABLE COMPLETE? IF NOT, THEN RETURN
C
C----- IF (IVAL.LT.5) RETURN
C
C----- CONTINUE
200 CONTINUE
C----- IF HERE, OUTPUT THE TABLE
C----- DRUM CAM
C
C----- WRITE(6,1000)
C----- DO 300 I=1,J
C----- WRITE(6,1001) I,TIME(I),MOT(I),V3(I,1),V3(I,2),V3(I,3),V3(I,4)
300 CONTINUE
C----- FEED MECHANISM
C----- WRITE(6,1000)
C----- WRITE(6,1003)
C----- DO 400 I=1,J
C----- WRITE(6,1001) I,TIME(I),MOT(I),V4(I,1),V4(I,2),V4(I,3),
C----- V4(I,4),V4(I,5),V4(I,6)
400 CONTINUE
C----- EJECT MECHANISM
C----- WRITE(6,1000)
C----- WRITE(6,1003)
C----- DO 500 I=1,J
C----- WRITE(6,1001) I,TIME(I),MOT(I),V5(I,1),V5(I,2),V5(I,3),
C----- V5(I,4),V5(I,5)
500 CONTINUE
C----- LOCK CAM
C----- WRITE(6,1000)
C----- WRITE(6,1003)
C----- DO 600 I=1,J
C----- WRITE(6,1001) I,TIME(I),MOT(I),V6(I,1),V6(I,2),V6(I,3),
C----- V6(I,4),V6(I,5)
600 CONTINUE
C----- CHAMBER ASSEMBLY
C----- WRITE(6,1000)

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TBLOUT

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0044 WRITE(6,7003)
0045 DO 700 I=1,J
0046 WRITE(6,1001) I,TIME(I),MOT(I),V7(I,1),V7(I,2),V7(I,3),
0047 V7(I,4),V7(I,5),V7(I,6)
0048 2 CONTINUE
0049 700 C
0050 1000 FORMAT(11)
0051 1001 FORMAT(11,14,8F16.5)
0052 3003 FORMAT(11,DRUM CAM (DC) PARAMETERS,/,
0053 2 8X,TIME (SEC) MOTOR (DEG) DC ROTATION,5X,
0054 3 DC VELOCITY DC ACCELERATION DC TORQUE,/,41X,
0055 4 (DEG),9X,(DEG/SEC),7X,(DEG/SEC**2) (FT-LBS),/,
0056 4003 FORMAT(11,FEED MECHANISM (FM) PARAMETERS,/,
0057 2 8X,TIME (SEC) MOTOR (DEG) FM ROTATION,5X,
0058 3 FM VELOCITY FM ACCELERATION SHAFT TORQUE,6X,
0059 4 CAM FORCE FORCE ON ARM,/,41X,
0060 5 (DEG),9X,(DEG/SEC),7X,(DEG/SEC**2) (FT-LBS),9X,
0061 6 (LBS),11X,(LBS),/,
0062 5003 FORMAT(11,EJECT MECHANISM (EM) PARAMETERS,/,
0063 2 8X,TIME (SEC) MOTOR (DEG) EM ROTATION,5X,
0064 3 EM VELOCITY EM ACCELERATION SHAFT TORQUE,6X,
0065 4 CAM FORCE ,/,41X,
0066 5 (DEG),9X,(DEG/SEC),7X,(DEG/SEC**2) (FT-LBS),9X,
0067 6 (LBS),/,
0068 6003 FORMAT(11,LOCK MECHANISM (LM) PARAMETERS,/,
0069 2 8X,TIME (SEC) MOTOR (DEG) LM ROTATION,5X,
0070 3 LM VELOCITY L4 ACCELERATION LOCK TORQUE,6X,
0071 4 GEAR FORCE ,/,41X,
0072 5 (DEG),9X,(DEG/SEC),7X,(DEG/SEC**2) (FT-LBS),9X,
0073 6 (LBS),/,
0074 7003 FORMAT(11,CHAMBER ASSEMBLY (CA) PARAMETERS,/,
0075 2 8X,TIME (SEC) MOTOR (DEG) CA DISPL ,5X,
0076 3 CA VELOCITY CA ACCELERATION CRJSH FORCE,4X,
0077 4 RESEAR FORCE STUD FORCE,/,41X,
0078 5 (DEG),9X,(DEG/SEC),7X,(DEG/SEC**2) (FT-LBS),9X,
0079 6 (LBS),11X,(LBS),/,
0080 RETURN
0081 END

```

```

0001      SUBROUTINE INTERP(XV,YV,NPTS,X,YINTER,DYDX,D2YDX2,ISM,IWRAP)
C-----
C----- ABSTRACT: SUBROUTINE INTERP SEARCHES THE
C----- XV AND YV VECTORS AND EXTRAPOLATES
C----- LOCAL DATA POINTS. THESE ARE PASSED TO
C----- THE POLATE ROUTINE THAT FITS A 5TH
C----- DEGREE POLYNOMIAL TO THEM.
C
C      DIMENSION XV(1),YV(1),XPOLY(6),YPOLY(6),COEFF(6)
C      REAL OFFSET
C
C----- DETERMINE STEP SIZE BETWEEN ADJACENT X(I)
C----- THEN ESTABLISH THE "LOCAL" REGION IN ARRAYS
C
      IF(NPTS.LT. 6) RETURN
      N=5
      N=6
      XVAL=X
      STEP=XV(2)-XV(1)
      NSTEP=IFIX(XVAL/STEP*.5)
      IF(.NOT.(NSTEP.LT.5)) GO TO 20
      NSTEP=4
      OFFSET=0.0
      GO TO 50
20      CONTINUE
      IF(.NOT.((NPTS-2).LI.NSTEP)) GO TO 40
      NSTEP=NPTS-2
      OFFSET=XV(NSTEP-4)
      GO TO 50
40      CONTINUE
      OFFSET=XV(NSTEP-4)
50      CONTINUE
C----- SET UP THE 6 ELEMENT ARRAYS TO BE FIT
C
      DO 100 J=1,6
        JVAL=NSTEP-4+J
        XPOLY(J)=XV(JVAL)-OFFSET
        YPOLY(J)=YV(JVAL)
100      CONTINUE
        XVAL=XVAL-OFFSET
C----- ARRAYS ARE NOW TO BE FIT
C
      CALL POLATE(XPOLY,YPOLY,COEFF)
C----- EVALUATE POLY FOR 0.1,2 DERIVATIVES
C----- AT VALUE XVAL BASED ON ISM
C
      Z=COEFF(6)
      DO 200 J=1,5

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FORTRAN IV 6 LEVEL 21 INTERP

```

0031      I=5-J
0032      PEP=XVAL+COEFF(I+1)
0033      200 CONTINUE
0034      C IF(15*LE-1) GO TO 9999
0035      DO 300 J=1,5
0036      COEFF(J)=J*COEFF(J+1)
0037      300 CONTINUE
0038      DP=COEFF(15)
0039      DO 400 J=1,4
0040      I=4-J
0041      DP=DP*XVAL+COEFF(I+1)
0042      400 CONTINUE
0043      DO 500 J=1,4
0044      COEFF(J)=J*COEFF(J+1)
0045      500 CONTINUE
0046      DP=COEFF(4)
0047      DO 600 J=1,3
0048      I=3-J
0049      DP=DP*XVAL+COEFF(I+1)
0050      600 CONTINUE
0051      CYDX=DP
0052      D2Y=X2=D2P
0053      9999 CONTINUE
0054      C YINTER=P
0055      RETURN
0056      END

```

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POLA:Z

FORTRAN IV G LEVEL 21

```

0001      SUBROUTINE POLATE(XV,YV,COEFF)
C----- ABSTRACT: SUBROUTINE POLATE PERFORMS A
C----- POLYNOMIAL REGRESSION ON THE
C----- DATA POINTS IN VECTORS XV,YV AND
C----- RETURNS A COEFFICIENT VECTOR. THE
C----- DEGREE OF THE POLY WILL BE 5.
C
0002      DIMENSION XV(1),YV(1),COEFF(1)
0003      DIMENSION FIT(36),FITINV(36),DCOEFF(6),DYPOLY(6)
0004      DOUBLE PRECISION FIT,FITINV,DCOEFF,DYPOLY
C
C----- INITIALIZE FIT MATRIX FOR CURVE FITTING
C
      DO 100 I=1,6
        FIT(I)=1.
        FIT(I,6)=XV(I)
        FIT(I,12)=XV(I)**2
        FIT(I,18)=XV(I)**3
        FIT(I,24)=XV(I)**4
        FIT(I,30)=XV(I)**5
        DYPOLY(I)=YV(I)
      100 CONTINUE
C
      ZERO THE INVERSE MATRIX THEN MAKE IT IDENTITY
C
      DO 200 I=2,35
        FITINV(I)=0.0
      200 CONTINUE
C
        FITINV(1)=1.
        FITINV(8)=1.
        FITINV(15)=1.
        FITINV(22)=1.
        FITINV(29)=1.
        FITINV(36)=1.
C
C----- INVERT THE FIT MATRIX USING GELG
C
      CALL CGELG(FITINV,FIT,6,6,1,E-07,ERR)
C
C----- DETERMINE THE POLY COEFFICIENTS
C
      CALL DGMPRD(FITINV,DYPOLY,DCOEFF,6,6,1)
C
C----- TRANSPOSE DOUBLE PRECISION COEFF TO SINGLE
C
      DO 300 I=1,6
        COEFF(I)=DCOEFF(I)
      300 CONTINUE
      RETURN
      END

```

00017620

00017630

00017640

00017650

00017660

00017670

00017680

00017690

00017700

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00017720

00017730

00017740

00017750

00017760

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00017780

00017790

00017800

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00017910

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00017960

00017970

00017980

00017990

00018000

00018010

00018020

00018030

00018040

00018050

00018060

00018070

00018080

00018090

00018100

00018110

00018120

00018130

00018140

```

0001      C      SUBROUTINE GMPRO(A,B,R,N,M,L)
0002      C      PUNCH
0003      C      MULTIPLY TWO GENERAL MATRICES TO FORM A RESULTANT GENERAL
0004      C      MATRIX
0005      C      USAGE
0006      C      CALL GMPRO(A,B,R,N,M,L)
0007      C
0008      C      DESCRIPTION OF PARAMETERS
0009      C      A - NAME OF FIRST INPUT MATRIX
0010      C      B - NAME OF SECOND INPUT MATRIX
0011      C      R - NAME OF OUTPUT MATRIX
0012      C      N - NUMBER OF ROWS IN A
0013      C      M - NUMBER OF COLUMNS IN A AND ROWS IN B
0014      C      L - NUMBER OF COLUMNS IN B
0015      C
0016      C      REMARKS
0017      C      ALL MATRICES MUST BE STORED AS GENERAL MATRICES
0018      C      MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX A
0019      C      MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX B
0020      C      NUMBER OF COLUMNS OF MATRIX A MUST BE EQUAL TO NUMBER OF
0021      C      ROWS OF MATRIX B
0022      C
0023      C      SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
0024      C      NONE
0025      C
0026      C      METHOD
0027      C      THE M BY L MATRIX B IS PREMULTIPLIED BY THE N BY M MATRIX A
0028      C      AND THE RESULT IS STORED IN THE N BY L MATRIX R.
0029      C
0030      C      .....
0031      C      SUBROUTINE GMPRO(A,B,R,N,M,L)
0032      C
0033      C      IMPLICIT REAL*8 (A-H,O-Z)
0034      C      DIMENSION A(1),B(1),R(1)
0035      C
0036      C      IR=0
0037      C      IK=-M
0038      C      DO 10 K=1,L
0039      C      IK=IK+M
0040      C      DO 10 J=1,N
0041      C      IR=IR+1
0042      C      JI=J-N
0043      C      IS=IK
0044      C      R(IR)=0
0045      C      DO 10 I=1,M
0046      C      JI=JI+M
0047      C      IS=IS+1
0048      C      10 R(IR)=R(IR)+A(JI)*B(IS)
0049      C      RETURN
0050      C      END

```

```

0001 SUBROUTINE DGMPRD(A,B,R,N,M,L)
0002 C
0003 C
0004 C
0005 C
0006 C
0007 C
0008 C
0009 C
0010 C
0011 C
0012 C
0013 C
0014 C
0015 C
0016 C
0017 C
0018 C
0019 C
0020 C
0021 C

PURPOSE
MULTIPLY TWO GENERAL MATRICES TO FORM A RESULTANT GENERAL
MATRIX

USAGE
CALL DGMPRD(A,B,R,N,M,L)

DESCRIPTION OF PARAMETERS
A - NAME OF FIRST INPUT MATRIX
B - NAME OF SECOND INPUT MATRIX
R - NAME OF OUTPUT MATRIX
N - NUMBER OF ROWS IN A
M - NUMBER OF COLUMNS IN A AND ROWS IN B
L - NUMBER OF COLUMNS IN B

REMARKS
ALL MATRICES MUST BE STORED AS GENERAL MATRICES
MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX A
MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX B
NUMBER OF COLUMNS OF MATRIX A MUST BE EQUAL TO NUMBER OF ROWS OF MATRIX B
OF MATRIX B

SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
NONE

METHOD
THE M BY L MATRIX B IS PREMULTIPLIED BY THE N BY M MATRIX A
AND THE RESULT IS STORED IN THE N BY L MATRIX R.
.....
SUBROUTINE DGMPRD(A,B,R,N,M,L)

IMPLICIT REAL*8 (A-H,O-Z)
DIMENSION A(1),B(1),R(1)
IR=0
IK=-M
DO 10 K=1,L
IK=IK+M
DO 20 J=1,N
IR=IR+1
JI=J-N
IB=IK
R(JR)=0.D+00
DO 30 I=1,M
JI=JI+N
IB=IB+1
R(JR)=R(JR)+A(JI)*B(IB)
CONTINUE
CONTINUE
CONTINUE
RETURN
END

```

```
C C C SUBROUTINE DSSELG(R,A,M,N,EPS,IER)C C C PURPOSEC C C TO SOLVE A GENERAL SYSTEM OF SIMULTANEOUS LINEAR EQUATIONS.C C C USAGEC C C CALL DSSELG(R,A,M,N,EPS,IER)C C C DESCRIPTION OF PARAMETERSC C R - DOUBLE PRECISION M BY N RIGHT HAND SIDE MATRIXC C (DESTROYED). ON RETURN R CONTAINS THE SOLUTIONSOF THE EQUATIONS.C C A - DOUBLE PRECISION M BY M COEFFICIENT MATRXC C (DESTROYED).C C M - THE NUMBER OF EQUATIONS IN THE SYSTEM.C C N - THE NUMBER OF RIGHT HAND SIDE VECTORS.C C EPS - SINGLE PRECISION INPUT CONSTANT WHICH IS USED ASRELATIVE TOLERANCE FOR TEST ON LOSS OFSIGNIFICANCE.C C IER - RESULTING ERROR PARAMETER CODED AS FOLLOWS:  
IER=0 - NO ERROR,  
IER=-1 - NO RESULT BECAUSE OF M LESS THAN 1 ORPIVOT ELEMENT AT ANY ELIMINATION STEP  
EQUAL TO 0.  
IER=M - WARNING DUE TO POSSIBLE LOSS OF SIGNIFI-  
CANCE INDICATED AT ELIMINATION STEP K+1,  
WHERE PIVOT ELEMENT WAS LESS THAN OR  
EQUAL TO THE INTERNAL TOLERANCE EPS TIMES  
ABSOLUTELY GREATEST ELEMENT OF MATRIX A.  
  
REMARKSC C INPUT MATRICES R AND A ARE ASSUMED TO BE STORED COLUMNWISEIN MEN RESP. MEM SUCCESSIVE STORAGE LOCATIONS. ON RETURN  
SOLUTION MATRIX X IS STORED COLUMNWISE TOO.  
THE PROCEDURE GIVES RESULTS IF THE NUMBER OF EQUATIONS M ISGREATER THAN 0 AND PIVOT ELEMENTS AT ALL ELIMINATION STEPSARE DIFFERENT FROM 0. HOWEVER WARNING IER=M - IF GIVEN =INDICATES POSSIBLE LOSS OF SIGNIFICANCE. IN CASE OF A WELL  
SCALED MATRIX A AND APPROPRIATE TOLERANCE EPS, IER=M MAY BEINTERPRETED THAT MATRIX A HAS THE RANK K. NO WARNING IS  
GIVEN IN CASE M=1.  
  
SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED  
NONE  
  
RETURN  
C C C SOLUTION IS DONE BY MEANS OF GAUSS-ELIMINATION WITHCOMPLETE PIVOTING.  
C C C .....DSSELG(4,A,M,N,EPS,IEF)  
C C C SUBROUTINE DSSELG(4,A,M,N,EPS,IEF)
```

```

C
0002 DIMENSION A(I),R(I)
0003 DOUBLE PRECISION R,A,PIV,TB,IOL,PIV1
0004 IF(I*23,23,1)

C
0005 SEARCH FOR GREATEST ELEMENT IN MATRIX A
1 IER=0
  PIV=0.00
  NM=NM+1
  NM=N*M
  DO 3 L=1,M
    TB=DABS(A(L))
    IF(TB-PIV)3,3,2
2 PIV=TB
  I=L
3 CONTINUE
  IOL=EPS*PIV
  A(I) IS PIVOT ELEMENT. PIV CONTAINS THE ABSOLUTE VALUE OF A(I).

C
0016
0017

C
0018 TEST ON SINGULARITY
  IF(PIV)23,23,4
  IF(ITER)7,5,7
5 IF(PIV-TOL)6,6,7
6 IER=K-1
7 PIV=1.00/A(I)
  J=(I-1)/4
  I=J*M-K
  J=J+1-K
  I+K IS ROW-INDEX, J+K COLUMN-INDEX OF PIVOT ELEMENT

C
0026 PIVOT ROW REDUCTION AND ROW INTERCHANGE IN RIGHT-HAND SIDE R
  DO 8 L=K,N,M+1
    LL=L+1
    TB=PIV*T*(LL)
    R(LL)=R(LL)
8 R(LL)=TB

C
0031 IS ELIMINATION TERMINATED
  IF(K-M)9,18,18

C
0032 COLUMN INTERCHANGE IN MATRIX A
  LEND=LST+M-K
  IF(J)12,12,10
10 II=J*M
  DO 11 L=LST+LEND
    TB=A(L)
    LL=L+11
    A(L)=A(LL)
0038
0039

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06ELG

FORTRAN IV G LEVEL 21

```

0039      11 A(LL)=TB
0040      C
0041      C ROW INTERCHANGE AND PIVOT ROW REDUCTION IN MATRIX A
0042      12 DO 13 L=1,MM,M
0043      LL=L+1
0044      TB=PIV1*A(LL)
0045      A(LL)=A(L)
0046      13 A(L)=TB
0047      C
0048      C SAVE COLUMN INTERCHANGE INFORMATION
0049      A(LST)=J
0050      C
0051      C ELEMENT REDUCTION AND NEXT PIVOT SEARCH
0052      PIV=0.00
0053      LST=LST+1
0054      J=0
0055      DO 16 I=LST,LEND
0056      PIV=A(I,I)
0057      IS=I+M
0058      J=J+1
0059      DO 15 L=IST,MM,M
0060      LL=L-J
0061      A(L)=A(L)+PIV*A(LL)
0062      TB=DABS(A(LL))
0063      IF(TB-PIV)15,15,14
0064      14 PIV=TB
0065      I=L
0066      15 CONTINUE
0067      DO 16 L=K,MM,M
0068      LL=L-J
0069      R(LL)=R(LL)+PIV*R(L)
0070      17 LST=LST+M
0071      END OF ELIMINATION LOOP
0072      C
0073      C BACK SUBSTITUTION AND BACK INTERCHANGE
0074      18 IF(M-1)23,22,19
0075      19 IST=MM+M
0076      LST=M+1
0077      DO 21 I=2,M
0078      II=LST-I
0079      IST=IST-LST
0080      L=IST-M
0081      L=A(LL)+.500
0082      DO 21 J=1,MM,M
0083      TB=R(IJ)
0084      LL=J
0085      DO 20 K=IST,MM,M
0086      LL=LL+1
0087      TB=TB-A(K)*R(LL)
0088      K=J+L
0089      R(J)=R(K)
0090      21 R(K)=TB

```

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06ELG

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```
0082      C      22 RETURN
          C
          C      ERROR RETURN
0083      23 IER=-1
0084      RETURN
0085      END
```

```
00020950
00020960
00020970
00020980
00020990
00021000
00021010
```

$\Theta_z(\text{DEG})$	$\dot{\Theta}_z(\text{D/S})$	$\ddot{\Theta}_z(\text{D/S}^2)$	TIME (SEC)
0.0	0.0	59096.7617	0.0
2.95483	590.96704	59096.7617	0.01000
11.81933	1181.93335	59096.7617	0.02000
26.59344	1772.89795	59096.7148	0.03000
47.27733	2362.58423	58730.9687	0.04000
73.82103	2945.10229	57901.1680	0.05000
106.15965	3520.11572	56920.0703	0.06000
144.19530	4083.24780	55615.5430	0.07000
187.77628	4631.78125	54075.6992	0.08000
235.77397	5181.73928	51502.6211	0.09000
291.69507	5743.07812	51495.2461	0.10000
366.80444	6386.75000	48803.3750	0.11250
450.43066	6982.94141	46810.2695	0.12500
522.57178	7443.44531	45264.7539	0.13500
634.27368	8102.93359	42436.7109	0.15000
722.36401	8523.12500	42221.6641	0.16000
809.78125	8941.42969	40695.0625	0.17000
901.08569	9335.79297	38505.7852	0.18000
996.39502	9710.42187	36218.4883	0.19000
1095.25439	10063.9648	34760.6867	0.20000
1197.64966	10404.8594	33254.5547	0.21000
1303.29712	10729.55596	31715.9180	0.22000
1412.15550	11039.6329	30062.2422	0.23000
1524.01587	11331.4238	28572.3477	0.24000
1638.74756	11609.9102	27102.1055	0.25000
1756.16821	11873.7031	25576.8203	0.26000
1876.16943	12123.6094	24316.6719	0.27000
1998.59619	12359.6523	22959.0508	0.28000
2123.30615	12581.0898	21469.0039	0.29000
2250.17261	12789.5234	20261.5820	0.30000
2379.06226	12985.0039	18993.6055	0.31000
2509.84375	13169.7930	17902.5508	0.32000
2642.41748	13341.7461	16561.7617	0.33000
2776.63525	13501.8203	15526.0898	0.34000
2912.42310	13651.9844	14470.9336	0.35000
3049.63867	13791.7500	13525.4414	0.36000
3188.22461	13922.6445	12660.8203	0.37000
3328.05543	14044.9414	11791.6133	0.38000
3469.09911	14159.6992	10981.5156	0.39000
3611.21289	14264.4023	10147.7266	0.40000
3754.36692	14361.8203	9356.73047	0.41000
3898.42261	14450.3291	8251.36719	0.42000
4043.30591	14529.6992	7501.77344	0.43000
4188.98437	14601.6250	5998.08984	0.44000
4335.30469	14665.8555	5875.50391	0.45000
4482.23828	14715.6680	4584.28516	0.46000
4629.63281	14764.5195	4415.93359	0.47000
4777.57912	14813.3928	4442.51562	0.48000
4925.84766	14857.7773	4589.20703	0.49000
5074.73437	14895.6797	2164.48926	0.50000
5149.21875	14905.3320	1779.16064	0.50500
5261.32031	14943.1211	12550.5406	0.51250
5411.26562	15019.0359	3983.45190	0.52250
5599.14453	15064.5751	3438.36060	0.53500
5749.87991	15060.2891	-9702.39062	0.54500
5900.17579	15034.6406	14209.6641	0.55500

6013.33203	15123.3008	5642.34375	0.56250
6164.80078	15169.0391	4991.80737	0.37250
6316.66016	15202.8437	3327.51099	0.58250
6468.83984	15233.6602	2809.43188	0.59250
6659.48437	15270.4844	2151.94839	0.60500
6773.96484	15253.2266	2571.46582	0.61250
6926.94922	15315.2227	2993.30566	0.62250
7118.53125	15348.7197	2758.30078	0.63500
7272.19531	15374.3437	2539.82983	0.64500
7426.05859	15400.1211	2391.57129	0.65500
7657.28906	15405.6299	-4325.06641	0.67000
7734.26953	15390.8242	2345.00244	0.67500
7888.37500	15432.0391	2424.74145	0.68500
8042.83984	15454.7695	2279.46948	0.69500
8197.47266	15475.6172	2175.76759	0.70500
8429.94531	15504.1055	1779.77808	0.72000
8585.06541	15520.3945	1456.92187	0.73000
8740.32812	15533.1602	1147.19214	0.74000
8895.69922	15544.5391	1224.47754	0.75000
9051.19531	15556.6211	1083.84595	0.76000
9206.77734	15565.4805	952.30737	0.77000
9362.47266	15573.9951	711.32397	0.78000
9518.23047	15580.7187	644.03491	0.79000
9674.05959	15585.4141	463.31714	0.80000
9839.92378	15590.4609	374.09595	0.81000
9985.94375	15593.7891	307.94873	0.82000
10141.7412	15595.6289	249.13017	0.83000
10297.7500	15599.4190	361.26001	0.84000
10453.7578	15602.3008	125.27588	0.85000
10609.7539	15603.4492	167.31493	0.86000
10765.8125	15603.3164	-257.59604	0.87000
10921.7773	15601.2344	-27.15523	0.88000
11077.8203	15600.1523	-219.96823	0.89000
11233.7451	15594.9102	-1065.71289	0.90000
11388.6211	15580.9531	-1515.16455	0.91000
11545.3555	15568.0195	-774.97534	0.92000
11701.0273	15564.0898	-156.42354	0.93000
11856.6211	15563.0703	-277.21343	0.94000
12012.2187	15561.0039	76.88417	0.95000
12167.8555	15590.3320	7674.27734	0.96000
12323.7451	15561.4453	715.29469	0.96500
12478.7617	15559.8203	394.79175	0.97125
12633.7451	15565.8398	975.53199	0.98250
12788.7617	15522.6992	-13599.5117	0.99250
12943.7617	15531.3008	10709.9453	1.00250
13098.7617	15593.2031	543.70117	1.01250
13253.7617	15597.5242	-171.56885	1.02249
13408.7617	15585.5371	-42.19145	1.03499
13563.7617	15589.5352	323.22485	1.04499
13718.7617	15569.0234	-9355.09375	1.05499
13873.7617	15589.1445	375.41577	1.06249
14028.7617	15585.9297	279.51035	1.07248
14183.7617	15590.5234	303.75122	1.08499
14338.7617	15592.5117	162.37150	1.09499
14493.7617	15598.6329	-1955.22217	1.10399
14648.7617	15560.9844	-3365.28613	1.11399
14803.7617	15541.8320	1215.02954	1.12399
14958.7617	15560.4375	958.34106	1.13399
15113.7617	15565.7539	731.02637	1.14399
15268.7617	15569.3477	901.11890	1.15399

15437.8828	15578.2969	694.05469	1.16998
15593.7461	15583.8984	522.41968	1.17997
15749.5703	15589.0039	419.08887	1.18797
15905.4648	15593.1602	357.86182	1.19997
16061.3984	15595.3056	260.78198	1.20997
16217.3555	15598.5596	198.06180	1.21997
16373.3437	15600.2539	169.48607	1.22997
16529.3398	15601.7734	133.93829	1.23997
16685.3477	15602.3750	-47.43010	1.24997
16841.3516	15602.2773	120.97285	1.25997
16997.3828	15603.7656	154.31264	1.26997
17153.4023	15605.1914	57.68726	1.27997
17309.4453	15605.4102	54.18924	1.28997
17465.4922	15605.1641	107.53809	1.29997
17621.5430	15607.0156	17.76927	1.30997
17777.5977	15603.0820	-1035.42163	1.31996
17933.5195	15595.1875	50.06320	1.32996
18089.5859	15594.0820	-588.69531	1.33996
18245.3203	15585.4102	-1176.40430	1.34996
18401.2070	15570.1211	-1532.37451	1.35996
18556.7617	15557.7969	-756.66040	1.36996
18712.3516	15555.4893	326.03296	1.37996
18867.8906	15559.4219	-276.51196	1.38996
19023.3867	15590.7031	9579.98437	1.39996
19101.3008	15644.9993	4918.26172	1.40996
19218.5000	15647.5459	-1379.20557	1.41246
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19570.0273	15578.4375	-13992.7031	1.43495
19725.3555	15523.9570	11791.2500	1.44495
19842.0781	15585.4336	2271.66992	1.45245
19997.9766	15598.5234	575.99512	1.46245
20153.9023	15598.2031	55.80971	1.47244
20309.8320	15597.3867	103.96130	1.48244
20465.7461	15595.7656	-455.89819	1.49244
20621.5078	15589.8628	32263.1016	1.50244
20757.9609	15625.0898	-503.02954	1.51118
20914.1133	15620.0312	-473.96021	1.52119
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21226.3828	15612.7383	-273.53687	1.54119
21400.5156	15605.1602	-137.74188	1.55618
21616.5664	15619.6357	3979.78639	1.56617
21773.1328	15643.3398	-822.71094	1.57617
21851.1875	15647.2305	-1037.47021	1.58117
22007.5352	15637.3789	-732.57544	1.59117
22163.8867	15629.2393	-532.70509	1.60117
22320.1328	15624.7344	-386.00929	1.61117
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22710.6484	15615.2655	-174.32469	1.63617
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27466.1714	15573.3477	-9720.69453	1.94113
27621.8359	15589.3437	-347.67969	1.95113
27777.7344	15592.2734	168.09805	1.96112
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28245.5000	15594.1836	-566.28296	1.99112
28401.3437	15571.8945	-4993.37500	2.00112
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30738.8945	15604.9961	59.34158	2.15110
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31207.0117	15604.9052	66.03467	2.18110
31363.0703	15605.5937	40.40504	2.19110
31519.0977	15604.9219	-282.68823	2.20110
31675.1172	15601.7266	-207.56853	2.21110
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32298.6211	15565.0039	-534.74315	2.25110
32454.4023	15562.7031	-473.08399	2.26110
32609.8291	15559.2109	-184.13727	2.27109
32755.5195	15557.4219	126.50465	2.28109
32921.0312	15583.0352	6487.98281	2.29109
33077.3328	15550.7148	442.62915	2.30109
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33427.0625	15492.5742	-13135.1641	2.32359
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2.47105
2.48104
2.49104
2.50104

DRUM CAM (DC) PARAMETERS

	TIME (SEC)	MOTOR (DEG)	DC ROTATION (DEG)	DC VELOCITY (DEG/SEC)	DC ACCELERATION (DEG/SEC**2)	DC TORQUE (FT-LBS)
1	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	3078.77368	7.72490
3	0.01000	2.95483	0.15394	30.78770	3078.77368	7.72490
4	0.02000	11.81933	0.61375	61.57538	3078.77368	7.72490
5	0.03000	26.59344	1.38544	92.36296	3078.77104	7.72490
6	0.04000	47.27733	2.46301	123.04394	3059.71704	7.57709
7	0.05000	73.82103	3.84587	153.48358	3016.68682	7.56862
8	0.06000	106.15965	5.53062	183.38805	2965.37427	7.44038
9	0.07000	144.19530	7.51217	212.72563	2897.41211	7.26985
10	0.08000	187.77528	9.78261	241.30267	2817.19067	7.06857
11	0.09000	236.77397	12.33255	269.95386	2705.72363	7.51552
12	0.10000	291.69507	15.18641	299.53442	2681.03149	6.76893
13	0.11250	366.80444	19.10939	332.62793	2542.35840	6.37999
14	0.12500	450.43066	23.46509	363.79272	2438.69214	6.11989
15	0.13500	522.57176	27.22437	387.81104	2353.02173	5.90393
16	0.15000	639.27368	33.30421	422.14136	2210.84104	5.54719
17	0.16000	722.36401	37.63300	444.03223	2199.63770	5.51908
18	0.17000	809.78125	42.16712	465.86353	2116.47607	5.31042
19	0.18000	901.08569	46.94382	486.42236	2006.05029	5.03335
20	0.19000	996.39502	51.90919	505.88135	1870.86035	4.59414
21	0.20000	1095.25439	57.05942	524.30615	1810.95093	4.54383
22	0.21000	1197.64966	62.37394	542.05567	1732.47495	4.34593
23	0.22000	1303.29712	67.87781	559.90381	1651.91040	4.14478
24	0.23000	1412.16550	73.59660	575.08374	1566.16392	3.92964
25	0.24000	1524.01587	79.39665	590.33740	1488.54419	3.73488
26	0.25000	1638.74756	85.37378	604.92983	1429.67358	3.58717
27	0.26000	1756.16921	91.49109	618.58862	1337.69482	3.35539
28	0.27000	1876.16943	97.74274	631.60962	1271.83618	3.19114
29	0.28000	1998.59519	104.12085	643.90527	1190.89648	2.98506
30	0.29000	2123.30515	110.61780	655.45459	1194.43262	2.97184
31	0.30000	2250.17261	117.22722	666.30054	1055.57520	2.64953
32	0.31000	2379.06226	123.54194	676.51807	965.32861	2.42209
33	0.32000	2509.84375	130.75531	685.11157	927.46606	2.32709
34	0.33000	2642.41748	137.66193	695.09131	945.70654	2.37537
35	0.34000	2776.63525	144.65433	703.40918	808.86841	2.02952
36	0.35000	2912.42310	151.72942	711.23389	759.34570	1.90526
37	0.36000	3049.83867	158.87700	718.51392	704.63929	1.76800
38	0.37000	3188.22461	166.09588	725.30959	645.81699	1.52041
39	0.38000	3328.06543	173.28220	731.70459	614.31201	1.54136
40	0.39000	3469.08911	180.72908	737.63086	572.10791	1.43547
41	0.40000	3611.21289	188.13325	743.13770	528.66992	1.32648
42	0.41000	3754.34592	195.59015	748.21313	487.46094	1.22308
43	0.42000	3899.42261	203.09512	752.82397	429.87427	1.07959
44	0.43000	4043.30591	210.64405	756.90698	395.03223	0.99368
45	0.44000	4188.98437	218.23344	760.72217	429.49048	1.07512
46	0.45000	4335.30469	225.85535	764.12793	313.92017	0.78765
47	0.46000	4482.29281	233.51120	766.78467	135.36295	0.33964
48	0.47000	4629.63281	241.19994	769.10034	282.91626	0.70986
49	0.48000	4777.57812	248.97745	771.73926	261.06177	0.55503
50	0.49000	4925.84766	256.52159	773.59062	148.75398	0.37324
51	0.50000	5074.73437	264.37817	775.91064	340.53965	0.35469
52	0.50500	5149.21975	269.25854	776.39867	193.05457	0.48439
53	0.51250	5261.32031	274.09863	779.53467	901.19824	2.01027
54	0.52250	5411.26562	281.91040	782.39478	192.66731	0.48342
55	0.53500	5599.14453	291.69924	795.01147	259.09351	0.37518

56	0.54500	5749.87991	299.55103	784.76660	-366.34595	-0.91919
57	0.55500	5900.17378	307.38110	783.33661	1011.96631	2.53911
58	0.56250	6013.33203	313.27612	788.01099	-20.84888	-0.05231
59	0.57250	6164.80078	321.16724	790.42993	0.05234	0.00013
60	0.58250	6316.66016	329.07961	792.21094	33.52705	0.08412
61	0.59250	6468.83984	337.00584	793.62124	283.20605	0.71059
62	0.60500	6659.48437	346.93996	795.36172	-24.36969	-0.06115
63	0.61250	6773.96484	352.90283	794.62136	239.33350	0.57542
64	0.62250	6928.94322	0.87426	797.93164	150.73302	0.37820
65	0.63500	7113.53125	10.85514	799.62476	143.69965	0.36055
66	0.64500	7272.19531	18.86050	800.96167	135.04910	0.33885
67	0.65500	7426.05359	26.87527	802.34961	193.97777	0.48671
68	0.67000	7657.28306	38.92279	802.59277	-225.32460	-0.56536
69	0.67500	7734.26353	12.93317	801.79980	87.45496	0.21943
70	0.68500	7888.37500	50.96164	803.96851	128.32265	0.31595
71	0.69500	8042.83984	59.00876	805.15283	118.75436	0.29796
72	0.70500	8197.47266	67.06473	806.26880	-7.26794	0.11960
73	0.72000	8423.94531	79.17584	807.72314	92.72174	0.23265
74	0.73000	8583.06341	87.25714	808.57178	75.90118	0.19044
75	0.74000	8740.32912	95.34575	809.16602	229.29829	0.57533
76	0.75000	8895.69322	103.44020	809.82959	63.79204	0.16006
77	0.76000	9051.19531	111.54105	810.45850	17.80133	0.04467
78	0.77000	9208.77734	119.64645	810.97266	44.40295	0.11141
79	0.78000	9362.47266	127.75749	811.36426	37.05809	0.09298
80	0.79000	9518.23047	135.87224	811.70508	-10.58400	-0.02556
81	0.80000	9674.05959	143.99037	812.01123	24.13759	0.06056
82	0.81000	9829.92378	152.11055	812.22632	22.44557	0.05532
83	0.82000	9985.84375	160.23347	812.39526	18.04330	0.04025
84	0.83000	10141.7812	168.35730	812.54321	12.92691	0.03243
85	0.84000	10297.7500	176.48283	812.62549	-99.10542	-0.24615
86	0.85000	10453.7578	184.61037	812.83887	5.52654	0.01538
87	0.86000	10609.7539	192.73727	812.88672	-37.13591	-0.09318
88	0.87000	10765.8125	200.86749	812.89185	-13.42530	-0.03369
89	0.88000	10921.7773	208.99275	812.78687	3.70398	0.00931
90	0.89000	11077.8203	217.12213	812.70972	-11.90322	-0.02987
91	0.90000	11233.7461	225.24539	812.47192	25.12585	0.06304
92	0.91000	11389.6211	233.35610	811.77197	-257.06934	-0.54501
93	0.92000	11545.3555	241.47931	810.99463	151.62437	0.40553
94	0.93000	11701.0273	249.59937	810.83130	-14.99984	-0.03764
95	0.94000	11856.6211	257.69507	810.78491	191.55727	0.48063
96	0.95000	12012.2197	265.80127	810.64185	72.37943	0.18161
97	0.96000	12167.8535	273.90942	812.18091	497.08472	1.24723
98	0.97000	12245.4697	279.00489	810.68921	153.82042	0.41104
99	0.97125	12343.7451	283.07275	810.57544	180.12204	0.45194
100	0.98250	12515.7617	292.19043	811.10156	-195.99330	-0.49178
101	0.99250	12674.2852	300.29297	808.81592	-1055.80566	-2.64911
102	1.00250	12829.2266	309.35499	809.22876	126.13232	0.31548
103	1.01250	12984.8857	315.47437	811.35532	379.45557	0.95209
104	1.02249	13140.6602	324.58936	812.26318	126.51671	0.31744
105	1.03499	13335.4492	334.73730	811.99414	101.01700	0.25346
106	1.04499	13491.3047	342.85718	812.00024	-157.69848	-0.42576
107	1.05499	13647.1552	350.97655	810.85693	-635.44653	-1.59590
108	1.06249	13763.8477	357.05591	812.14331	173.71335	0.45092
109	1.07248	13919.6641	5.17471	812.03467	14.56691	0.03555
110	1.08498	14114.4258	15.32119	812.28076	-51.08390	-0.12317
111	1.09493	14270.3242	23.44302	812.32886	3.49036	0.02130
112	1.10998	14504.1675	35.52662	812.12671	-95.70430	-0.24264
113	1.11998	14659.8672	43.73700	810.68823	-167.07449	-0.41321
114	1.12998	14815.3594	51.83774	809.66213	28.91371	0.07255
115	1.13994	14971.0536	59.94915	810.65795	49.92703	0.12527

116	1.14998	15126.3359	68.03860	910.87744	92.71118	0.20753
117	1.15998	15282.2930	76.16354	911.12207	41.73618	0.10472
118	1.16998	15437.8828	84.26930	911.64331	-4.65164	-0.01167
119	1.17997	15593.7451	92.38934	911.88013	27.21667	0.06929
120	1.18997	15749.5703	100.50729	912.14600	21.83340	0.05478
121	1.19997	15904.4648	108.62897	912.36279	-0.32829	-0.00082
122	1.20997	16061.3994	116.75261	912.52661	13.58605	0.03409
123	1.21997	16217.3555	124.87745	912.64722	17.83720	0.04476
124	1.22997	16373.3437	133.00404	912.73218	8.82977	0.02215
125	1.23997	16529.3398	141.13092	912.81129	6.97782	0.01751
126	1.24997	16685.3477	149.25941	912.76807	108.34863	0.27186
127	1.25997	16841.3516	157.38982	912.83765	6.30235	0.01581
128	1.26997	16997.3828	165.51455	912.91577	-36.59045	-0.09181
129	1.27997	17153.4023	173.64275	912.98950	3.00535	0.02754
130	1.28997	17309.4453	181.77208	913.00073	2.82310	0.00708
131	1.29997	17465.4922	189.90172	913.02905	-41.90919	-0.10515
132	1.30997	17621.5430	198.03143	913.08447	0.92572	0.00232
133	1.31996	17777.5977	206.16139	912.79395	21.41220	0.05373
134	1.32996	17933.5195	214.28450	912.45581	-9.71982	-0.02439
135	1.33996	18089.5859	222.41509	912.39038	-23.35052	-0.05859
136	1.34996	18245.3203	230.52837	911.92871	-71.23912	-0.17975
137	1.35996	18401.2070	238.64957	911.14524	-54.56219	-0.13590
138	1.36996	18556.7617	246.75354	910.59790	-11.32091	-0.02941
139	1.37996	18712.3516	254.85934	910.34009	-55.19897	-0.13350
140	1.38996	18867.8906	262.96191	910.75513	-62.31030	-0.15634
141	1.39996	19023.3857	271.05299	912.22551	379.22583	0.95151
142	1.40995	19101.3008	275.12207	915.24414	73.92143	0.19548
143	1.41246	19214.5000	281.22754	915.20728	-98.59637	-0.22230
144	1.42445	19374.8672	289.37402	914.20630	182.14789	0.45702
145	1.43695	19570.0273	299.54125	911.76465	-577.28296	-1.44845
146	1.44495	19725.3555	307.63330	908.94141	734.50562	1.84294
147	1.45245	19842.0781	313.71460	911.87842	-125.27484	-0.31433
148	1.46245	19997.9756	321.83643	912.47437	-163.08568	-0.40320
149	1.47244	20153.9023	329.95947	912.43213	-128.91532	-0.32321
150	1.48244	20309.8320	338.08275	912.76929	-146.81227	-0.36936
151	1.49244	20465.7461	346.20557	912.70508	-291.09790	-0.73039
152	1.50244	20621.5078	354.32031	912.29256	1288.45288	3.23284
153	1.51118	20757.9609	1.43043	914.02271	-31.41612	-0.07983
154	1.52118	20914.1133	9.56553	913.75928	-24.69197	-0.06195
155	1.53118	21070.2576	17.70012	913.56250	-13.27355	-0.03330
156	1.54118	21226.3828	25.83376	913.28613	-29.60391	-0.01177
157	1.55618	21460.5156	38.03147	912.99779	-7.17599	-0.01301
158	1.56617	21615.5654	46.15115	913.74194	207.33643	0.52022
159	1.57617	21773.1328	54.31774	915.02905	-104.29030	-0.26167
160	1.58117	21851.1875	58.38420	915.17944	-54.04947	-0.13561
161	1.59117	22007.5352	65.52951	914.66895	-53.36440	-0.13390
162	1.60117	22163.8857	74.67491	914.24219	-27.75253	-0.06963
163	1.61117	22320.1328	82.81487	913.91138	-38.22545	-0.03591
164	1.62617	22554.5156	95.02547	913.52026	23.09720	0.05795
165	1.63617	22710.6494	103.15954	913.14116	-9.08197	-0.02279
166	1.64616	22865.7959	111.29447	913.50099	-54.95911	-0.13790
167	1.65616	23022.9102	119.42744	913.41553	-5.86181	-0.01722
168	1.66616	23179.0117	127.55384	913.35620	-5.51768	-0.01384
169	1.67616	23335.1250	135.66929	913.30811	-29.74899	-0.07444
170	1.69616	23491.2227	143.82512	91.28784	-4.05880	-0.01021
171	1.69616	23647.3154	151.95711	913.24634	2.02344	0.00508
172	1.70616	23803.4052	160.08997	913.20874	-2.24352	-0.00563
173	1.71616	23959.4844	168.22014	913.19165	-1.75584	-0.00441
174	1.72616	24115.5547	176.35094	913.15454	-90.23256	-0.22540
175	1.73616	24271.6406	184.45254	913.23315	-2.58500	-0.30549

176	1.74616	2427.7070	192.61313	813.20996	-45.25417	-0.11355
177	1.75616	24583.8125	200.74579	813.14404	-19.26743	-0.04934
178	1.76616	24739.8242	208.87350	812.98462	0.15035	0.00038
179	1.77616	24895.9062	217.00491	812.88916	-9.54167	-0.02394
180	1.78615	25051.879	225.13062	812.66406	9.42046	0.02113
181	1.79615	25207.7773	233.25255	811.96338	-209.85748	-0.52555
182	1.80615	25363.5506	241.35780	811.10474	86.18420	0.21324
183	1.81615	25519.2393	249.47867	811.08691	-41.02216	-0.10293
184	1.82615	25674.9258	257.58911	811.19238	178.76428	0.44953
185	1.83615	25830.5391	265.69629	811.01001	57.46159	0.14418
186	1.84615	25986.3437	273.81323	812.47705	443.40137	1.11253
187	1.85115	26064.9697	277.90918	810.97998	133.77261	0.33585
188	1.86114	26220.6094	286.01758	810.95337	80.13707	0.20107
189	1.87114	26375.2422	294.12549	811.21973	22.91066	0.05748
190	1.88114	26531.5703	302.21753	807.64014	-492.19043	-1.23495
191	1.89114	26686.6036	310.29858	811.00464	660.44800	1.55712
192	1.90114	26842.5742	318.42017	812.26807	339.53979	0.85193
193	1.91113	26998.4766	326.54199	812.34521	94.62389	0.23742
194	1.92113	27154.3594	334.66309	812.28906	97.78813	0.24336
195	1.93113	27310.2695	342.79589	812.27539	-203.52345	-0.51166
196	1.94113	27466.1719	350.90796	811.14600	-665.58984	-1.57002
197	1.95113	27621.8359	359.01758	811.96191	-107.53307	-0.26981
198	1.96112	27777.7344	367.14057	812.31323	8.75743	0.02197
199	1.97112	27933.6953	375.26562	812.30273	-23.62325	-0.07162
200	1.98112	28089.5977	383.38768	812.33984	9.25840	0.02072
201	1.99112	28245.5000	391.50969	812.41602	-29.18927	-0.07324
202	2.00112	28401.3437	399.62874	811.25513	-282.15918	-0.70796
203	2.01112	28556.8555	407.75039	809.75244	65.54272	0.16445
204	2.02111	28712.2691	415.87197	810.42798	50.15885	0.15094
205	2.03111	28867.8994	423.99481	810.92065	45.29399	0.11365
206	2.04111	29023.5703	432.11765	811.32422	38.13901	0.09569
207	2.05111	29179.2812	440.24048	811.70825	30.60529	0.07579
208	2.06111	29335.1094	448.36331	811.98218	26.37979	0.06619
209	2.07111	29490.9727	456.48614	812.30151	-84.40973	-0.21179
210	2.08111	29646.9023	464.60897	812.48340	14.63077	0.03571
211	2.09111	29802.8298	472.73180	812.59839	18.59821	0.04566
212	2.10111	29958.7591	480.85463	812.69849	-21.70271	-0.05445
213	2.11111	30114.6854	488.97746	812.81665	5.97600	0.01750
214	2.12111	30270.6242	497.10029	812.75073	40.18839	0.10084
215	2.13110	30426.5639	505.22312	812.89185	5.12908	0.01287
216	2.14110	30582.5033	513.34595	812.94409	3.89248	0.00977
217	2.15110	30738.4445	521.46878	812.97925	3.09152	0.00776
218	2.16110	30894.3857	529.59161	813.00366	2.63441	0.00561
219	2.17110	31050.3269	537.71444	813.02441	93.13914	0.23369
220	2.18110	31206.2681	545.83727	812.97461	3.44022	0.00963
221	2.19110	31362.2093	553.96010	813.01392	9.08891	0.02280
222	2.20110	31518.1505	562.08293	812.97534	-14.72733	-0.03595
223	2.21110	31674.0917	570.20576	812.80884	-10.81900	-0.02715
224	2.22110	31830.0329	578.32859	812.69385	67.73746	0.17498
225	2.23110	31986.9741	586.45142	812.44165	-221.78366	-0.55647
226	2.24110	32142.9153	594.57425	811.78052	-57.94076	-0.14539
227	2.25110	32298.8565	602.69708	810.92995	-42.76021	-0.10729
228	2.26110	32454.7977	610.82001	810.75952	-24.64590	-0.06184
229	2.27109	32609.7389	618.94284	810.77417	-50.15254	-0.12584
230	2.28109	32764.6801	627.06567	810.70093	-60.74057	-0.15240
231	2.29109	32919.6213	635.18850	812.02222	193.57945	0.47557
232	2.30109	33074.5625	643.31133	810.19067	237.96172	0.59582
233	2.31109	33229.5037	651.43416	810.49194	278.32983	0.69835
234	2.32359	33427.0625	659.55699	806.97900	-327.55332	-0.52211
235	2.33108	33543.1328	667.67982	809.75000	783.12591	1.96494

236	2.34108	33698.7656	315.60915	912.70729	93.39699	0.23434
237	2.35107	33854.7461	323.73437	813.00195	37.28123	0.09354
238	2.36107	34010.7656	331.86255	812.91504	66.12245	0.16591
239	2.37107	34166.7500	339.98853	912.84448	46.79245	0.11741
240	2.38357	34361.7266	350.14648	912.07446	-592.80176	-1.46230
241	2.39106	34478.4844	356.22900	913.39429	-26.07263	-0.06542
242	2.40106	34634.5547	4.36131	813.42187	-16.38130	-0.04110
243	2.41106	34790.6055	12.49111	913.28564	-13.11359	-0.03290
244	2.42105	34946.6836	20.62225	913.16333	-10.15202	-0.02547
245	2.43105	35102.7344	28.75198	913.08203	-1.72947	-0.00434
246	2.44105	35258.7812	36.68164	913.72266	156.61163	0.39295
247	2.45105	35415.2852	45.03496	914.51807	-69.98241	-0.17559
248	2.46105	35571.8242	53.19012	912.54844	99.20624	0.22383
249	2.47105	35727.7422	61.31305	912.90501	5.03535	0.01263
250	2.48104	35883.7148	69.43975	913.02881	-122.58806	-0.30758
251	2.49104	36039.7461	77.56754	913.03613	2.17371	0.00545
252	2.50104	36195.7891	85.69587	913.06494	8.17526	0.02051
253	2.50104	0.0	0.0	0.0	0.0	0.0

FEED MECHANISM (FM) PARAMETERS

	TIME (SEC)	MOTOR (DEG)	F4 ROTATION (DEG)	FM VELOCITY (DEG/SEC)	FM ACCELERATION (DEG/SEC*2)	SHAFT TORQUE (FT-LBS)	CAM FORCE (LBS)	FORCE ON AMMO (LBS)
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	139.53050	0.0	-0.00000	0.0	0.00639	0.03831
3	0.01000	2.95483	139.53050	-0.00000	-0.00000	-0.00000	0.00239	0.01436
4	0.02000	11.81933	139.53050	0.00000	0.00000	0.0	-0.01415	-0.08490
5	0.03000	26.59344	139.53050	0.00000	0.00000	0.0	-0.02311	-0.13867
6	0.04000	47.27733	139.53050	0.00000	0.00000	0.0	-0.04517	-2.70943
7	0.05000	73.82103	139.53050	0.00000	0.00000	0.0	-4.83046	-28.98270
8	0.06000	106.15965	139.53049	0.00000	0.00000	0.0	-5.62919	-33.77507
9	0.07000	144.19330	139.53049	0.00000	0.00000	0.0	-7.33554	-44.01917
10	0.08000	187.77528	139.53049	0.00000	0.00000	0.0	-11.27948	-67.67676
11	0.09000	236.77397	139.53049	0.00000	0.00000	0.0	-19.36844	-116.21040
12	0.10000	291.69507	139.53049	-0.00000	-0.00000	-0.00000	54.59380	327.56201
13	0.11250	366.80444	139.53049	-0.00000	-0.00000	-0.00000	53.03960	318.23682
14	0.12500	420.43066	139.53049	-0.00000	-0.00000	-0.00000	83.15187	499.91016
15	0.13500	522.57178	139.53049	-0.00000	-0.00000	-0.00000	78.39244	470.35352
16	0.15000	639.27368	139.53049	-0.00000	-0.00000	-0.00000	98.48995	590.93237
17	0.15000	722.36401	139.53049	-0.00000	-0.00000	-0.00000	109.20630	373.76221
18	0.17000	809.78125	139.53049	-0.00000	-0.00000	-0.00000	102.47989	655.23633
19	0.18000	901.08569	139.53049	-0.00000	-0.00000	-0.00000	97.54070	585.84302
20	0.19000	996.39502	139.53049	-0.00000	-0.00000	-0.00000	102.47989	614.87793
21	0.20000	1095.25439	139.53049	-0.00000	-0.00000	-0.00000	124.53221	747.19165
22	0.21000	1197.64966	139.53049	-0.00000	-0.00000	-0.00000	172.56261	1035.97363
23	0.22000	1303.29712	139.53049	-0.00000	-0.00000	-0.00000	123.69138	742.14673
24	0.23000	1412.16550	139.53049	-0.00000	-0.00000	-0.00000	98.08337	588.50024
25	0.24000	1524.01587	139.53049	-0.00000	-0.00000	-0.00000	204.86046	1229.16040
26	0.25000	1638.74756	139.53049	-0.00000	-0.00000	-0.00000	211.31259	1267.87305
27	0.26000	1756.16821	139.53049	-0.00000	-0.00000	-0.00000	241.05710	1446.33960
28	0.27000	1876.16443	139.53049	-0.00000	-0.00000	-0.00000	137.96355	827.77954
29	0.28000	1998.59519	139.53049	-0.00000	-0.00000	-0.00000	196.55057	1179.90161
30	0.29000	2123.30515	139.53049	-0.00000	-0.00000	-0.00000	132.88852	797.32959
31	0.30000	2250.17261	139.53049	-0.00000	-0.00000	-0.00000	228.89168	1373.34741
32	0.31000	2379.06226	139.53049	-0.00000	-0.00000	-0.00000	187.50111	1125.00439
33	0.32000	2507.84375	139.53049	-0.00000	-0.00000	-0.00000	164.43955	985.62939
34	0.33000	2642.41748	139.53049	-0.00000	-0.00000	-0.00000	155.39529	932.35987
35	0.34000	2776.63525	139.53049	-0.00000	-0.00000	-0.00000	158.04533	948.27002
36	0.35000	2912.42310	129.53049	-0.00000	-0.00000	-0.00000	172.54234	1035.25195
37	0.36000	3049.63967	139.52049	-0.00000	-0.00000	-0.00000	200.14058	1200.84106
38	0.37000	3188.22461	139.53049	-0.00000	-0.00000	-0.00000	244.48074	1466.88159
39	0.38000	3328.06543	139.53049	-0.00000	-0.00000	-0.00000	310.45215	1962.70923
40	0.39000	3469.08311	139.53049	-0.00000	-0.00000	-0.00000	185.64731	1113.88159
41	0.40000	3611.21289	139.53049	-0.00000	-0.00000	-0.00000	264.16333	1594.97681
42	0.41000	3754.34592	139.53049	-0.00000	-0.00000	-0.00000	169.70036	1012.20020
43	0.42000	3898.42261	139.53049	-0.00000	-0.00000	-0.00000	263.11548	1578.68970
44	0.43000	4043.30391	139.50035	-0.00000	-0.00000	-0.00000	9520.89062	1578.68970
45	0.44000	4189.98437	139.75076	-16.65686	-15543.9062	-3.46304	9520.89062	1578.68970
46	0.45000	4335.30669	135.97501	-168.65324	-32601.3164	-7.26329	9520.89062	1578.68970
47	0.46000	4482.23928	130.01825	-424.00806	-38531.5195	-8.58449	9520.89062	1578.68970
48	0.47000	4629.63281	120.66725	-775.50293	-26144.4453	-5.82475	9520.89062	1578.68970
49	0.48000	4777.57312	108.64427	-1079.41260	-15378.3711	-3.42516	9520.89062	1578.68970
50	0.49000	4925.94766	95.66457	-1266.19092	-9354.27734	-1.36126	9520.89062	1578.68970
51	0.50000	5074.73437	81.61202	-1365.04658	-19193.7656	-0.27520	9520.89062	1578.68970
52	0.51000	5149.21375	74.28598	-1443.59385	-33319.0117	-7.42318	9520.89062	1578.68970
53	0.52500	5261.32031	65.47772	-1480.86621	205924.375	45.37814	9520.89062	1578.68970
54	0.52500	5411.26562	64.63979	-138.89819	0.00000	0.0	-57.17070	-343.02344
55	0.53500	5599.14453	64.61503	-40.67044	-26196.9414	-5.93645	9520.89062	1578.68970

56	0.54500	5749.87891	74.12500	2863.67822	493320.187	0.0	0.00000	34.79472	208.76793
57	0.55500	5900.17578	111.91002	2938.29469	-283597.937	0.0	0.00000	31.29500	187.76962
58	0.56250	6013.33203	128.19601	1604.75732	-127738.250	0.0	0.00000	29.39609	176.37617
59	0.57250	6164.80078	138.72484	486.81982	-117630.375	0.0	0.00000	-1.80970	-10.85816
60	0.58250	6316.66016	139.53061	1.05517	870.71484	0.0	0.00000	-124.25261	-745.51416
61	0.59250	6468.83984	139.53049	-0.00000	-0.00000	-0.00000	0.00000	244.76599	1468.59302
62	0.60500	6599.48437	139.53049	-0.00000	-0.00000	-0.00000	0.00000	248.91231	1493.47095
63	0.61250	6773.96484	139.53049	-0.00000	-0.00000	-0.00000	0.00000	258.89722	1553.38013
64	0.62250	6926.94922	139.53050	-0.00000	-0.00000	-0.00000	0.00000	260.81372	1584.87915
65	0.63500	7118.53125	139.53049	-0.00000	-0.00000	-0.00000	0.00000	268.50488	1511.02612
66	0.64500	7272.19531	139.53049	-0.00000	-0.00000	-0.00000	0.00000	279.98340	1579.89697
67	0.65500	7426.05959	139.53049	-0.00000	-0.00000	-0.00000	0.00000	322.27710	1763.18799
68	0.67000	7657.28906	139.53049	-0.00000	-0.00000	-0.00000	0.00000	344.12207	2064.72827
69	0.67500	7734.26953	139.53049	-0.00000	-0.00000	-0.00000	0.00000	368.88354	2213.29687
70	0.68500	7888.37500	139.53049	-0.00000	-0.00000	-0.00000	0.00000	396.49780	2378.98218
71	0.69500	8042.83984	139.53049	-0.00000	-0.00000	-0.00000	0.00000	188.99678	1133.97852
72	0.70500	8197.47266	139.53049	-0.00000	-0.00000	-0.00000	0.00000	208.25117	1243.50464
73	0.72000	8429.94531	139.53049	-0.00000	-0.00000	-0.00000	0.00000	230.00760	1380.04272
74	0.73000	8585.06541	139.53049	-0.00000	-0.00000	-0.00000	0.00000	250.03076	1524.18164
75	0.74000	8740.32812	139.53049	-0.00000	-0.00000	-0.00000	0.00000	309.53027	1857.17798
76	0.75000	8895.69922	139.53049	-0.00000	-0.00000	-0.00000	0.00000	341.16895	2047.00977
77	0.76000	9051.19531	139.53049	-0.00000	-0.00000	-0.00000	0.00000	375.27393	2251.63916
78	0.77000	9206.77734	139.53049	-0.00000	-0.00000	-0.00000	0.00000	412.18433	2473.10107
79	0.78000	9362.47266	139.53049	-0.00000	-0.00000	-0.00000	0.00000	202.60162	1215.60742
80	0.79000	9518.23047	139.53049	-0.00000	-0.00000	-0.00000	0.00000	226.08455	1361.30469
81	0.80000	9674.05859	139.53049	-0.00000	-0.00000	-0.00000	0.00000	253.83435	1523.00317
82	0.81000	9829.82578	139.53049	-0.00000	-0.00000	-0.00000	0.00000	-5.92761	-523.00317
83	0.82000	9985.84375	139.53049	-0.00000	-0.00000	-0.00000	0.00000	-2.89252	-289.252
84	0.83000	10141.7812	139.53049	-0.00000	-0.00000	-0.00000	0.00000	-8.44174	-84.4174
85	0.84000	10297.7500	139.53049	-0.00000	-0.00000	-0.00000	0.00000	-9.56373	-95.6373
86	0.85000	10453.7578	139.53049	-0.00000	-0.00000	-0.00000	0.00000	-6.50313	-65.0313
87	0.86000	10609.7539	139.53049	-0.00000	-0.00000	-0.00000	0.00000	-2.05407	-20.5407
88	0.87000	10765.8125	139.53049	-0.00000	-0.00000	-0.00000	0.00000	-1.44457	-14.4457
89	0.88000	10921.7773	139.53049	-0.00000	-0.00000	-0.00000	0.00000	-1.56482	-15.6482
90	0.89000	11077.8203	138.96571	-0.00000	-0.00000	-0.00000	0.00000	47.41747	474.1747
91	0.90000	11233.7461	136.30382	-0.00000	-0.00000	-0.00000	0.00000	-6.52557	-65.2557
92	0.91000	11389.6211	130.15461	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
93	0.92000	11545.3555	120.25931	-0.00000	-0.00000	-0.00000	0.00000	1.18970	11.8970
94	0.93000	11701.0273	107.70465	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
95	0.94000	11856.6211	93.76491	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
96	0.95000	12012.197	79.94930	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
97	0.96000	12167.8555	65.63882	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
98	0.97000	12323.4697	51.43905	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
99	0.98000	12479.1751	37.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
100	0.99000	12634.7451	23.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
101	0.99250	12790.2852	19.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
102	1.00250	12945.8256	15.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
103	1.01250	13101.3657	11.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
104	1.02249	13256.9052	7.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
105	1.03499	13412.4452	3.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
106	1.04499	13567.9852	0.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
107	1.05499	13723.5252	0.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
108	1.06249	13879.0652	0.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
109	1.07248	14034.6052	0.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
110	1.08498	14189.1452	0.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
111	1.09498	14344.6852	0.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
112	1.10998	14500.2252	0.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
113	1.11998	14655.7652	0.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
114	1.12998	14811.3052	0.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0
115	1.13998	14966.8452	0.43979	-0.00000	-0.00000	-0.00000	0.00000	0.0	0.0

116	1.14998	15126.3359	139.53049	-0.00000	-0.00001	-0.00000	291.05322	1746.31592
117	1.15998	15282.2930	139.53049	-0.00000	-0.00001	-0.00000	321.83398	1931.00000
118	1.16998	15437.8828	139.53049	-0.00000	-0.00001	-0.00000	342.93335	2099.59595
119	1.17997	15593.7461	139.53049	-0.00000	-0.00001	-0.00000	383.3721	2301.81885
120	1.18997	15749.5703	139.53049	-0.00000	-0.00001	-0.00000	183.92659	1103.55737
121	1.19997	15905.4648	139.53049	-0.00000	-0.00001	-0.00000	205.68384	1234.10059
122	1.20997	16061.3994	139.53049	-0.00000	-0.00001	-0.00000	229.62247	1377.73193
123	1.21997	16217.3555	139.53049	-0.00000	-0.00001	-0.00000	255.73103	1534.38306
124	1.22997	16373.3437	139.53049	-0.00000	-0.00001	-0.00000	284.24453	1705.46436
125	1.23997	16529.3398	139.53049	-0.00000	-0.00001	-0.00000	315.02981	1890.16919
126	1.24997	16685.3477	139.53049	-0.00000	-0.00001	-0.00000	348.20166	2089.20581
127	1.25997	16841.3516	139.53049	-0.00000	-0.00001	-0.00000	383.55796	2301.94336
128	1.26997	16997.3628	139.53049	-0.00000	-0.00001	-0.00000	185.60231	1113.61157
129	1.27997	17153.4023	139.53049	-0.00000	-0.00001	-0.00000	208.65594	1251.93311
130	1.28997	17309.4453	139.53049	-0.00000	-0.00001	-0.00000	233.91925	1403.51270
131	1.29997	17465.4922	139.53049	-0.00000	-0.00001	-0.00000	261.35864	1568.14868
132	1.30997	17621.5430	139.53049	-0.00000	-0.00001	-0.00000	291.05542	1746.32910
133	1.31996	17777.5977	139.52924	-20965.1914	-0.00000	-0.00000		
134	1.32996	17933.5195	139.52019	-51.28806	17134.0039	3.81730		
135	1.33996	18089.5859	137.54888	-302.80566	-33616.5820	-7.48948		
136	1.34996	18245.3203	132.73749	-669.76099	-34674.4922	-7.72517		
137	1.35996	18401.2070	124.09119	-1045.73584	-32764.1055	-7.29555		
138	1.36996	18556.7617	112.30412	-1289.43140	-18510.8750	-4.12406		
139	1.37996	18712.3516	98.75179	-1407.44800	-5847.99219	-1.30288		
140	1.38996	18867.8906	86.23149	-1496.15503	-6022.76562	-1.34182		
141	1.39996	19023.3867	69.21889	-1267.54492	129948.875	28.95146		
142	1.40996	19101.3008	64.83427	-345.04543	287805.187	64.12045		
143	1.41246	19218.5000	64.63979	0.00000	0.00000	0.0	-56.14722	-336.88257
144	1.42244	19374.8672	64.63979	0.00000	0.00000	0.0	-52.24561	-313.47900
145	1.43495	19570.0273	74.08939	2955.82471	527291.187	0.0		
146	1.44495	19725.3555	112.84401	2942.34082	-291468.562	0.0		
147	1.45245	19842.0781	129.06648	1580.05562	-127070.812	0.0		
148	1.46245	19997.9766	139.08825	395.62793	-149057.187	0.0		
149	1.47244	20153.9023	139.53049	0.11794	172.61935	0.0		
150	1.48244	20309.8320	139.53049	-0.00000	-0.00000	-0.00000	41.19847	247.19035
151	1.49244	20465.7461	139.53049	-0.00000	-0.00000	-0.00000	49.63661	297.81909
152	1.50244	20621.5078	139.53049	-0.00000	-0.00000	-0.00000	58.48513	350.91602
153	1.51118	20757.9609	139.53049	0.00000	0.00000	0.0	-1.40954	-8.45724
154	1.52118	20914.1133	139.53049	0.00000	0.00000	0.0	-106.22581	-537.35352
155	1.53118	21070.2578	139.53050	0.00000	-0.00000	0.0	60.20271	361.21558
156	1.54118	21226.3828	139.53049	-0.00000	-0.00001	-0.00000	246.67977	1480.06958
157	1.55618	21460.5156	139.53049	-0.00000	-0.00001	-0.00000	290.69312	1744.15527
158	1.56617	21616.5644	139.53049	-0.00000	-0.00001	-0.00000	323.33518	1940.01318
159	1.57617	21773.1328	139.53049	-0.00000	-0.00001	-0.00000	366.11499	2196.68555
160	1.58117	21951.1875	139.53049	-0.00000	-0.00001	-0.00000	385.16455	2310.98267
161	1.59117	22007.5352	139.53049	-0.00000	-0.00001	-0.00000	188.84993	1133.09741
162	1.60117	22163.8967	139.53049	-0.00000	-0.00001	-0.00000	215.25922	1291.55273
163	1.61117	22320.1328	139.53049	-0.00000	-0.00001	-0.00000	243.16514	1459.00586
164	1.62617	22554.5156	139.53049	-0.00000	-0.00001	-0.00000	289.85352	1739.11768
165	1.63617	22710.6484	139.53049	-0.00000	-0.00001	-0.00000	322.74097	1936.44189
166	1.64616	22866.7959	139.53049	-0.00000	-0.00001	-0.00000	358.41870	2150.50806
167	1.65616	23022.9102	139.53049	-0.00000	-0.00001	-0.00000	396.24341	2377.45581
168	1.66616	23179.0117	139.53049	-0.00000	-0.00001	-0.00000	193.67072	1152.02197
169	1.67616	23335.1250	139.53049	-0.00000	-0.00001	-0.00000	218.32104	1303.92358
170	1.68616	23491.2227	139.53049	-0.00000	-0.00001	-0.00000	244.98607	1459.91357
171	1.69615	23647.3154	139.53049	-0.00000	-0.00001	-0.00000	273.92959	1542.97437
172	1.70615	23803.4052	139.53049	-0.00000	-0.00001	-0.00000	304.95093	1929.70190
173	1.71616	23959.4844	139.53049	-0.00000	-0.00001	-0.00000	338.32788	2029.96338
174	1.72616	24115.5547	139.53049	-0.00000	-0.00001	-0.00000	374.08911	2244.53027
175	1.73616	24271.6406	139.53049	-0.00000	-0.00001	-0.00000	412.56040	2475.95752

176	1.74616	24427.7070	139.53049	-0.00000	-0.00001	203.31081	1219.86230
177	1.75616	24583.8125	139.53049	-0.00000	-0.00001	228.71701	1372.29932
178	1.76616	24739.8242	139.52802	-28.81087	-38186.3242	-8.50758	
179	1.77616	24895.9052	139.52802	-92.24298	10386.1914	2.31395	
180	1.78615	25051.8799	135.36298	-416.29712	-36878.5625	-8.21622	
181	1.79615	25207.7773	130.27798	-806.56300	-41865.7656	-9.32733	
182	1.80615	25363.5508	120.41698	-1144.69019	-29202.8984	-6.50515	
183	1.81615	25519.2393	107.88585	-1340.44556	-2558.42310	-0.56399	
184	1.82615	25676.9258	93.95261	-1438.20728	-5900.53516	-1.31236	
185	1.83615	25830.5391	79.14575	-1517.08154	-4272.96484	-0.95198	
186	1.84615	25986.3437	64.72523	-741.84546	207762.000	46.28755	
187	1.85115	26064.9687	64.64253	-27.15811	-41925.8711	-9.34072	
188	1.86114	26220.6094	64.63979	0.00000	0.00000	0.0	
189	1.87114	26376.2422	64.68686	212.88474	206290.937	0.0	
190	1.88114	26531.5703	86.42979	4343.56250	220000.750	0.0	
191	1.89114	26686.6836	121.19069	2194.48364	-177232.125	0.0	
192	1.90114	26842.5742	136.30907	917.99269	-111335.687	0.0	
193	1.91113	26998.4766	139.52531	0.94677	30453.3867	0.0	
194	1.92113	27154.3594	139.53049	-0.00000	-0.00000	-0.00000	115.17467
195	1.93113	27310.2695	139.53049	-0.00000	-0.00000	-0.00000	148.11345
196	1.94113	27466.1719	139.53049	-0.00000	-0.00000	-0.00000	185.13455
197	1.95113	27621.8359	139.53049	-0.00000	-0.00000	-0.00000	223.86395
198	1.96112	27777.7344	139.53049	0.00000	0.00000	-37.31073	-307.76245
199	1.97112	27933.6953	139.53049	-0.00000	-0.00001	-151.29404	2418.59741
200	1.98112	28089.5977	139.53049	-0.00000	-0.00001	403.10034	2300.62354
201	1.99112	28245.5000	139.53049	-0.00000	-0.00001	383.43799	1306.16870
202	2.00112	28401.3437	139.53049	-0.00000	-0.00001	184.36183	1229.42852
203	2.01112	28556.8555	139.53049	-0.00000	-0.00001	204.90512	1341.49902
204	2.02111	28712.2891	139.53049	-0.00000	-0.00001	223.58362	1462.51392
205	2.03111	28867.8984	139.53049	-0.00000	-0.00001	243.75282	1602.75122
206	2.04111	29023.5703	139.53049	-0.00000	-0.00001	261.12573	1756.60845
207	2.05111	29179.2812	139.53049	-0.00000	-0.00001	292.76531	1923.67285
208	2.06111	29335.1094	139.53049	-0.00000	-0.00001	320.61279	2111.00854
209	2.07111	29490.9727	139.53049	-0.00000	-0.00001	351.83445	2313.94897
210	2.08111	29646.9023	139.53049	-0.00000	-0.00001	385.55594	1115.09009
211	2.09111	29802.8398	139.53049	-0.00000	-0.00001	186.01540	1249.91431
212	2.10111	30114.8154	139.53049	-0.00000	-0.00001	208.31949	1398.13965
213	2.11111	30270.8242	139.53049	-0.00000	-0.00001	233.02374	1558.55396
214	2.12111	30426.8359	139.53049	-0.00000	-0.00001	259.75352	1732.77783
215	2.13110	30582.8633	139.53049	-0.00000	-0.00001	286.79587	1920.56445
216	2.14110	30738.8945	139.53049	-0.00000	-0.00001	320.09473	2123.61060
217	2.15110	30894.9375	139.53049	-0.00000	-0.00001	353.93579	2341.44409
218	2.16110	31050.9844	139.53049	-0.00000	-0.00001	390.24146	1137.66040
219	2.17110	31207.0117	139.53049	-0.00000	-0.00001	185.51044	1279.49048
220	2.18110	31363.0703	139.53049	-0.00000	-0.00001	213.24883	1432.28735
221	2.19110	31519.0977	139.53049	-0.00000	-0.00001	238.71503	1500.06763
222	2.20110	31675.1172	139.53049	-0.00000	-0.00001	266.57947	1778.61426
223	2.21110	31831.1250	139.53049	-0.00000	-0.00001	295.43529	
224	2.22110	31987.0536	139.53049	-0.00000	-0.00001		
225	2.23110	32142.9697	129.92239	-181.40750	-4753.89062	-1.06581	
226	2.24110	32298.6211	118.55179	-8319.69922	-8319.69922	-1.95356	
227	2.25110	32454.4023	135.64572	-31116.4453	-31116.4453	-6.93247	
228	2.26110	32609.8291	105.72319	-475.25415	-475.25415	-9.19705	
229	2.27109	32765.5195	91.65392	-981.51615	-981.51615	-4.96704	
230	2.28109	32921.0312	75.59702	-1184.55984	-1184.55984	-2.72399	
231	2.29109	33077.3828	64.84784	-1359.10449	-1359.10449	-2.32566	
232	2.30109	33232.8906	64.63477	-1455.81396	-1455.81396	-1.58477	
233	2.31109	33387.0625	82.44212	-1552.14917	-1552.14917	63.16299	
234	2.32358	33543.1328	112.35504	-354.75954	-354.75954	0.0	
235	2.33109			-4230.7187	-4230.7187	-55.28360	-331.71289
.....				369678.937	369678.937	0.0	
.....				300361.312	300361.312	0.0	

235	2.34108	33698.7656	132.44289	1309.32300	-121341.250	0.0	*****	*****	*****
237	2.35107	33854.7461	139.57043	60.19624	-85668.3759	0.0	*****	*****	*****
238	2.36107	34010.7656	139.53049	-0.00000	-0.00000	-0.00000	*****	*****	*****
239	2.37107	34166.7500	139.53049	-0.00000	-0.00000	-0.00000	*****	*****	*****
240	2.38357	34361.7256	139.53049	-0.00000	-0.00000	-0.00000	*****	*****	*****
241	2.39106	34478.4844	139.53049	-0.00000	-0.00000	-0.00000	*****	*****	*****
242	2.40106	34634.5547	139.53050	-0.00000	-0.00000	-0.00000	*****	*****	*****
243	2.41106	34790.6055	139.53049	-0.00000	-0.00000	-0.00000	*****	*****	*****
244	2.42105	34946.6836	139.53049	-0.00000	-0.00000	-0.00000	*****	*****	*****
245	2.43105	35102.7344	139.53049	-0.00000	-0.00000	-0.00000	*****	*****	*****
246	2.44105	35259.7812	139.53049	-0.00000	-0.00000	-0.00000	*****	*****	*****
247	2.45105	35415.2852	139.53049	-0.00000	-0.00000	-0.00000	*****	*****	*****
248	2.46105	35571.8242	139.53049	-0.00000	-0.00000	-0.00000	*****	*****	*****
249	2.47105	35727.7422	139.53049	-0.00000	-0.00000	-0.00000	*****	*****	*****
250	2.48104	35883.7148	139.53049	-0.00000	-0.00000	-0.00000	*****	*****	*****
251	2.49104	36039.7461	139.53049	-0.00000	-0.00000	-0.00000	*****	*****	*****
252	2.50104	36195.7891	0.0	-0.00000	-0.00000	-0.00000	*****	*****	*****
253	2.50104	0.0	0.0	0.0	0.0	0.0	*****	*****	*****

EJECT MECHANISM (EM) PARAMETERS

	TIME (SEC)	MOTOR (DEG)	EM ROTATION (DEG)	EM VELOCITY (DEG/SEC)	EM ACCELERATION (DEG/SEC**2)	SHAFT TORQUE (FT-LBS)	CAM FORCE (LBS)
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	234.52350	0.0	-0.00000	-0.00100	-0.00600
3	0.01000	2.95483	234.52350	-0.00000	-0.00000	-0.00039	-0.00231
4	0.02000	11.81933	234.52350	-0.00000	-0.00000	-0.00000	-0.01330
5	0.03000	26.59344	234.52350	-0.00000	-0.00000	-0.28042	-1.68250
6	0.04000	47.27733	234.52350	-0.00000	-0.00000	-0.63946	-3.83574
7	0.05000	73.82103	234.52350	-0.00000	-0.00000	1.87823	11.26934
8	0.06000	106.15965	234.52348	-0.00000	0.00000	1.69019	10.14112
9	0.07000	144.19330	234.52348	-0.00000	0.00000	2.29129	13.74773
10	0.08000	187.77328	234.52348	-0.00000	0.00000	4.18051	25.08299
11	0.09000	235.77397	234.52348	-0.00000	0.00000	8.40058	50.40338
12	0.10000	291.69507	234.52348	-0.00000	-0.00000	-43.75214	-262.51221
13	0.11250	366.80444	234.52348	-0.00000	-0.00000	-62.85841	-377.14966
14	0.12500	450.43066	234.52348	-0.00000	-0.00001	-97.32593	-586.95435
15	0.13500	522.57178	234.52348	-0.00000	-0.00000	-92.56182	-555.96973
16	0.15000	539.27368	234.52348	-0.00000	-0.00001	-116.21716	-697.30151
17	0.16000	722.36401	234.52348	-0.00000	-0.00000	-74.54481	-447.86792
18	0.17000	809.78125	234.52348	-0.00000	-0.00001	-129.16513	-774.98926
19	0.18000	901.08569	234.52348	-0.00000	-0.00001	-116.10312	-596.61719
20	0.19000	994.39502	234.52348	-0.00000	-0.00001	-121.95221	-731.71167
21	0.20000	1095.25439	234.52348	-0.00000	-0.00001	-147.68588	-886.11353
22	0.21000	1197.64366	234.52348	-0.00000	-0.00001	-203.34579	-1220.07537
23	0.22000	1303.29717	234.52348	-0.00000	-0.00001	-147.52529	-883.34985
24	0.23000	1412.16550	234.52348	-0.00000	-0.00001	-117.70776	-706.24512
25	0.24000	1524.01587	234.52348	-0.00000	-0.00001	-241.74323	-1447.45654
26	0.25000	1638.74756	234.52348	-0.00000	-0.00001	-248.34891	-1493.69043
27	0.26000	1756.16921	234.52348	-0.00000	-0.00001	-283.35156	-1700.10596
28	0.27000	1876.16943	234.52348	-0.00000	-0.00001	-232.87595	-988.92749
29	0.28000	1998.59519	234.52348	-0.00000	-0.00001	-159.26382	-397.25903
30	0.29000	2123.30515	234.52348	-0.00000	-0.00001	-270.44409	-955.58105
31	0.30000	2250.17261	234.52348	-0.00000	-0.00001	-222.92513	-1622.66138
32	0.31000	2379.06826	234.52348	-0.00000	-0.00001	-196.38220	-1337.55420
33	0.32000	2509.84375	234.52348	-0.00000	-0.00001	-186.01973	-1178.29077
34	0.33000	2642.41748	234.52348	-0.00000	-0.00001	-189.52553	-1116.11621
35	0.34000	2776.63525	234.52348	-0.00000	-0.00001	-206.19533	-1135.38590
36	0.35000	2912.42310	234.52348	-0.00000	-0.00001	-238.30988	-1237.16943
37	0.36000	3049.63967	234.52348	-0.00000	-0.00002	-289.55308	-1429.85645
38	0.37000	3188.22461	234.52348	-0.00000	-0.00002	-365.65527	-1737.91504
39	0.38000	3328.06543	234.52348	-0.00000	-0.00002	-421.84923	-2193.92725
40	0.39000	3467.08911	234.52348	-0.00000	-0.00001	-312.72217	-1331.09277
41	0.40000	3611.21299	234.52348	-0.00000	-0.00002	-202.31860	-1876.32935
42	0.41000	3744.522	234.52348	-0.00000	-0.00001	-52374.1289	-1213.90918
43	0.42000	3898.42261	234.52348	-40.59589	-52374.1289	-4022.81909	
44	0.43000	4033.30591	229.70009	-735.98511	-4022.81909		
45	0.44000	4188.98437	222.56187	-599.52148	-709.81641		
46	0.45000	4335.30469	215.65725	-582.11377	2577.82886		
47	0.46000	4482.23329	209.83504	-582.53247	-394.53247		
48	0.47000	4629.63281	202.01921	-531.50293	104572.875		
49	0.48000	4777.57812	200.10593	-4.11779	-5875.06641		
50	0.49000	4925.94766	200.06538	-0.00000	-0.00000	-33.56232	-201.37350
51	0.50000	5074.73937	201.58972	503.02832	130179.687		
52	0.50500	5147.21975	204.05082	550.04321	-6796.85937		
53	0.51250	5261.32031	209.62575	579.31592	-60131.4961		
54	0.52500	5411.26562	212.66661	-11.61521	-5805.93750		
55	0.53500	5599.14453	212.64655	-0.00000	-0.00000	-33.99087	-203.34490

55	0.54500	5749.87891	212.64179	-8.25502	1918.72119	8.23444	49.40552
56	0.55500	5900.17578	225.94923	2256.33008	-138257.500	14.69263	88.15562
57	0.56250	6013.33203	234.53416	18.85678	-77523.0625	19.58591	117.51521
58	0.57250	6164.80078	234.52348	0.00000	0.00000	23.93765	143.62564
59	0.58250	6316.66016	234.52348	0.00000	0.00000	26.01506	156.09006
60	0.59250	6468.83984	234.52348	0.00000	0.00000	29.15387	177.30564
61	0.60500	6659.48437	234.52348	0.00000	0.00000	30.58005	191.46216
62	0.61250	6773.96484	234.52348	0.00000	0.00000	31.90764	199.15967
63	0.62250	6926.94922	234.52348	0.00000	0.00000	33.23660	209.41870
64	0.63500	7118.53125	234.52348	0.00000	0.00000	34.56578	2287.02686
65	0.64500	7272.19531	234.52348	0.00000	0.00000	35.89484	2437.91406
66	0.65500	7426.95859	234.52348	0.00000	0.00000	37.22335	2598.67358
67	0.67000	7657.28906	234.52348	0.00000	0.00000	38.55181	2798.92031
68	0.67500	7734.26953	234.52348	0.00000	0.00000	39.88038	2907.16724
69	0.68500	7888.37500	234.52348	0.00000	0.00000	41.20895	305.80005
70	0.69500	8042.83984	234.52348	0.00000	0.00000	42.53752	1778.30564
71	0.70500	8197.47266	234.52348	0.00000	0.00000	43.86609	1847.59544
72	0.72000	8429.94531	234.52348	0.00000	0.00000	45.19466	1960.94302
73	0.73000	8585.06541	234.52348	0.00000	0.00000	46.52323	1914.46216
74	0.74000	8740.32812	234.52348	0.00000	0.00000	47.85180	1994.15967
75	0.75000	8895.69922	234.52348	0.00000	0.00000	49.18037	2090.41870
76	0.76000	9051.19531	234.52348	0.00000	0.00000	50.50894	2287.02686
77	0.77000	9206.77734	234.52348	0.00000	0.00000	51.83751	2437.91406
78	0.78000	9362.47266	234.52348	0.00000	0.00000	53.16608	2598.67358
79	0.79000	9518.23047	234.52348	0.00000	0.00000	54.49465	2798.92031
80	0.80000	9674.05959	234.52348	0.00000	0.00000	55.82322	2907.16724
81	0.81000	9829.92578	234.52348	0.00000	0.00000	57.15179	305.80005
82	0.82000	9985.84375	234.52348	0.00000	0.00000	58.48036	1778.30564
83	0.83000	10141.7812	234.52348	0.00000	0.00000	59.80893	1847.59544
84	0.84000	10297.7500	234.52348	0.00000	0.00000	61.13750	1960.94302
85	0.85000	10453.7578	234.52348	0.00000	0.00000	62.46607	1914.46216
86	0.86000	10609.7539	234.52348	0.00000	0.00000	63.79464	1994.15967
87	0.87000	10765.8125	234.52348	0.00000	0.00000	65.12321	2090.41870
88	0.88000	10921.7773	234.52348	0.00000	0.00000	66.45178	2287.02686
89	0.89000	11077.8203	234.52348	0.00000	0.00000	67.78035	2437.91406
90	0.90000	11233.7451	234.52348	0.00000	0.00000	69.10892	2598.67358
91	0.91000	11389.6211	234.52348	0.00000	0.00000	70.43749	2798.92031
92	0.92000	11545.3555	234.52348	0.00000	0.00000	71.76606	2907.16724
93	0.93000	11701.0273	234.52348	0.00000	0.00000	73.09463	305.80005
94	0.94000	11856.6211	234.52348	0.00000	0.00000	74.42320	1778.30564
95	0.95000	12012.2197	234.52348	0.00000	0.00000	75.75177	1847.59544
96	0.96000	12167.8555	234.52348	0.00000	0.00000	77.08034	1960.94302
97	0.97000	12323.4913	234.52348	0.00000	0.00000	78.40891	1914.46216
98	0.98000	12479.1271	234.52348	0.00000	0.00000	79.73748	1994.15967
99	0.99250	12634.7629	234.52348	0.00000	0.00000	81.06605	2090.41870
100	0.99500	12790.3987	234.52348	0.00000	0.00000	82.39462	2287.02686
101	1.00250	12946.0345	234.52348	0.00000	0.00000	83.72319	2437.91406
102	1.01000	13101.6703	234.52348	0.00000	0.00000	85.05176	2598.67358
103	1.01250	13257.3061	234.52348	0.00000	0.00000	86.38033	2798.92031
104	1.02250	13412.9419	234.52348	0.00000	0.00000	87.70890	2907.16724
105	1.03499	13568.5777	234.52348	0.00000	0.00000	89.03747	305.80005
106	1.04499	13724.2135	234.52348	0.00000	0.00000	90.36604	1778.30564
107	1.05499	13879.8493	234.52348	0.00000	0.00000	91.69461	1847.59544
108	1.06249	14035.4851	234.52348	0.00000	0.00000	93.02318	1960.94302
109	1.07249	14191.1209	234.52348	0.00000	0.00000	94.35175	1914.46216
110	1.08498	14346.7567	234.52348	0.00000	0.00000	95.68032	1994.15967
111	1.09498	14502.3925	234.52348	0.00000	0.00000	97.00889	2090.41870
112	1.10998	14658.0283	234.52348	0.00000	0.00000	98.33746	2287.02686
113	1.11998	14813.6641	234.52348	0.00000	0.00000	99.66603	2437.91406
114	1.12998	14969.2999	234.52348	0.00000	0.00000	100.99460	2598.67358
115	1.13998	15124.9357	234.52348	0.00000	0.00000	102.32317	2798.92031

116	1.14998	15126.3359	234.52349	-0.00000	-0.00002	-345.26782	-2071.50278
117	1.15998	15882.2930	234.52349	-0.00000	-0.00002	-380.74334	-2284.47363
118	1.16998	15937.8828	234.52349	-0.00000	-0.00002	-413.07910	-2478.46973
119	1.17997	15993.7461	234.52349	-0.00000	-0.00002	-451.78320	-2710.69385
120	1.18997	15749.5703	234.52349	-0.00000	-0.00001	-221.07011	-1326.41797
121	1.19997	15905.6648	234.52349	-0.00000	-0.00001	-246.42044	-1478.51978
122	1.20997	16061.3984	234.52349	-0.00000	-0.00001	-274.23437	-1645.40308
123	1.21997	16217.3555	234.52349	-0.00000	-0.00001	-304.48950	-1826.93335
124	1.22997	16373.3437	234.52349	-0.00000	-0.00002	-337.44971	-2024.69434
125	1.23997	16529.3398	234.52349	-0.00000	-0.00002	-372.95068	-2237.69971
126	1.24997	16685.3477	234.52349	-0.00000	-0.00002	-411.12085	-2466.72021
127	1.25997	16841.3516	234.52349	-0.00000	-0.00002	-451.83374	-2710.99707
128	1.26997	16997.3828	234.52349	-0.00000	-0.00001	-223.03596	-1338.21899
129	1.27997	17153.4023	234.52349	-0.00000	-0.00001	-249.88455	-1499.32937
130	1.28997	17309.4453	234.52349	-0.00000	-0.00001	-279.22927	-1675.36621
131	1.29997	17465.4922	234.52349	-0.00000	-0.00002	-311.00879	-1866.04907
132	1.30997	17621.5430	234.52350	-0.01983	52.984041199995140.	7139956990.	
133	1.31996	17777.5977	233.76839	-452.35791	-16001.937		
134	1.32996	17933.5195	226.22750	-764.33195	7562.35156		
135	1.33996	18089.5859	218.75067	-734.59863	8545.01953		
136	1.34996	18245.3203	211.48796	-723.32178	925.69653		
137	1.35996	18401.2070	204.25688	-722.24927	-1767.20190		
138	1.36996	18556.7617	200.10675	-15.69490	28860.2070		
139	1.37996	18712.3516	200.10639	-0.00000	-0.00000	-48.86787	-293.20554
140	1.38996	18867.8906	200.72810	352.67822	144517.312		
141	1.39996	19023.3857	207.16837	560.22314	-2773.41187		
142	1.40996	19101.3098	210.39035	509.10767	-3493.727		
143	1.41245	19218.5000	212.6262	-3.42737	-20699.9320		
144	1.42245	19374.8672	212.64659	-0.00000	-0.00000	-93.97930	-563.86865
145	1.43495	19570.0273	212.64189	-9.56004	1553.64282		
146	1.44495	19725.3555	226.60765	2282.45020	-14244.562		
147	1.45245	19842.0791	234.53221	-14.36829	-32548.9844		
148	1.46245	19997.9766	234.52349	0.00000	0.00000	31.54199	189.25159
149	1.47244	20153.9023	234.52349	0.00000	0.00000	23.79404	142.76395
150	1.48244	20309.8320	234.52349	0.00000	0.00000	89.82775	89.82775
151	1.49244	20465.7461	234.52349	0.00000	0.00000	5.08766	30.52592
152	1.50244	20621.5078	234.52349	0.00000	-0.00000	-4.58865	-28.13187
153	1.51118	20757.9609	234.52350	-0.00000	-0.00000	-18.77205	-112.63206
154	1.52118	20914.1133	234.52349	-0.00000	0.00000	39.07079	234.42426
155	1.53118	21070.2578	234.52349	-0.00000	-0.00001	-140.40285	-842.41529
156	1.54118	21226.3828	234.52349	-0.00000	-0.00002	-294.02319	-1764.13574
157	1.55618	21460.3156	234.52349	-0.00000	-0.00002	-344.99795	-2069.38354
158	1.56617	21616.5654	234.52349	-0.00000	-0.00002	-382.54712	-2295.27932
159	1.57617	21773.1328	234.52349	-0.00000	-0.00002	-431.75757	-2590.54028
160	1.58117	21851.1875	234.52349	-0.00000	-0.00002	-453.62769	-2721.76074
161	1.59117	22007.5352	234.52349	-0.00000	-0.00001	-226.85188	-1361.10964
162	1.60117	22163.8857	234.52349	-0.00000	-0.00001	-257.58740	-1545.52124
163	1.61117	22320.1328	234.52349	-0.00000	-0.00001	-289.96924	-1739.81201
164	1.62617	22554.5156	234.52349	-0.00000	-0.00002	-343.94385	-2063.65934
165	1.63617	22710.5494	234.52349	-0.00000	-0.00002	-381.94312	-2291.09033
166	1.64616	22865.7959	234.52349	-0.00000	-0.00002	-422.37744	-2537.25977
167	1.65616	23022.9102	234.52349	-0.00000	-0.00002	-466.28247	-2797.58945
168	1.66616	23179.0117	234.52349	-0.00000	-0.00001	-232.45061	-1394.70093
169	1.67616	23335.1250	234.52349	-0.00000	-0.00001	-261.12966	-1566.76980
170	1.68616	23491.2227	234.52349	-0.00000	-0.00002	-292.06104	-1752.36279
171	1.69616	23647.3154	234.52349	-0.00000	-0.00002	-325.43140	-1952.58447
172	1.70616	23803.4052	234.52349	-0.00000	-0.00002	-361.34741	-2169.08032
173	1.71616	23959.4844	234.52349	-0.00000	-0.00002	-399.77783	-2398.66235
174	1.72616	24115.5547	234.52349	-0.00000	-0.00002	-440.86450	-2645.10189
175	1.73616	24271.5406	234.52349	-0.00000	-0.00003	-485.09933	-2910.53538

176	1.74616	24427.7070	234.52348	-0.00000	-0.00001	-243.67404	-1462.04126
177	1.75616	24583.8125	234.54547	33.47558	21105.9453		
178	1.76616	24739.8242	231.42702	-799.05811	32989.2227		
179	1.77616	24895.9062	223.69290	-749.49780	4937.58594		
180	1.78615	25051.8789	216.30669	-730.71021	3931.03229		
181	1.79615	25207.7773	209.06615	-722.86450	-504.32617		
182	1.80615	25363.5508	201.87627	-636.58813	152538.562		
183	1.81615	25519.2393	200.10345	-2.99287	13588.1562		
184	1.82615	25674.9258	200.10638	0.00120	-19.82202	-377656576.	
185	1.83615	25830.5391	202.70125	681.05884	-30926.1484		
186	1.84615	25986.3437	209.30585	890.69189	183970.625		
187	1.85615	26064.9697	212.22864	277.07007	-167765.937		
188	1.86114	26220.6094	212.64661	0.40319	495.22192	35156480.	
189	1.87114	26376.2422	212.54559	-0.00000	-0.00000	-68.65422	-411.92432
190	1.88114	26531.5703	213.13673	542.60962	396777.437		
191	1.89114	26686.6836	233.06734	1258.96484	-828540.937		
192	1.90114	26842.5742	231.52353	0.08090	-192.05516		
193	1.91113	26998.4756	234.52348	0.00000	0.00000	45.75195	274.51099
194	1.92113	27154.3594	234.52348	0.00000	0.00000	40.43474	242.60796
195	1.93113	27310.2695	234.52348	0.00000	0.00000	34.14438	204.86588
196	1.94113	27466.1719	234.52348	0.00000	0.00000	26.65042	159.90222
197	1.95113	27621.8359	234.52348	0.00000	0.00000	19.43445	116.60546
198	1.96112	27777.7344	234.52348	-0.00000	0.00000	65.50393	399.05273
199	1.97112	27933.6953	234.52348	-0.00000	-0.00002	-327.51338	-1965.71240
200	1.98112	28089.5977	234.52348	-0.00000	-0.00002	-451.56489	-2709.39600
201	1.99112	28245.5000	234.52348	-0.00000	-0.00001	-221.58148	-1329.48633
202	2.00112	28401.3437	234.52348	-0.00000	-0.00001	-245.48997	-1472.93701
203	2.01112	28556.8555	234.52348	-0.00000	-0.00002	-267.17456	-1603.04419
204	2.02111	28712.2891	234.52348	-0.00000	-0.00002	-290.57593	-1743.45215
205	2.03111	28867.8984	234.52348	-0.00000	-0.00002	-317.63354	-1905.79761
206	2.04111	29023.5703	234.52348	-0.00000	-0.00002	-347.25464	-2083.52363
207	2.05111	29179.2812	234.52348	-0.00000	-0.00002	-379.35425	-2276.12109
208	2.06111	29335.1094	234.52348	-0.00000	-0.00002	-415.27490	-2491.54453
209	2.07111	29490.9727	234.52348	-0.00000	-0.00002	-454.11255	-2724.66992
210	2.08111	29646.9023	234.52348	-0.00000	-0.00001	-223.51184	-1341.06835
211	2.09111	29802.8398	234.52348	-0.00000	-0.00001	-249.49037	-1496.93921
212	2.10111	29958.8291	234.52348	-0.00000	-0.00001	-278.18359	-1669.09914
213	2.11111	30114.8164	234.52348	-0.00000	-0.00002	-309.15430	-1854.92212
214	2.12111	30270.8242	234.52348	-0.00000	-0.00002	-342.70579	-2056.23557
215	2.13110	30426.8359	234.52348	-0.00000	-0.00002	-378.78735	-2272.71973
216	2.14110	30582.8633	234.52348	-0.00000	-0.00002	-417.71387	-2506.27932
217	2.15110	30738.8945	234.52348	-0.00000	-0.00002	-459.38943	-2756.32520
218	2.16110	30894.9375	234.52348	-0.00000	-0.00001	-227.71230	-1366.27100
219	2.17110	31050.9844	234.52348	-0.00000	-0.00001	-255.22888	-1531.37036
220	2.18110	31207.0117	234.52348	-0.00000	-0.00001	-284.78909	-1708.72510
221	2.19110	31363.0703	234.52348	-0.00000	-0.00002	-317.16040	-1902.95974
222	2.20110	31519.0977	234.52348	-0.00000	-0.00002	-317.16040	-1902.95974
223	2.21110	31675.1172	230.14964	-782.54722	1300.20898		
224	2.22110	31831.1250	222.49153	-701.50317	-701.50317		
225	2.23110	31987.0596	215.14220	-725.09914	-3933.22290		
226	2.24110	32142.9687	207.90594	-720.36572	2034.2334		
227	2.25110	32298.6211	201.05211	-427.29321	114157.250		
228	2.26110	32454.0023	200.10591	-0.07127	-234.84541		
229	2.27109	32609.8281	200.10591	1.98808	9439.79516		
230	2.28109	32765.5195	203.79262	587.03076	-486.31665		
231	2.29109	32921.0312	210.37354	509.21875	-6643.5625		
232	2.30109	33077.3828	212.54545	-7.17527	14249.5234		
233	2.31109	33232.8906	212.64659	-0.00000	-0.00000	-89.20090	-535.20435
234	2.32358	33427.0625	212.77570	226.78322	274140.375		
235	2.33168	33543.1328	225.23949	2309.94678	-145219.587		

236	2.34108	33698.7656	234.52475	-0.73926	-8782.22266	37.10735	222.64355
237	2.35107	33854.7461	234.52348	0.00000	0.00000	29.89752	179.38478
238	2.36107	34010.7656	234.52348	0.00000	0.00000	21.70374	130.22215
239	2.37107	34166.7500	234.52348	0.00000	0.00000	9.75488	58.52914
240	2.38357	34361.7266	234.52348	0.00000	0.00000	2.93563	17.61374
241	2.39106	34478.4844	234.52349	0.00000	0.00000	122.33462	734.00732
242	2.40106	34634.5547	234.52350	0.00000	0.00001	84.07433	504.44482
243	2.41106	34790.6055	234.52348	0.00000	0.00000	-245.31941	-1471.90747
244	2.42105	34946.6836	234.52348	-0.00000	-0.00001	-274.31434	-1445.88647
245	2.43105	35102.7344	234.52348	-0.00000	-0.00002	-306.23533	-1837.41431
246	2.44105	35258.7812	234.52348	-0.00000	-0.00002	-347.16382	-2082.97876
247	2.45105	35415.2852	234.52348	-0.00000	-0.00002	-390.07227	-2340.42996
248	2.46105	35571.8242	234.52348	-0.00000	-0.00002	-428.10136	-2568.60425
249	2.47105	35727.7422	234.52348	-0.00000	-0.00002	-469.50269	-2817.01050
250	2.48104	35883.7148	234.52348	-0.00000	-0.00001	-233.71546	-1402.65601
251	2.49104	36039.7461	234.52348	-0.00000	-0.00001	-261.76394	-1570.70044
252	2.50104	36195.7891	234.52348	0.0	0.0	0.0	0.0
253	2.50104	0.0	0.0	0.0	0.0	0.0	0.0

LOCK MECHANISM (LM) PARAMETERS							LOCK TORQUE (FT-LBS)		GEAR FORCE (LBS)	
	TIME (SEC)	MOTOR (DEG)	LM ROTATION (DEG)	LM VELOCITY (DEG/SEC)	LM ACCELERATION (DEG/SEC**2)					
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	14.79820	0.0	0.0	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
3	0.01000	2.95483	14.79820	-0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
4	0.02000	11.81333	14.79820	-0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
5	0.03000	26.59334	14.79820	-0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
6	0.04000	47.27733	14.79820	-0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
7	0.05000	73.82103	14.79820	-0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
8	0.06000	106.15965	14.79820	-0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
9	0.07000	144.19336	14.79820	-0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
10	0.08000	187.77528	14.79820	-0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
11	0.09000	236.77397	14.79820	-0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
12	0.10000	291.69507	14.79820	-0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
13	0.11250	366.80444	14.79820	-0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
14	0.12500	450.43066	14.79820	-0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
15	0.13500	522.57178	14.79820	-0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
16	0.15000	639.27368	13.49980	-263.72998	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
17	0.16000	722.35401	9.63173	-284.09521	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
18	0.17000	809.73125	4.68554	-232.81740	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
19	0.18000	901.03569	1.36282	-157.47238	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
20	0.19000	995.39502	0.19435	-62.28990	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
21	0.20000	1095.25439	0.00004	-0.31376	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000
22	0.21000	1197.6966	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.22000	1303.29712	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.23000	1412.16550	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.24000	1524.61587	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.25000	1638.14756	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.26000	1756.16921	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.27000	1876.16943	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.28000	1998.59619	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.29000	2123.30515	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.30000	2250.17261	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	0.31000	2379.06226	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.32000	2509.04375	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.33000	2642.01748	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.34000	2776.03525	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.35000	2912.02310	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	0.36000	3049.03867	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	0.37000	3188.02461	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	0.38000	3328.06543	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	0.39000	3469.08911	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.40000	3611.21289	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	0.41000	3754.34592	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	0.42000	3899.02261	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	0.43000	4043.30591	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	0.44000	4188.08437	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	0.45000	4335.30469	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47	0.46000	4482.23829	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	0.47000	4629.03281	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	0.48000	4777.57512	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	0.49000	4925.44766	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	0.50000	5074.73437	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52	0.50500	5149.21975	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53	0.51250	5261.32021	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
54	0.52250	5411.26562	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55	0.53500	5599.14453	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[illegible]

236	2.34108	33698.7656	0.0	0.0	258160.500	9.30572	57.56063
237	2.35107	33854.7461	0.0	0.0	-33013.5781	-1.19002	-7.39922
238	2.36107	34010.7656	0.0	0.0	0.00000	0.00000	0.00000
239	2.37107	34166.7500	0.0	0.0	0.00000	0.00000	0.00000
240	2.38357	34361.7256	3.35762	1155.68996	0.00000	0.00000	0.00000
241	2.39106	34478.4844	13.18603	250.76680	0.00000	0.00000	0.00000
242	2.40106	34634.5547	14.79820	0.00000	0.00000	0.00000	0.00000
243	2.41106	34790.6055	14.79820	0.00000	0.00000	0.00000	0.00000
244	2.42105	34946.6836	14.79820	-0.00000	-0.00000	-0.00000	-0.00000
245	2.43105	35102.7344	14.30006	-2.27782	-2069.6836	-0.72344	-4.49815
246	2.44105	35258.7812	10.25149	-955.36108	15538.625	5.59938	34.51552
247	2.45105	35415.2852	2.74294	-692.38916	-27133.9062	-0.87308	-6.08143
248	2.46105	35571.8242	0.07647	-53.07686	24359.8359	0.87308	5.45969
249	2.47105	35727.7422	0.0	0.0	0.0	0.0	0.0
250	2.48104	35883.7148	0.0	0.0	0.0	0.0	0.0
251	2.49104	36039.7451	0.0	0.0	0.0	0.0	0.0
252	2.50104	36195.7891	0.0	0.0	0.0	0.0	0.0
253	2.50104	0.0	0.0	0.0	0.0	0.0	0.0

CHAMBER ASSEMBLY (CA) PARAMETERS	CA	DISPL	CA VELOCITY	CA ACCELERATION	CRUSH FORCE	RESEAR FORCE	STUD FORCE
TIME (SEC)	MOTOR (DEG)	(INCH)	(DEG/SEC)	(DEG/SEC**2)	(FT-LBS)	(LBS)	(LBS)
1	0.0	0.0	0.0	0.0	584.05371	0.0	0.0
2	0.0	0.0	0.0	0.0	584.05371	0.0	0.0
3	0.01000	2.95483	0.0	0.0	584.05371	0.0	0.0
4	0.02000	11.81933	0.0	0.0	584.05371	0.0	0.0
5	0.03000	26.59344	0.0	0.0	584.05371	0.0	0.0
6	0.04000	47.27733	0.0	0.0	584.05371	0.0	0.0
7	0.05000	73.82103	0.0	0.0	584.05371	0.0	0.0
8	0.06000	106.15965	0.0	0.0	584.05371	0.0	0.0
9	0.07000	144.19530	0.0	0.0	584.05371	0.0	0.0
10	0.08000	187.77528	0.0	0.0	584.05371	0.0	0.0
11	0.09000	236.77397	0.0	0.0	584.05371	0.0	0.0
12	0.10000	291.69507	0.0	0.0	584.05371	0.0	0.0
13	0.11250	366.80444	0.0	0.0	584.05371	0.0	0.0
14	0.12500	450.43066	0.0	0.0	584.05371	0.0	0.0
15	0.13500	522.57178	0.0	0.0	584.05371	0.0	0.0
16	0.15000	639.27368	0.0	0.0	584.05371	0.0	0.0
17	0.16000	722.36401	0.0	0.0	0.0	0.0	0.0
18	0.17000	809.78125	0.0	0.0	0.0	0.0	0.0
19	0.18000	901.08569	0.0	0.0	0.0	0.0	0.0
20	0.19000	996.39502	0.0	0.0	0.0	0.0	0.0
21	0.20000	1095.25439	0.0	0.0	0.0	0.0	0.0
22	0.21000	1197.64966	0.01813	141.38092	0.0	0.0	10.61064
23	0.22000	1303.29712	0.05454	445.63379	0.0	0.0	33.44481
24	0.23000	1412.16550	0.13755	-1617.14673	0.0	0.0	-121.36685
25	0.24000	1524.01587	0.31442	678.14648	0.0	0.0	50.89490
26	0.25000	1638.74756	0.51764	651.40234	0.0	0.0	49.88774
27	0.26000	1756.18921	0.87250	-5225.99219	0.0	0.0	-270.48853
28	0.27000	1876.16943	1.23987	238.68201	0.0	0.0	12.35378
29	0.28000	1999.59519	1.79720	872.70752	0.0	0.0	45.16988
30	0.29000	2123.30515	55.14091	791.56787	0.0	0.0	40.97023
31	0.30000	2250.17261	3.04389	62.70477	0.0	0.0	35.33479
32	0.31000	2379.06226	3.71151	68.11208	0.0	0.0	21.10283
33	0.32000	2509.84375	4.51172	407.71875	0.0	0.0	7.05388
34	0.33000	2642.41748	5.14295	135.28494	0.0	0.0	-10.51583
35	0.34000	2776.65525	5.73347	-203.17181	0.0	0.0	-26.50453
36	0.35000	2912.42310	6.31565	-512.68228	0.0	0.0	-45.49786
37	0.36000	3049.63967	5.80742	-879.04419	0.0	0.0	-113.38246
38	0.37000	3188.22461	6.30499	-2190.61304	0.0	0.0	-60.59360
39	0.38000	3328.06543	7.39499	-1170.76025	0.0	0.0	-62.09859
40	0.39000	3469.08911	7.53110	1199.77954	0.0	0.0	-54.31285
41	0.40000	3611.21299	8.17488	-1049.35474	0.0	0.0	-42.42474
42	0.41000	3754.34592	8.87581	-816.15332	0.0	0.0	-25.13792
43	0.42000	3898.42261	0.14817	-495.67871	0.0	0.0	-1.56303
44	0.43000	4043.30591	-0.02185	-29.81223	0.0	0.0	-2.97829
45	0.44000	4189.98437	-2.83506	-57.54227	0.0	0.0	-28.57672
46	0.45000	4335.30469	-6.04524	-552.11841	0.0	0.0	38.86626
47	0.46000	4482.23328	-19.57260	6740.25391	0.0	0.0	-61.09483
48	0.47000	4629.63281	-32.00559	-1316.38135	0.0	0.0	-69.13370
49	0.48000	4777.57512	-45.59264	-1452.24243	0.0	0.0	-75.16565
50	0.49000	4925.94766	-59.56225	-1227.75610	0.0	0.0	-63.54660
51	0.50000	5074.73437	-79.55710	-832.23970	0.0	0.0	-43.11157
52	0.50500	5149.21375	-79.91760	-502.33521	0.0	0.0	-26.00003
53	0.51250	5261.32931	-81.67354	-450.55200	0.0	0.0	-23.31981
54	0.52500	5411.26562	-71.42545	-127.52103	0.0	0.0	-8.60545
55	0.53500	5599.14453	-2.07930	377.59253	0.0	0.0	19.54355
				922.59863	0.0	0.0	47.75217

56	0.54500	5749.87891	1.41743	-59.49763	1711.56250	0.0	0.0	0.0	88.58762
57	0.55500	5900.17578	0.87991	-47.02523	1092.83032	0.0	0.0	0.0	56.56306
58	0.56500	6013.33203	0.56511	-36.87286	1691.27612	0.0	0.0	0.0	87.53763
59	0.57250	6164.80078	0.26555	-23.42027	0.26555	0.0	0.0	0.0	98.80630
60	0.58250	6316.6016	0.09154	-12.06980	1023.96460	0.0	0.0	0.0	76.84854
61	0.59250	6468.83984	0.01615	-3.79880	715.46973	0.0	0.0	0.0	53.69600
62	0.60500	6659.8437	-0.00003	0.06800	58.08842	0.0	0.0	0.0	4.35954
63	0.61250	6773.96484	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64	0.62250	6926.74922	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65	0.63500	7118.53125	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66	0.64500	7272.19531	0.0	0.0	0.0	0.0	0.0	0.0	0.0
67	0.65500	7426.05959	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68	0.67000	7657.28906	0.0	0.0	0.0	0.0	0.0	0.0	0.0
69	0.67500	7734.26953	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70	0.68500	7888.37500	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71	0.69500	8042.83984	0.00562	1.94765	399.60132	0.0	0.0	0.0	29.99007
72	0.70500	8197.47266	0.05490	9.58755	915.59790	0.0	0.0	0.0	66.71562
73	0.72000	8429.94531	0.30720	26.23604	1291.51465	0.0	0.0	0.0	96.92816
74	0.73000	8585.06541	0.65677	59.12297	-35186.5742	0.0	0.0	0.0	-1821.19824
75	0.74000	8740.32912	1.11909	55.18683	1522.08301	0.0	0.0	0.0	78.78047
76	0.75000	8895.69922	1.73933	68.48915	985.98462	0.0	0.0	0.0	51.03291
77	0.76000	9051.19531	2.47666	75.41043	737.35327	0.0	0.0	0.0	38.16417
78	0.77000	9206.77734	3.29311	84.06819	255.00128	0.0	0.0	0.0	13.19844
79	0.78000	9362.47266	4.14092	84.66840	-174.31560	0.0	0.0	0.0	-9.02228
80	0.79000	9519.23047	4.96830	80.03989	-712.06079	0.0	0.0	0.0	-36.85507
81	0.80000	9674.05959	5.72595	70.93344	-1097.73853	0.0	0.0	0.0	-56.81711
82	0.81000	9829.32578	6.37277	57.13953	-1644.87842	0.0	0.0	0.0	-85.23967
83	0.82000	9985.84375	6.88212	43.51314	-1432.39331	0.0	0.0	0.0	-74.13829
84	0.83000	10141.7812	7.28325	28.79276	-1479.21167	0.0	0.0	0.0	-76.56152
85	0.84000	10257.7500	7.46377	15.76344	-987.54858	0.0	0.0	0.0	-51.11386
86	0.85000	10453.7578	7.56922	5.92855	-752.31812	0.0	0.0	0.0	-38.93872
87	0.86000	10609.7539	7.59869	0.71323	-324.67871	0.0	0.0	0.0	-16.80482
88	0.87000	10765.9125	7.60000	-0.00000	-0.00000	0.0	0.0	0.0	-0.00000
89	0.88000	10921.7773	7.59441	-1.95941	-408.73389	0.0	0.0	0.0	-21.15538
90	0.89000	11077.8203	7.54465	-8.82653	-933.47534	0.0	0.0	0.0	-48.31512
91	0.90000	11233.7461	7.40419	-19.80145	-1283.12573	0.0	0.0	0.0	-66.41245
92	0.91000	11389.6211	7.13957	-33.62480	-1447.56736	0.0	0.0	0.0	-74.92368
93	0.92000	11545.3555	6.72927	-48.77694	-453.42407	0.0	0.0	0.0	-23.46846
94	0.93000	11701.0273	6.17205	-62.50518	-1174.25171	0.0	0.0	0.0	-60.77731
95	0.94000	11856.6211	5.48582	-74.36183	-1219.37378	0.0	0.0	0.0	-63.11275
96	0.95000	12012.2137	4.70113	-81.92316	-525.63501	0.0	0.0	0.0	-27.20599
97	0.96000	12167.8555	3.86192	-85.08286	-99.95529	0.0	0.0	0.0	-5.17352
98	0.96500	12346.4697	3.43325	-84.54340	231.40100	0.0	0.0	0.0	21.97693
99	0.97125	12434.7461	2.91163	-82.07689	533.75464	0.0	0.0	0.0	27.62624
100	0.99250	12519.7617	2.03369	-73.14853	1162.36377	0.0	0.0	0.0	60.16230
101	1.09250	12674.2852	1.36171	-60.57499	-824.75806	0.0	0.0	0.0	-42.68910
102	1.00250	12829.2256	0.82177	-46.54799	1731.57090	0.0	0.0	0.0	89.62321
103	1.01250	12984.8857	0.42736	-32.07072	1487.42212	0.0	0.0	0.0	111.63103
104	1.02250	13140.6602	0.17609	-18.49471	1336.18408	0.0	0.0	0.0	109.28059
105	1.03499	13335.4492	0.02989	-5.96221	567.95654	0.0	0.0	0.0	50.13013
106	1.04499	13491.3047	0.00119	-0.57490	271.55234	0.0	0.0	0.0	20.38751
107	1.05499	13647.1552	0.0	0.0	0.0	0.0	0.0	0.0	0.0
108	1.06249	13763.3477	0.0	0.0	0.0	0.0	0.0	0.0	0.0
109	1.07248	13919.6641	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110	1.08498	14114.4258	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111	1.09498	14270.3242	0.0	0.0	0.0	0.0	0.0	0.0	0.0
112	1.10998	14504.1875	0.0	0.0	0.0	0.0	0.0	0.0	0.0
113	1.11998	14659.9672	0.0	0.0	0.0	0.0	0.0	0.0	0.0
114	1.12998	14815.3594	0.0	0.0	0.0	0.0	0.0	0.0	0.0
115	1.13998	14971.5596	0.00915	2.44272	535.52769	0.0	0.0	0.0	40.19885

116	1.14998	15126.3359	0.06599	7.97100	-5011.14844	0.0	0.0	0.0	-376.08667
117	1.15998	15282.2930	0.21908	12.27145	1331.42041	0.0	0.0	0.0	99.92308
118	1.16998	15437.8828	0.49974	35.25810	1541.67090	0.0	0.0	0.0	115.70238
119	1.17997	15593.7461	0.92682	50.15285	1415.16895	0.0	0.0	0.0	73.24678
120	1.18997	15749.5703	1.45945	64.17888	1429.76685	0.0	0.0	0.0	74.00233
121	1.19997	15905.4648	2.20032	75.44072	824.69897	0.0	0.0	0.0	42.68504
122	1.20997	16061.3994	2.95545	82.78993	479.88135	0.0	0.0	0.0	24.83784
123	1.21997	16217.3555	3.83956	85.14056	-45.02480	0.0	0.0	0.0	-2.33041
124	1.22997	16373.3437	4.66140	82.35945	-505.93066	0.0	0.0	0.0	-28.18611
125	1.23997	16529.3398	5.44983	74.63824	-918.61645	0.0	0.0	0.0	-47.54605
126	1.24997	16685.3477	6.16031	62.63705	-2372.48437	0.0	0.0	0.0	-122.79582
127	1.25997	16841.3516	6.72037	48.75954	-1352.14966	0.0	33.84259	33.84259	-69.98502
128	1.26997	16997.3828	7.11364	33.95499	-1516.48657	0.0	36.73550	36.73550	-78.49080
129	1.27997	17153.4023	7.40145	20.00966	-1299.34863	0.0	38.61021	38.61021	-87.25211
130	1.28997	17309.4453	7.56333	8.97471	-872.24585	0.0	39.60332	39.60332	-45.14598
131	1.29997	17465.4922	7.59416	2.06235	-462.99463	0.0	39.95909	39.95909	-23.96384
132	1.30997	17621.5430	7.50000	0.23535	33.45605	0.0	40.00000	40.00000	1.73163
133	1.31996	17777.5977	7.59887	-0.69019	-276.03735	0.0	39.99207	39.99207	-14.28724
134	1.32996	17933.5195	7.56999	-5.94545	-773.98096	0.0	39.78990	39.78990	-40.05997
135	1.33996	18089.5859	7.46440	-17.95152	3875.60156	0.0	200.59465	200.59465	200.59465
136	1.34996	18245.3203	7.24728	-28.56450	-1554.61694	0.0	37.53096	37.53096	-80.46437
137	1.35996	18401.2070	6.89159	-46.76321	-2144.61328	0.0	35.04112	35.04112	-110.01611
138	1.36996	18556.7617	6.39267	-57.75146	-1350.76050	0.0	0.0	0.0	-69.91310
139	1.37996	18712.3516	5.73905	-70.50798	-1228.61719	0.0	0.0	0.0	-63.59117
140	1.38996	18867.8906	4.93464	-79.71808	-772.17896	0.0	0.0	0.0	-39.96669
141	1.39996	19023.3857	4.15982	-84.72903	-340.93677	0.0	0.0	0.0	-17.64632
142	1.40995	19101.3009	3.73491	-85.46280	-22.46910	0.0	0.0	0.0	-1.16296
143	1.41246	19218.5000	3.09975	-83.58397	393.99390	0.0	0.0	0.0	20.39246
144	1.42245	19374.8672	2.29361	-76.81078	1032.20874	0.0	0.0	0.0	53.42538
145	1.43495	19570.0273	1.41822	-61.56624	1861.61572	0.0	0.0	0.0	96.35411
146	1.44495	19725.3555	0.85476	-48.20395	1331.93491	0.0	0.0	0.0	69.93872
147	1.45245	19842.0781	0.54498	-36.94009	1661.34302	0.0	0.0	0.0	85.98833
148	1.46245	19997.9766	0.24627	-22.86908	1384.78149	0.0	0.0	0.0	103.92784
149	1.47244	20153.9023	0.07893	-11.00697	1129.18018	0.0	0.0	0.0	84.66992
150	1.48244	20309.8320	0.01159	-3.02922	519.34326	0.0	0.0	0.0	39.90166
151	1.49244	20465.7461	-0.00003	-0.09578	160.22702	0.0	0.0	0.0	12.02504
152	1.50244	20621.5078	0.0	0.0	0.0	0.0	0.0	0.0	0.0
153	1.51118	20757.9609	0.0	0.0	0.0	0.0	0.0	0.0	0.0
154	1.52118	20914.1133	0.0	0.0	0.0	0.0	0.0	0.0	0.0
155	1.53118	21070.2578	0.0	0.0	0.0	0.0	0.0	0.0	0.0
156	1.54118	21226.3828	0.0	0.0	0.0	0.0	0.0	0.0	0.0
157	1.55618	21460.5156	0.0	0.0	0.0	0.0	0.0	0.0	0.0
158	1.56617	21616.5664	0.0	0.0	0.0	0.0	0.0	0.0	0.0
159	1.57617	21773.1328	0.00017	0.21013	150.49234	0.0	0.0	0.0	11.29445
160	1.58117	21851.1875	0.00423	1.54789	424.16968	0.0	0.0	0.0	31.83394
161	1.59117	22007.5352	0.04933	9.17620	897.55298	0.0	0.0	0.0	67.36133
162	1.60117	22163.8857	0.18224	18.97775	1172.97451	0.0	0.0	0.0	98.03174
163	1.61117	22320.1329	0.43895	32.71567	1449.46592	0.0	0.0	0.0	108.78239
164	1.62617	22554.5156	1.09737	54.90837	1412.71899	0.0	0.0	0.0	73.11998
165	1.63617	22710.6484	1.71566	68.42329	1194.58423	0.0	0.0	0.0	51.31210
166	1.64616	22866.7959	2.45284	73.45351	734.57300	0.0	0.0	0.0	39.02028
167	1.65616	23022.9102	3.27044	84.27498	219.51642	0.0	0.0	0.0	11.31004
168	1.66616	23179.0117	4.2027	84.90811	-151.13398	0.0	0.0	0.0	-7.82555
169	1.67616	23335.1250	4.15060	80.35417	-706.43604	0.0	0.0	0.0	-36.56395
170	1.68616	23491.2227	5.71149	71.26131	-1030.31519	0.0	0.0	0.0	-53.35327
171	1.69616	23647.3154	6.36194	57.59180	-2339.92505	0.0	0.0	0.0	-121.05885
172	1.70616	23803.4052	6.37435	43.81329	-1451.98867	0.0	0.0	0.0	-75.14734
173	1.71616	23959.4844	7.23936	29.06366	-1458.80696	0.0	0.0	0.0	-75.58540
174	1.72616	24115.5547	7.5120	15.93818	-1042.10474	0.0	0.0	0.0	-53.93759
175	1.73616	24271.6406	7.55927	6.11377	-773.31519	0.0	0.0	0.0	-40.02550

176	1.74616	24427.7070	7.59857	0.76390	-333.86792	0.0	39.99001	-17.28044
177	1.75616	24583.8125	7.60000	-0.00000	-0.00000	0.0	39.99998	-0.00000
178	1.76616	24739.8242	7.59470	-1.89950	-414.00977	0.0	39.98288	-21.42845
179	1.77616	24895.9052	7.54572	-8.69436	-926.14819	0.0	39.62006	-47.93588
180	1.78615	25051.9789	7.40697	-19.62723	-1251.38452	0.0	38.64880	-64.76956
181	1.79615	25207.7773	7.14326	-33.42886	-1447.64355	0.0	36.80284	-74.92761
182	1.80615	25363.5508	6.73498	-48.63501	-975.16699	0.0	33.94482	-50.47301
183	1.81615	25519.2383	6.18055	-62.40639	-1022.16699	0.0	0.0	-52.90565
184	1.82615	25674.9258	5.49552	-74.24002	-1252.44019	0.0	0.0	-64.82420
185	1.83615	25830.5391	4.71174	-81.89594	-513.52148	0.0	0.0	-26.57901
186	1.84615	25986.3437	3.87200	-85.10817	-94.80296	0.0	0.0	-4.90684
187	1.85615	26064.9687	3.44322	-84.60139	207.34387	0.0	0.0	10.73177
188	1.86114	26220.6094	2.61735	-79.83606	723.77661	0.0	0.0	37.46147
189	1.87114	26376.2422	1.85215	-70.75964	1261.83472	0.0	0.0	65.31046
190	1.88114	26531.5703	1.21965	-56.74446	957.52100	0.0	0.0	50.07727
191	1.89114	26686.6836	0.71436	-43.36931	1303.10303	0.0	0.0	67.44643
192	1.90114	26842.5742	0.35461	-28.70421	1374.96289	0.0	0.0	103.19095
193	1.91113	26998.4766	0.13502	-15.76981	1027.97705	0.0	0.0	77.14967
194	1.92113	27154.3594	0.03043	-5.92597	678.12402	0.0	0.0	50.89320
195	1.93113	27310.2695	0.00125	-0.69922	276.54419	554.69702	0.0	20.75464
196	1.94113	27466.1719	0.0	0.0	0.0	584.05371	0.0	0.0
197	1.95112	27621.8359	0.0	0.0	0.0	584.05371	0.0	0.0
198	1.96112	27777.7344	0.0	0.0	0.0	584.05371	0.0	0.0
199	1.97112	27933.6953	0.0	0.0	0.0	584.05371	0.0	0.0
200	1.98112	28089.5977	0.0	0.0	0.0	584.05371	0.0	0.0
201	1.99112	28245.5000	0.0	0.0	0.0	584.05371	0.0	0.0
202	2.00112	28401.3437	0.0	0.0	0.0	0.0	0.0	0.0
203	2.01112	28556.8555	0.0	0.0	0.0	0.0	0.0	0.0
204	2.02111	28712.2891	0.00087	0.58040	251.48328	0.0	0.0	18.87381
205	2.03111	28867.8984	0.02756	5.52727	659.59814	0.0	0.0	49.50284
206	2.04111	29023.5703	0.12739	17.87590	3841.26562	0.0	0.0	288.28687
207	2.05111	29179.2812	0.33987	27.83414	1380.32886	0.0	0.0	103.59366
208	2.06111	29335.1094	0.69349	20.05383	25105.3594	0.0	0.0	1299.41138
209	2.07111	29490.9727	1.19197	57.34219	1414.87427	0.0	0.0	73.23154
210	2.08111	29646.9023	1.83140	70.14079	1122.63281	0.0	0.0	58.10559
211	2.09111	29802.8398	2.58393	79.69543	787.92041	0.0	0.0	40.78143
212	2.10111	29958.8231	3.40372	84.50385	253.52802	0.0	0.0	13.12219
213	2.11111	30114.8164	4.25935	84.37996	-307.39038	0.0	0.0	-15.91002
214	2.12111	30270.9242	5.09103	79.08188	-794.78369	0.0	0.0	-41.13667
215	2.13110	30426.8359	5.82593	69.16716	-1131.18018	0.0	0.0	-58.54799
216	2.14110	30582.8633	6.45529	56.56294	-1697.91333	0.0	0.0	-97.88115
217	2.15110	30738.8945	6.94354	41.41702	-1595.48437	0.0	0.0	-82.57361
218	2.16110	30894.9375	7.29323	26.76347	-1359.42651	0.0	35.40480	-70.35165
219	2.17110	31050.9844	7.48555	14.95666	-1197.06763	0.0	37.78471	-61.44064
220	2.18110	31207.0117	7.57718	4.94490	-707.90698	0.0	39.19993	-36.64009
221	2.19110	31363.0703	7.59947	0.37323	-195.31305	0.0	39.99626	-10.16084
222	2.20110	31519.0977	7.60000	-0.00000	-0.00000	0.0	39.99998	-0.00000
223	2.21110	31675.1172	7.59112	-2.61740	-629.54810	0.0	39.93785	-32.58437
224	2.22110	31831.1250	7.53147	-5.67940	8884.03125	0.0	39.52171	-459.82275
225	2.23110	31987.0596	7.37377	-21.75818	-1328.92676	0.0	38.41541	-68.78302
226	2.24110	32142.9687	7.09738	-36.03567	119.08269	0.0	36.41164	6.16352
227	2.25110	32299.6211	5.55607	-50.59018	-1418.20874	0.0	33.39247	-73.40411
228	2.26110	32454.4023	5.07579	-64.46192	-1323.65141	0.0	0.0	-68.77084
229	2.27109	32609.8231	5.37644	-75.52530	-759.10278	0.0	0.0	-39.28989
230	2.28109	32765.5195	4.55044	-82.79935	-509.67871	0.0	0.0	-25.38011
231	2.29109	32921.0312	3.73912	-85.12440	-35.51691	0.0	0.0	-1.89005
232	2.30109	33077.3858	2.89512	-81.92569	538.42896	0.0	0.0	27.86818
233	2.31109	33232.6906	2.11124	-74.18102	928.62695	0.0	0.0	48.06418
234	2.32358	33427.0635	1.27375	-59.51309	4924.57031	0.0	0.0	254.88753
235	2.33108	33543.1328	0.67273	-49.47719	1310.32935	0.0	0.0	57.52045

236	2.34108	33698.7656	0.46244	-33.74258	1531.00366	0.0	0.0	114.90181
237	2.35107	33854.7461	0.19631	-19.93600	1268.22290	0.0	0.0	95.18013
238	2.36107	34010.7656	0.05573	-8.86019	844.41870	0.0	0.0	63.37363
239	2.37107	34166.7500	0.00567	-1.98653	462.92310	0.0	0.0	34.74237
240	2.38357	34361.7266	0.0	0.0	0.0	0.0	0.0	0.0
241	2.39106	34478.4844	0.0	0.0	0.0	451.47998	0.0	0.0
242	2.40106	34634.5547	0.0	0.0	0.0	584.05371	0.0	0.0
243	2.41106	34790.6055	0.0	0.0	0.0	584.05371	0.0	0.0
244	2.42105	34946.6836	0.0	0.0	0.0	584.05371	0.0	0.0
245	2.43105	35102.7344	0.0	0.0	0.0	584.05371	0.0	0.0
246	2.44105	35258.7812	0.0	0.0	0.0	584.05371	0.0	0.0
247	2.45105	35415.2852	0.0	0.0	0.0	584.05371	0.0	0.0
248	2.46105	35571.8242	0.00001	0.03194	79.54527	0.0	0.0	5.96987
249	2.47105	35727.7422	0.01321	3.47876	354.61597	0.0	0.0	26.61394
250	2.48104	35883.7148	0.07198	13.25315	33784.3008	0.0	0.0	2535.51147
251	2.49104	36039.7451	0.25782	23.51338	1270.00049	0.0	0.0	95.31354
252	2.50104	36195.7891	0.55732	28.08549	2321.32178	0.0	0.0	120.14774
253		0.0	0.0	0.0	0.0	0.0	0.0	0.0

A P P E N D I X A-5

DRAWING DATA SMOOTHING

The numerical integration routine (IBM-S/P routine HPCG) can quite possibly iterate excessively about a first derivative discontinuity such as exists in the drawing data for the feed, eject, and lock ring cam data. To avoid this excessive iteration the data has been treated to "smooth" the sharp corners. The "smoothing" algorithm used is a cubic fit that fits exactly at the endpoints in both displacement and slope.

Development:

CUBIC FIT

$$Y_1 = a_3 X_1^3 + a_2 X_1^2 + a_1 X_1 + a_0$$

$$Y_2 = a_3 X_2^3 + a_2 X_2^2 + a_1 X_2 + a_0$$

$$M_1 = 3a_3 X_1^2 + 2a_2 X_1 + a_1$$

$$M_2 = 3a_3 X_2^2 + 2a_2 X_2 + a_1$$

Unknowns are a_0, a_1, a_2, a_3

$$a_3(X_1^3) + a_2(X_1^2) + a_1(X_1) + a_0(1) = Y_1$$

$$a_3(X_2^3) + a_2(X_2^2) + a_1(X_2) + a_0(1) = Y_2$$

$$a_3(3X_1^2) + a_2(2X_1) + a_1(1) + a_0(0) = M_1$$

$$a_3(3X_2^2) + a_2(2X_2) + a_1(1) + a_0(0) = M_2$$

X_1^3	X_1^2	X_1	1	a_3	Y_1
X_2^3	X_2^2	X_2	1	a_2	Y_2
$3X_1^2$	$2X_1$	1	0	a_1	M_1
$3X_2^2$	$2X_2$	1	0	a_0	M_2

which is of form

$$[A]\{a\} = \{RHS\} \text{ where}$$

only $\{a\}$ is unknown. IBM-SSP

sinθ can be used to determine $\{a\}$

when {a} is found, the Y values in the region of interest are then

$$Y(J) = a(4) + X(J)(a(3) + X(J)(a(2) + X(J)(a(1))))$$

For Range of X(J) between and including endpoints X1 and X2.

PROGRAM: The original drawing data and the regions of each curve to be fit must be supplied to the fitting program. The graphical output only is included as the program output.

FORTRAN IV G LEVEL 21 MAIN

```

0001      REAL X(1000),Y(1000),Z(1000)
0002      DATA J/0,'N'./

C      INPUT DATA
C
C      10      CONTINUE
C      J=J+1
0003      READ(5,100,ERR=101) X(J),Y(J)
0004      IF(X(J).GT.900.) GO TO 101
0005      N=N+1
0006      Z(J)=Y(J)
0007      GO TO 10
0008
C      101      CONTINUE
C
C      101      CONTINUE
C
0009      READ(5,200,END=201, ISTART,IEND)
0010      WRITE(6,4001) ISTART,IEND
0011      FORM F(,'',2110)
0012      CALL FIT3(X,Z,ISTART,IEND)
0013      GO TO 101
0014
C      201      CONTINUE
C
C      300      J=1,N
0015      DIFF=Y(J)-Z(J)
0016      WRITE(6,4005) X(J),Y(J),Z(J),DIFF, I
0017      FORMAT(' ',4F16.4,I10)
0018      CONTINUE
0019
C      4005      CALL PUNCHG(X,Z,N)
0020      CALL P INGX,Y,Z,N)
0021
C
C      STOP
0022      FORMAT(2F16.4)
0023      FORMAT(2110)
0024      END
0025
0026

```

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FORTRAN IV G LEVEL 21 PUNCHG

```
0001 SUBROUTINE PUNCHG(X,Z,N)
0002 REAL X(1),Z(1)
      C
0003 DO 300 J=1,N
0004   PUNCH260,X(J),Z(J)
0005   FORMAT(2F16.4)
0006   CONTINUE
      C
0007   RETURN
0008   END
```

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PLOTNG

FORTRAN IV G LEVEL 21

```

0001 SUBROUTINE PLOTNG(X,Y,Z,N)
0002 REAL X(1),Y(1),Z(1),Z2(1),Z (1)
0003 DIMENSION IBUF(1000)
0004 CALL PLOTS(IBUF,1000,14)
0005 CALL FACTOR(1,0)
0006 CALL NEWPEN(1)
0007 CALL PLOT(10,-36,-3)
0008 CALL PLOT(0,0,2,5,-3)
0009 CALL SCALE(X,10,N,1)
0010 CALL SCALE(Y,8,N,1)
0011 X1=X(N+1)
0012 X2=X(N+2)
0013 Y1=Y(N+1)
0014 Y2=Y(N+2)
0015 Z(N+1)=Y1
0016 Z(N+2)=Y2
0017 CALL AXIS(0,0,0,8H
0018 CALL AXIS(0,0,0,8H
0019 CALL LINE(X,Y ,N+1, 0,0)
0020 CALL LINE(X,Z ,N+1, 0,2)
0021 CALL PLOT(20,0,0,999)
0022 RETURN
0023 END

```

```

      *-8,10,0,0,X1,X2)
      *-8,8,0,0,Y1,Y2)

```

SUBROUTINE FIT3(X,Y,ISTART,IEND)

C- ABSTRACT: SUBROUTINE FIT3 GIVES A SMOOTH CUBIC FIT WITH EXACT FIT IN THE
C- 0 AND 1 DERIVATIVE FOR THE ENDPOINTS OF THE INDICATED INTERVAL...WHICH
C- IS DETERMINED BY THE RANGE FROM X(ISTART+1) THRU X(IEND-1)

REAL X(1),Y(1),M1,M2
DOUBLE PRECISION DX(30),DY(30),DRS(4),DA(4,4)

C- DETERMINE THE SLOPES FROM END DATA AND CHECK NUMBER OF POINTS

IS=ISTART+1
IE=IEND-1
DELTA=X(IE)-X(ISTART)
INUM=IFIX((X(IE)-X(ISTART))/DELTA)+1
IF(INUM.LT.6 .AND. INUM.GT.27) RETURN

DO 100 J=1,INUM
DX(J)=FLOAT(J)*DELTA
DY(J)=Y(IE+J-1)
CONTINUE
M1=(Y(IE)-Y(ISTART))/DELTA
M2=(Y(IEND)-Y(IE))/DELTA

DA(1,1)=DX(1)**3
DA(2,1)=DX(INUM)**3
DA(3,1)=3.00*DX(1)*DX(1)
DA(4,1)=3.00*DX(INUM)*DX(INUM)

DA(1,2)=DX(1)**2
DA(2,2)=DX(INUM)**2
DA(3,2)=2.00*DX(1)
DA(4,2)=2.00*DX(INUM)

DA(1,3)=DX(1)
DA(2,3)=DX(INUM)
DA(3,3)=1.00
DA(4,3)=1.00

DA(1,4)=1.00
DA(2,4)=1.00
DA(3,4)=0.00
DA(4,4)=0.00

DRMS(1)=DY(1)
DRMS(2)=DY(INUM)
DRMS(3)=M1
DRMS(4)=M2

CALL DSIMQ(DA,DRMS,4,KS)

IF(KS.EQ.0) GO TO 200

```

0037      WRITE(6,1000)
0038      FORMAT(' PROBLEMS OUT OF SIMQ',
0039      C      CONTINUE
0040      DO 300 J=1,1NUM
0041      Y(IIS+J-1)=DRHS(4)+
0042      1      DX(J)* (DRHS(3)+DX(J)* (DRHS(2)+DX(J)* (DRHS(1))))
0043      CONTINUE
0044      RETURN
0045      END

```

[illegible]

0001
0002
0003

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DSIMQ

FORTRAN IV G LEVEL 21

```

0004      TOL=0.00      SIMQ 530
0005      KS=0          SIMQ 550
0006      JJ=N          SIMQ 560
0007      DO 65 J=1,N  SIMQ 570
0008      JY=J+1       SIMQ 580
0009      JJ=JJ+N+1     SIMQ 590
0010      BIGA=0.00     SIMQ 610
0011      IT=JJ-J      SIMQ 620
0012      DO 30 I=J,N  SIMQ 630
                      SIMQ 640
                      SIMQ 650
                      SIMQ 660
                      SIMQ 680
                      SIMQ 690
                      SIMQ 700
                      SIMQ 710
                      SIMQ 720
                      SIMQ 730
                      SIMQ 750
                      SIMQ 760
                      SIMQ 770
                      SIMQ 780
                      SIMQ 790
                      SIMQ 800
                      SIMQ 810
                      SIMQ 820
                      SIMQ 830
                      SIMQ 840
                      SIMQ 850
                      SIMQ 860
                      SIMQ 870
                      SIMQ 880
                      SIMQ 890
                      SIMQ 900
                      SIMQ 910
                      SIMQ 920
                      SIMQ 930
                      SIMQ 940
                      SIMQ 950
                      SIMQ 960
                      SIMQ 970
                      SIMQ 980
                      SIMQ 990
                      SIMQ1000
                      SIMQ1010
                      SIMQ1020
                      SIMQ1030
                      SIMQ1040
                      SIMQ1050

C
0013      IJ=IT+1
0014      IF (DABS(BIGA)-DABS(A(IJ))) 20,30,70
0015      20 BIGA=A(IJ)
0016      IMAX=1
0017      30 CONTINUE

C
C      TEST FOR PIVOT LESS THAN TOLERANCE (SINGULAR MATRIX)
0018      IF (DABS(BIGA)-TOL) 35,35,40
0019      35 KS=1
0020      RETURN

C
C      INTERCHANGE ROWS IF NECESSARY
0021      40 II=J+N*(J-2)
0022      IT=IMAX-J
0023      DO 50 K=J,N
0024      II=II+N
0025      I2=II+IT
0026      SAVE=A(II)
0027      A(II)=A(I2)
0028      A(I2)=SAVE

C
C      DIVIDE EQUATION BY LEADING COEFFICIENT
0029      50 A(II)=A(II)/BIGA
0030      SAVE=B(IMAX)
0031      B(IMAX)=B(IJ)
0032      B(IJ)=SAVE/BIGA

C
C      ELIMINATE NEXT VARIABLE
0033      IF (J=N) 55,70,55
0034      55 IOS=N*(J-1)
0035      DO 65 IX=JY,N
0036      IXJ=IOS+IX
0037      IT=J-IX
0038      DO 60 JX=JY,N
0039      JXJ=N*(JX-1)+IX
0040      JXJ=IXJX+IT

```

FORTRAN IV G LEVEL 21

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0041 60 A(I,XJ)=A(I,XJ)-(A(I,XJ)*A(J,XJ))
0042 65 B(I,X)=B(I,X)-(B(J)*A(I,XJ))

C
C
C

BACK SOLUTION

70 NY=N-1
IT=N*N
DO 80 J=1,NY
IA=IT-J
IB=N-J
IC=N
DO 80 K=1,J
B(IB)=B(IB)-A(IA)*B(IC)
IA=IA-N
80 IC=IC-1
RETURN
END

SIMO1060
SIMO1070
SIMO1080
SIMO1090
SIMO1100
SIMO1110
SIMO1120
SIMO1130
SIMO1140
SIMO1150
SIMO1160
SIMO1170
SIMO1180
SIMO1190
SIMO1200
SIMO1210
SIMO1220

0043
0044
0045
0046
0047
0048
0049
0050
0051
0052
0053
0054

33.0000	33.0000	0.0	1
33.0000	33.0000	0.0	2
33.0000	33.0000	0.0	3
33.0000	33.0000	0.0	4
33.0000	33.0000	0.0	5
33.0000	33.0000	0.0	6
33.0000	33.0000	0.0	7
33.0000	33.0000	0.0	8
33.0000	33.0000	0.0	9
33.0000	33.0000	0.0	10
33.0000	33.0000	0.0	11
33.0000	33.0000	0.0	12
33.0000	33.0000	0.0	13
33.0000	33.0000	0.0	14
33.0000	33.0000	0.0	15
33.0000	33.0000	0.0	16
33.0000	33.0000	0.0	17
33.0000	33.0000	0.0	18
33.0000	33.0000	0.0	19
33.0000	33.0000	0.0	20
33.0000	33.0000	0.0	21
33.0000	33.0000	0.0	22
33.0000	33.0000	0.0	23
33.0000	33.0000	0.0	24
33.0000	33.0000	0.0	25
33.0000	33.0000	0.0	26
33.0000	33.0000	0.0	27
33.0000	33.0000	0.0	28
33.0000	33.0000	0.0	29
32.8523	33.0000	0.1477	30
32.3987	33.0000	0.6013	31
31.6238	33.0000	1.3762	32
30.5120	33.0000	2.4880	33
29.8474	33.0000	-1.9522	34
27.2157	33.0000	0.5557	35
25.0000	33.0000	0.0	36
22.5874	33.0000	0.0	37
21.0000	33.0000	0.0	38
19.0698	33.0000	0.0	39
16.4636	33.0000	0.0	40
13.0000	33.0000	0.0	41
10.6801	33.0000	0.0	42
9.4764	33.0000	0.0	43
8.0000	33.0000	0.0	44
6.1829	33.0000	0.0	45
4.2031	33.0000	0.0	46
3.0000	33.0000	0.0	47
2.4868	33.0000	0.0	48
1.7910	33.0000	0.0	49
1.1813	33.0000	0.0	50
0.7284	33.0000	-0.1813	51
0.085	33.0000	-0.4760	52
0.1997	33.0000	-0.5089	53
0.0774	33.0000	-0.1997	54
0.0189	33.0000	-0.0774	55
0.0009	33.0000	-0.0189	56

57.0000	0.0	0.0000	0.0	57
58.0000	0.0	0.0	0.0	58
59.0000	0.0	0.0	0.0	59
60.0000	0.0	0.0	0.0	60
61.0000	0.0	0.0	0.0	61
62.0000	0.0	0.0	0.0	62
63.0000	0.0	0.0	0.0	63
64.0000	0.0	0.0	0.0	64
65.0000	0.0	0.0	0.0	65
66.0000	0.0	0.0	0.0	66
67.0000	0.0	0.0	0.0	67
68.0000	0.0	0.0	0.0	68
69.0000	0.0	0.0	0.0	69
70.0000	0.0	0.0	0.0	70
71.0000	0.0	0.0	0.0	71
72.0000	0.0	0.0	0.0	72
73.0000	0.0	0.0	0.0	73
74.0000	0.0	0.0	0.0	74
75.0000	0.0	0.0	0.0	75
76.0000	0.0	0.0	0.0	76
77.0000	0.0	0.0	0.0	77
78.0000	0.0	0.0	0.0	78
79.0000	0.0	0.0	0.0	79
80.0000	0.0	0.0	0.0	80
81.0000	0.0	0.0	0.0	81
82.0000	0.0	0.0	0.0	82
83.0000	0.0	0.0	0.0	83
84.0000	0.0	0.0	0.0	84
85.0000	0.0	0.0	0.0	85
86.0000	0.0	0.0	0.0	86
87.0000	0.0	0.0	0.0	87
88.0000	0.0	0.0	0.0	88
89.0000	0.0	0.0	0.0	89
90.0000	0.0	0.0	0.0	90
91.0000	0.0	0.0	0.0	91
92.0000	0.0	0.0	0.0	92
93.0000	0.0	0.0	0.0	93
94.0000	0.0	0.0	0.0	94
95.0000	0.0	0.0	0.0	95
96.0000	0.0	0.0	0.0	96
97.0000	0.0	0.0	0.0	97
98.0000	0.0	0.0	0.0	98
99.0000	0.0	0.0	0.0	99
100.0000	0.0	0.0	0.0	100
101.0000	0.0	0.0	0.0	101
102.0000	0.0	0.0	0.0	102
103.0000	0.0	0.0	0.0	103
104.0000	0.0	0.0	0.0	104
105.0000	0.0	0.0	0.0	105
106.0000	0.0	0.0	0.0	106
107.0000	0.0	0.0	0.0	107
108.0000	0.0	0.0	0.0	108
109.0000	0.0	0.0	0.0	109
110.0000	0.0	0.0	0.0	110
111.0000	0.0	0.0	0.0	111
112.0000	0.0	0.0	0.0	112
113.0000	0.0	0.0	0.0	113
114.0000	0.0	0.0	0.0	114
115.0000	0.0	0.0	0.0	115
116.0000	0.0	0.0	0.0	116
117.0000	0.0	0.0	0.0	117

179.0000	0.0	0.0	0.0	179
180.0000	0.0	0.0	0.0	180
181.0000	0.0	0.0	0.0	181
182.0000	0.0	0.0	0.0	182
183.0000	0.0	0.0	0.0	183
184.0000	0.0	0.0	0.0	184
185.0000	0.0	0.0	0.0	185
186.0000	0.0	0.0	0.0	186
187.0000	0.0	0.0	0.0	187
188.0000	0.0	0.0	0.0	188
189.0000	0.0	0.0	0.0	189
190.0000	0.0	0.0	0.0	190
191.0000	0.0	0.0	0.0	191
192.0000	0.0	0.0	0.0	192
193.0000	0.0	0.0	0.0	193
194.0000	0.0	0.0	0.0	194
195.0000	0.0	0.0	0.0	195
196.0000	0.0	0.0	0.0	196
197.0000	0.0	0.0	0.0	197
198.0000	0.0	0.0	0.0	198
199.0000	0.0	0.0	0.0	199
200.0000	0.0	0.0	0.0	200
201.0000	0.0	0.0	0.0	201
202.0000	0.0	0.0	0.0	202
203.0000	0.0	0.0	0.0	203
204.0000	0.0	0.0	0.0	204
205.0000	0.0	0.0	0.0	205
206.0000	0.0	0.0	0.0	206
207.0000	0.0	0.0	0.0	207
208.0000	0.0	0.0	0.0	208
209.0000	0.0	0.0	0.0	209
210.0000	0.0	0.0	0.0	210
211.0000	0.0	0.0	0.0	211
212.0000	0.0	0.0	0.0	212
213.0000	0.0	0.0	0.0	213
214.0000	0.0	0.0	0.0	214
215.0000	0.0	0.0	0.0	215
216.0000	0.0	0.0	0.0	216
217.0000	0.0	0.0	0.0	217
218.0000	0.0	0.0	0.0	218
219.0000	0.0	0.0	0.0	219
220.0000	0.0	0.0	0.0	220
221.0000	0.0	0.0	0.0	221
222.0000	0.0	0.0	0.0	222
223.0000	0.0	0.0	0.0	223
224.0000	0.0	0.0	0.0	224
225.0000	0.0	0.0	0.0	225
226.0000	0.0	0.0	0.0	226
227.0000	0.0	0.0	0.0	227
228.0000	0.0	0.0	0.0	228
229.0000	0.0	0.0	0.0	229
230.0000	0.0	0.0	0.0	230
231.0000	0.0	0.0	0.0	231
232.0000	0.0	0.0	0.0	232
233.0000	0.0	0.0	0.0	233
234.0000	0.0	0.0	0.0	234
235.0000	0.0	0.0	0.0	235
236.0000	0.0	0.0	0.0	236
237.0000	0.0	0.0	0.0	237
238.0000	0.0	0.0	0.0	238
239.0000	0.0	0.0	0.0	239

240.0000	0.0	0.0	0.0	240
241.0000	0.0	0.0	0.0	241
242.0000	0.0	0.0	0.0	242
243.0000	0.0	0.0	0.0	243
244.0000	0.0	0.0	0.0	244
245.0000	0.0	0.0	0.0	245
246.0000	0.0	0.0	0.0	246
247.0000	0.0	0.0	0.0	247
248.0000	0.0	0.0	0.0	248
249.0000	0.0	0.0	0.0	249
250.0000	0.0	0.0	0.0	250
251.0000	0.0	0.0	0.0	251
252.0000	0.0	0.0	0.0	252
253.0000	0.0	0.0	0.0	253
254.0000	0.0	0.0	0.0	254
255.0000	0.0	0.0	0.0	255
256.0000	0.0	0.0	0.0	256
257.0000	0.0	0.0	0.0	257
258.0000	0.0	0.0	0.0	258
259.0000	0.0	0.0	0.0	259
260.0000	0.0	0.0	0.0	260
261.0000	0.0	0.0	0.0	261
262.0000	0.0	0.0	0.0	262
263.0000	0.0	0.0	0.0	263
264.0000	0.0	0.0	0.0	264
265.0000	0.0	0.0	0.0	265
266.0000	0.0	0.0	0.0	266
267.0000	0.0	0.0	0.0	267
268.0000	0.0	0.0	0.0	268
269.0000	0.0	0.0	0.0	269
270.0000	0.0	0.0	0.0	270
271.0000	0.0	0.0	0.0	271
272.0000	0.0	0.0	0.0	272
273.0000	0.0	0.0	0.0	273
274.0000	0.0	0.0	0.0	274
275.0000	0.0	0.0	0.0	275
276.0000	0.0	0.0	0.0	276
277.0000	0.0	0.0	0.0	277
278.0000	0.0	0.0	0.0	278
279.0000	0.0	0.0	0.0	279
280.0000	0.0	0.0	0.0	280
281.0000	0.0	0.0	0.0	281
282.0000	0.0	0.0	0.0	282
283.0000	0.0	0.0	0.0	283
284.0000	0.0	0.0	0.0	284
285.0000	0.0	0.0	0.0	285
286.0000	0.0	0.0	0.0	286
287.0000	0.0	0.0	0.0	287
288.0000	0.0	0.0	0.0	288
289.0000	0.0	0.0	0.0	289
290.0000	0.0	0.0	0.0	290
291.0000	0.0	0.0	0.0	291
292.0000	0.0	0.0	0.0	292
293.0000	0.0	0.0	0.0	293
294.0000	0.0	0.0	0.0	294
295.0000	0.0	0.0	0.0	295
296.0000	0.0	0.0	0.0	296
297.0000	0.0	0.0	0.0	297
298.0000	0.0	0.0	0.0	298
299.0000	0.0	0.0	0.0	299
300.0000	0.0	0.0	0.0	300

301.0000	0.0	0.0	0.0	301
302.0000	0.0	0.0	0.0	302
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305.0000	0.0	0.0	0.0	305
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309.0000	0.0	0.0	0.0	309
310.0000	0.0	0.0	0.0	310
311.0000	0.0	0.0	0.0	311
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313.0000	0.0	0.0	0.0	313
314.0000	0.0	0.0	0.0	314
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316.0000	0.0	0.0	0.0	316
317.0000	0.0	0.0	0.0	317
318.0000	0.0	0.0	0.0	318
319.0000	0.0	0.0	0.0	319
320.0000	0.0	0.0	0.0	320
321.0000	0.0	0.0	0.0	321
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324.0000	0.0	0.0	0.0	324
325.0000	0.0	0.0	0.0	325
326.0000	0.0	0.0	0.0	326
327.0000	0.0	0.0	0.0	327
328.0000	0.0	0.0	0.0	328
329.0000	0.0	0.0	0.0	329
330.0000	0.0	0.0	0.0	330
331.0000	0.0	0.0	0.0	331
332.0000	0.0	0.0	0.0	332
333.0000	0.0	0.0	0.0	333
334.0000	0.0	0.0	0.0	334
335.0000	0.0	0.0	0.0	335
336.0000	0.0	0.0	0.0	336
337.0000	0.0	0.0	0.0	337
338.0000	0.0	0.0	0.0	338
339.0000	0.0	0.0	0.0	339
340.0000	0.0	0.0	0.0	340
341.0000	0.0	0.0	0.0	341
342.0000	0.0	0.0	0.0	342
343.0000	0.0	0.0	0.0	343
344.0000	0.0	0.0000	-0.0000	344
345.0000	0.0	0.0977	-0.0977	345
346.0000	0.0	0.4687	-0.4687	346
347.0000	0.0	1.2305	-1.2305	347
348.0000	0.0	2.5000	-0.6000	348
349.0000	1.9000	4.3945	1.1055	349
350.0000	5.5000	7.0312	0.9688	350
351.0000	8.0000	10.5273	-0.0273	351
352.0000	10.5000	15.0000	0.0000	352
353.0000	15.0000	20.0000	0.0	353
354.0000	20.0000	25.0000	0.0	354
355.0000	25.0000	28.0000	0.0	355
356.0000	28.0000	29.2428	0.0	356
357.0000	29.2428	30.0000	0.0	357
358.0000	30.0000	30.3029	0.0	358
359.0000	30.3029	31.2707	0.0000	359
360.0000	31.2707	32.0709	-0.0709	360
361.0000	32.0709	32.5793	0.4207	361

362.0000	33.0000	32.8612	0.1388	362
363.0000	33.0000	32.9818	0.0182	363
364.0000	33.0000	33.0063	-0.0063	364
365.0000	33.0000	33.0000	0.0	365
366.0000	33.0000	33.0000	0.0	366
367.0000	33.0000	33.0000	0.0	367
368.0000	33.0000	33.0000	0.0	368
369.0000	33.0000	33.0000	0.0	369
370.0000	33.0000	33.0000	0.0	370

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Small Caliber Weapons Systems Laboratory
ARRADCOM (West) DRDAR-SC
Rock Island Arsenal, Rock Island, IL 61201
A Mathematical Model of the 30MM Advanced Medium
Caliber Weapon System (AMCAWS-30)
Prepared by: Michael R. Kane
Technical Report R-TR-77-017

Pages, Incl Figures, 265

A mathematical model for the AMCAWS-30MM weapon is developed using the generalized d'Alembert force equations. The development of the one degree of freedom differential equation of motion for the weapon is shown. The equation accounts for operations including feed, eject, chamber locking, round crush-up, chamber translation, face cam rotation, and drum cam rotation. The resultant equation is numerically

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