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SWITCH DRIVER CONCEPT DEVELOPMENT

FINAL REPORT

Prepared by

AVCO SYSTEMS DIVISION
201 Lowell Street
Wilmington, Massachusetts 01887

AVSD-0318-76-RR
Contract DAAA21-76-C-0203

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Picatinny Arsenal
Dover, New Jersey 07801

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Strong Link/Weak Link Design
Mechanical Code Response
Fail Safe Device
Optical Signals
Intent Switch Driver

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The report describes the design concept of a unique signal switch driver along with program objectives, design requirements, supporting analyses and functional test results.

The report concludes that the design concept is sound and will meet all the design requirements with a 60 Hz response capability. Follow-on development is recommended.

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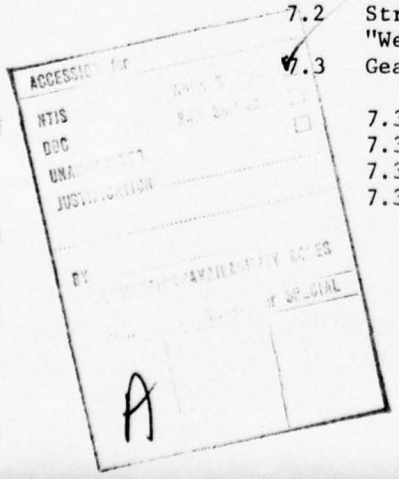


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1.0 INTRODUCTION

This report describes the Switch Driver concept developed by Avco Systems Division under Contract DAAA21-76-C-0203 for Picatinny Arsenal. The effort conducted in this program has included a detailed preliminary design documented on Avco's format layouts, assembly and detail drawings. Extensive functional analysis has been performed to support the design and a complete operating model has been fabricated and functionally tested at 60 Hz, successfully demonstrating concept feasibility. The report is organized as follows:

Section 2.0 - Program Objectives.

Section 3.0 - A description of the Switch Driver design concept.

Section 4.0 - A detailed description of the mechanism.

Section 5.0 - Describes the design requirements and the concept features and characteristics addressing them.

Section 6.0 - Describes design features addressing additional requirements developed during the program.

Section 7.0 - Presents supporting design analyses.

Section 8.0 - A description of the Switch Driver Model.

Section 9.0 - Breadboard Model Code.

Section 10.0 - Describes the functional tests conducted and presents the resulting performance data.

Section 11.0 - Conclusions.

Section 12.0 - Recommendations.

Appendix A - Detail Drawings of the Breadboard Model.

2.0 PROGRAM OBJECTIVE

The program objective is to develop a Switch Driver (SD) mechanism concept which has the inherent fail/safe features required for current nuclear weapons safety criteria. The device incorporates features for enhancing fail/safe functioning through use of multiple stimuli including a coded signal which is maintained throughout the mechanism.

The scope of this effort was to develop and document a design concept which meets the requirements stated in Section 5.0, contains the design features of Section 6.0, and to demonstrate concept feasibility by analyses and laboratory bench tests of a functional model of the device.

3.0 DESIGN DESCRIPTION

The Switch Driver (SD) is a single channel fail safe electromechanical device which provides a safety and arming function. The device must remain safe until a predetermined code has been received and subsequently provide a 90° rotation of the output shaft. The SD is designed to receive electrical power and an optical code, convert the code signal to electrical pulses, then to mechanical pulses which provides the output function. A block diagram of the SD is shown in Figure 1.

3.1 FUNCTIONAL DESCRIPTION

The Switch Driver (SD) consists of an optical/electronic package, electromagnetic dc torque motor (torquer), code mechanism and main shaft as shown in Figure 1. The optical/electronic package receives a two channel complementary optical code signal and converts it to a series of positive and negative electrical signal inputs to the torquer. The torquer converts the positive and negative electrical code sequence to a corresponding series of clockwise and counterclockwise rotations. The main shaft, which is coupled to the torquer through the code mechanism, thus advances as long as the generated code is correct.

After 19 consecutive correct codes have been received, the main shaft has rotated but the output shaft has been inhibited by the clutch mechanism and remains in a locked position. The output shaft is then coupled to the main shaft (through the clutch) when the 20th correct electrical pulse is applied to the torquer. (No rotation of the output shaft has occurred to and including this point). An additional 8 pulses will then incrementally rotate the output shaft 90° where it will be locked in place by the final position lock. In all, 28 electrical codes must be sensed for arming, the first 20 of which must correspond to the preprogrammed mechanical code (the last 8 electrical signals, if desired, could also be a coded word).

In the event that an incorrect complementary optical code is received during the first 20 bits of information, the code mechanism will lock-up and prevent any further motion of the main shaft (abort mode). The unit will thus fail safe. If the code bits are received on both lines or none is received at all (i.e., two "1's" or two "0's") no electrical signal is delivered to the torquer and no main shaft motion occurs.

The SD can be reset from the locked or abort modes without disassembly.

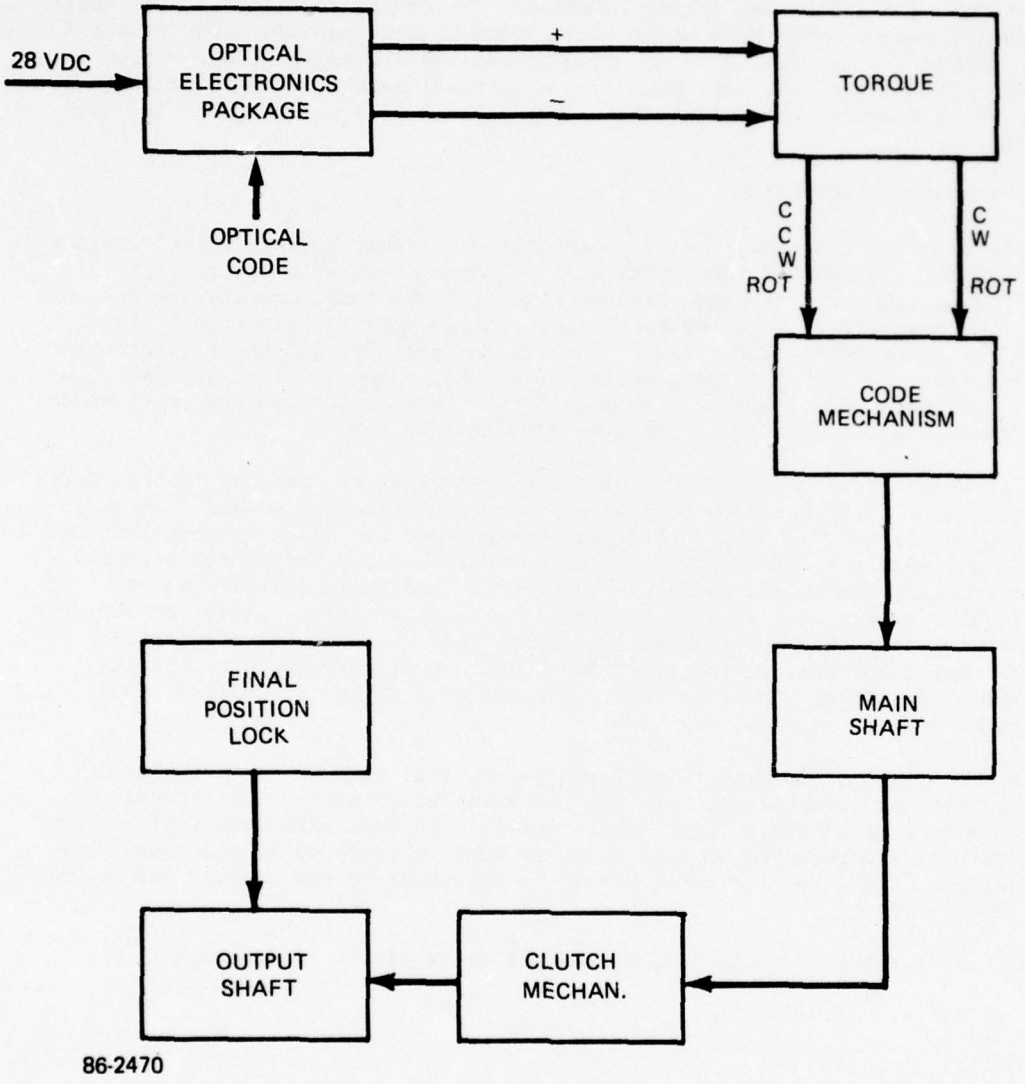


Figure 1 SWITCH DRIVER BLOCK DIAGRAM

3.2 CODE MECHANISM

A block diagram of the code mechanism is shown in Figure 2. The code mechanism primarily consists of a pair of drive mechanisms, two drive pawls, two lock ratchets, two lock arms, a drive ratchet and dual transfer pins. The drive ratchet, which is keyed to the main shaft, has the code machined into the configuration such that a tooth is always presented to one or the other drive pawls. A clockwise rotation (from the torquer) will only actuate Drive Mechanism 1 which will rotate Drive Pawl 1. This will engage the drive ratchet only if a ratchet tooth is available at that location. Conversely, a counterclockwise rotation will only actuate Drive Mechanism 2 which will in turn rotate Drive Pawl 2. A correct code (CW or CCW rotation) therefore, depends on which drive pawl has a tooth presented to it from the drive ratchet. When the drive ratchet receives the correct code, it indexes the main shaft via the key and the lock ratchets via the transfer pins to a new position.

The lock ratchets are configured to have the code machined on the outside face. The code is in the form of a mechanical interference with the lock arm. If the correct drive pawl is actuated, the adjacent lock arm will be cammed to a non-interfering position with the lock ratchet protrusion. No interference is presented to the other lock arm which remains stationary. If an incorrect complementary code is received, the main shaft will not rotate (no tooth will be presented to the drive pawl), the lock arm will not be lifted, the lock ratchets will be rotated into permanent interference with the lock arm, and the unit will be locked up. Thus, with the code being purely mechanical and machined directly into the ratchet configuration prior to machining, it is completely flexible and can be any desired binary combination, (i.e., no constraint on the combination of "0's" of "1's").

The sequence of operation is shown in the functional schematics of Figures 3 through 6. These are plan views of each of the ratchet elements during an operating cycle. The most significant features of the function are explained in the following paragraphs.

Normal Operating Cycle

In a normal operating cycle, the drive ratchet rotates the main shaft through the key and rotates both lock ratchets via the dual transfer pins.

a. Figure 3 -- Initial position (start of each optical code bit).

   View A Left lock arm (1) in potential interference with a coded protrusion (dark area) of the left lock ratchet (2).

   View B Tooth presented to left drive pawl (3).

   View C No tooth presented to right drive pawl (4).

   View D No potential interference with right lock arm (5).

This code position dictates a left arm index as shown in Figures 5 and 6.

b. Figure 4 -- Mid-stroke of correct operating cycle.

   View A Lock arm (1) is moved to non-interfering position by the camming pin (6).

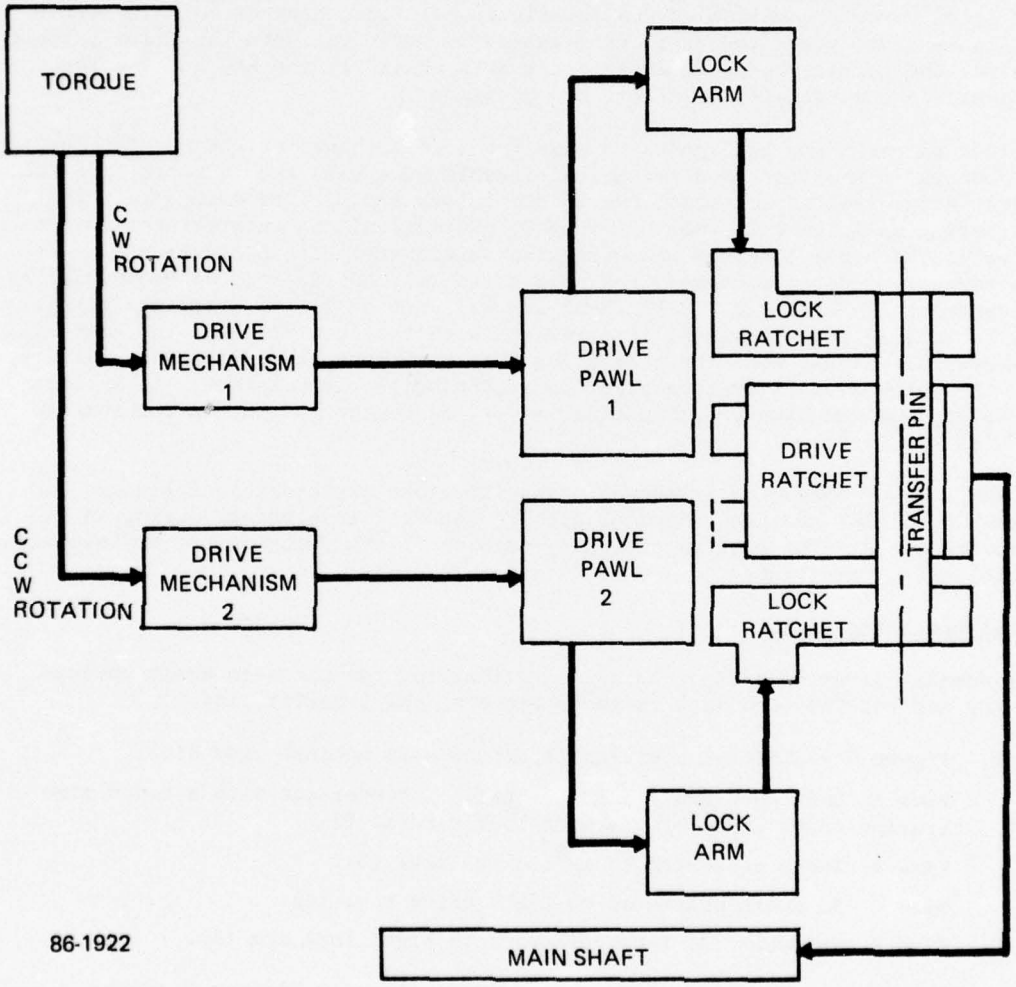


Figure 2 CODE MECHANISM BLOCK DIAGRAM

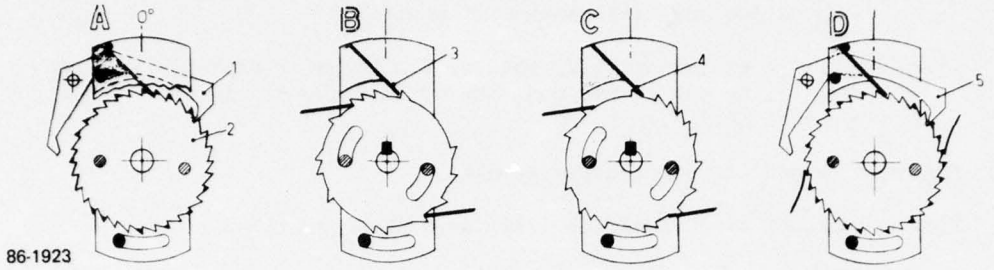


Figure 3 INITIAL POSITION SD CODE MECHANISM

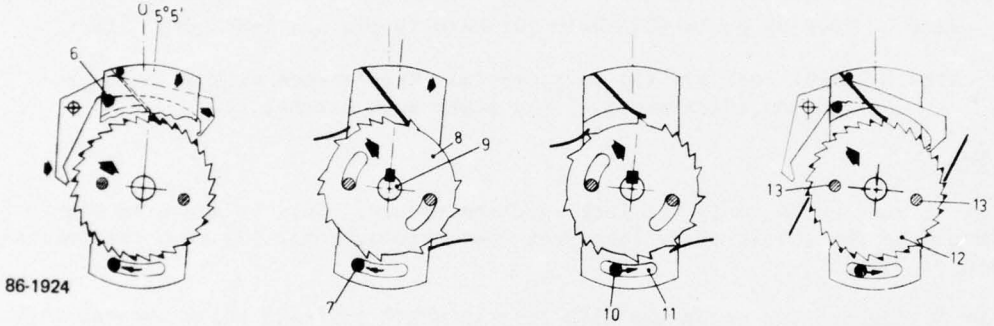


Figure 4 MID-STROKE POSITION SD CODE MECHANISM

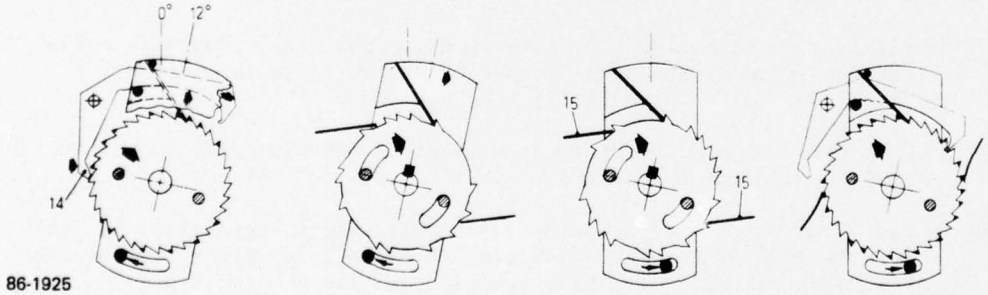


Figure 5 FINAL POSITION SD CODE MECHANISM

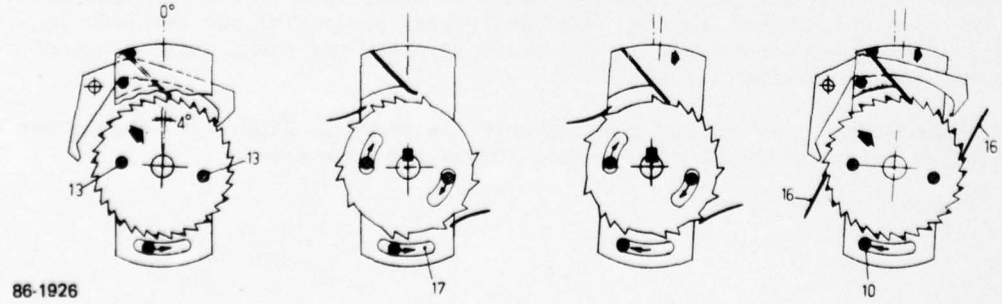


Figure 6 ABORT POSITION SD CODE MECHANISM

View B Drive mechanism (7) rotates drive pawl (3) which rotates drive ratchet (8) through the ratchet tooth. Main shaft (9) rotates via key.

View C Right drive mechanism (10) rotates in clearance slot (11) so that drive pawl (4) remains in position.

View D Right lock ratchet (12) rotates via transfer pins (13). Lock arm (5) is not cammed out, but no interference is present to prevent motion.

c. Figure 5 -- End of normal drive stroke.

View A Ratchet overtravel stop (14) cams into position.

View B Drive ratchet (8) at end of 1 drive stroke. Main shaft (9) has rotated 1 code increment.

View C Locking pawls (15) hold ratchets in the new indexed position.

View D Right lock arm (5) in potential interference with a coded protrusion (dark area) of the right lock ratchet (12).

Abort Mode

In an abort mode cycle, only the lock ratchets rotate. This is shown in Figure 6 which would be the result of an incorrect code sequence starting from the initial position of Figure 3.

View D Right drive mechanism (10) rotates drive pawl (4) which rotates lock ratchet (12). Abort locking pawls (16) hold ratchets in the partially advanced position.

View C Right drive mechanism (10) rotates drive pawl (4). However, drive ratchet (8) does not move because the drive tooth is missing. Therefore, the main shaft (9) does not move.

View B Left drive mechanism (7) rotates in clearance slot (17) so that drive pawl (3) remains in position.

View A Left lock ratchet (2) rotates a partial cycle being limited by the interference of the left lock arm (1) and a coded protrusion of the left lock ratchet (2). Lock ratchet rotation due to transfer pins (13).

The geometry of the code mechanism components is such, that in this aborted position, the ratchets are captured between the locking pawls (16) and the left lock arm (1). No further advancement of the drive ratchets can occur until a manual unlock and reset operation is performed.

A three dimensional view of the code mechanism is shown in Figure 7. This shows the relative relationship of the ratchets, pawls and lock arms.

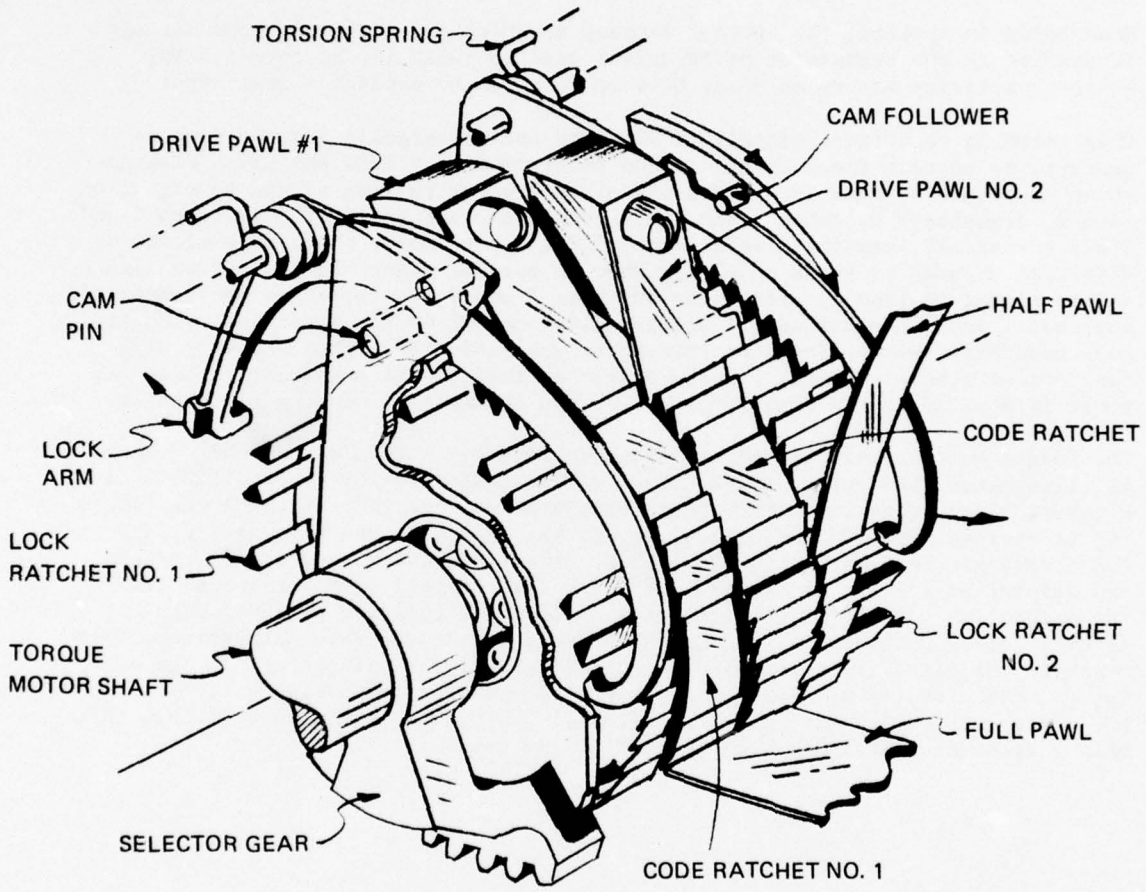


Figure 7 THREE DIMENSIONAL VIEW OF THE CODE MECHANISM

3.3 ELECTRONICS AND OPTICS

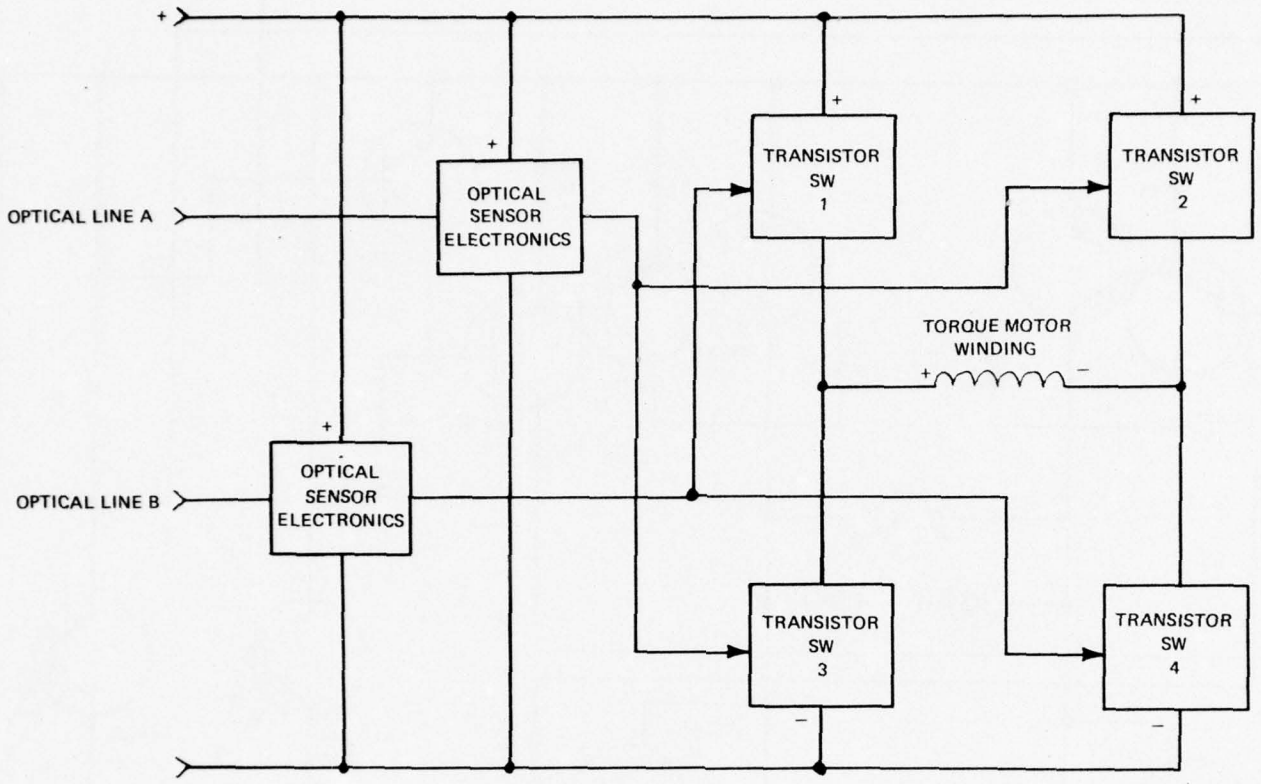
The Switch Driver Electronics consists of an optical fiber/photo-detector interface, sensing electronics, and circuitry to interface the optically coded input to a bidirectional, limited angle torque motor which provides the switch driver actuation.

The SD Electronics Subsystem accepts data as an optical pulse train on two fiber optic signal cables. The optical data is digital in nature and the two signal lines are complementary.

When power is applied, the optical sensing circuits are energized, and voltage is present at the transistor power driver used to pulse the dc torque motor. No motor activity occurs at power or when there is no optical signal input.

When there is no optical signal, or when the optical signals are not complementary, no current flows in the torque motor winding. From the block diagram shown in Figure 8, when an optical signal is present on line A, and no signal on line B, transistor switches 1 and 4 are turned on, and transistor switches 2 and 3 are turned off, causing displacement of the torque motor shaft in a clockwise direction through an angle of $+15^{o}$. When an optical signal is present on line B, and no signal on line A, transistor switches 2 and 3 are turned on and transistor switches 1 and 4 are turned off causing displacement of the torque motor shaft in a counterclockwise direction through an angle of -15^{o}. This activity will continue as long as optical signals appear at the optical sensing circuits, and power is applied to the transistor driver and the optical sensing electronics.

The Torque Motor Driver Circuit is shown in Figure 9. When either phototransistor is illuminated, the output pulse drives either transistor Q_1 or Q_6 (2N2222A) into saturation depending upon which phototransistor was excited. For the case where PT_1 is excited, transistors Q_4, Q_5, Q_6, Q_7 and Q_8 are driven into saturation. This connects the plus (+) terminal of M_1 (the DC torque motor) at +28V minus the saturation voltage of Q_8, and the minus (-) terminal of M_1 at ground plus the saturation voltage of Q_4, producing a clockwise rotation of 15^{o}. When PT_2 is excited, transistors Q_1, Q_2, Q_3, Q_9 and Q_{10} are driven into saturation. This connects the minus (-) terminal of M_1 at +28V minus the saturation voltage of Q_9, and the plus (+) terminal of M_1 at ground plus the saturation voltage of Q_3, producing counterclockwise rotation of 15^{o}. Q_{11} and Q_{12} are used to ensure that only 2 transistor switches will be "on" at any time.



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Figure 8 BLOCK DIAGRAM -- OPTICAL/ELECTRONICS SUBSYSTEM

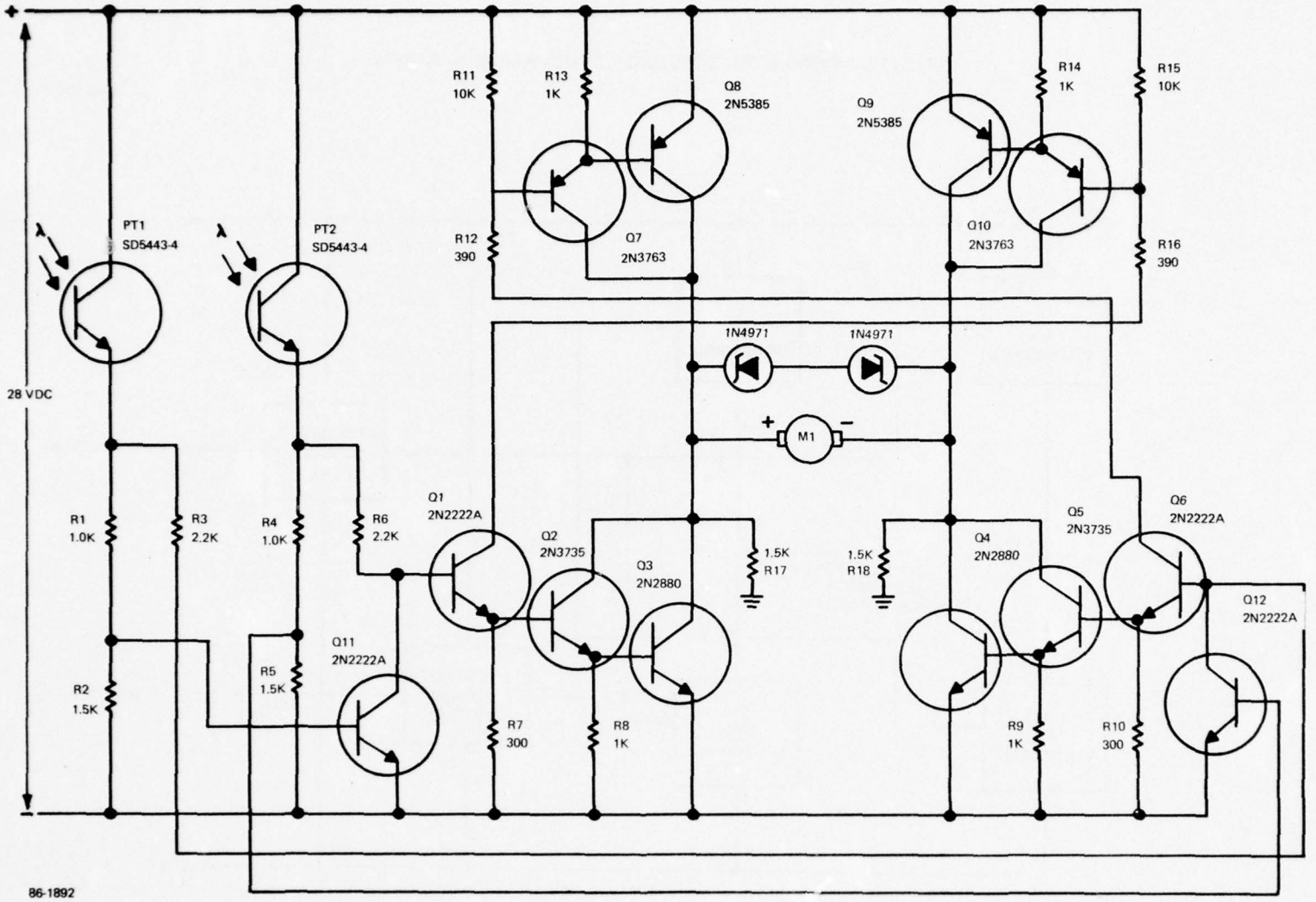


Figure 9 SCHEMATIC – SD ELECTRONICS

4.0 MECHANICAL DESCRIPTION

Figure 10 is a layout of the SD. The area indicated as the optical/electronics module (1) can ultimately house the miniaturized optics and hybridized electronics.

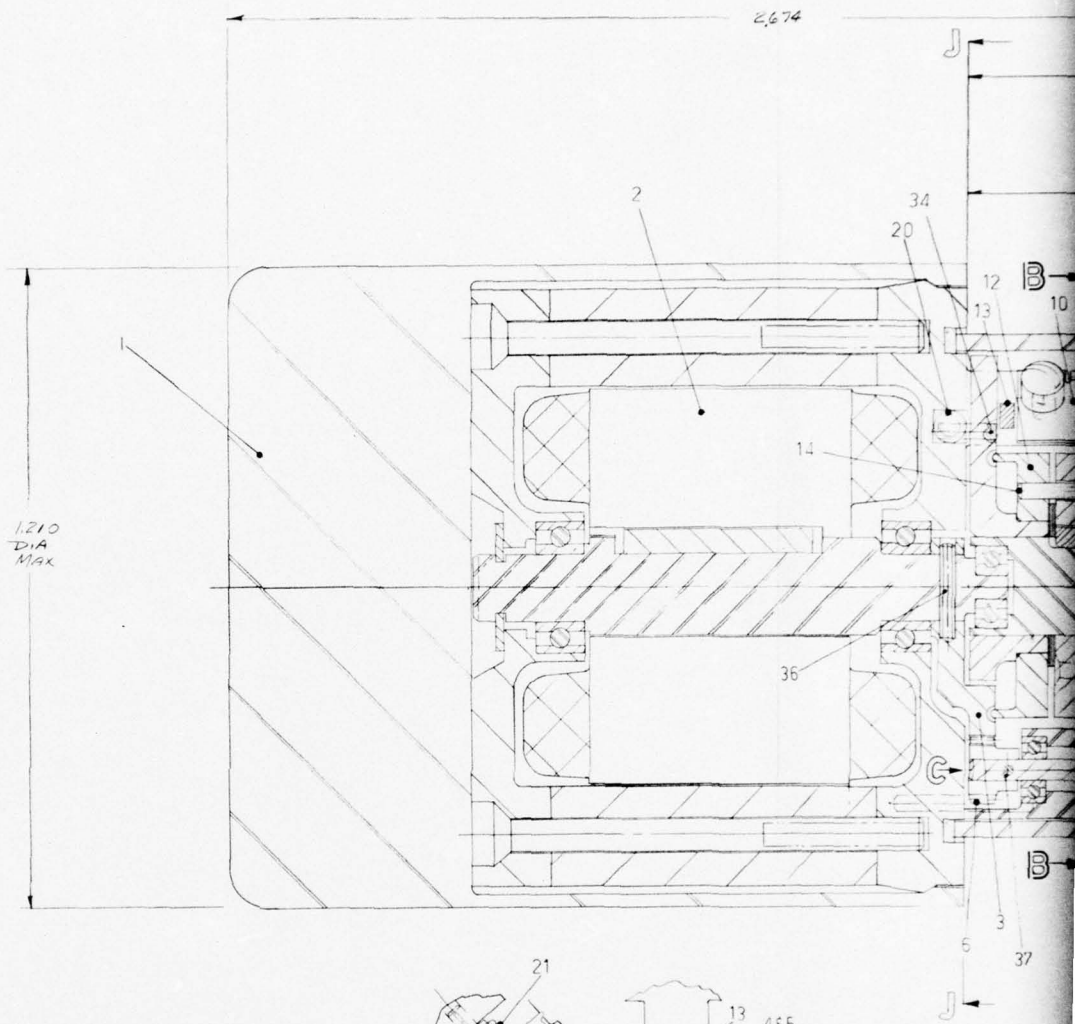
Referring to Figure 10, an input optical code is converted to an electrical pulse by the electronics module (1). This drives the torquer (2) in a direction dictated by the code. An optical signal on line 1 would result in a positive electrical pulse which drives the torquer clockwise. A drive gear (3), keyed to the torquer rotor, is coupled to drive pawl 1 (4). The drive gear is also coupled to drive pawl 2 (5) through gears (6), (7), (8) and drive ring (9). The interrelationship of these parts is shown in Views C and D of Figure 10. A clockwise rotation of the torquer moves drive pawl 1 by bearing against surface "y" (View C). At the same time the drive ring goes counterclockwise via the gear train and moves away from surface "z" of drive pawl 2 (View D). Thus drive pawl 2 remains stationary. Conversely a counterclockwise rotation of the torquer will rotate drive pawl 2 clockwise by bearing against surface "z" while drive pawl 1 remains stationary. By using this technique, a single drive mechanism (torquer) will drive either pawl clockwise solely dependent upon the polarity of the electrical signal input.

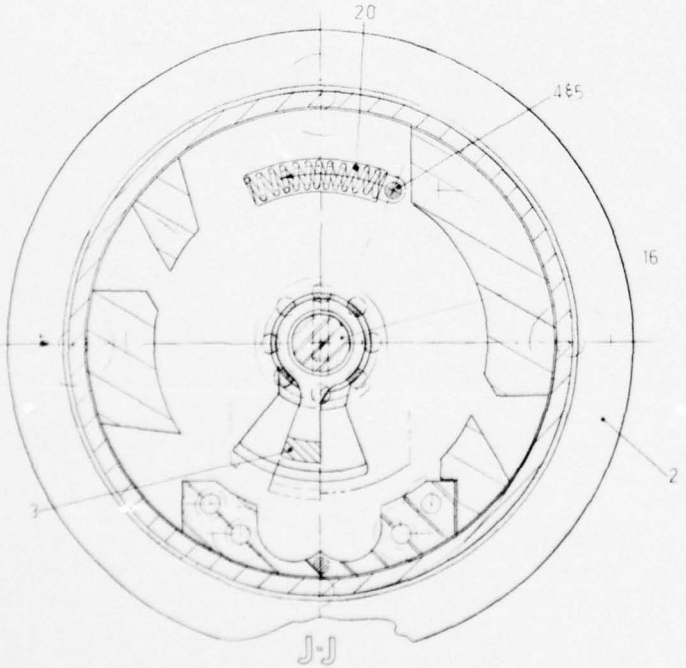
A pawl (10) mounted on the drive pawl mechanism rotates the ratchet assemblies. The ratchets are designed to respond to a correct code by advancing, or, to an incorrect code, by aborting the mechanism. This is accomplished by having the drive ratchet (11) configured so that a tooth is presented only to one of the pawls at a time. If that pawl is actuated, the ratchets advance. If the incorrect pawl is actuated, the drive ratchet will not move (no tooth on the drive ratchet) and the unit will be locked up by the lock ratchets (12) and lock arms (13) as shown in Figure 6, View A.

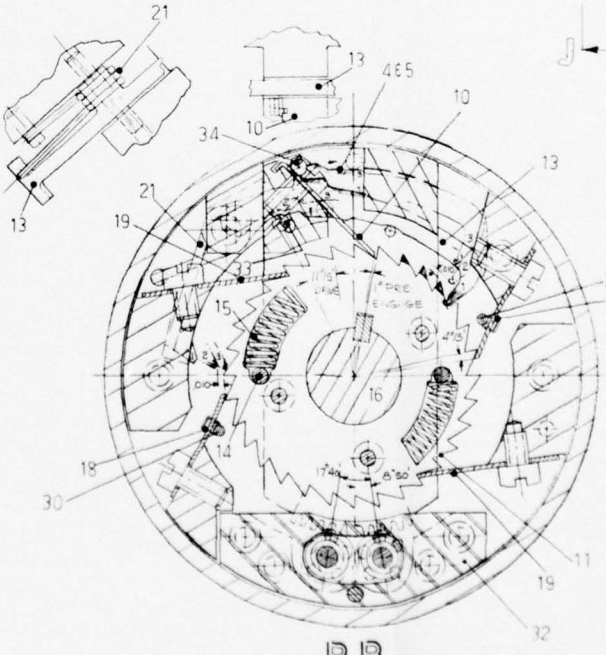
If the code is correct, the central drive ratchet will be advanced by the pawl, and the correct lock arm will be cammed into the proper position by a pin (33) in the drive pawl. Transfer pins (14) allow the drive ratchet to carry both adjacent lock ratchets along with it. A spring (15) maintains the relative position of the ratchets. As long as all three ratchets advance in this manner, the drive ratchet will rotate the main shaft (16) via key (17), driving through the code.

If the code is incorrect and does not agree with the ratchet configuration, only the lock ratchets will advance and the correct lock arm will not move. The mechanism will thus lock up, with the protrusion of the lock ratchets being caught by the hook on the lock arm. The lock ratchets will be held in this interference position by a pair of locking pawls (18).

Each step of the ratchet assembly is controlled from overshooting by the lock arm shown in Figure 5, View A. Locking pawls (19) maintain the ratchets in the new indexed position. The drive pawl mechanism and torquer are driven back to the neutral position by the return springs (20) and the lock arms are returned to the initial position by torsion springs (21) and limit pin (34).


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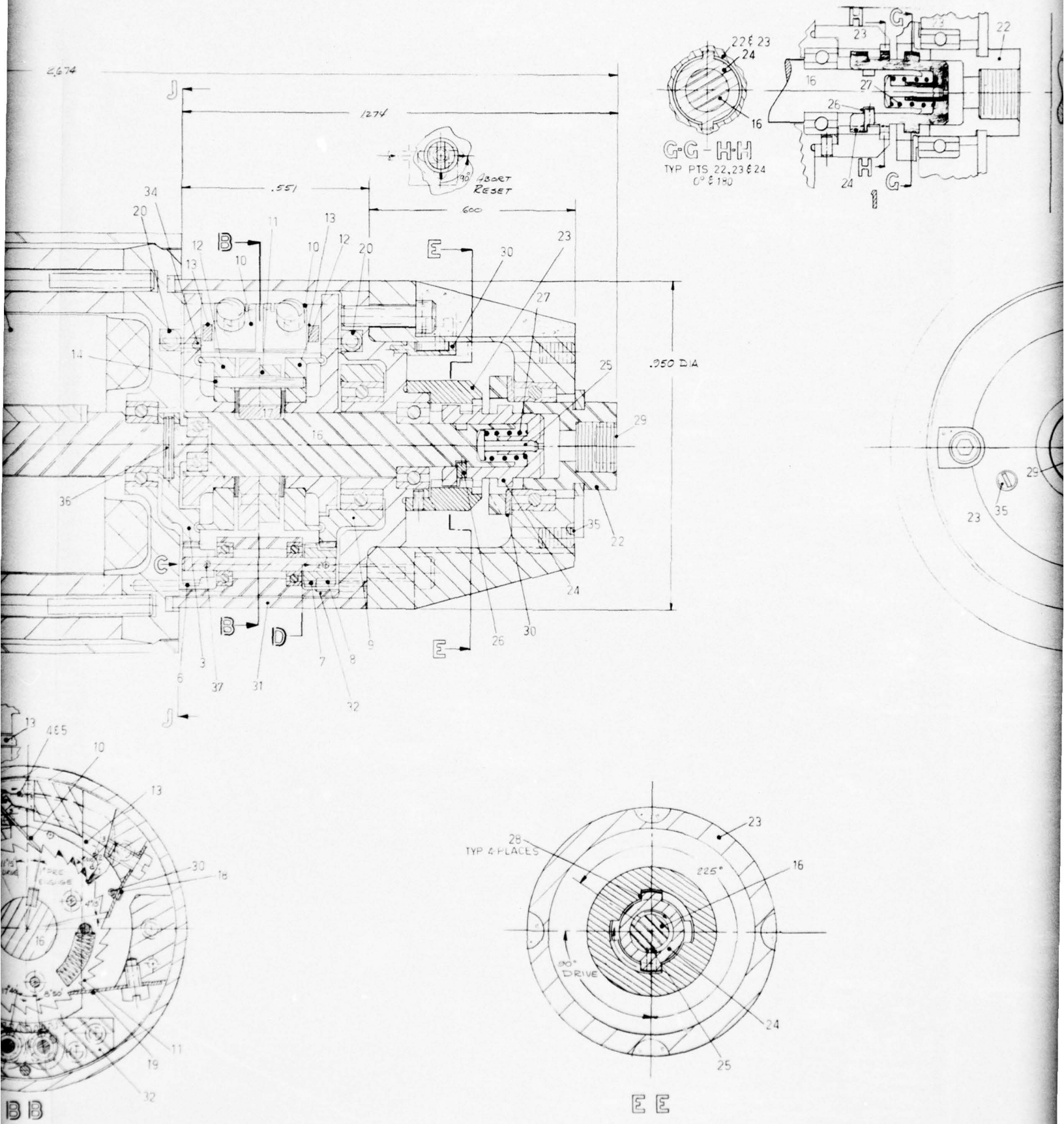
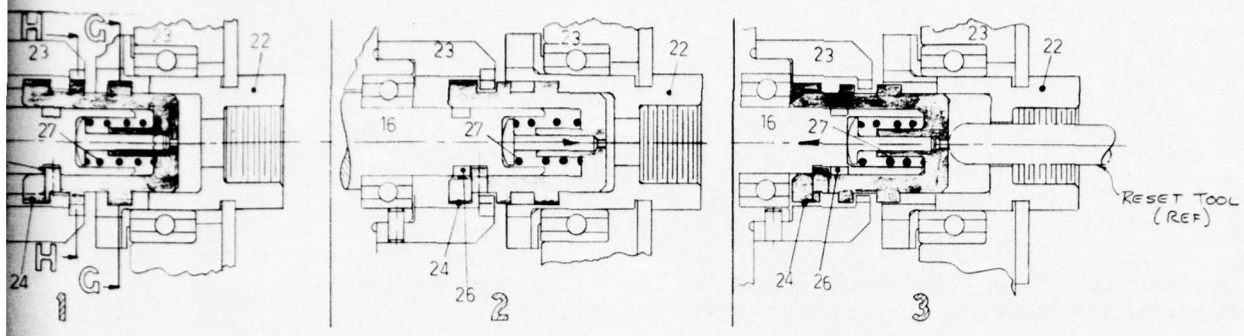
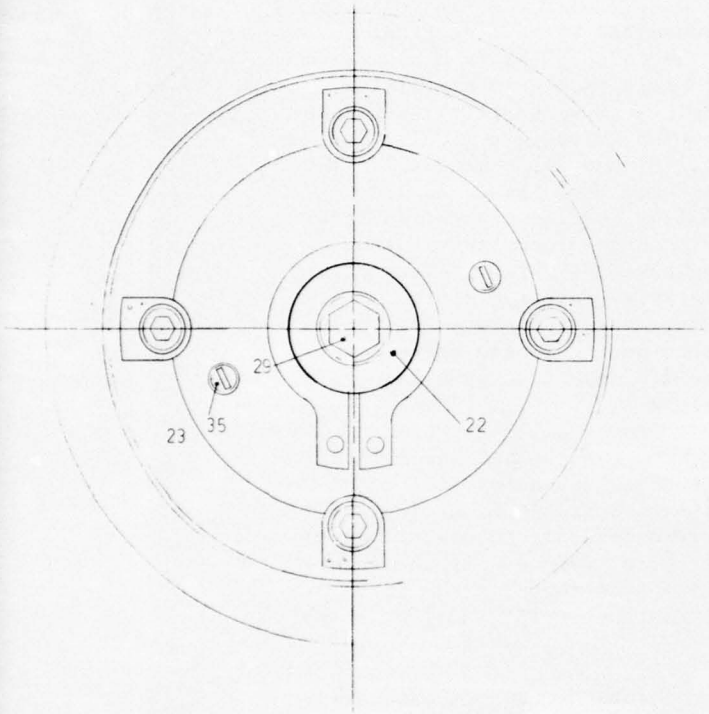
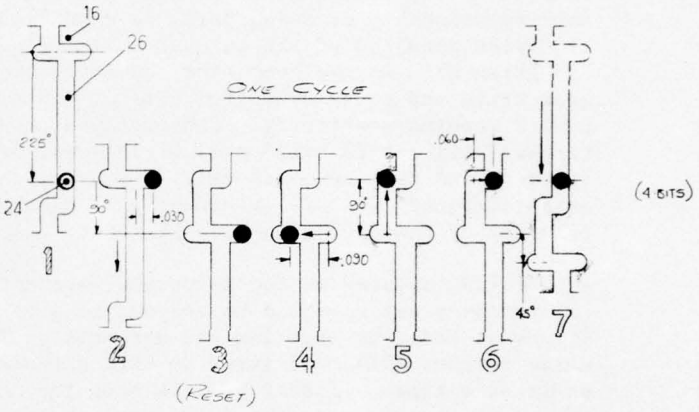


Figure 10 LAYOUT OF SD

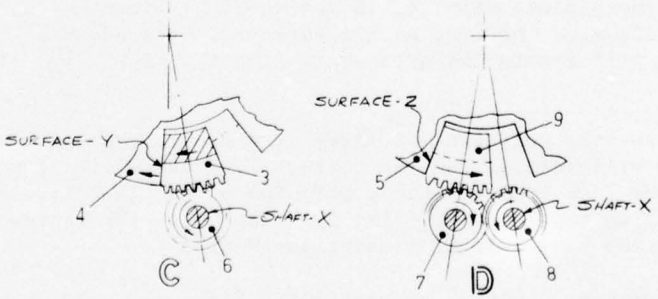
2







1.	OPTICAL/ELECTRONICS MODULE
2.	TORQUER
3.	DRIVE GEAR
4.	DRIVE PAWL #1
5.	DRIVE PAWL #2
6.	PINION
7.	PINION
8.	PINION
9.	DRIVE RING
10.	DRIVE PAWLS
11.	DRIVE RATCHET
12.	LOCK RATCHETS
13.	LOCK ARMS
14.	TRANSFER PINS
15.	SPRING
16.	MAIN SHAFT
17.	KEY
18.	LOCKING PAWLS
19.	LOCKING PAWLS
20.	RETURN SPRING
21.	TORSION SPRING
22.	OUTPUT SHAFT
23.	STRUCTURE
24.	CLUTCH
25.	GUIDE PIN
26.	CAM TRACK
27.	CLUTCH SPRING
28.	STOP
29.	RESET PLUG
30.	THRUST WASHER
31.	WINDOW
32.	BEARING BLOCK
33.	CAMMING PIN
34.	LIMIT PIN
35.	RESET/ACCESS SCREW
36.	DRIVE GEAR PIN
37.	PINION PIN



The main shaft of the SD is always locked in position. Any forward motion would be similar to an abort mode; i.e., the main shaft would rotate the ratchets via the key but neither locking pawl would be removed. A reverse rotation is prevented by the locking pawls (19).

After receiving 20 correct codes, the main shaft incrementally indexes 225° (32 ratchet teeth -- 20/32 of a revolution). However, the output shaft (22) has remained stationary, being locked to structure (23) until completion of the 20th bit by the clutch (24). The mechanics of operation of the clutch is shown in functioned schematic Views 1 and 2 of Figure 10. A guide pin (25), pressed into the clutch rides in a cam track (26) which is cut into the main shaft. Plan views of the cam track/guide pin relationships are shown in schematic cycle diagrams 1 through 7 of Figure 10.

Initially (View 1), the output shaft is restrained from moving, being locked to the clutch which is locked to the structure. These locks are shown in Sections G-G and H-H respectively. The clutch is under a spring load by the clutch spring (27) but is prevented from moving by the configuration of the cam track and guide pin.

After receiving 20 code bits, the main shaft and therefore cam track advance to position 2. The clutch now snaps to a new position under the force of the clutch spring. This motion uncouples the clutch from structure (View 2) and couples the clutch to the main shaft through the guide pin. Eight more electrical pulses will now rotate both the main and output shafts 90° (8-32nds of a revolution - plan View 3). Further rotation of the output shaft and mechanism is prevented by positive structural stops (28). A reverse rotation is prevented by the locking pawls (19). The unit is thus locked in the desired position.

4.1 RESET OF SWITCH DRIVER

The SD uses a 32 tooth ratchet. The apportionment of these 32 increments is as follows:

20 increments	Verify code word
8 increments	Rotate output shaft 90° (8/32 revolutions)
4 increments	Reset

The SD can be readily reset from either an abort, partial or full cycle mode.

Normal Position

End of 28 correct code bits (90° rotation of output shaft). The following procedure will reset the unit from the final output position:

a. Remove reset plug (29).

b. Insert rounded dowel (1/16 in.) into the reset cavity to drive clutch to the position shown in View 3 of Figure 10. This corresponds to cam track position 4.

c. Rotate the output shaft back to the original position. Clutch through guide pin follows cam track position shown in View 5.

d. Release dowel. Clutch will snap to the position shown in View 6.

e. Apply 4 code pulses to the torquer. The mechanisms are now back to the initial positions (Views 7 and 1).

Partially Advanced Position

The unit can be reset from any partially advanced position by applying the proper code to complete the actuation cycle and then proceeding for a normal reset as described above. The proper code is embossed on the right lock ratchet and can be seen through the view window (31).

Abort Position

When the unit is in the abort mode position, reset is accomplished as follows:

a. Remove reset access screws (35). Insert resetting tool. This will cam the locking pawls (18) out of engagement with the lock ratchets. The lock ratchets will then return to their initial relationship with the drive ratchet being driven by the spring (15) and transfer pin (14).

b. The unit is now out of the abort mode but is in a partially advanced position.

c. Replace the reset access screws.

d. Apply the proper code to complete the actuation and normal reset cycles.

4.2 OPTICAL FIBER/PHOTODETECTOR MECHANICAL INTERFACE

The optical input fiber optics cable is specified as a fiber optic bundle, 0.045-inch in diameter. The spectral range is 800 to 900nm with an optical bandwidth of 50 nanometers, and a Radiant Power Input (RPI) of 10^{-5} watts in the "on" state, and 10^{-8} watts in the "off" state.

Figure 11 shows a single optical channel termination in cross section. The bundle has the jacket stripped and a brass ferrule epoxied in place at the end. The fiber-optic cable/ferrule surface is polished to achieve optical flatness on the fiber end. ATO-46 lensed can, welded to a Kovar eyelet, is epoxied to the ferrule in the axial position which places the fiber ends in the focal plane of the lens. The terminated fiber/optic cable is then inserted into a Delrin adapter and slipped over the detector which is housed in a TO-46 lensed can, epoxied together, and the detector is then soldered directly to the printed circuit board. In this manner, minimum area is used to effect the fiber/optic cable/photodetector interface. Mechanical tolerances assure optimum repeatability in coupling the optical signal to the photo detector.

Photodetector Selection

The ultimate electrical load of the electronics subsystem is a limited angle dc torque motor having a rare earth magnet stator, which develops 17.5 oz-in peak torque at a power input of approximately 100 watts. The power source is a constant voltage source designed to deliver current pulses at a nominal 28 vdc to the torque motor. The total operating cycle will consist of 28 pulses in a 1 second interval. Assuming a pulsed duty cycle of 50%, at 30 pulses/second, the pulse duration is 16.67 milliseconds. The electrical time constant of the torque motor is approximately 500 microseconds. Considering the foregoing, the photodetector proposed is a silicon phototransistor, Spectronics type SD 5443-4, whose principal electrical characteristics are:

I_L	Light Current 16.0 ma VCE = 5.0V,H* = 5.0 mw/cm^2
I_D	Dark Current 100 ma VCE = 30V,H = 0
B_{VCEO}	Collector Breakdown 30 volts min. I_C = 100 μa
B_{VECO}	Emitter Breakdown 7 volts min. I_E = 100 μa
t_r	Light Current Rise Time 8 μsec R_L = 1K, V_{CC} = 5 V, I_L = 1.0 ma
V_{CESat}	Saturation Voltage 0.2V I_C = 0.4 ma H = 5.0 mw/cm^2
0**	Angular Response 9 degrees

The determination of phototransistor current at the expected Radiant Power Input is derived in Section 7.4.

4.3 DRIVER PACKAGING

The torque motor driver electronics could be packaged as a hybrid assembly together with miniaturized optics terminations such that they will be contained in

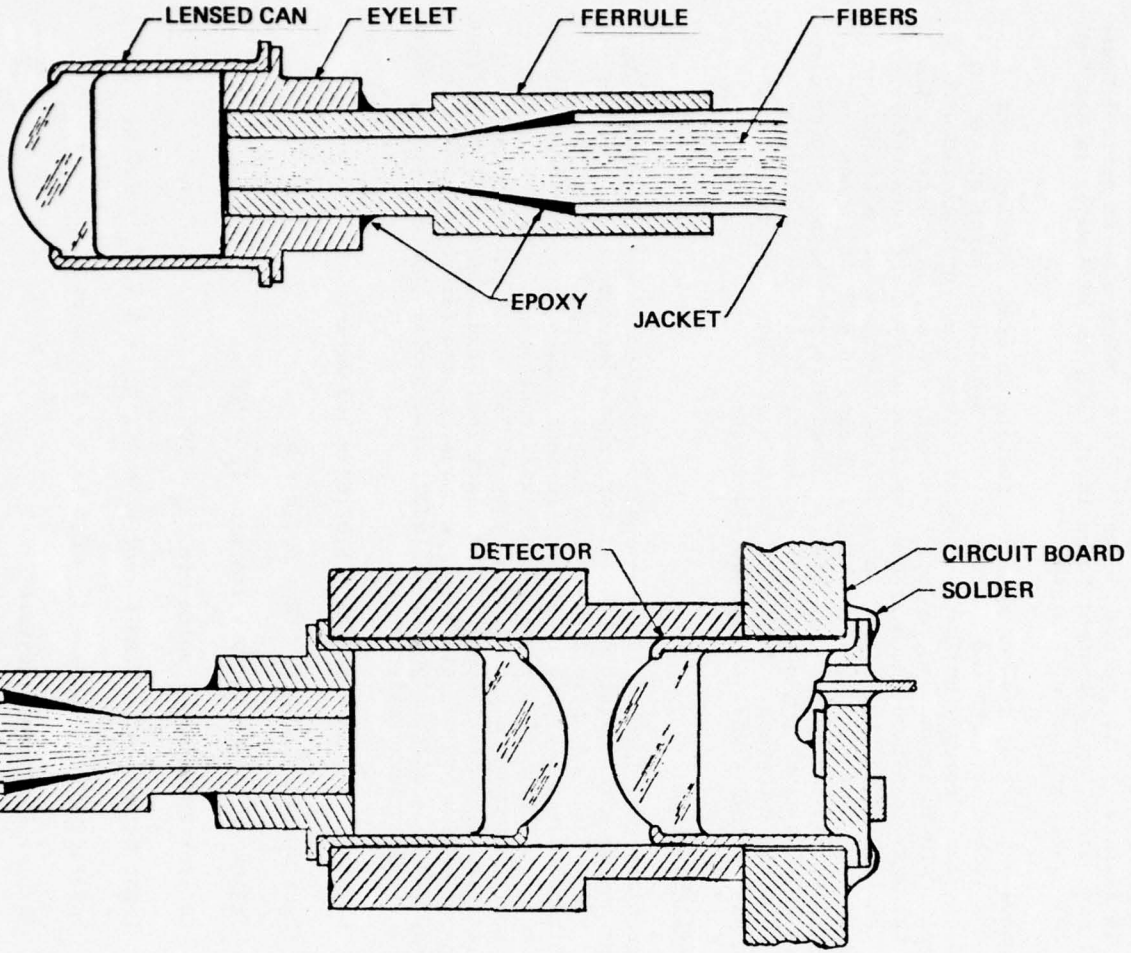


Figure 11 FIBER OPTIC CABLE TERMINATION AND DETECTOR INTERFACE

a 1.125-inch diameter x 0.5-inch volume. The total power dissipation is expected to be less than 15 watts during operation. Special attention will be given to adequate heat sinking of the dissipating elements, which are primarily the power transistor switches.

5.0 CONFORMANCE TO DESIGN REQUIREMENTS

The Switch Driver has been designed to satisfy all the requirements delineated in the contractural documents and those agreed to by Picatinny Arsenal and Avco/SD personnel. The following is a list of these requirements along with a description showing design conformance.

5.1 FUNCTIONAL REQUIREMENTS

5.1.1 Optical Code/Electrical Power

The SD is to respond only through two actuating input stimuli-optical code and electrical power combined.

The driving mechanism is a limited angle dc torque motor which converts electrical power to a mechanical rotational output. The direction of rotation (CW or CCW) will be a direct function of the polarity of the electrical signal. The electrical power can only be applied to the torque motor when an optical signal is present. The optical stimulus is converted to an electrical signal which supplies current drive to a transistor power driver. The power driver produces bi-directional rotation of the torque motor dependent upon the input optical code. No rotation of the torque motor will occur if either the electrical power and/or optical stimuli is not present.

5.1.2 Output

- The output shaft must rotate 90^{o} only after receipt of the correct code.

  The output shaft is initially locked to the structure of the SD. This lock is maintained through and including 19 correct code bits. At the completion of the 20th correct code bit, the lock is removed and the driving torque is then (and only then) connected to the output shaft. If at any time during and including the first 20 bits an incorrect complementary code is received, the lock ratchets will partially advance and will become locked by the locking pawls and lock arm. The unit will then be aborted.

- Provide a 10 in-oz. minimum torque.

  The torque motor has a peak torque (Tp) of 17.5 in-oz. The output torque (T) varies by twice the cosine of the mechanical indexing angle (θ), i.e., $T = Tp \cos 2\theta$. If the mechanical angle is 15^{o} (11.25^{o} per tooth + 3.75^{o} for backlash, overthrow, etc.) the torque is 15.16 in-oz. If 4.82 in-oz. is required to index the mechanism in the proper time cycle then the output shaft will have a 10.34 to 12.68 in-oz. output torque. (See Section 6.1 for analysis.)

- Output shaft must lock in the on, off, and abort positions.

  The output shaft is always in a locked mode and can only be advanced by driving the mechanism through the code. It is either locked to structure (0-19 bits) or coupled to the main shaft (20-28 bits). The main shaft is

also locked in position. It is prevented from unintentionally advancing by the lock arms on returning by the locking pawls (19). In the abort mode the main shaft is locked in position by the lock arm and locking pawls (18).

5.1.3 Reset by External Means

The SD can be reset from the locked and/or abort modes without disassembly. A detailed description of the reset is presented in Section 4.1. Basically, reset is accomplished as follows:

- From the armed position

  a. Uncouple the clutch (requires manual movement of clutch).

  b. Rotate output shaft back to safe position (release clutch).

  c. Apply a 4 bit word to the torque motor (word could be coded) to complete rotation of main shaft.

- From the abort position

  a. Uncouple locking pawls (through access ports).

  b. Complete actuation cycle to arm unit.

  c. Proceed as above.

5.1.4 Fail Safe

The SD should fail safe by ceasing to respond to further signal inputs any time an improper complementary code signal is detected.

At any time during the first 20 bits an improper code signal is received, the lock ratchets will partially advance where they will become locked by the locking pawls (18) and lock arm (13). The unit will be aborted. If the code bits are received on both lines or none are received at all, no electrical signal is delivered to the torquer and no main or output shaft movement occurs.

5.1.5 Response Time (1 second maximum)

The analyses presented in Section 7.1 show that the SD will function in approximately 0.5 second with a 10 in-oz. resisting load on the output shaft.

5.2 PROBABILITY

5.2.1 Premature Random Probability

The probability of premature operation of the SD output due to applied signals randomly generated, in the proper, or any other format, shall be less than 1 in 10^6 in all environments.

The output shaft of the SD will be locked to the structure of the mechanism until 20 correct bits of code signals have been received by the optical/electronics package. These signals can be construed as being either a "0" or a "1" with each having the same probability of occurrence. Therefore, the probability of the output shaft becoming unlocked from the structure by a random signal is 1 in 2^{20} or 1 in 1.05×10^6 or 9.54×10^{-7}.

In addition, the output shaft is still locked at this point by the mechanism which requires 8 more signals to rotate. These signals could also be a coded word in which case the probability of getting a 90^o output from a random signal is 1 in 2.68×10^8 or 3.73×10^{-9} (i.e., 1 in $2^{(20+8)}$ = 1 in 2^{28}).

5.2.2 Premature Due to Component Part Failure

The probability of an inadvertent or premature operation of the SD output due to component part failures (electrical or physical) shall be less than 1 in 10^5 in normal environments.

The SD is designed so that no single component failure will cause the output shaft to rotate; rather it takes a series of positive events.

Because the unit has been designed to drive through the code, the code mechanism must fail, or be by-passed, and torque, either from the torquer or from an external source, must be applied. For the code mechanism to fail either the 20 protrusions of the lock ratchets or the two lock arms must fail. The design of these members are with sufficient safety factor so that each will have a probability of failure less than 1 in 1000 in normal environments. This makes the probability of code mechanism failure less than 1 in 10^6 since at least two members must fail.

In addition, no stored arming energy is used in the SD. This means that the torquer must also fail or driving torque must be externally applied. This has the effect of further reducing the probability of output due to component failures.

5.2.3 Premature Due to Abnormal Environments

The probability of inadvertent or premature operation of the SD output should be less than 1 in 10^3 when exposed to levels of abnormal environments that an associated strong link is required to survive.

A "strong link/weak link" philosophy has been used in the design of the SD. The output shaft and associated ratchets, locking pawls, lock arms, structure, etc., are of rugged construction (strong link). The drive pawls, which index the mechanism by driving through the code, are designed to be the weak link, their

stress level being proportionally lower than the strong link components so that they would fail first in any abnormal condition.

The established failure priority (see Section 7.2) removes the drive torque from the code mechanism -- first by a buckling failure of the drive pawl and second by sheering the pin coupling the torquer to the drive gear.

5.3 PHYSICAL CONSTRAINTS

5.3.1 Weight (4 oz. maximum)

The estimated weight of the breadboard design (Figure 10) with a hybrid electronics circuit is 4.48 oz. The weight breakdown is as follows:

Optical/Electronics Package	0.44 oz.
Torquer	1.60 oz.
Structure	1.42 oz.
Mechanism	1.02 oz.
	4.48 oz.

However, discussions with torque motor vendors indicate that the torque motor weight and size can be significantly reduced for our application (limited angle). This would require a small development effort which should be entertained during the next program phase. The projected weight would be 3.88 oz. which is based upon a 1.0 oz. projected torque motor weight.

5.3.2 Size

The size of the SD shall be limited by the equivalent volume of a 0.93 x 0.93 x 2.125 rectangular parallelepiped (1.84 cubic inches). The size of the breadboard SD (Figure 10) with hybridized electronics and miniaturized optics is 2.26 cubic inches. However, the torque motor development effort will reduce the design configuration to approximately 1.9 to 2.0 cubic inches without advancing the current state-of-the-art.

5.3.3 Storage Life (20 years)

To obtain a long term 20 year storage life cycle, the following design precautions are being taken:

- Use of compatible metals.
- Use of fungus non-nutrient materials.
- Non use of outgasing materials.
- Non use of age hardening materials.
- Non use of materials subject to cold flow.
- Environmentally sealed.

6.0 DESIGN FEATURES

- The decoding concept uses only physical code storage methods. The drive ratchet and the lock ratchets have the code machined into their configuration.
- Electronic logic decoding techniques that result in the simple switching of power to the rotary driving source and/or to an output shaft unlocking feature are not used. The optical/electronics package merely converts the code to an electrical signal which is transmitted to the torquer. For the mechanism to advance the optical code must be correct.
- The physical decoding feature (drive ratchet) is located between the source providing the power for rotation of output shaft (torquer) and the output shaft itself. For the output shaft to advance the mechanism must drive through the code.
- The entire unique signal (code word) must be verified prior to initiation of output shaft rotation. No rotation of the output shaft occurs until the 21st signal. During the code word initiation the output shaft is locked to the structure of the mechanism. If an incorrect code bit is delivered the unit will lock up and fail safe.
- A physical barrier not prone to single point failures, which prevents output shaft rotation by the driving force, is present until the entire code word is verified. The output shaft is locked to structure until the complete code word is sent.
- The decoding process detects the presence of improper code events by locking out the device. The device does not respond to 2 "1"s or 2 "0"s nor is there any maximum time limitation on the delivery of the code (i.e.: 10 correct bits now 10 correct bits later will unlock the output shaft).
- The proper performance of a deliberate sequence of physical events is necessary to accomplish the decoding process. The improper code response feature is inherent in the design and not dependent on reactions which could be prevented by single, or combinations of, short or open circuit failures. The response to an improper code is the impending lock on the lock ratchets.
- Dual locks on the output shaft.
- Use of standard hardware items (ratchets, torque motors, etc.).
- Flexibility to increase code premature probability from 1 in 10^6 to 1 in 10^9 without a significant design change.
- All components to the greatest extent possible are balanced to provide good dynamic stability.
- Reset is simple and is accomplished without the use of special tools.
- Single torque motor used to index code mechanism and provide torque to output shaft.
- Code not constrained can by any combination of "0"'s or "1"'s.

- Reverse drive mechanism cannot index both drive arms simultaneously because of controlled clearances between the drive gears and drive pawls; i.e., the code cannot be bypassed if the drive pawl mechanism "freezes" to the main shaft.
- The code mechanism uses the principle of active advance and passive abort. Therefore, any jamming tends to abort the system.
- No stored arming energy is used.

7.0 SUPPORTING DESIGN ANALYSES

7.1 MECHANISM FUNCTION TIME

The response of the system can be determined by analyzing one complete cycle of the code word. The forward stroke of a cycle can be broken down as follows:

0	- 1°	Take up of backlash in reversing mechanism gear train.
1	- 2°	Take up of backlash between drive pawl and drive ratchet.
2	- 13° 45'	One ratchet tooth index.
13° 45'	- 15°	Overtravel.

Therefore, one complete cycle requires a 15 degree forward stroke of the torquer and a 15 degree return stroke.

System Parameters

The parameters of the system are presented in the following paragraphs.

Driving Torque

The torque motor has a peak torque (T_p) of 17.5 in-oz. The output torque (T) varies by twice the cosine of the mechanical indexing angle (θ), i.e., $T = T_p \times \cos 2\theta$. If the mechanical angle is 15°, the driving torque will vary from 17.5 in-oz at 0° to 15.2 in-oz at 15° (i.e., T = 17.5 x cos 30 = 15.16).

System Inertia

The effective inertia (i.e., moment of inertia caused by rotation about the torque motor axis) of each of the components of the system are shown in Table I along with a matrix showing where applicable. For conservatism the total inertia is used during the complete stroke even though there are portions of the drive stroke in which all parts do not move, (i.e., first degree only torque motor, middle portion of stroke lock arms do not move, etc.).

Resisting Torque

The resisting torque of the components of the system are shown in Table II along with a matrix showing where applicable. For conservatism the maximum frictional resisting torque of the drive and locking pawls are used even though they do not occur simultaneously during the drive stroke.

Analysis

$$T = I\ddot{\theta}$$

TABLE I

EFFECTIVE SD INERTIAS

	Moment of Inertia ($in\text{-}lb\text{-}sec^2$)	Drive	Stroke	Return Stroke
		First 20 Cycles	Last 8 Cycles	
Torque Motor	7.175×10^{-6}	X	X	X
Reversing Mechanism	1.679×10^{-6}	X	X	X
Drive Pawl	1.202×10^{-6}	X	X	X
Lock Arm	0.625×10^{-6}	X	X	X
Drive and Lock Ratchets	1.125×10^{-6}	X	X	-
Torque Motor Shaft	0.067×10^{-6}	X	X	X
Main Shaft	0.085×10^{-6}	X	X	-
Clutch	0.012×10^{-6}	-	X	-
Output Shaft	0.074×10^{-6}	-	X	-
Totals		1.196×10^{-5}	1.204×10^{-5}	1.075×10^{-5}

TABLE II

RESISTING TORQUE SD

	Resisting Torque (in-oz)	Drive	Stroke	Return Stroke
		First 20 Cycles	Last 8 Cycles	
Return Spring (Ave)	2.70	X	X	-
Locking Pawls (Max.)	0.88	X	X	-
Abort Lock Pawls (Max.)	0.61	X	X	-
SD Friction (Est.)	0.50	X	X	X
Drive Pawl (Max.)	0.13	X	X	X
Output Shaft Torque Load	10.00	-	X	-
Total		4.82	14.82	0.63

For a Constant Torque (T)

$$\ddot{\theta} = \frac{T_{net}}{I}$$

$$\theta = 1/2 \frac{T_{net}}{I} t^2$$

$$t = \left[\frac{2\theta I}{T_{net}}\right]^{1/2}$$

- Forward Stroke First 20 Cycles

  $\theta = 15^{o} = 0.2618$ rad

  $I = 1.196 \times 10^{-5}$ in-lb sec^2

  $$T_{net} = \left[\frac{17.5 + 15.16}{2} - 4.82\right] \div 16 = 0.7194 \text{ in-lb}$$

  $$t = \left[\frac{2 \times 0.2618 \times 1.196 \times 10^{-5}}{0.7194}\right]^{1/2} = 0.002950 \text{ sec}$$

  $t = 2.950$ milliseconds

- Forward Stroke Last 8 Cycles

  $I = 1.204 \times 10^{-5}$ in-lb sec^2

  $$T_{net} = \left[\frac{17.5 + 15.12}{2} - 14.82\right] \div 16 = 0.0944 \text{ in-lb}$$

  $t = 8.172$ milliseconds

- Return Stroke

  $I = 1.075 \times 10^{-5}$ in-lb sec^2

  $T_{net} = (2.70 - 0.63) \div 16 = 0.1294$ in-lb

  $t = 6.596$ milliseconds

- Time Delay

  The torque motor has an electrical time constant of 0.35 millisecond. If we allow 0.8 millisecond time delay in which time we consider no motion has occurred, this parameter will be treated conservatively.

- Conclusion

  A conservative estimate of the total cycle time capability of the Switch Driver is 348 milliseconds. This estimate is based on a duty cycle of 4 milliseconds on, 7 ms off for the first 20 code cycles (to unlock the output shaft) and 8 code cycles of 9 ms on 7 ms off to rotate the output shaft 90°. If a 50% duty cycle for all 28 bits is desired, the cycle time is 504 ms (i.e., 28 (9 + 9) = 504). The total time can be reduced further by matching the forward and return cycle times.

7.2 STRESS ANALYSIS OF CRITICAL ITEMS ASSOCIATED WITH "WEAK LINK/STRONG LINK" PHILOSOPHY

A stress analysis of the drive and abort mechanisms was conducted for a worst case abort mode. The results of this study are shown in Table III along with the material chosen and resulting safety factors.

The rationale used in the selection of material is the desired priority of failures in an abnormal condition. These are presented in the chronological order of failure:

- Drive Pawl (10) -- S.F. buckling 2.6 -- to remove drive torque from the drive ratchets (11).

- Drive Gear Pin (36) -- S.F. 3.7 rupture -- to remove drive torque from drive mechanism (4).

- Protrusion of Lock Ratchets (12) -- S.F. 3.8 yield -- failure results in loss of 1 code bit.

7.3 GEAR BACKLASH

The following analysis shows the backlash in the reversing gear mechanism (from the drive pawl to the drive ring) to be 1.1 degrees.

Backlash is defined as the clearance between adjacent teeth of mating gears measured at the common pitch circle. It is, therefore, the amount by which a tooth space exceeds the thickness of the engaging tooth.

Two elements contribute to the backlash between gears; the variation in gear center distance due to manufacturing tolerances, and the normal clearances between teeth to prevent jamming. The former variation is a function of the gear pressure angle while the latter variation is a function of the class of gears.

TABLE III

SUMMARY PIECE PART STRESS – ABORT MODE

Part (Numbers refer to Figure 10)	Material	Stress[a] (psi)	Allowable Stress (psi)	Safety Factor Based on Yielding
Drive Gear (3)	303 SS	8,300	35,000	4.2
Drive Gear Pin (36)	446 SS	23,200	55,000	2.4[b]
Drive Pawl Mechanism (4)	Brass	2,300	51,000	22.2
Drive Pawl (10)	Berylco Nickel 440	22,000	200,000	9.1[c]
Camming Pin (33)	303 SS	4,900	35,000	7.1
Drive Ratchet (11)	303 SS	3,700	35,000	9.5
Lock Ratchet (12)	AM355 SS	48,700	183,000	3.8
Lock Arm (13)	AM355 SS	33,400	183,000	5.5
Lock Pawl (18)	Berylco Nickel 440	21,700	200,000	9.2[d]
Drive Gear Tooth (3)	303 SS	1,900	35,000	18.4
Pinion Tooth (6)	416 SS	29,600	145,000	4.9
Pinion Pin (37)	416 SS	47,000	145,000	3.1[e]

(a) Factor of two applied for dynamic condition.

(b) Drive Gear Pin will rupture prior to yielding of other members -- @ 85,000 psi tensile strength, i.e.,

$$\text{S.F. rupture } \frac{85,000}{23,200} = 3.66$$

(c) S.F. Buckling 2.6

(d) S.F. Buckling 3.0 with reverse torque equal to drive torque.

(e) At 190,000 psi tensile strength -

$$\text{S.F. rupture} = \frac{190,000}{47,000} = 4.0$$

The gear train in the reversing mechanism has three pairs of mating gears. The characteristics of each of the gears are given in Table IV.

TABLE IV

GEAR CHARACTERISTICS FOR 20° PRESSURE ANGLE

	No. of Teeth	Pitch Diameter (in)	Gear Class	Maximum Backlash Per Pair (in)
Drive Gear 1	56	0.5833	Prec 3	0.00055
Pinion 1	10	0.1042	Prec 1	0.00146
Pinion 2	10	0.1042	Prec 1	0.00146
Drive Gear 2	56	0.5833	Prec 3	0.00055

The backlash for each mating pair is calculated below.

7.3.1 Drive Gear 1 and Pinion 1

a. Clearance due to 0.001 center distance change (CD). The backlash due to variations in the center distance is approximately equal to the change in center distance multiplied by twice the tangent of the transverse pressure angle.

$$CD = 0.001 \times 2 \times \tan 20^{\circ} = 0.00073 \text{ in.}$$

b. Normal clearance between teeth (CL).

$$CL = \frac{0.00055 + 0.00146}{2} = 0.001005 \text{ in.}$$

c. Total backlash = CD + CL = 0.001735 in.

7.3.2 Pinion 1 and Pinion 2

a. CD due to 0.001 center distance change = 0.00073

b. Normal clearance between teeth = 0.00146

c. Total = 0.00219 in.

7.3.3 Pinion 2 to Drive Gear 2

a. CD due to 0.001 center distance change = 0.00073

b. Normal clearance between teeth = 0.001005

c. Total = 0.001735

7.3.4 Total Backlash for Mechanism

a. Total linear clearances = 0.001735 + 0.00219 + 0.001735 = 0.00566 in.

b. Angular backlash (θ)

$$\theta = \frac{\text{Linear Distance}}{\pi \times \text{Pitch Dia.}} \times 360$$

$$= \frac{0.00566 \times 360}{\pi \times 0.5833} = 1.11^{o}$$

7.4 PHOTOTRANSISTOR OUTPUT - SPECTRONICS SD5443-4

For the SD application at a Radiant Power Input of 10^{-5} watts, the following analysis is used to select the photodetector.

The input fiber/optic bundle has a diameter of 0.045 in. (0.1143). The Photodetector chip diameter is 0.050 in. (0.127 cm). The lens can termination shown in Figure 11 collimates the light output of the fiber bundle, and effectively places the detector chip directly over the fiber/optic cable output.

The Power Input to the detector is:

1.0×10^{-5} watts.

A loss of -3 dB is expected due to coupling losses in the fiber optic/detector interface. The total input power in the "on"state is:

1.0×10^{-5} (0.5) = 0.5×10^{-5} watts

From the Specification sheet for the SD5443-4 its light current output is:

$3.2\ ma/_{mw/_{cm^2}}$

to determine the photocurrent, Irradiance equals

$$H = \frac{P}{A} \quad w/cm^2$$

$$\frac{0.5 \times 10^{-5}}{\frac{\pi (0.127)^2}{4}} = 39.5 \times 10^{-5}\ w/cm^2 = 0.395\ mw/cm^2$$

and the photocurrent is:

$$I_p = 3.2\ ma/_{mw/_{cm^2}} \times 0.395\ mw/cm^2$$

$$= 1.264\ ma$$

To compensate for the monochromatic source the total photocurrent output is multiplied by a factor of 2.7, making the photocurrent output at 10^{-5} watts input.

$$1.264 \text{ ma} \times 2.7 = 3.413 \text{ ma}$$

The photocurrent for an "off" condition of 10^{-8} watts input is:

$$0.0034 \text{ ma} = 3.4 \ \mu\text{a}$$

The total "off" current is the photocurrent plus the "dark current" and for the SD5443-4 is:

$$3.4 \ \mu\text{a} + 0.1 \ \mu\text{a} = 3.41 \ \mu\text{a}$$

Under actual operating conditions, saturated operation of the phototransistor results in excessive rise and fall times which can produce excessive dissipation by causing all power switches to be on simultaneously. Therefore the phototransistor load resistors are selected such that the phototransistors operate in a non-saturated mode.

8.0 SWITCH DRIVER MODEL

8.1 SPECIAL TEST EQUIPMENT

To facilitate functional testing of the Switch Driver, an auxiliary piece of test equipment has been designed and is referred to as the SD Data Generator.

8.1.1 Functional Description

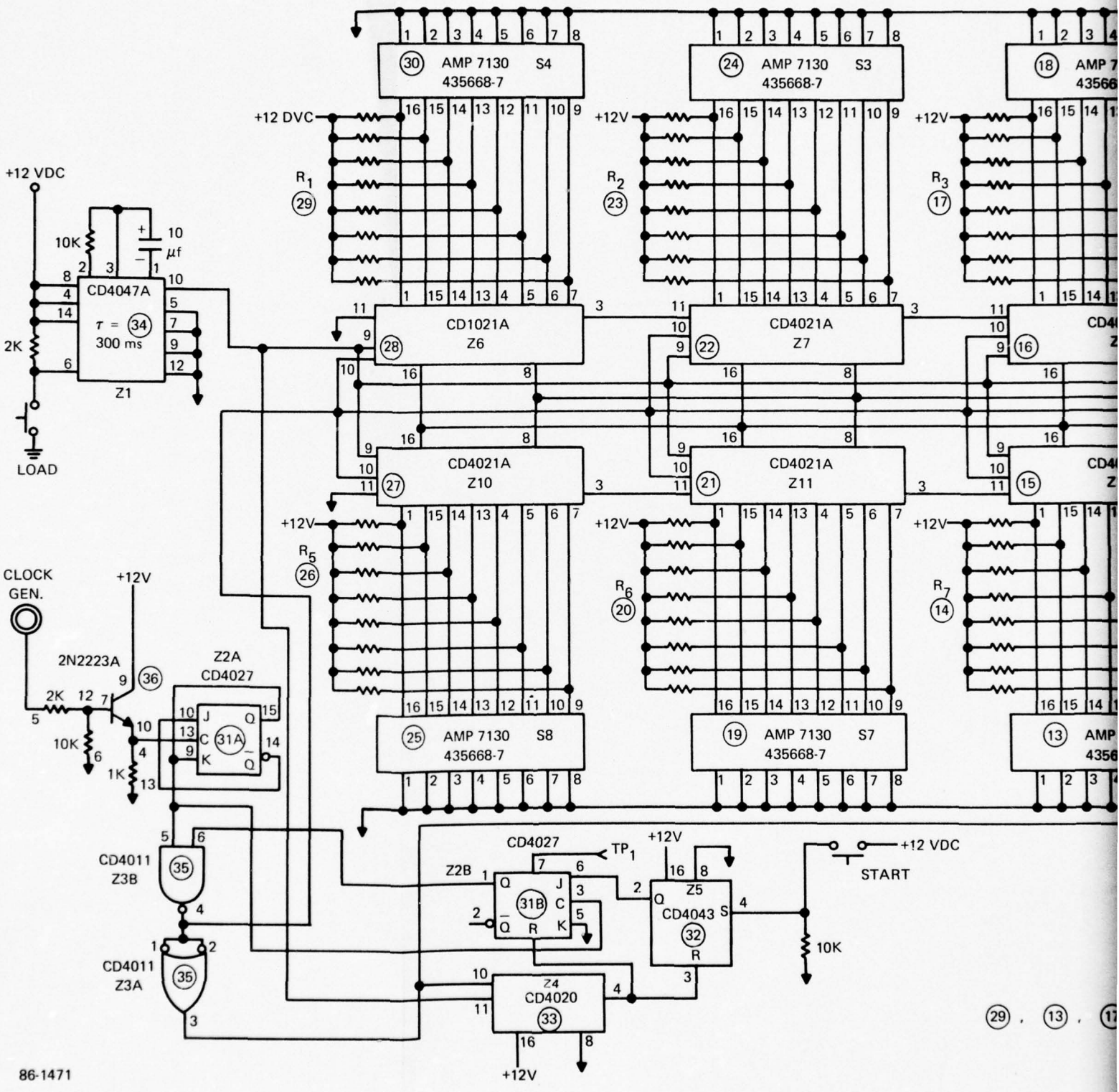
The Data Generator is illustrated in schematic diagram Figure 12. It is comprised of two 32 bit parallel in/serial out shift registers, with presettable inputs, and auxiliary logic to load the preset data and output the coded data on command. There are two controls actuated by push button switches; Load and Start. An external +10 to +12V power supply is required as well as an external pulse generator to provide the necessary timing pulses. The Data Generator provides the capability of generating dual coded pulse trains of from 1 to 32 bits, at a rate determined by the setting of the external pulse generator. These coded outputs can, at the operator's discretion, be either complementary or non-complementary to allow functional testing of both true and dud modes of operation.

Data is loaded by presetting the 64 data switches, access to which is made through the open underside of the Data Generator. Switches are set to logic "1" in "on" position, and logic "0" in the "off" position. Switch settings are changed using a ball point pen to actuate the switch rockers.

The "Load" switch actuates a 300 ms monostable multivibrator Z1 (CD4047A) to produce the load pulse. The Load pulse also clears the pulse counter Z4 (CD4020), and enables the end of cycle flip flop Z2B (CD4027) and the Start switch latch Z5 (CD4043).

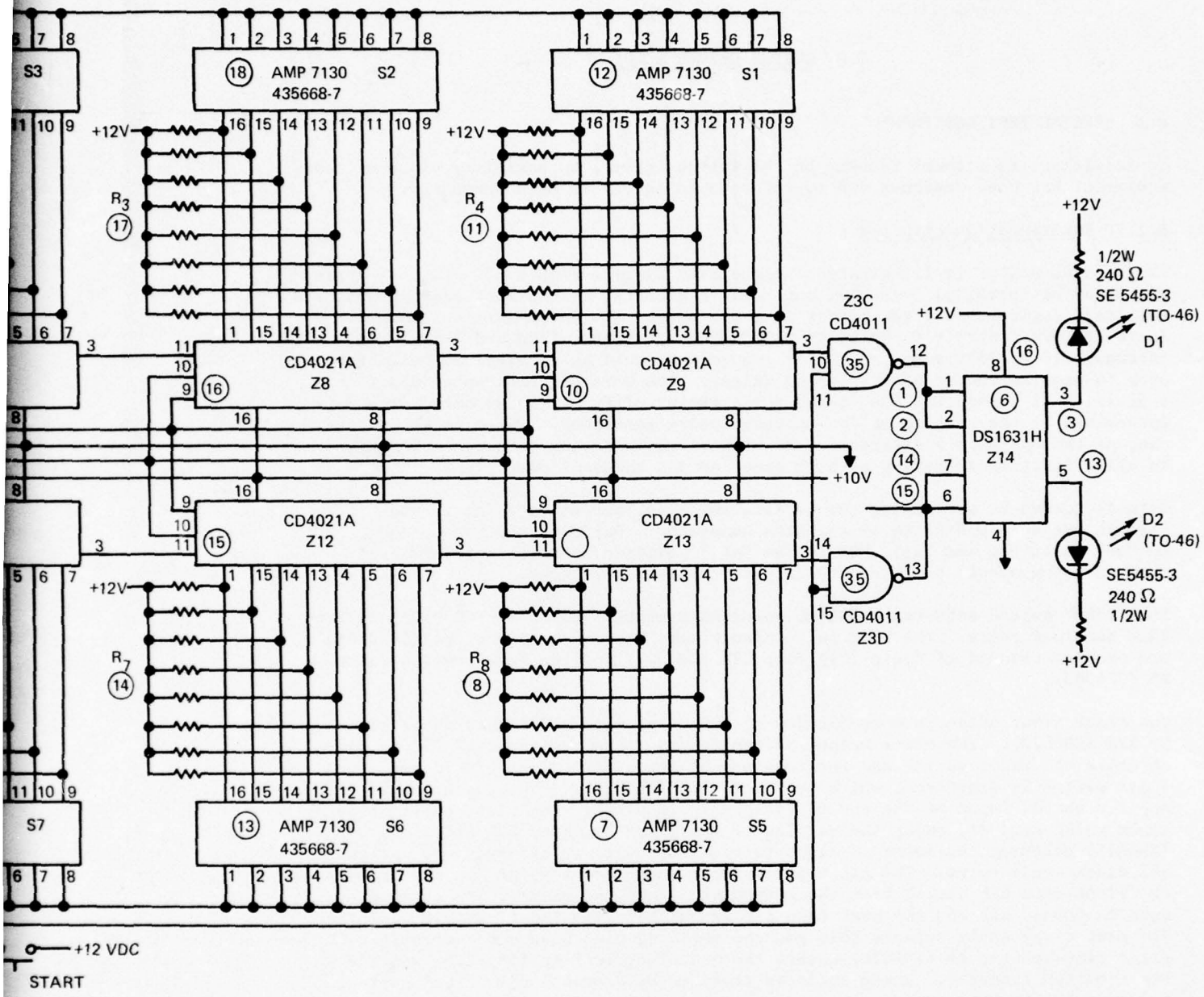
The clock input pulse rate is divided by two to produce a 50% duty cycle clock by Z2A (CD4027). The clock output is applied to the clock input of Z2B to synchronize the Start switch and the issuance of data. After data is loaded, the Start switch is depressed, which sets latch Z5 (CD4043). The latch output is applied to the input of the end of cycle flip flop Z2B. The first positive going clock pulse edge following the setting of the latch Z5, sets Z2B and enables Z3B (CD4011) allowing the inverted clock to clock the data shift registers, at the 50% clock cycle point. The clock is inverted once more through Z3A and enables the first data bit output from the generator. When the clock pulse terminates, data is turned off and the next data bit is shifted into the first bit position. The next clock cycle repeats this process until 32 bits have been output, at which time counter Z4 (CD4020) Resets the end of cycle flip flop Z2B, and the Start switch latch Z5. A new cycle is produced by depressing the Load switch, followed by the Start switch.

> Note: The input clock pulse generator must operate at 2 x the desired data rate output: (i.e., a 40 Hz output rate, requires an 80 Hz clock pulse input to produce a 40 Hz 50% duty cycle output).



-38-

Figure 12 DATA GENERATOR



29 , 13 , 17 , 11 , 7 , 14 , 20 , 26 BECKMAN 898-3-R-22K

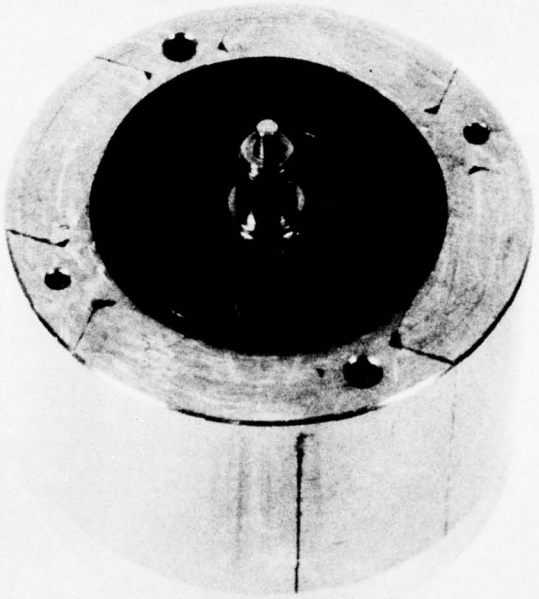
Figure 12 DATA GENERATOR

To generate less than 32 bits, all the bit switches following the desired bits are set to logic "0", or "off", on both channels. Z14 (DS1631H) is the current driver for the LED's, Spectronics SD5455-3.

Controls and input terminals to the Data Generator are clearly marked for function on the face of the unit.

8.2 PHOTOGRAPHS

The following photographs (Figures 13 through 19) show the major piece part components of the Switch Driver and the assembled model with the special test equipment.



24799F

Figure 13 STANDARD OFF-THE-SHELF TORQUE MOTOR

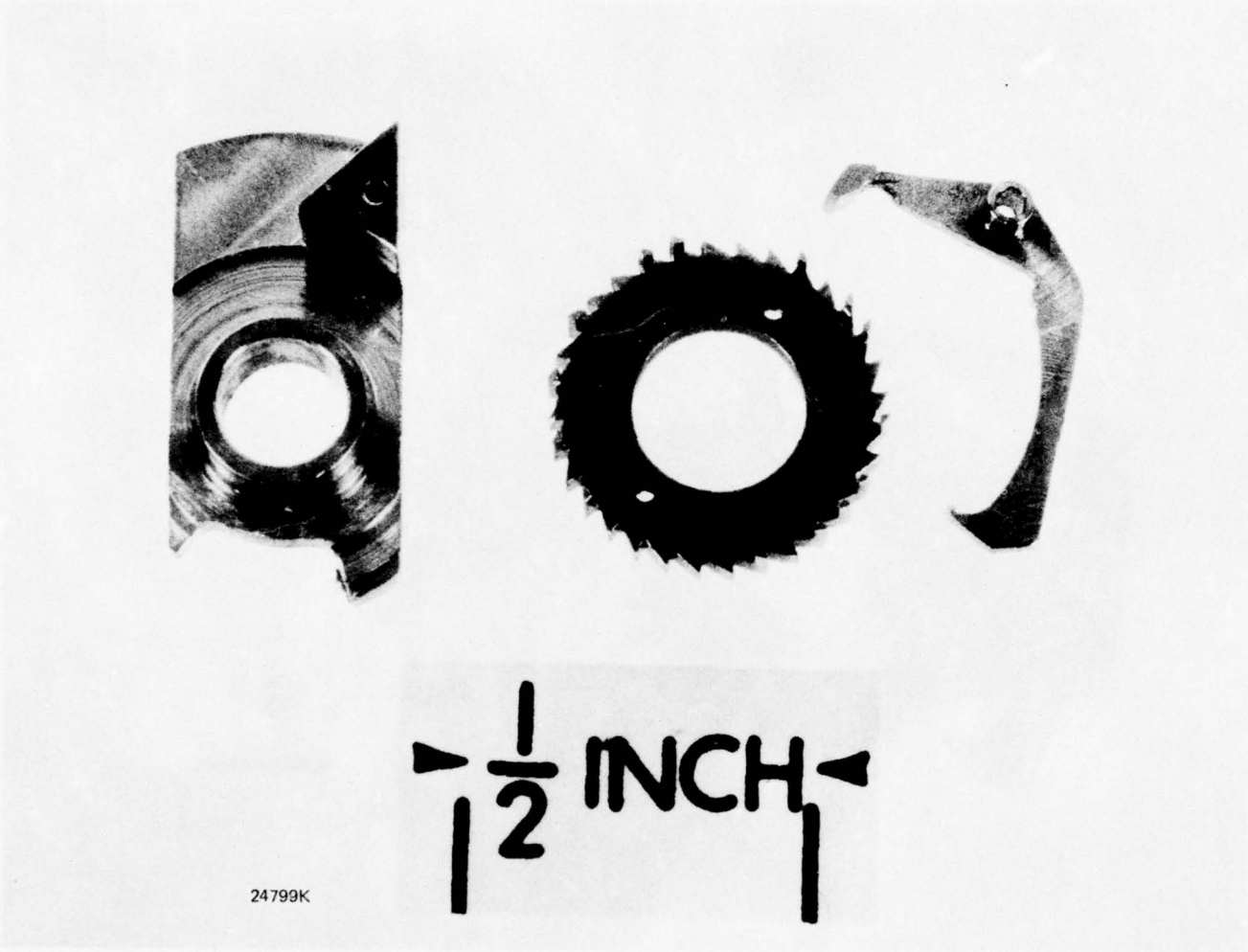


Figure 14 ABORT RATCHET, LOCK ARM AND DRIVE PAWL

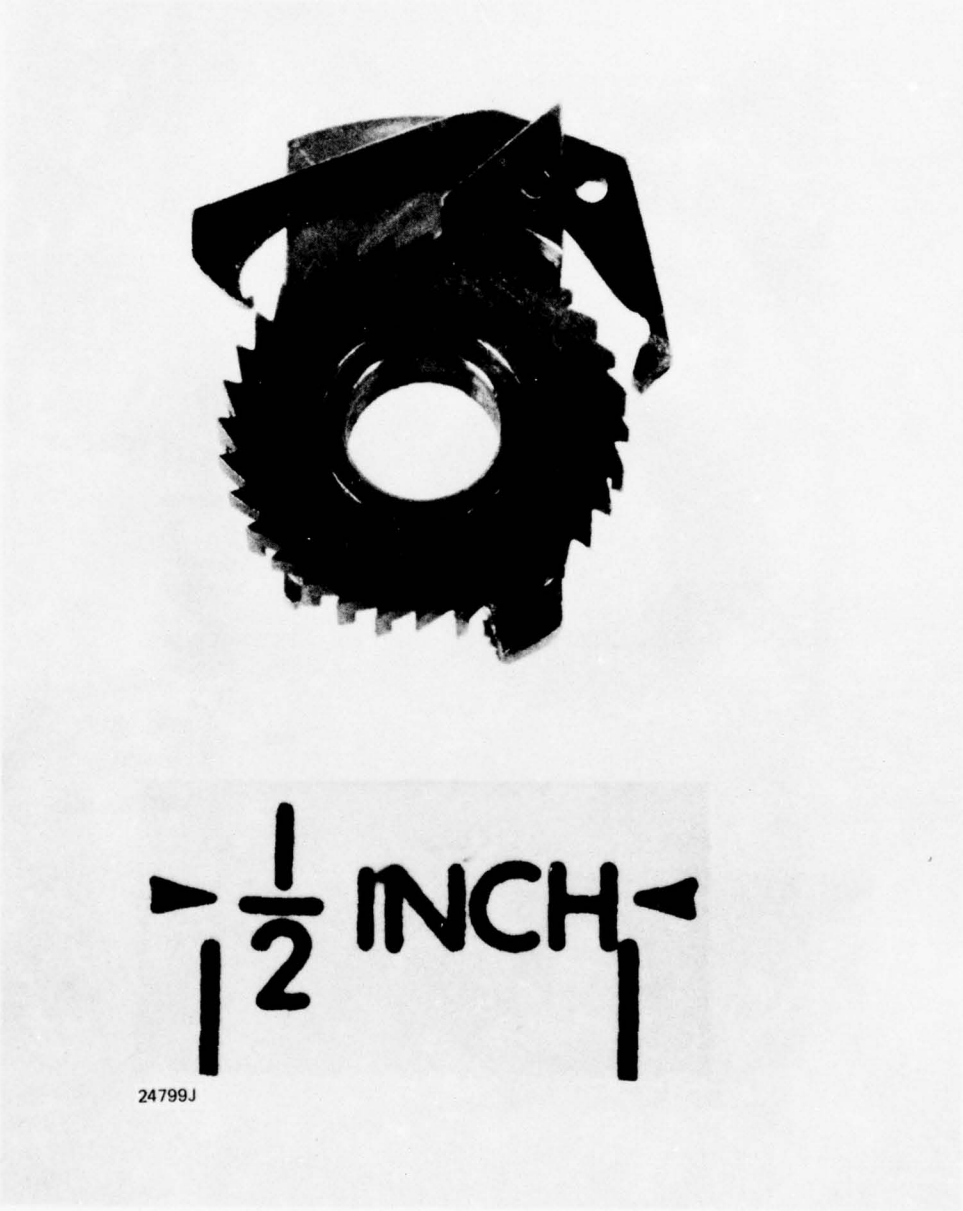


Figure 15 RELATIVE POSITION OF COMPONENTS OF FIGURE 14

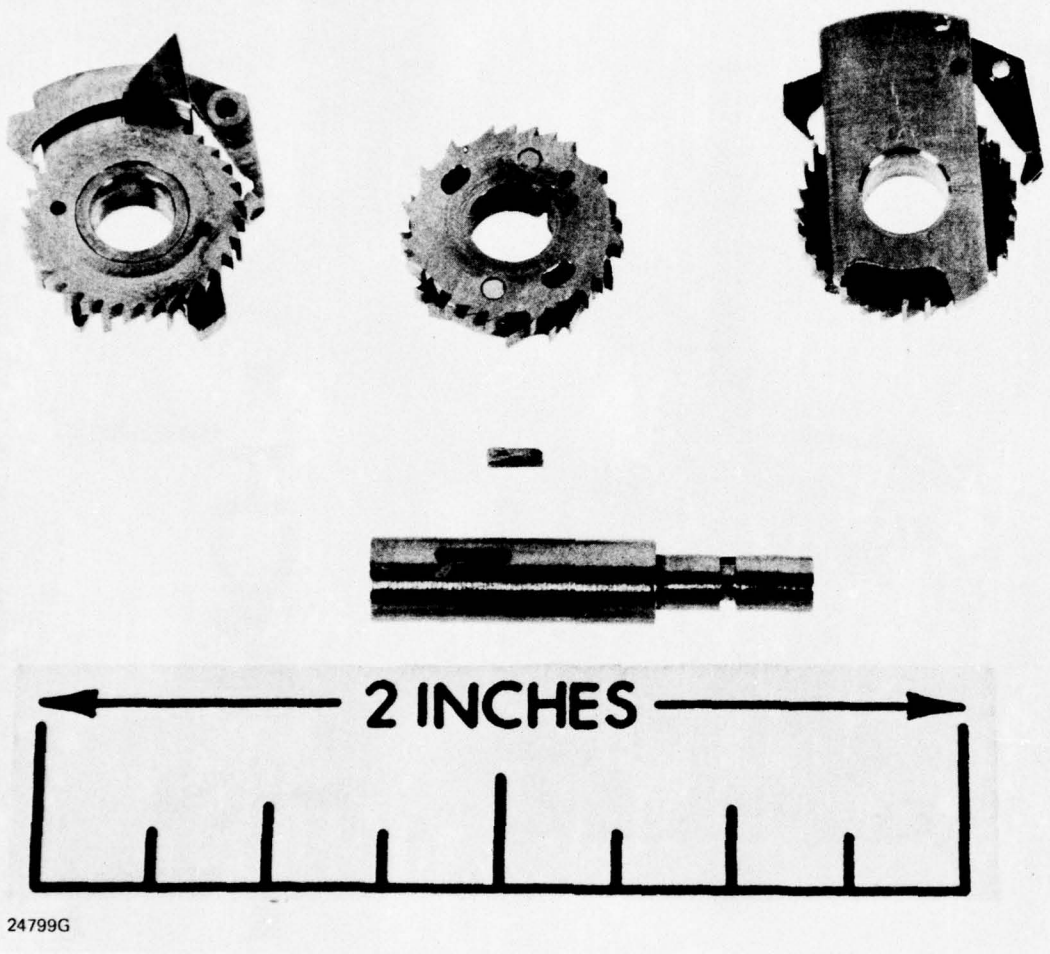


Figure 16 MAJOR CODE MECHANISM COMPONENTS

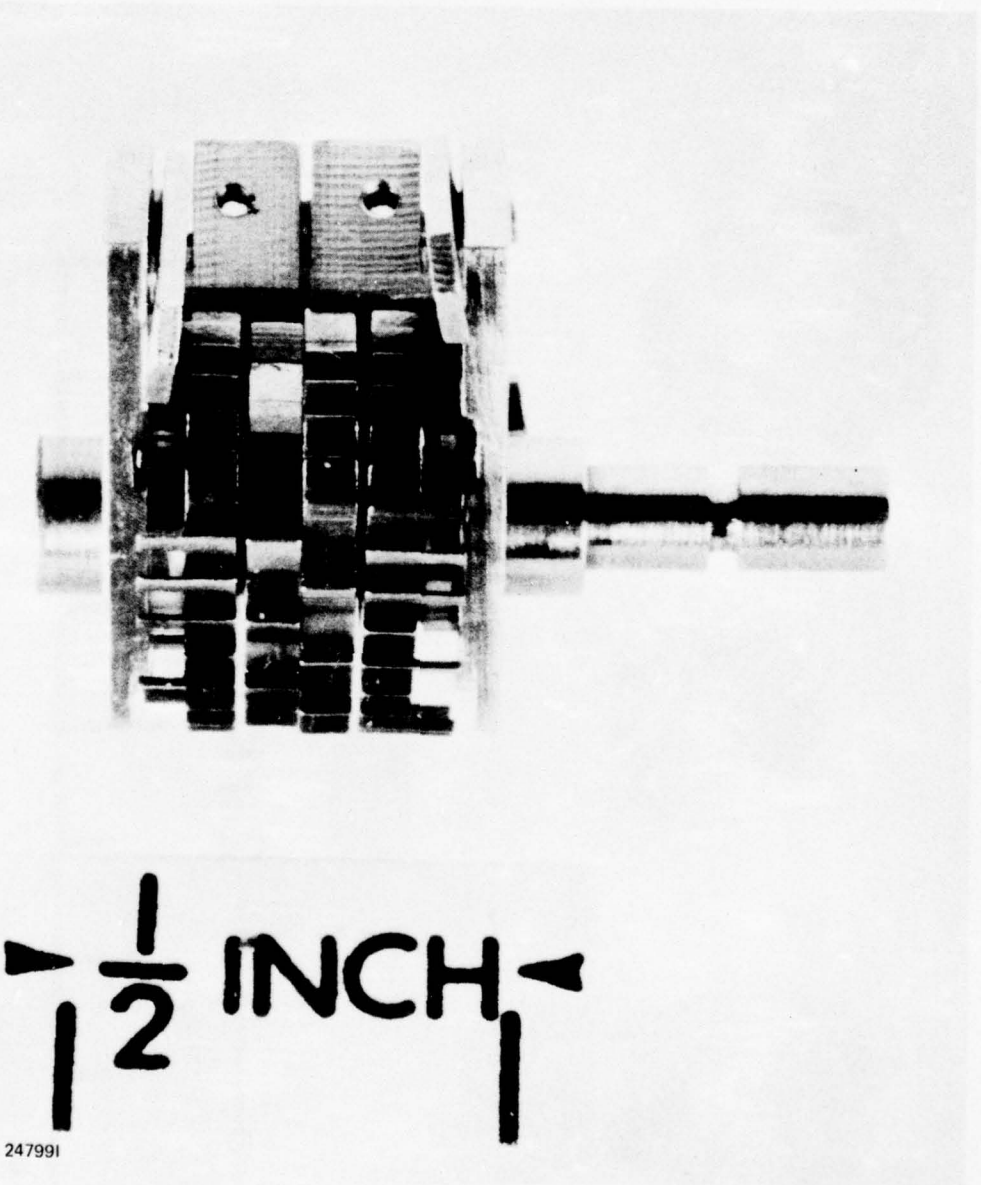


Figure 17 ASSEMBLY OF COMPONENTS OF FIGURE 16

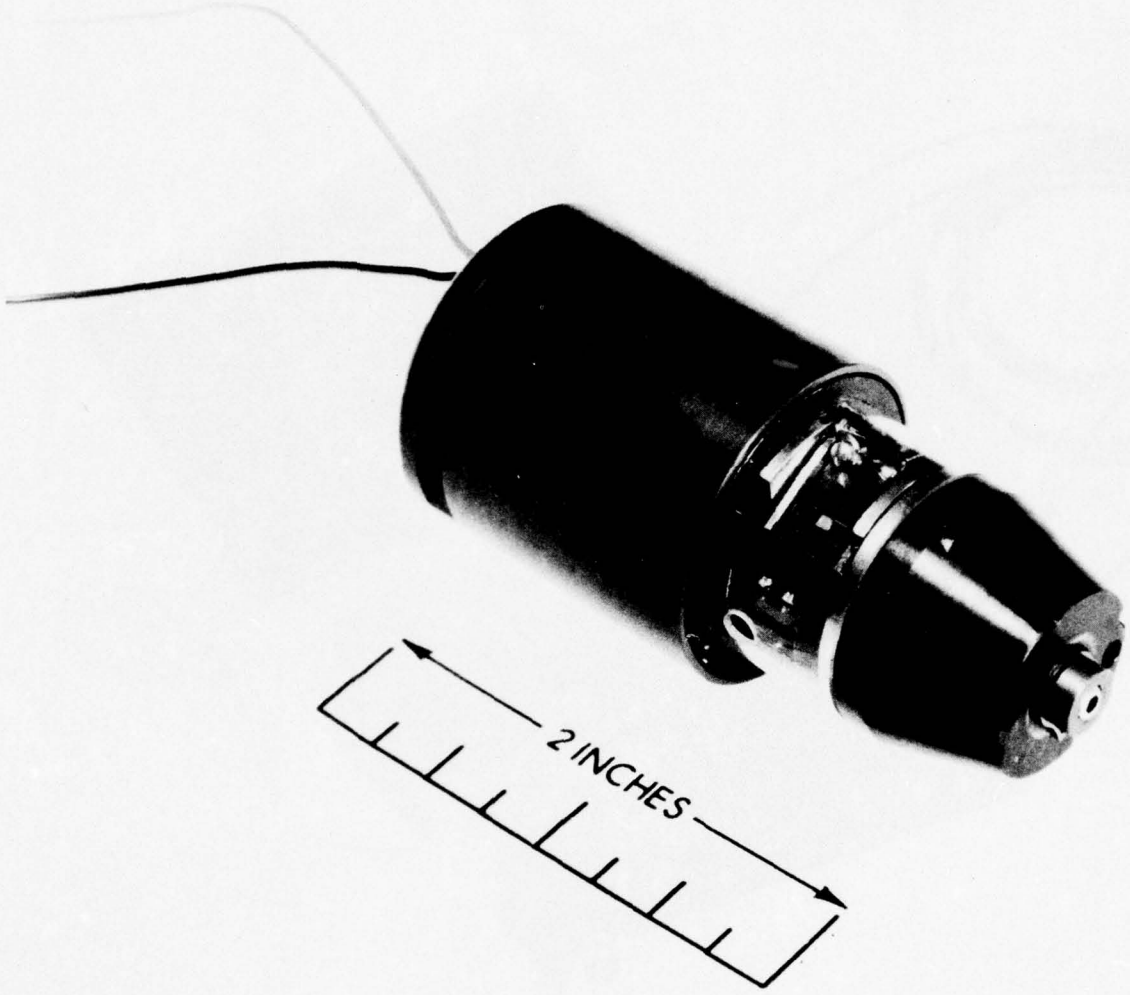


Figure 18 SWITCH DRIVER

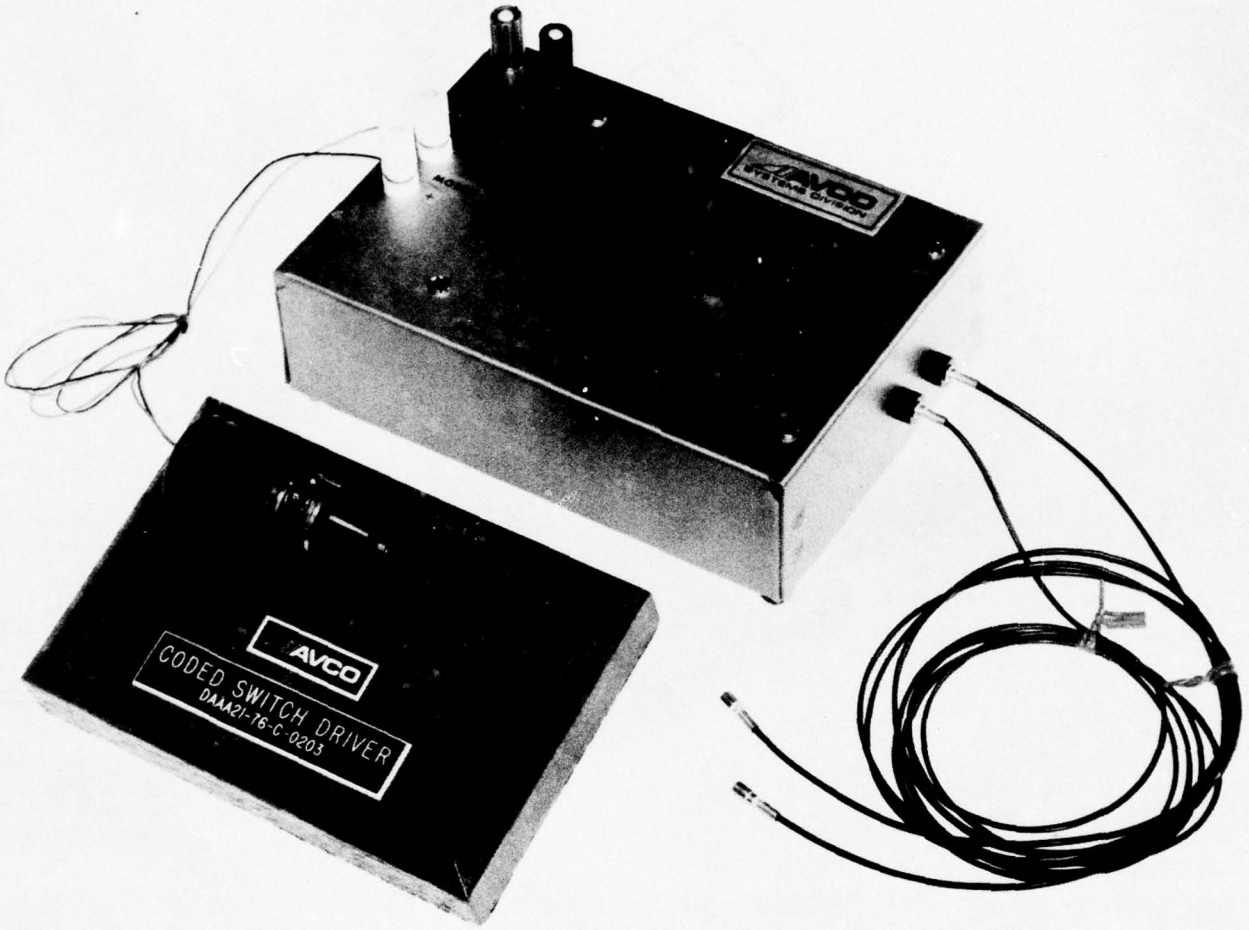


Figure 19 SWITCH DRIVER AND SPECIAL TEST EQUIPMENT

9.0 CODE

As previously mentioned, the code is not constrained and can be any desired binary combination. The code for the first 20 bits of the Switch Driver model was selected using a random number table. Odd numbers were assigned a "1" and even numbers a "0". The drive ratchets were then machined so that a "1" corresponded to a left drive pawl index (clockwise rotation of torquer) and a "0" to a right drive pawl index (counterclockwise rotation of torquer). The complete code is presented in Table V.

TABLE V

SWITCH DRIVER MODEL CODE

Verifying Code		Drive		Reset	
Bit	Code	Bit	Code	Bit	Code
1	1	21	1	29	0
2	0	22	0	30	0
3	1	23	1	31	0
4	1	24	0	32	0
5	1	25	1		
6	0	26	0		
7	1	27	1		
8	0	28	0		
9	0				
10	1				
11	1				
12	0				
13	1				
14	0				
15	0				
16	0				
17	1				
18	1				
19	0				
20	0				

10.0 FUNCTIONAL TEST RESULTS

The driver electronics circuit was breadboarded per the schematic of Figure 9. Initial operation had both phtotransistors operating saturated. Rise time and fall time were greatly in excess of acceptable limits, causing all transistor switches to be "on" simultaneously at the beginning and end of each pulse. Resistors R1, R2, R3, R4, R5, and R6 were changed to keep the phototransistors out of saturation, and the rise and fall times were restored to 10 microseconds or less. The base pull up resistors on Q7 and Q10 were increased to 10K from 300 ohms to reduce power consumption, and Resistors R17 and R18 were added to allow the collector capacitances to discharge when all power switches are in the "off" condition. These modifications resulted in successful performance of the optical and electronics driver modules.

The mechanical driver mechanism was fabricated to the configuration of the Appendix A drawings. The mechanism was manually functioned to check out normal, abort and reset operation modes. After successful operation was achieved, the mechanism was then connected with the optical/electronics driver module. The SD data generator described in Figure 12 was connected to the optical/electronics module with 2 fiber optic bundles with lens terminations. This was used as a source for the optical signals. The following functional tests were then conducted:

TEST RUN 1

The SD was operated in a semi automatic mode using the data generator push buttons. This functioning verified:

1. The device responded to the correct design code.
2. Correct clutch operating sequence.
3. Resettability from normal arm condition.
4. Proper response to incorrect codes (i.e., abort mode).
5. Resettability from abort condition.

TEST RUN 2

The SD was operated in an automatic mode using the data generator with an external variable frequency pulse generator.

Device response to correct design code, correct clutch operating sequence and response to incorrect code was verified at each of the following frequencies:

5 Hz (5.6 seconds total cycle time)

10 Hz (2.3 seconds total cycle time)

30 Hz (0.933) second total cycle time)

60 Hz (0.467 seconds total cycle time)

11.0 CONCLUSION

The Switch Driver, represented by the configuration of Figure 10 and the details delineated in Appendix A, will meet the design requirements of Section 5.0 and contain the design features of Section 6.0 including a 60 Hz response capability.

11.0 CONCLUSION

The Switch Driver, represented by the configuration of Figure 10 and the details delineated in Appendix A, will meet the design requirements of Section 5.0 and contain the design features of Section 6.0 including a 60 Hz response capability.

12.0 RECOMMENDATIONS

The described concept should be further developed to:

- optimize the code mechanism design and definition.
- develop miniaturized optics and electronics.
- optimize torque motor.
- demonstrate performance in the normal and abnormal environments associated with weapon systems stockpile to target sequence.

APPENDIX A

DETAIL DRAWINGS OF THE BREADBOARD MODEL

DFT GROUP LDR		S 5 2 0 DRAWING TRANSMITTAL AND HISTORY SHEET	DATE	SEPT 3,76	SHEET 1 OF 2
JOB NUMBER	T151-F300-003		ENG.	M. WOLF	SECT F310
[redacted]	D287-AA11-A00		REL SCHED DOC		

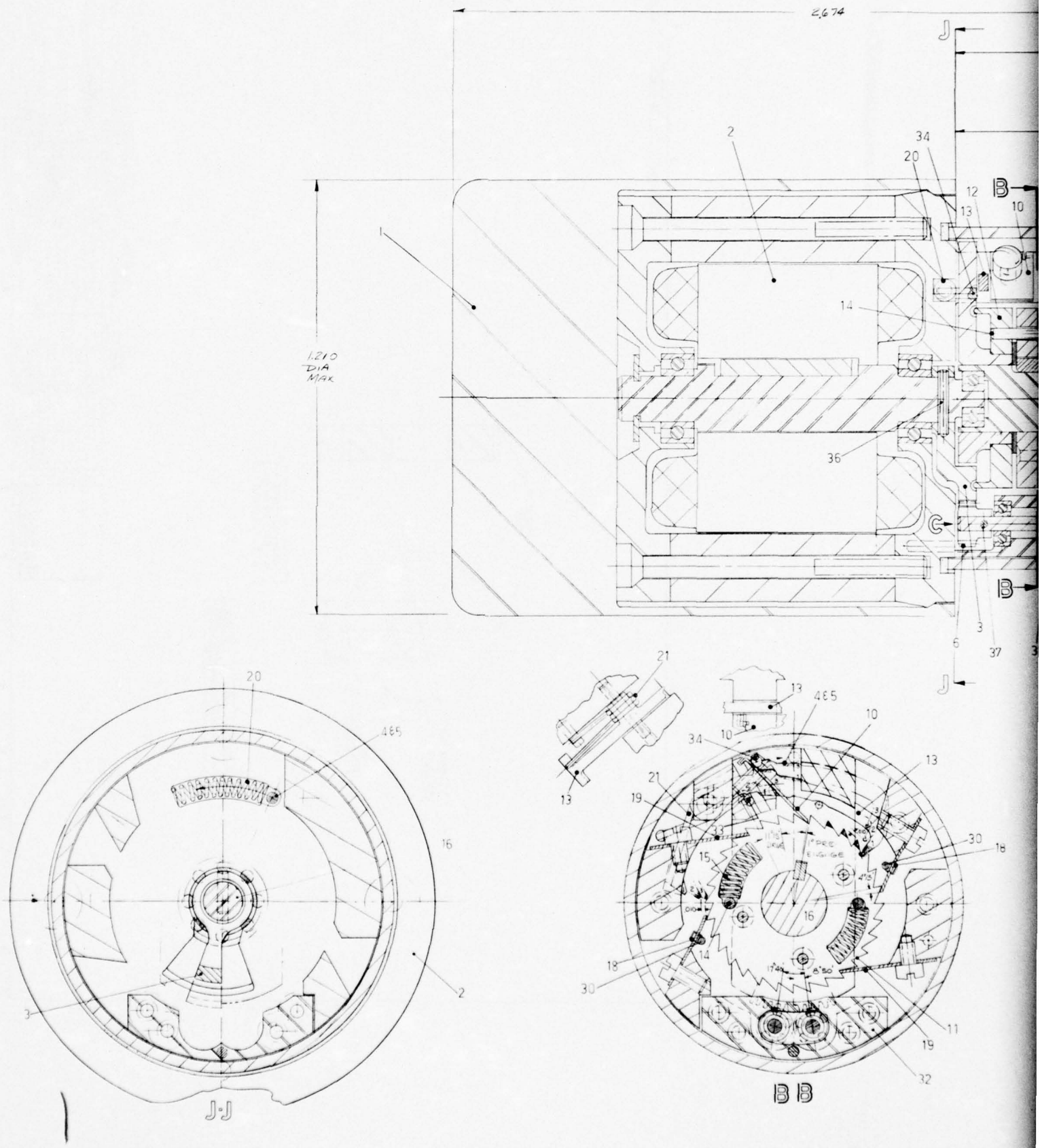
NEXT ASSY NO.	REV	TITLE	PROGRAM USED ON
		SWITCH DRIVER	

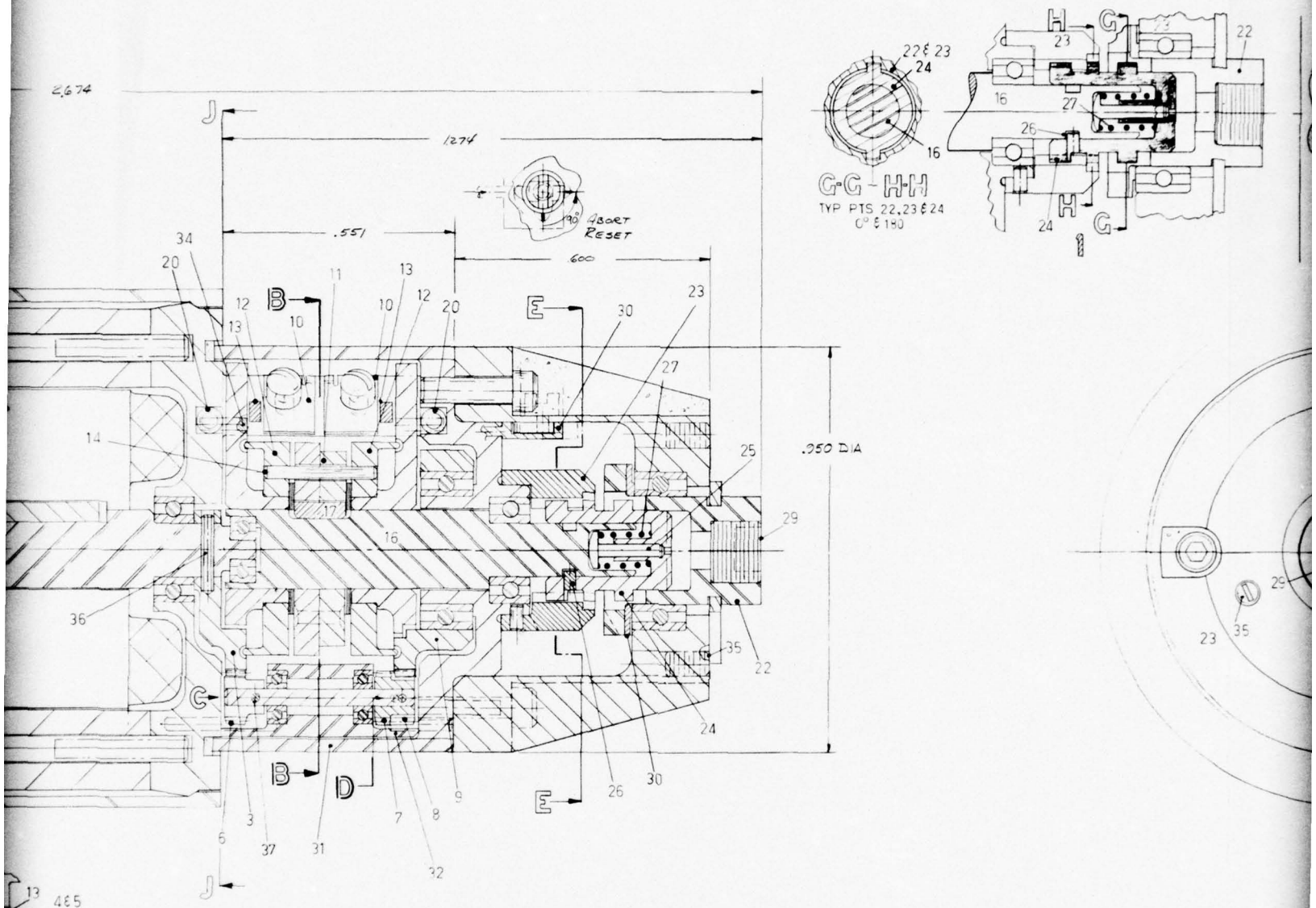
DWG NO.	TITLE	DRWN	CHK	REMARKS AND REF DATA
LA23216	SWITCH DRIVER	✓	✓	
EX23251	RATCHET WHEEL BLK	✓	✓	
EX23252	END PLATE	✓	✓	
EX23253	SHAFT TORQUE MOTOR	✓	✓	
EX23254	THRUST MOTOR SHAFT KEY	✓	✓	
EX23255	DRIVE GEAR	✓	✓	
EX23256	MAIN SHAFT	✓	✓	
EX23257	SPRING THRUST PIN	✓	✓	
EX23258	LOCK ARM	✓	✓	
EX23259	MAIN SHAFT KEY	✓	✓	
EX23260	BASE SUPPORT	✓	✓	
EX23261	PAWL NO 1	✓	✓	
EX23262	PAWL NO 2	✓	✓	
EX23263	INNER COVER	✓	✓	
EX23264	LOCK RING	✓	✓	
EX23265	CLUTCH	✓	✓	
EX23266	OUTPUT SHAFT	✓	✓	
EX23267	COVER	✓	✓	
EX23268	DRIVE RATCHET	✓	✓	
EX23269	MOTOR COVER	✓	✓	
EX23270	SLEEVE WASHER	✓	✓	
EX23271	GEAR	✓	✓	
EX23272	DRIVE PAWL	✓	✓	
EX23273	FULL PAWL	✓	✓	
EX23274	HALF PAWL	✓	✓	

DFT GROUP LDR		S 5 2 0	DATE	SEPT 3, 7[illegible]	SHEET 2 OF 2
JOB NUMBER	T151-F300-003	DRAWING TRANSMITTAL AND	ENG.	M WOLF	SECT E310
[redacted]	D287-AA11-A00	HISTORY SHEET	REL SCHED DOC		

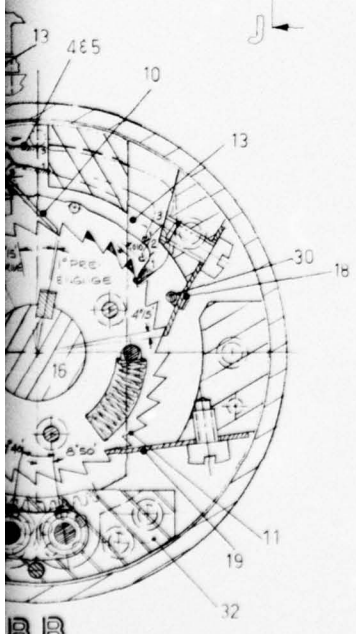
NEXT ASSY NO.	REV	TITLE	PROGRAM USED ON
		SWITCH DRIVER	

DWG NO.	TITLE	DRWN	CHK	REMARKS AND REF DATA
EX-23275	PINNION ASSEMBLY	✓	✓	
EX-23276	PINNION	✓	✓	
EX-23277	CAGE ASSEMBLY	✓	✓	
EX-23278	PINNION	✓	✓	
EX-23279	BLOCK BEARING	✓	✓	
EX-23280	SECTOR GEAR	✓	✓	
EX-23281	THRUST WASHER	NOT REQ'D		
EX-23282	WINDOW	✓	✓	
EX-23283	GASKET	NOT REQ'D		
EX23284	RATCHET ASSY.	✓	✓	
EX23285	LOCK RATCHET	✓	✓	
EX23286	RESET PLUG	✓	✓	
EX23287	TORSION SPRING	✓	✓	

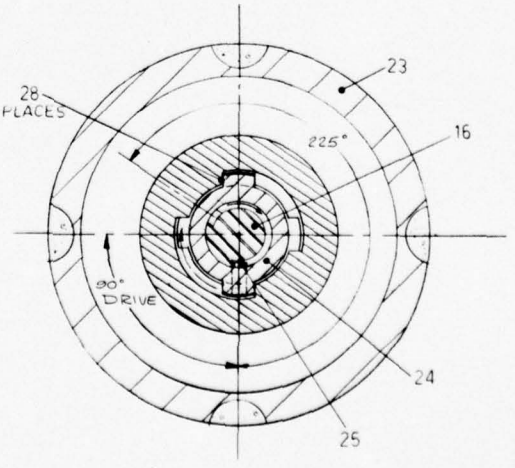

2.674
1.210 DIA MAX
J
B
C
2
34
20
12
13
10
14
36
3
6
37
21
4.65
16
18
30
19
11
32
J-J
B B


2.674
1.274
.551
.600
ABORT
RESET
.050 DIA

22 & 23
24
16
G-G - H-H
TYP PTS 22,23 & 24
0° & 180
H
G
23
22
16
27
26
24


13
4 & 5
10
13
30
18
16
11
19
32

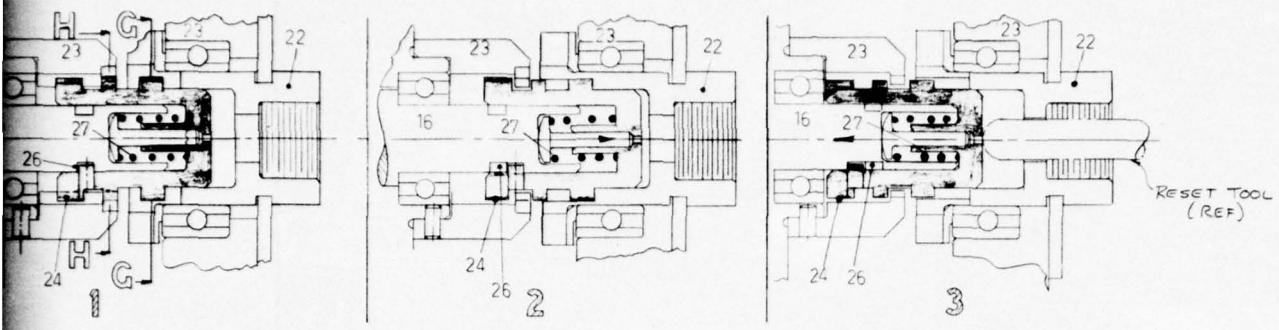
B B

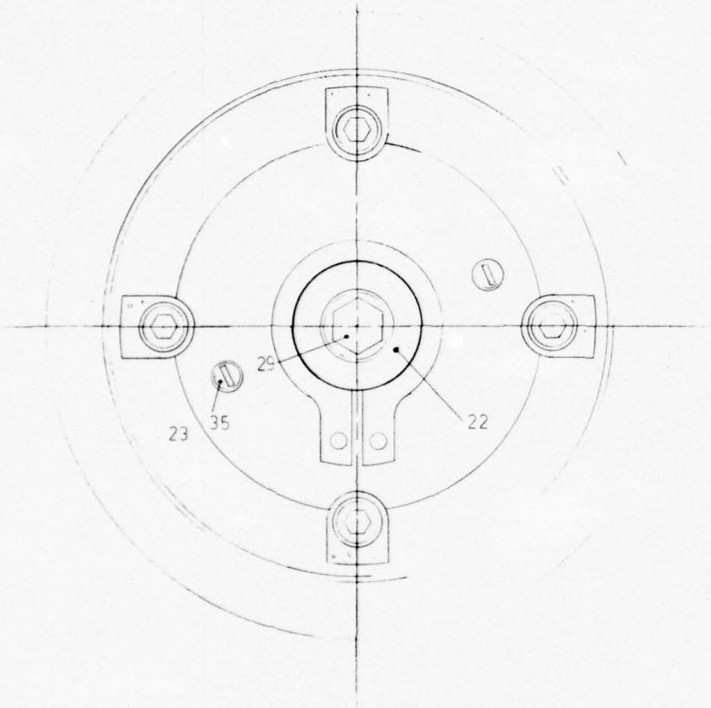

28
TYP 4 PLACES
23
225°
16
90°
DRIVE
24
25

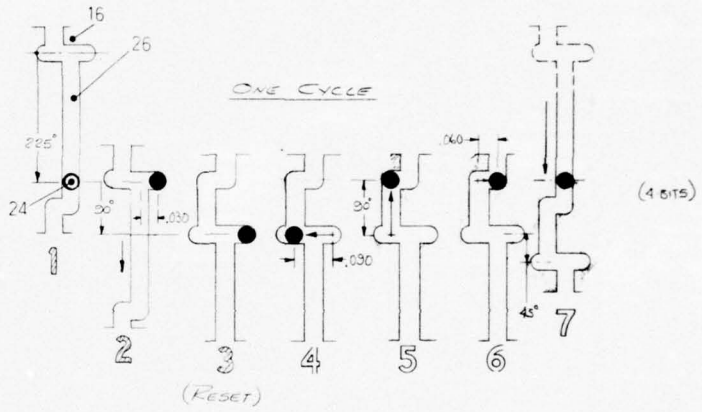
E E

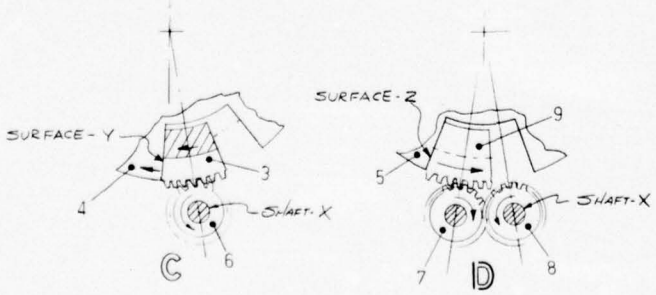
29
23
35

2









1.	OPTICAL/ELECTRONICS MODULE
2.	TORQUER
3.	DRIVE GEAR
4.	DRIVE PAWL #1
5.	DRIVE PAWL #2
6.	PINION
7.	PINION
8.	PINION
9.	DRIVE RING
10.	DRIVE PAWLS
11.	DRIVE RATCHET
12.	LOCK RATCHETS
13.	LOCK ARMS
14.	TRANSFER PINS
15.	SPRING
16.	MAIN SHAFT
17.	KEY
18.	LOCKING PAWLS
19.	LOCKING PAWLS
20.	RETURN SPRING
21.	TORSION SPRING
22.	OUTPUT SHAFT
23.	STRUCTURE
24.	CLUTCH
25.	GUIDE PIN
26.	CAM TRACK
27.	CLUTCH SPRING
28.	STOP
29.	RESET PLUG
30.	THRUST WASHER
31.	WINDOW
32.	BEARING BLOCK
33.	CAMMING PIN
34.	LIMIT PIN
35.	RESET/ACCESS SCREW
36.	DRIVE GEAR PIN
37.	PINION PIN

QTY REQD | CODE IDENT | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MATERIAL OR NOTE | SPECIFICATION | ZONE | ITEM NO.

ASSY NO.

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X = 06 XX = 04 XXX = 020
MACHINED ANGLES = 0° 30'
SHEET METAL BEND ANGLES = 2°
P1000
SURFACE ROUGHNESS ✓

CONTR NO.
RELEASE
DWG APPL
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

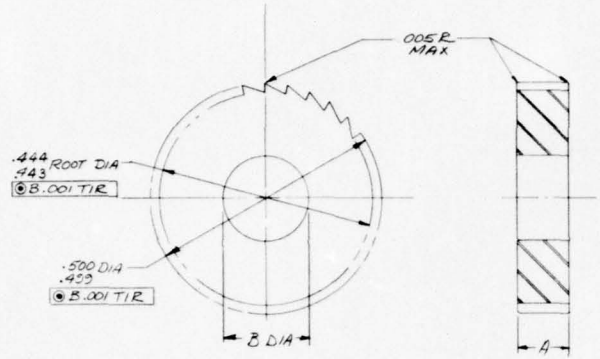
TITLE: SWITCH DRIVER

SIZE: D | CODE IDENT NO.: 04614 | DWG NO.: LA-23216

SCALE: 1/1 | WT | SHEET

PART CLASS
DWG CLASS
ASG BY

DASH NO. | NEXT ASSY | USED ON (APPLICATION) | QTY PER NHA | END ITEM NUMBER | SERIAL NO. (EFFECTIVITY)



RATCHET DATA
NO. OF TEETH 32
11°15' PER TOOTH

DASH NO	A	B DIA
-1	.060-.062	.1874-.1880
-3	.110-.112	.2499-.2505

REVISIONS

ENGR CHG	ZONE	LTR	DESCRIPTION	DATE	APPROVED

LIST OF PARTS

QTY REQ	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
		SEE TABULATION		H11355 S.S.			

DASH NO	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO. EFFECTIVITY
-3	EX23253	SD	1		
-1	EX23253	SD	2		

APPLICATION

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER DOD
X = ± .06 XX = ± .04 XXX = ± .005
MACHINED ANGLES = 0° 30'
SHEET METAL BEND ANGLES = 1°
FINISH: ____
SURFACE ROUGHNESS 125

CONTR NO. RELEASE
DWG APPV
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT OR DESIGNER

AVCO
SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS

TITLE: RATCHET WHEEL BLANK

SIZE D | CODE IDENT NO. 04614 | DWG NO. EX-23251

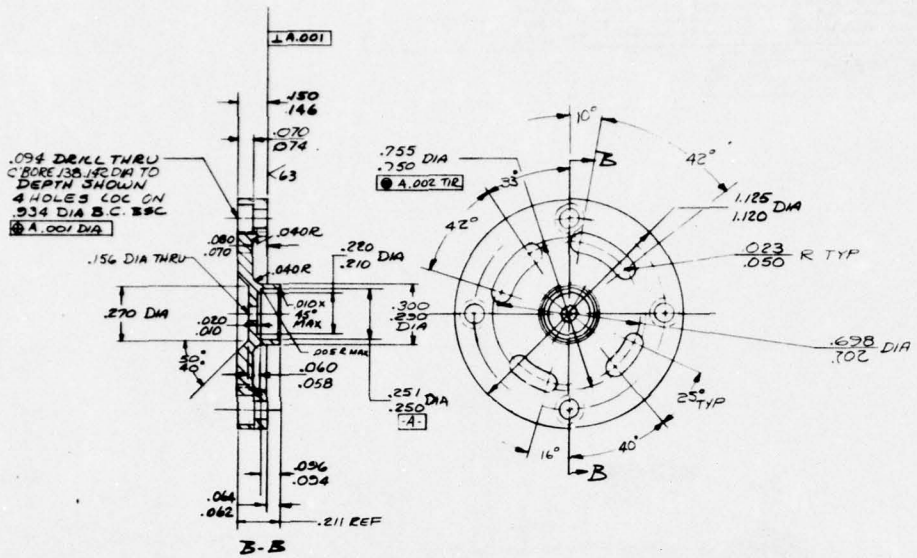
SCALE 10/1 WT SHEET

PART CLASS ENGINEERING
DWG CLASS ENGINEERING
ADD BY [illegible] DATE [illegible]

DO NOT SCALE DRAWING

EX-23251

NOTE
ANODIZE



ZONE	LTR	DESCRIPTION	DATE	APPROVED
		REVISIONS		

LIST OF PARTS

QTY REQD	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	DRWG NO.	ITEM NO.
		-1		AL 6061-T6			

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER DOD-D-1000
X ± .XX .XX ± .XX .XXX ± .XXX
MACHINED ANGLES ± 1°
SHEET METAL BEND ANGLES ± 1°
FINISH
SURFACE ROUGHNESS ✓

CODE IDENT NO.	RELEASE
DRWG APPD	
CHECKED	
ENGR APPD	
DRAWN	
DEPT CH	

AMCO SYSTEMS DIVISION

TITLE: END PLATE

SIZE	CODE IDENT NO.	DRWG NO.
B	04614	EX-23252

SCALE 4/1 WT SHEET

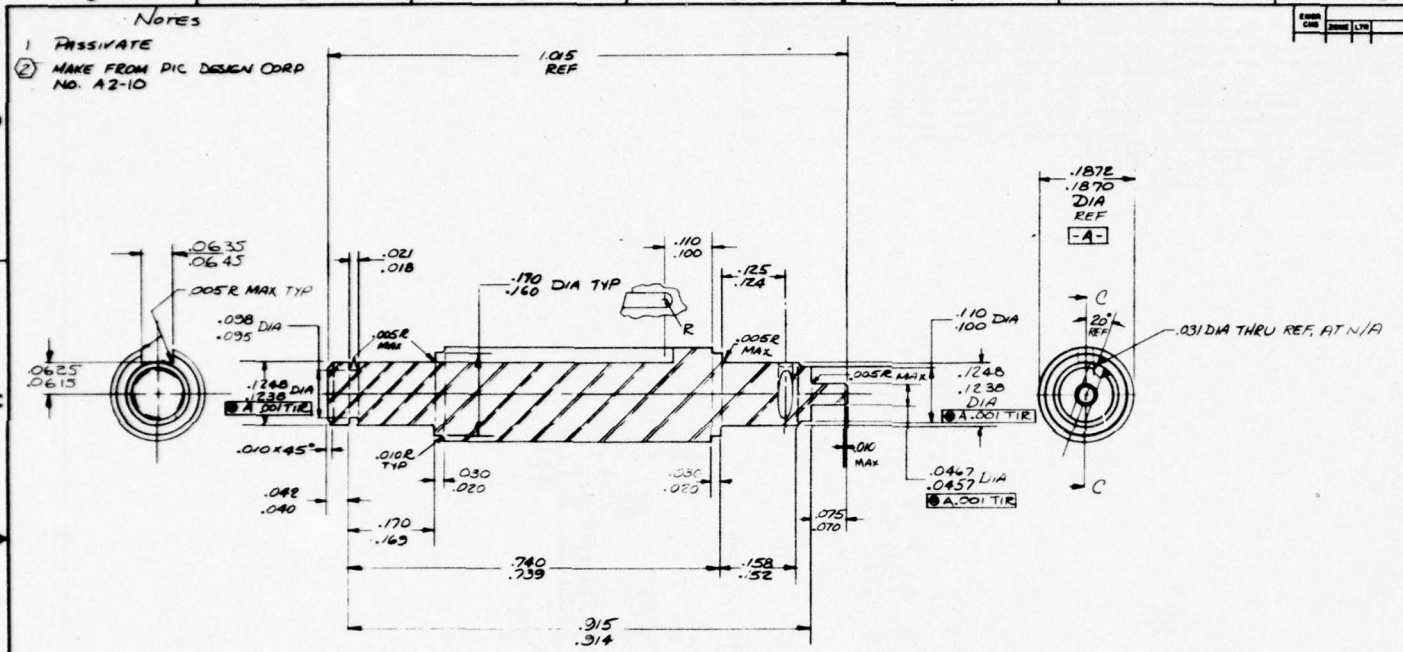
CODE IDENT NO.	DRAWN	CHECKED	ENGR APPD	DEPT CH	APPLICATION	USED ON	NEXT ASSY	EFFECTIVITY	SERIAL NO.
	4/8/76	SD							

EX-23252 B

A-7

Notes

1. PASSIVATE
2. MAKE FROM PIC DESIGN ODRP NO. A2-10



A-8

EX-23253

QTY REQD	CODE IDENT	PART OR IDENTYFING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO
	ASSY NO	-1		CRES 303 (2)	MIL-S-7720		

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .03 .XX ± .01 .XXX ± .005
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P1800
SURFACE ROUGHNESS ✓

CONTR NO
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AMCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS

TITLE: SHAFT, TORQUE MOTOR

SIZE	CODE IDENT NO	DWG NO
D	04614	EX-23253

SCALE 10/1 WT SHEET

PART CLASS	UNCLASSIFIED
DWG CLASS	UNCLASSIFIED
ASG BY	Johnny S. Ref

DASH NO	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO
-1	AA23316	-10	1		

APPLICATION — EFFECTIVITY

DO NOT SCALE DRAWING

NOTES

PASSIVATE



REVISIONS					
ENGR CHG	ZONE	LTR	DESCRIPTION	DATE	APPROVED

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
	ASSY NO.	-1		303 CRES			

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001 _____
SURFACE ROUGHNESS ✓

CONTR NO
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: TORQUE MOTOR SHAFT KEY

SIZE	CODE IDENT NO	DWG NO.
C	04614	EX-23254

SCALE 20/1 WT SHEET

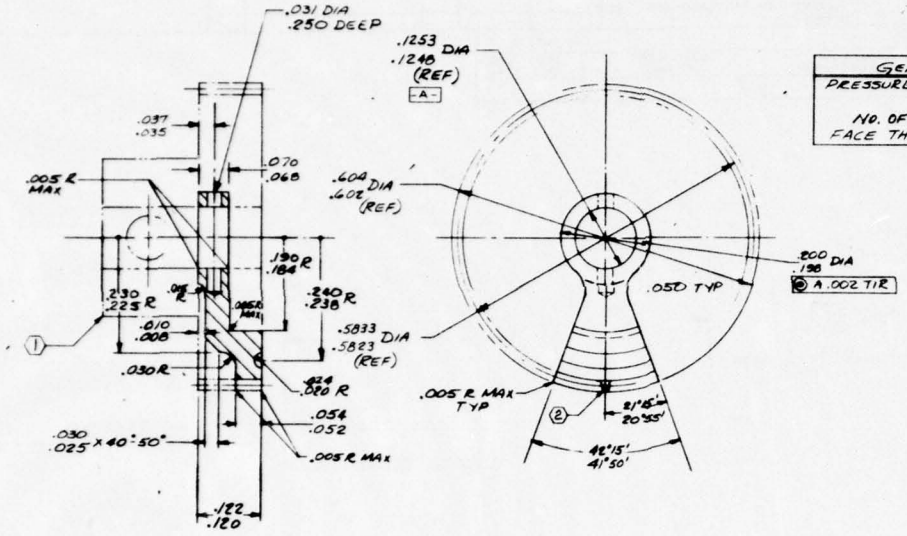
DO NOT SCALE DRAWING

PART CLASS: UNCLASSIFIED						
DWG CLASS: UNCLASSIFIED						
ABS BY: [illegible]						
BASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.	
-1	LA23216	SD	1			
APPLICATION				EFFECTIVITY		

The Drafboard Inc

EX-23254

A-9



GEAR DATA (REF)	
PRESSURE ANGLE	20°
PITCH	36
NO. OF TEETH	56
FACE THICKNESS	.187

(3) PASSIVATE
(2) LOCATE CENTERLINE THRU CENTER OF TOOTH
(1) MAKE FROM NORDEX CO. NO. LAS-J5-56 Q14 OR EQUIVALENT

NOTE

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ITEM NO.
		-1		(1) CRES 303	QQ-S-764	

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 1°
FINISH
SURFACE ROUGHNESS

AVCO SYSTEMS DIVISION

TITLE: DRIVE GEAR

SIZE D | CODE IDENT NO. 04614 | DWG NO. EX-23255

SCALE 10/1 | WT | SHEET

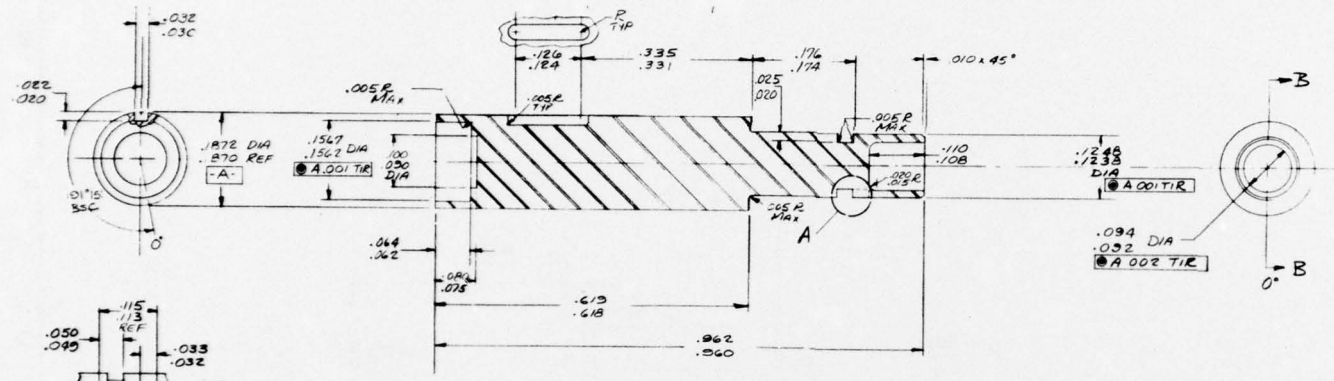
NEXT ASSY | USED ON | APPLICATION | EFF ITEM NUMBER | SERIAL NO. | EFFECTIVITY

EX-23255

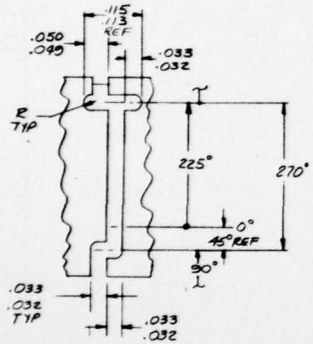
NOTES
1. PASSIVATE
2) MILL FROM BILLET CA-
110 AZ 11

REVISIONS

ENGR CHG	ZONE	LTR	DESCRIPTION	DATE	APPROVED



SECTION B-B



VIEW A
PLAN VIEW

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
1		EX-23256	MAIN SHAFT	CRES 303 (E)			

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .03 XX ± .01 XXX ± .005
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
PI 0001
SURFACE ROUGHNESS ✓

CONTR NO
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE MAIN SHAFT

SIZE D | CODE IDENT NO 04614 | DWG NO EX-23256

SCALE 10/1 | WT | SHEET

DO NOT SCALE DRAWING

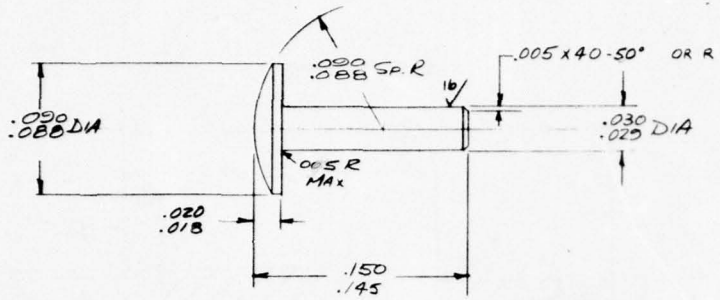
DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
-1	EA 23216	30	1	EFFECTIVITY	

APPLICATION

PART CLASS HARDWARE GEO
DWG CLASS HARDWARE GEO
APD BY Richard T. Bell Date

EX-23256

ENGR CHG	REVISIONS ZONE	LTR	DESCRIPTION	DATE	APPROVED



QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
	ASSY NO.	-1		BRASS ½ HARD			

LIST OF PARTS

PART CLASS: UNCLASSIFIED	DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
DWG CLASS: UNCLASSIFIED	-1	LA23216	SD	1		
ASG BY:	APPLICATION				EFFECTIVITY	

-UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
.X ± .08 .XX ± .04 .XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001 _____
SURFACE ROUGHNESS ✓

CONTR NO.	
RELEASE	
DWG APPD	
CHECKED	8/31/76
DRAWN	8-23-76
DESIGN APPROVAL	
MANAGER	
SECT CH	
DESIGNER	

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: SPRING THRUST PIN

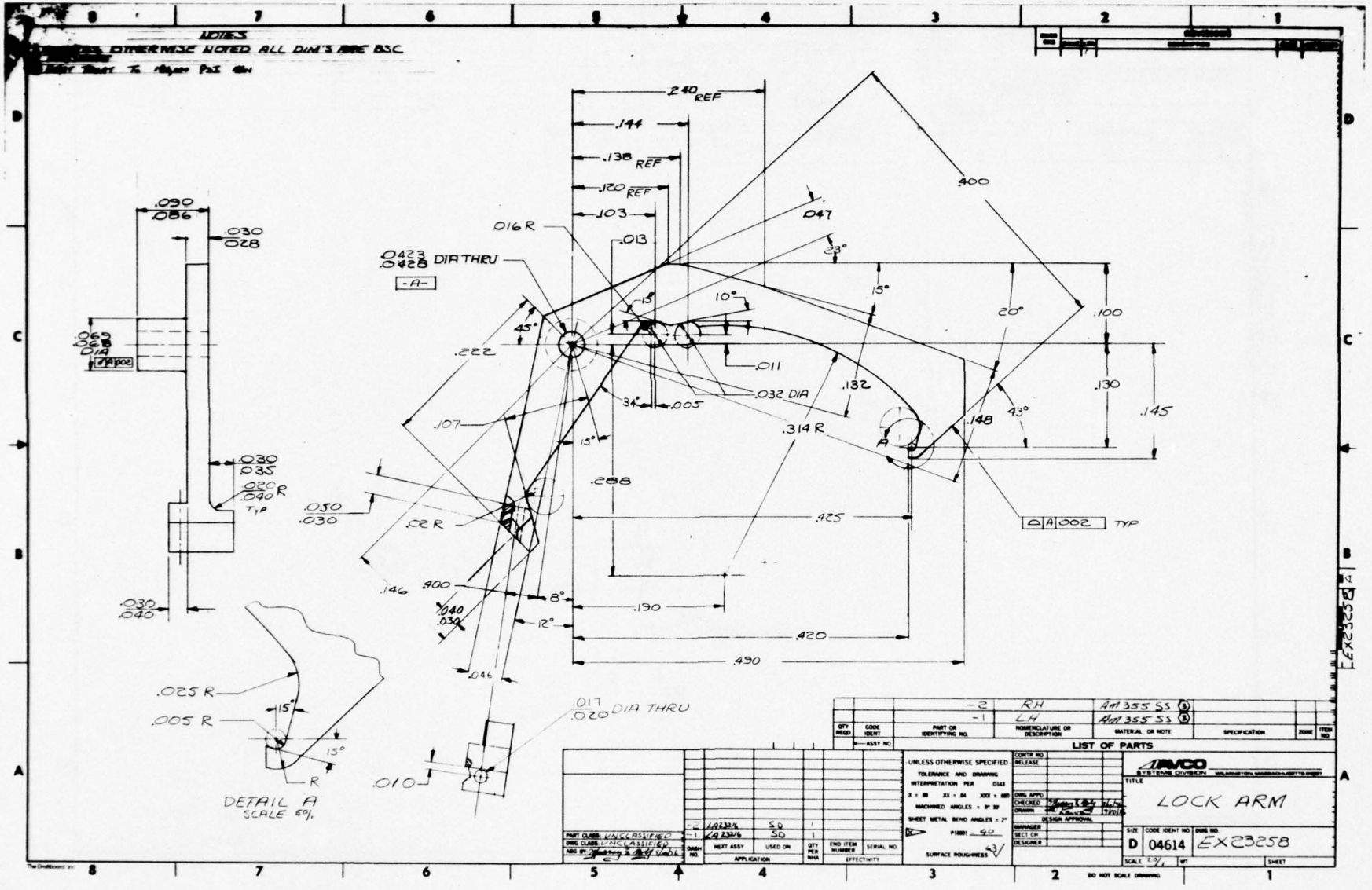
SIZE	CODE IDENT NO.	DWG NO.
C	04614	EX-23257

SCALE 20/1 WT SHEET

DRAWING NUMBER EX-23257 REV

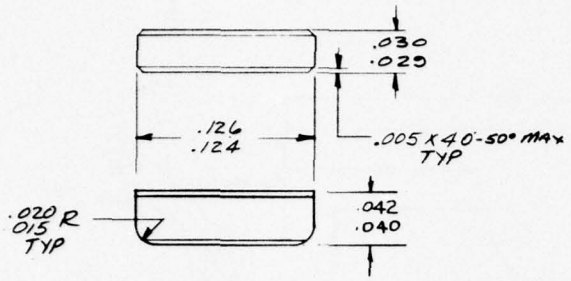
DO NOT SCALE DRAWING

The Drafthoard, Inc.


NOTES
UNLESS OTHERWISE NOTED ALL DIM'S ARE BSC
2.40 REF
.144
.138 REF
.120 REF
.103
.400
.047
.016 R
.013
.0423
.0428 DIA THRU
-A-
33°
15°
10°
20°
.100
45°
.222
.011
.032 DIA
.132
.130
.145
34°
.005
43°
.148
.107
.314 R
.288
.425
.050
.030
.02 R
.146
.400
.040
.030
8°
12°
.190
.420
.490
.046
.030
.086
.030
.028
.030
.035
.020 R
.040
TYP
.030
.040
.025 R
.005 R
15°
15°
R
DETAIL A
SCALE 6/1
.017
.020 DIA THRU
.010
A002 TYP
EX23258
-2 RH Am 355 SS
-1 LH Am 355 SS
LIST OF PARTS
UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
SURFACE ROUGHNESS
AVCO SYSTEMS DIVISION
TITLE
LOCK ARM
SIZE D
CODE IDENT NO 04614
DWG NO EX23258
SCALE 6/1
SHEET
DO NOT SCALE DRAWING
PART CLASS UNCLASSIFIED
DWG CLASS UNCLASSIFIED
-1 LA2324 50 50 1
APPLICATION
DESIGN APPROVAL

NOTES

PASSIVATE



ENGR CHG	REVISIONS				
	ZONE	LTR	DESCRIPTION	DATE	APPROVED

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
	ASSY NO.	-1		303 CRES			

LIST OF PARTS

PART CLASS: UNCLASSIFIED	DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
DWG CLASS: UNCLASSIFIED	-1	LA23216	SD	1		
ARG BY:	APPLICATION				EFFECTIVITY	

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001 _____
SURFACE ROUGHNESS ✓

CONTR NO.	
RELEASE	
DWG APPD	
CHECKED	
DRAWN	
DESIGN APPROVAL	
MANAGER	
SECT CH	
DESIGNER	

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: MAIN SHAFT KEY

SIZE	CODE IDENT NO.	DWG NO.
C	04614	EX-23259

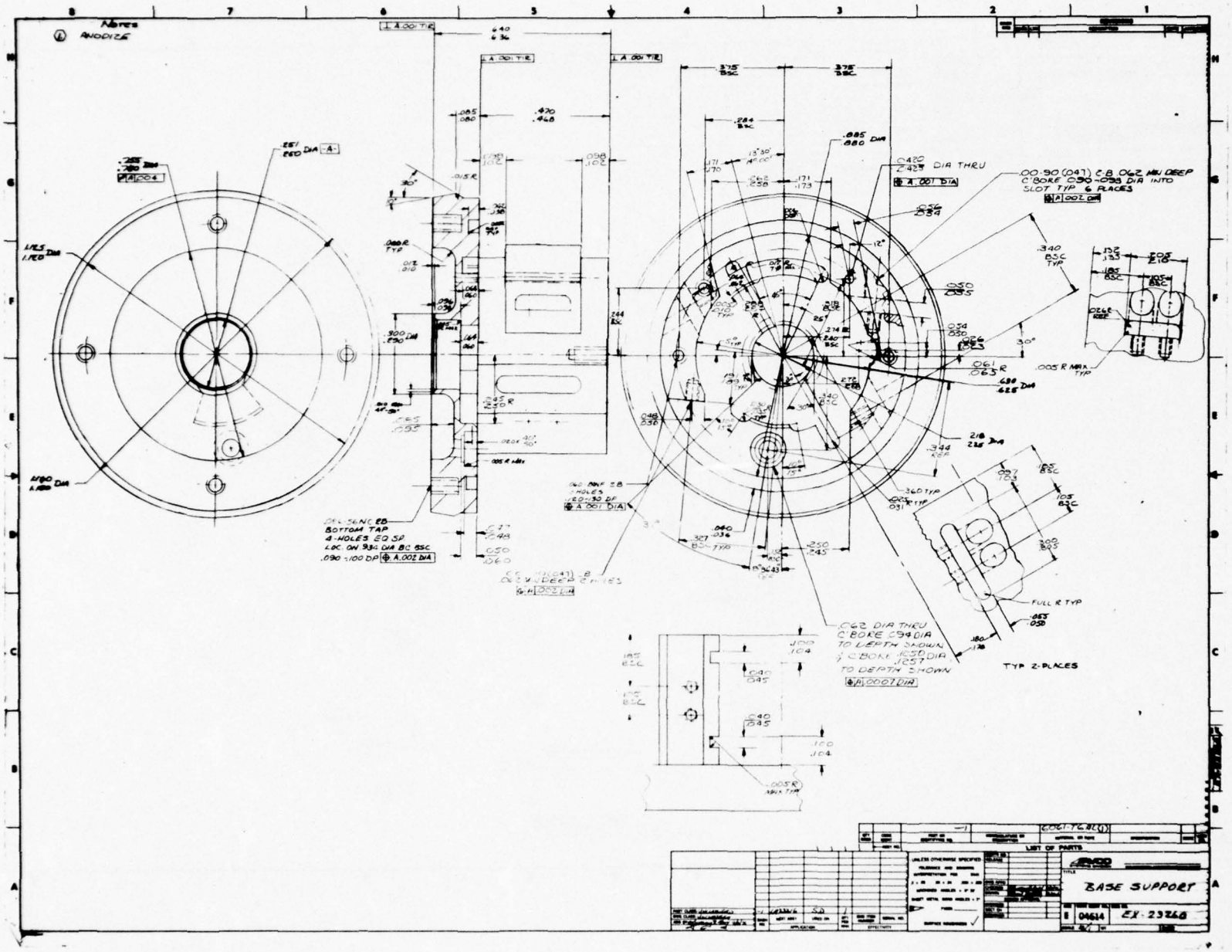
SCALE 20/1 WT SHEET

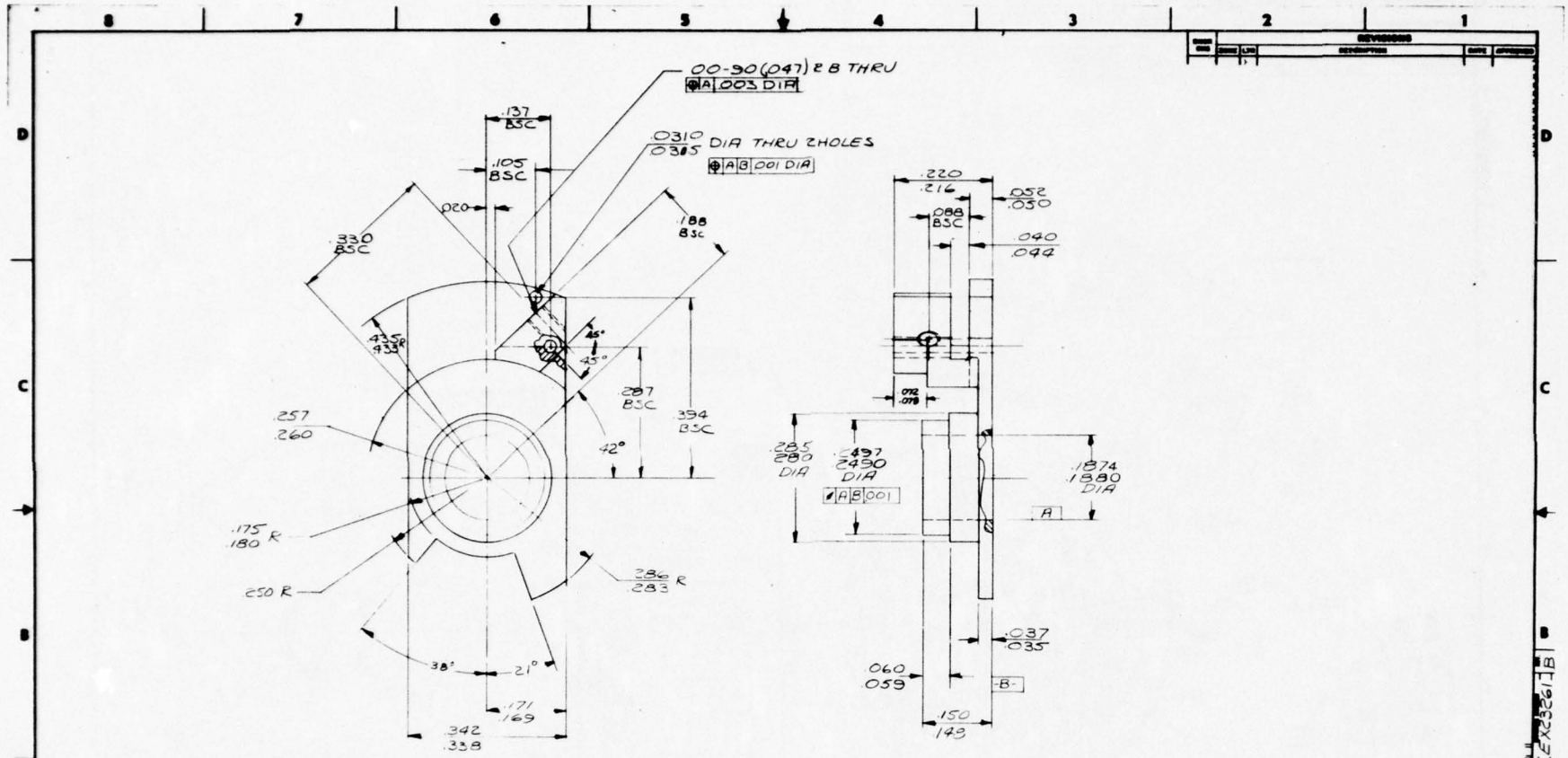
DO NOT SCALE DRAWING

The Drafthoard Inc

EX-23259 REV

A-14


NOTES
4. ANODIZE
BASE SUPPORT
B
04614
EX-23268
LIST OF PARTS
TYP 2-PLACES
FULL R TYP



QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
	ASSY NO	-1		BRASS ½ HARD			

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .03 XX ± .01 XXX ± .005
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P1000 -40
SURFACE ROUGHNESS 63

CONTR NO
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: PAWL NO 1

SIZE D | CODE IDENT NO 04614 | DWG NO EX23261

SCALE 10/1 | WT | SHEET

DO NOT SCALE DRAWING

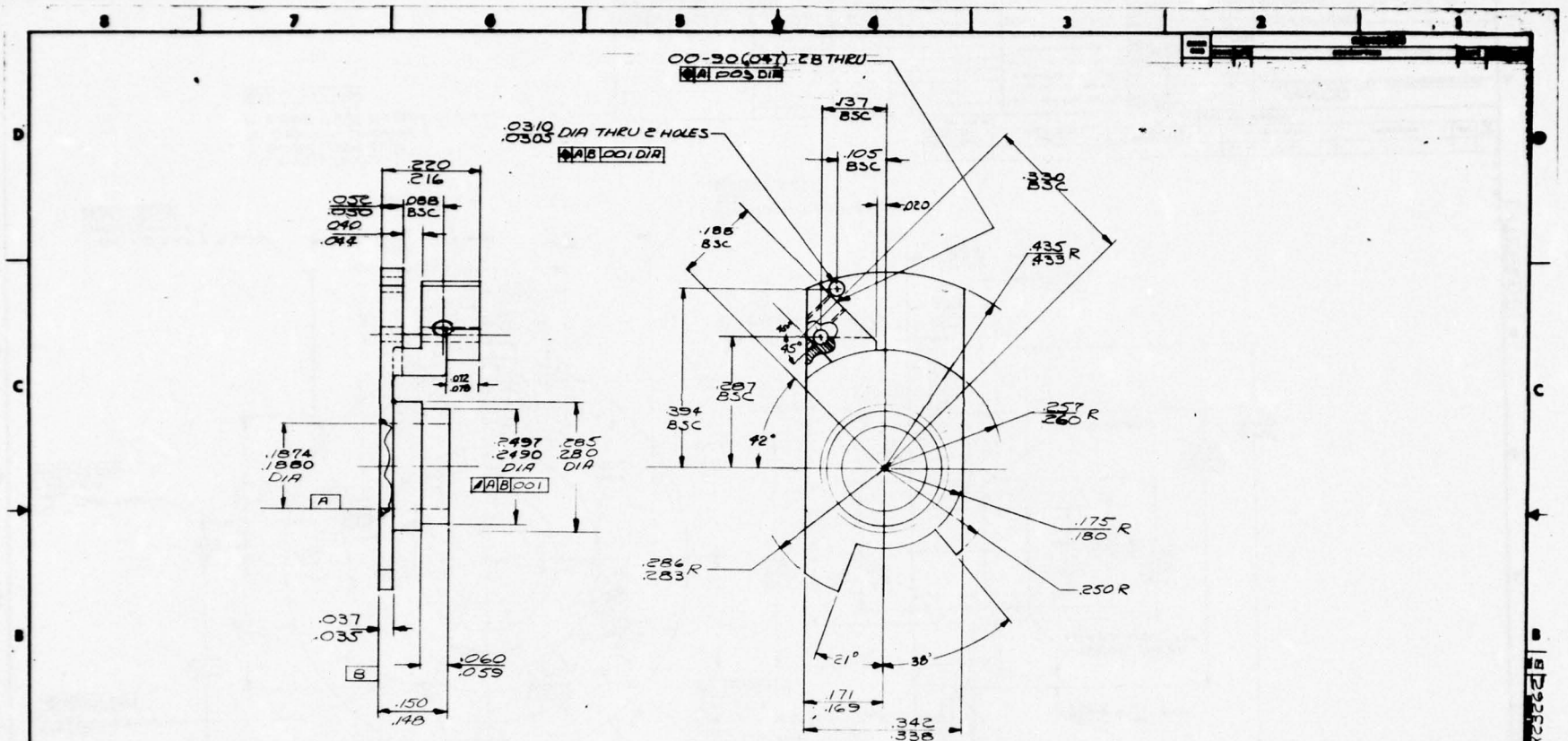
PART CLASS UNCLASSIFIED
DWG CLASS UNCLASSIFIED
ADD BY [illegible]

DASH NO.	NEXT ASSY	USED ON	QTY PER ASSY	END ITEM NUMBER	SERIAL NO.
-1	4732/6	SD	1		

APPLICATION EFFECTIVITY

EX23261 B1

A-16



QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO
ASSY NO.		-1		BRASS ½ HARD			

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X = .05 XX = .01 XXX = .005
MACHINED ANGLES = 0° 30'
SHEET METAL BEND ANGLES = 2°
FINISH — 40
SURFACE ROUGHNESS 63

CONTR NO
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE PAWL, NO 2

SIZE D | CODE IDENT NO 04614 | DWG NO EX23262

SCALE 10/1 | WT | SHEET

PART CLASS	DWG CLASS	DASH NO	NEXT ASSY	USED ON	QTY PER ASSY	END ITEM NUMBER	SERIAL NO.
UNCLASSIFIED	UNCLASSIFIED	-1	AA 33216	SD	1	EFFECTIVITY	

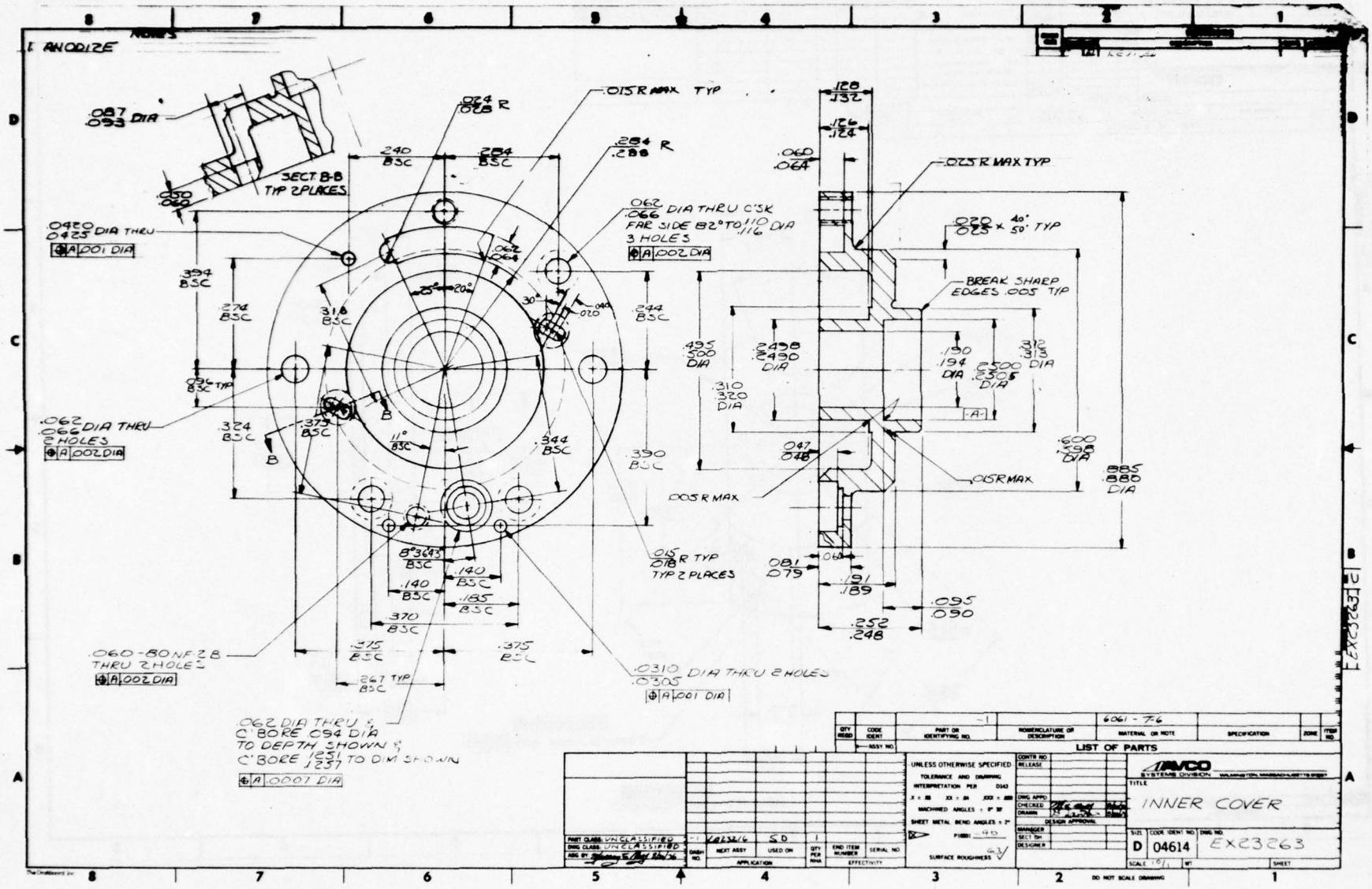
APPLICATION

ADD BY

DO NOT SCALE DRAWING

EX23262

A-17



QTY REQD	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
		-1		6061 - T6			

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
FINISH 90
SURFACE ROUGHNESS

AVCO SYSTEMS DIVISION

TITLE: INNER COVER

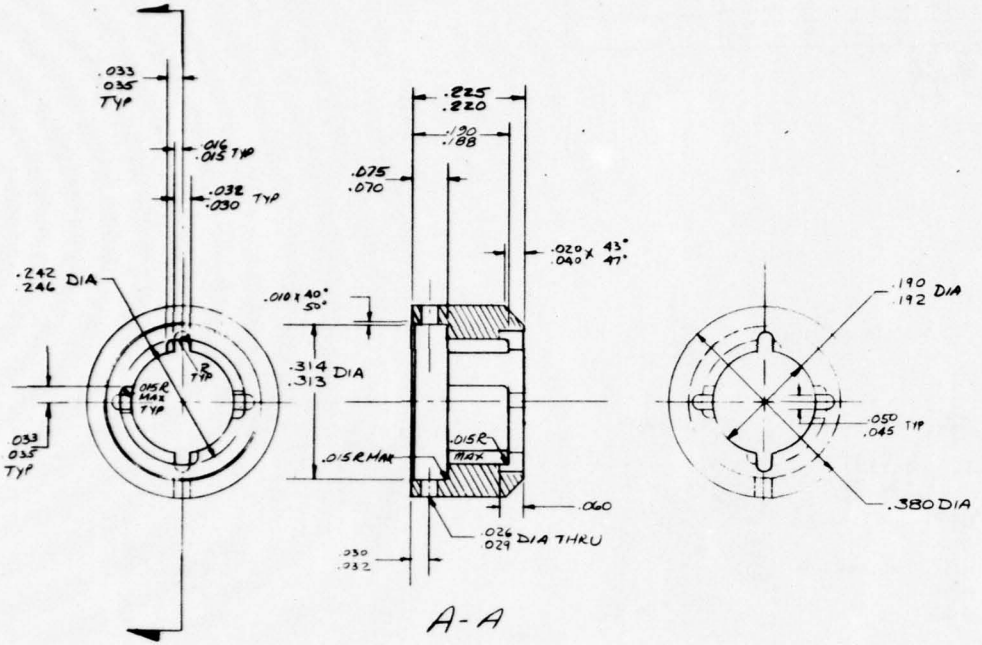
SIZE D | CODE IDENT NO. 04614 | DWG NO. EX23263

SCALE 1/1 | WT | SHEET

PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
DASH NO. -1
NEXT ASSY: VA1324
USED ON: SD
QTY PER ASSY: 1
END ITEM NUMBER
SERIAL NO. EFFECTIVITY

DO NOT SCALE DRAWING

NOTE
ANODIZE HARDLUBE



A-A

REVISIONS					
ENGR CHG	ZONE	LTR	DESCRIPTION	DATE	APPROVED

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
	ASSY NO	-1		AL 6061-T6			

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X = ±.03 XX = ±.04 XXX = ±.015
MACHINED ANGLES = 0° 30'
SHEET METAL BEND ANGLES = 2°
P1000
SURFACE ROUGHNESS ✓

CONTR NO
RELEASE
ENG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AMCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: LOCK RING

SIZE D | CODE IDENT NO 04614 | DWG NO EX-23264

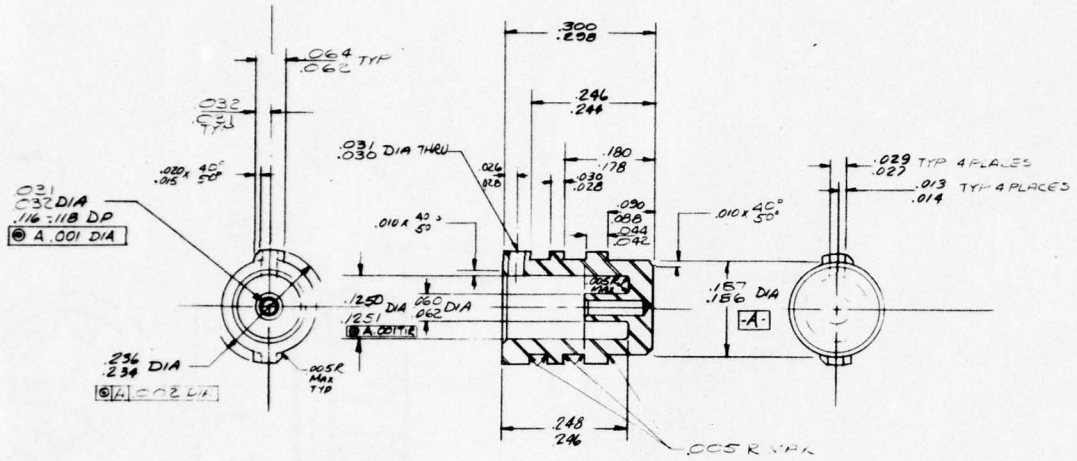
SCALE 10/1 | WT | SHEET

DO NOT SCALE DRAWING

PART CLASS	DASH NO	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
DWG CLASS	-1	EX-23264	SD	1	EFFECTIVITY	
ADD BY	APPLICATION					

NOTES
ANODIZE

ECOR CHG	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED



QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO
	ASSY NO	-1		Al 6061-T6			

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .01 .XX ± .04 .XXX ± .010
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P1001
SURFACE ROUGHNESS ✓

CONTR NO
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: CLUTCH

SIZE D | CODE IDENT NO 04614 | DWG NO EX-23265

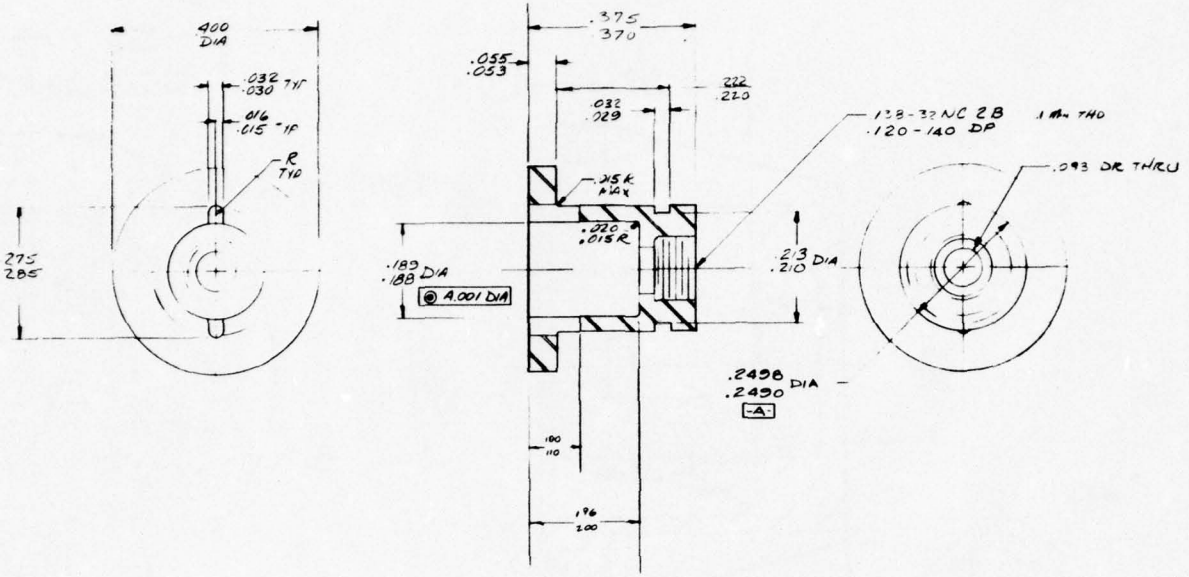
SCALE 10/1 | WT | SHEET

DO NOT SCALE DRAWING

PART CLASS	DASH NO	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO
INCLASS SAW	-1	EX-23276		1		
DWG CLASS UNCLASSIFIED		APPLICATION			EFFECTIVITY	
AGG BY						

EX-23265

NOTES
ANODIZE HARD COAT



QTY REQD	CODE IDENT ASSY NO	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO
1		-1		AL 6061-T6			

LIST OF PARTS

ENGR CHG	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D1610
X ± .01 XX ± .01 XXX ± .005
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
FINISH ____
SURFACE ROUGHNESS ✓

CONTR NO
RELEASE
ENG APPD
CHECKED
DRAWN
DESIGNS APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION

TITLE: OUTPUT SHAFT

SIZE	CODE IDENT NO	DWG NO
D	04614	EX-23266

SCALE 10/1 WT SHEET

PART CLASS	DWG CLASS	DASH NO	NEXT ASSY	USED ON	QTY PER ASSY	END ITEM NUMBER	SERIAL NO EFFECTIVITY
MACHINING & ANODIZE	MACHINING & ANODIZE	-1	EX 23216	SD	1		

APPLICATION

DO NOT SCALE DRAWING

The Drafting Room Inc

NOTES

1. ANGULARITY

.062 / .066 DIA THRU 4 HOLES
⊕ A.002 DIA

⊥ A.001 TIR

.950 / .940 DIA

.245 / .240 TYP

.324 BSC

.060 / .030 TYP

.032 / .030 TYP

.120 / .115 TYP

R TYP

.375 BSC

.603 / .601 DIA

.060 DIA TO DEPTH .070 SHOWN TYP

.255 BSC TYP

.375 BSC

.375 BSC

.600 / .598

.135 / .130

.3758 / .3750 DIA
-A-

.110 / .105

R TYP

15°

.010 x 40° / 50°

.050R

.XXR MAX

.300 / .290 DIA

.126 / .125

.015 / .085 x 40° / 50°

.420 / .418

.050 / .060

SECT B-B
2 PLACES

REVISIONS

ENGR CHG	ZONE	LTR	DESCRIPTION	DATE	APPROVED

LIST OF PARTS

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
ASSY NO. -1				AL 6061-T6			

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .03 XX ± .04 XXX ± .010
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P1000 _____
SURFACE ROUGHNESS ✓

CONTR NO.
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AMCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: COVER

PART CLASS: UNCLASSIFIED	DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO. EFFECTIVITY
DWG CLASS: UNCLASSIFIED	-1	4073226	SD	1		
ADD BY:	APPLICATION					

SIZE D | CODE IDENT NO. 04614 | DWG NO. EX-23267 | SCALE 10/1 | WT | SHEET

DO NOT SCALE DRAWING

EX-23267C

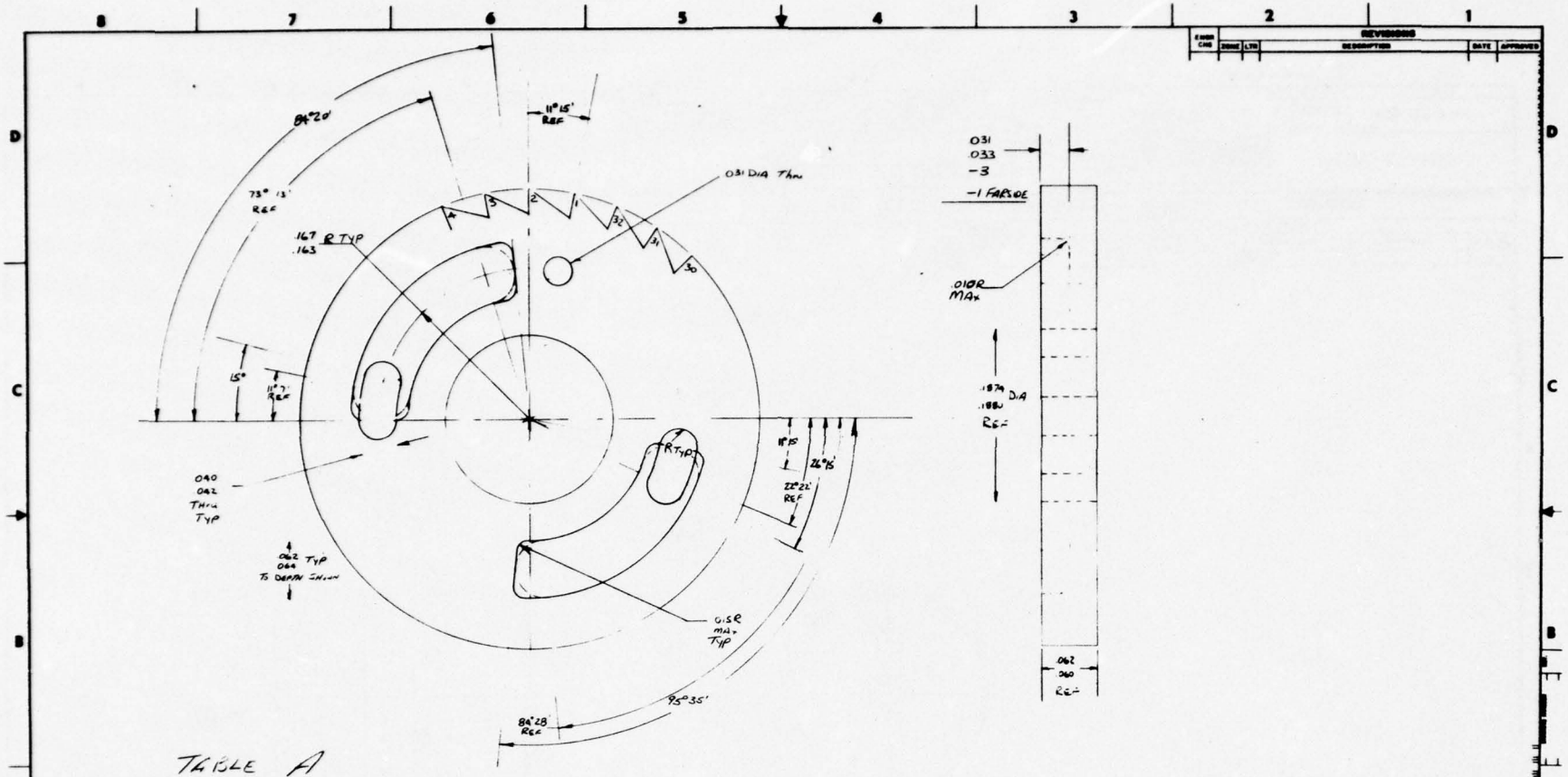


TABLE A

DASH NO	REMOVE TEETH AS SHOWN IN TABLE
-1	2, 6, 8, 9, 12, 14, 15, 16, 19, 20, 22, 24, 26, 28, 29, 30, 31, 32
-3	1, 3, 4, 5, 7, 10, 11, 13, 17, 18, 21, 23, 25, 27

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO
	ASSY NO	SEE TABULATION		MAKE FROM EX23251-1			

LIST OF PARTS

DASH NO	NEXT ASSY	USED ON
-3	AR23284	SO
-1	AR23284	SO

APPLICATION

QTY PER NHA | END ITEM NUMBER | SERIAL NO. EFFECTIVITY

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .01 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P15001
SURFACE ROUGHNESS 125

CONTR NO
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

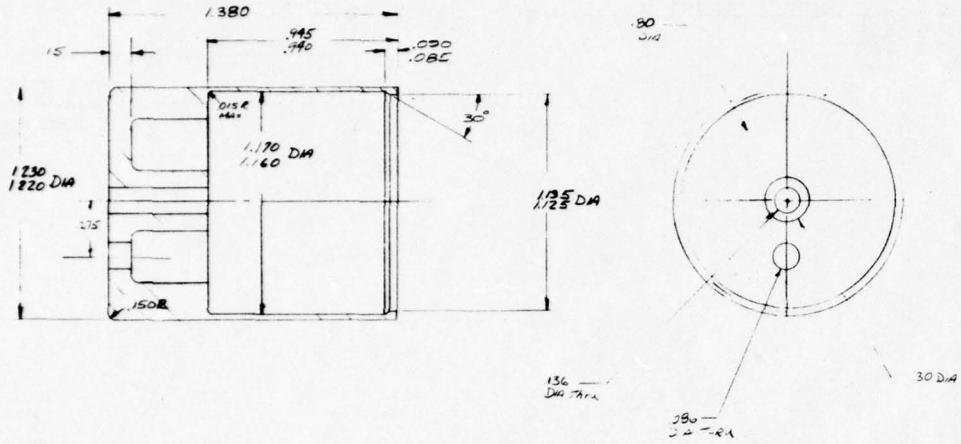
TITLE: DRIVE LATCH ET

SIZE D | CODE IDENT NO. 04614 | DWG NO. EX23251-8

SCALE 20:1 | WT | SHEET

PART CLASS ENGINEERING
DWG CLASS ANCILLARY GEN
ASG BY

DO NOT SCALE DRAWING



A-24

REVISIONS

ENGR CHG	ZONE	LTR	DESCRIPTION	DATE	APPROVED

LIST OF PARTS

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
	ASSY NO.	-1		VESPEL			

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X = ±.03 XX = ±.04 XXX = ±.020
MACHINED ANGLES = 0° 30'
SHEET METAL BEND ANGLES = 2°
SURFACE ROUGHNESS ✓

CONTR NO.
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AMCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: MOTOR COVER

SIZE	CODE IDENT NO	DWG NO.
D	04614	EX-E3269

SCALE 4/1 WT SHEET

PART CLASS: UNCLASSIFIED						
DWG CLASS: UNCLASSIFIED						
ABC BY: [illegible] 3/21/76						
DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO. EFFECTIVITY
-1	LA 23376	SD	1		

APPLICATION

DO NOT SCALE DRAWING

The Circlewood Inc

DRAWING NUMBER | REV

ENGR CHG	REVISIONS LTR	DESCRIPTION	DATE	APPROVED

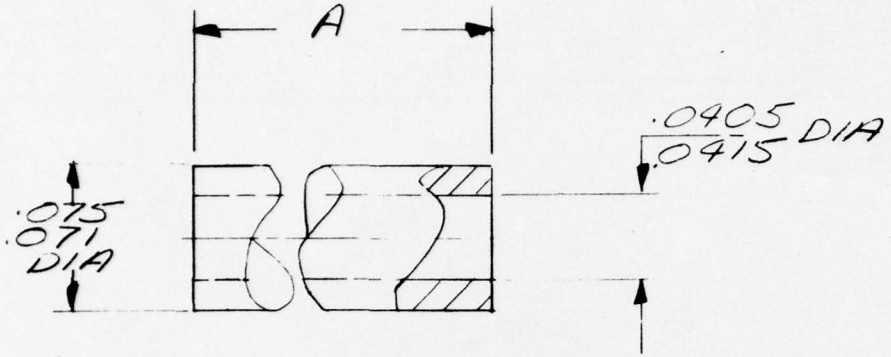


TABLE I

DASH NO	DIM A"
-1	.160 .158
-3	.030 .035

SEE TABLE I	303 CRES	
PART OR IDENTIFYING NO.	MATERIAL OR NOTE	SPECIFICATION

LIST OF PARTS

DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
	APPLICATION			EFFECTIVITY	
-3	Ex 23277	SD	1		
-1	Ex-23277	SD	1		

-UNLESS OTHERWISE SPECIFIED-
TOLERANCE AND DRAWING INTERPRETATION PER D143
.X ± .08 .XX ± .04 .XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001-40
SURFACE ROUGHNESS 63

CONTR NO.	
RELEASE	
DWG APPD	
CHECKED	M.S. Thackeray 9.3.74
DRAWN	D. Lawson 9.3.74
DESIGN APPROVAL	
MANAGER	
SECT CH	
DESIGNER	

AVCO M S D / WILMINGTON, MASSACHUSETTS

TITLE SLEEVE, WASHER

SIZE	CODE IDENT NO.	DWG NO.
B	04614	EX 23270

SCALE 2/1 | WT | SHEET

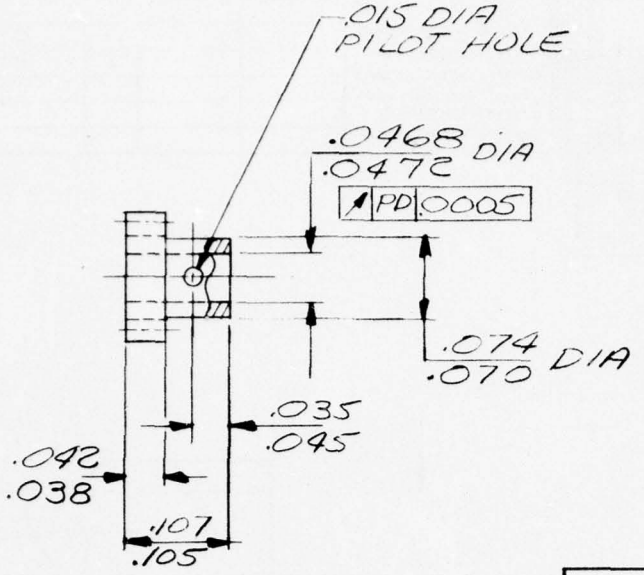
DO NOT SCALE DRAWING

DRAWING NUMBER | REV

ENGR CHG	REVISIONS LTR	DESCRIPTION	DATE	APPROVED

NOTES

1. MAKE FROM F5-2 PINION PURCHASE FROM PIC FED CODE NO. 00141
   H-11 SS HT TO 170,000 PSI MIN



PART OR IDENTIFYING NO.	MATERIAL OR NOTE	SPECIFICATION
-1	1	

LIST OF PARTS

DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
-1	EX23275	SD	1		

APPLICATION | EFFECTIVITY

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
.X ± .08 .XX ± .04 .XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001-40
SURFACE ROUGHNESS 32

CONTR NO.	
RELEASE	
DWG APPD	
CHECKED	
DRAWN	D. HASSON 9-27
DESIGN APPROVAL	
MANAGER	
SECT CH	
DESIGNER	

AVCO M S D / WILMINGTON, MASSACHUSETTS

TITLE: GEAR

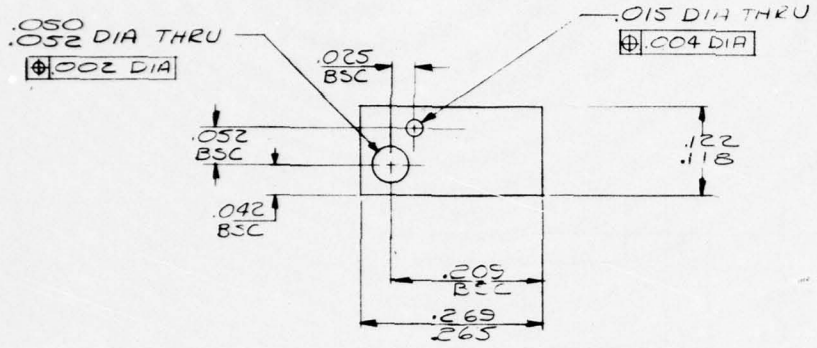
SIZE	CODE IDENT NO.	DWG NO.
B	04614	EX 23271

SCALE 10/1 | WT | SHEET

DO NOT SCALE DRAWING

NOTES

ENGR CHG	REVISIONS ZONE	LTR	DESCRIPTION	DATE	APPROVED



QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
	ASSY NO.	-1		.004 THK BERYLCO NICKEL 440 ½ HT			

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001 - 40
SURFACE ROUGHNESS 63

CONTR NO.
RELEASE
DWG APPD
CHECKED
DRAWN D. Lavoie 9-2-74
DESIGN APPROVAL
MANAGER
SECT. CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: DRIVE PAWL

SIZE C | CODE IDENT NO. 04614 | DWG NO. EX23272

SCALE 10/1 | WT | SHEET

PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
ASG BY:

DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
-1	LA23216	SD	2		

APPLICATION | EFFECTIVITY

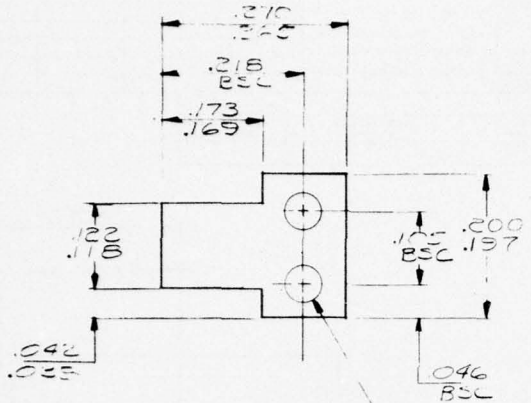
DO NOT SCALE DRAWING

The Draftboard, Inc.

A-27

NOTE:

ENGR CHG	REVISIONS ZONE	LTR	DESCRIPTION	DATE	APPROVED



QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
	ASSY NO.	-1		.004 THK BERYLCO NICKEL 440 ½ H/T			

LIST OF PARTS

PART CLASS: UNCLASSIFIED	DWG CLASS: UNCLASSIFIED	ASG BY: [illegible] 9/16/76
DASH NO.	NEXT ASSY	USED ON
-1	LA 23276	3D
APPLICATION		
QTY PER NHA	END ITEM NUMBER	SERIAL NO.
2		
EFFECTIVITY		

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
.X ± .08 .XX ± .04 .XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P1000 -40
SURFACE ROUGHNESS 63 √

	CONTR NO.	RELEASE
DWG APPD		
CHECKED	[illegible]	9/16/76
DRAWN	D. Krawczyk	9/23/76
DESIGN APPROVAL		
MANAGER		
SECT CH		
DESIGNER		

AVCO SYSTEMS DIVISION WILMINGTON MASSACHUSETTS 01887

TITLE: FULL PAWL

SIZE	CODE IDENT NO.	DWG NO.
C	04614	EX23273

SCALE 10/1 WT SHEET

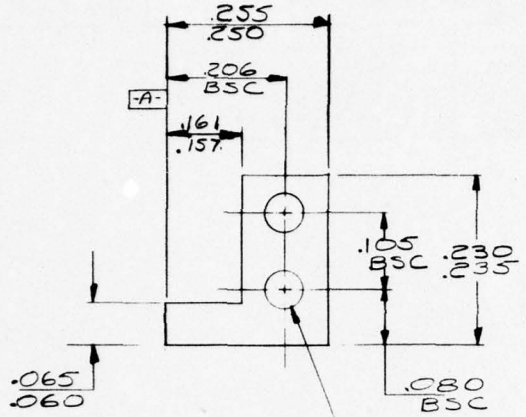
DO NOT SCALE DRAWING

The Drafthoard Inc

A-28

NOTES

ENGR CHG	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED



.050
.053 DIA THRU
2 HOLES
⊕ A .002 DIA

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
	← ASSY NO.	-1		.004 THK BERYLCO NICKEL 440 ½ H.T.			

LIST OF PARTS

PART CLASS: UNCLASSIFIED	DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
DWG CLASS: UNCLASSIFIED	-1	LA 2326	SD	2		
ASG BY: [illegible] 9/16/76	APPLICATION				EFFECTIVITY	

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001 — 90
SURFACE ROUGHNESS 63

CONTR NO.	
RELEASE	
DWG APPD	
CHECKED	[illegible] 9/16/76
DRAWN	T.L. Larson 9/27/76
DESIGN APPROVAL	
MANAGER	
SECT CH	
DESIGNER	

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: HALF PAWL

SIZE	CODE IDENT NO.	DWG NO.
C	04614	EX23274

SCALE 10/1 WT SHEET

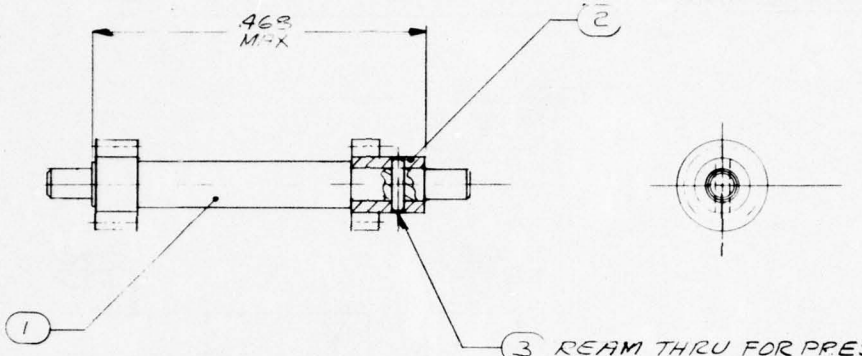
DO NOT SCALE DRAWING

The Drafthoard Inc

NOTES

(1) MAKE FROM .016 DIA X .070-.065 LG
416 SS HT TO 140,000 PSI MIN

ENGR CHG	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED



QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
1		-3	PIN	(1)			3
1		EX23271-1	GEAR				2
1		EX23276-1	PINION				1
-1	ASSY NO.						

LIST OF PARTS

PART CLASS:	-1	LA232/6	SD	1	
DWG CLASS:	DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER
ADD BY:	APPLICATION				EFFECTIVITY

SERIAL NO.

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
.X ± 08 .XX ± 04 .XXX ± 020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001 _____
SURFACE ROUGHNESS ✓

CONTR NO.	
RELEASE	
DWG APPD	
CHECKED	[signature] 9/16/71
DRAWN	D. Larsen 9-27-71
DESIGN APPROVAL	
MANAGER	
SECT CH	
DESIGNER	

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: PINION ASSEMBLY

SIZE	CODE IDENT NO.	DWG NO.
C	04614	EX 23275

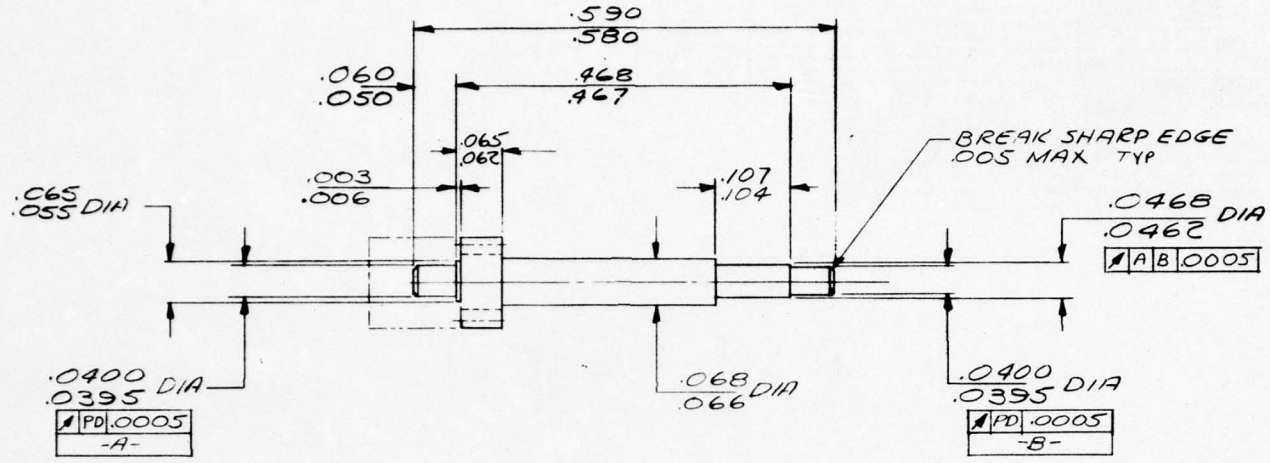
SCALE 10/1 WT SHEET

DO NOT SCALE DRAWING

The Draftboard, Inc.

NOTES:
1. MAKE FROM FS-2 PINION. PURCHASE FROM. PIC FED CODE NO. 00141
416 SS H.T. To 190,000 PSI MIN

ENGR CHG	REVISIONS				
	ZONE	LTR	DESCRIPTION	DATE	APPROVED



QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
	ASSY NO.	-1		⟨1⟩			

LIST OF PARTS

DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
-1	EX-23275	SD	1		
	APPLICATION			EFFECTIVITY	

PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
ABG BY:

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001-90
SURFACE ROUGHNESS 32

CONTR NO	
RELEASE	
DWG APPD	
CHECKED	
DRAWN	Don Lacy 10-3-74
DESIGN APPROVAL	
MANAGER	
SECT CH	
DESIGNER	

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

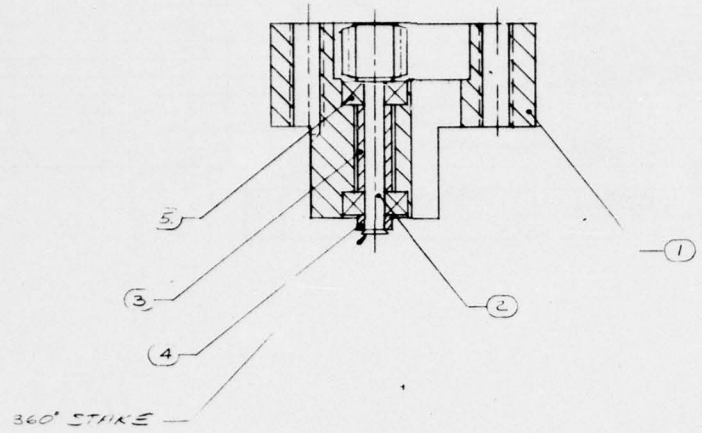
TITLE: PINION

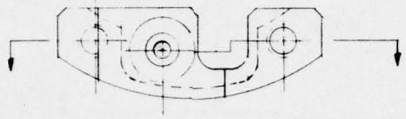
SIZE	CODE IDENT NO	DWG NO.
C	04614	EX23276

SCALE WT SHEET

DO NOT SCALE DRAWING

The Draftboard Inc





REVISIONS					
ENGR CHG	ZONE	LTR	DESCRIPTION	DATE	APPROVED

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO
			ASSY NO				
-		3R09	SEMI -				5
1		EX23276-3					4
1		EX23270-1	SLEEVE				3
1		EX23278-1	PISTON				2
1		EX23279-1	BLOCK				1

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .03 XX ± .04 XXX ± .005
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P1000 ——
SURFACE ROUGHNESS √

CONTR NO
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE

SIZE D | CODE IDENT NO. 04614 | DWG NO. EX-23277

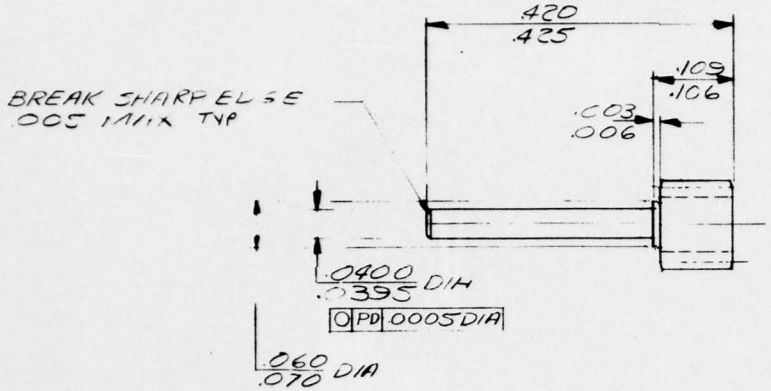
SCALE | WT | SHEET

DO NOT SCALE DRAWING

PART CLASS
DWG CLASS
ASG BY

DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
	EX23216	50			
	APPLICATION			EFFECTIVITY	

NOTES
1. MAKE FROM F5-2 PINION. PURCHASE FROM PIC FED CODE NO. 00141
416 SS HT TO 190,000 PSI MIN



ENGR CHG	REVISIONS ZONE	LTR	DESCRIPTION	DATE	APPROVED

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
	ASSY NO.	-1		(1)			

LIST OF PARTS

PART CLASS: UNCLASSIFIED	-1	EX-23278	SD	1		
ENG CLASS: UNCLASSIFIED	BASIC NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
ASG BY:		APPLICATION			EFFECTIVITY	

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P1000 ~ 40
SURFACE ROUGHNESS 63

	CONTR NO.	RELEASE
	DWG APPD	
	CHECKED	
	DRAWN	D. DAVISON
DESIGN APPROVAL	MANAGER	
	SECT CH	
	DESIGNER	

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: PINION.

SIZE	CODE IDENT NO.	DWG NO.
C	04614	EX23278

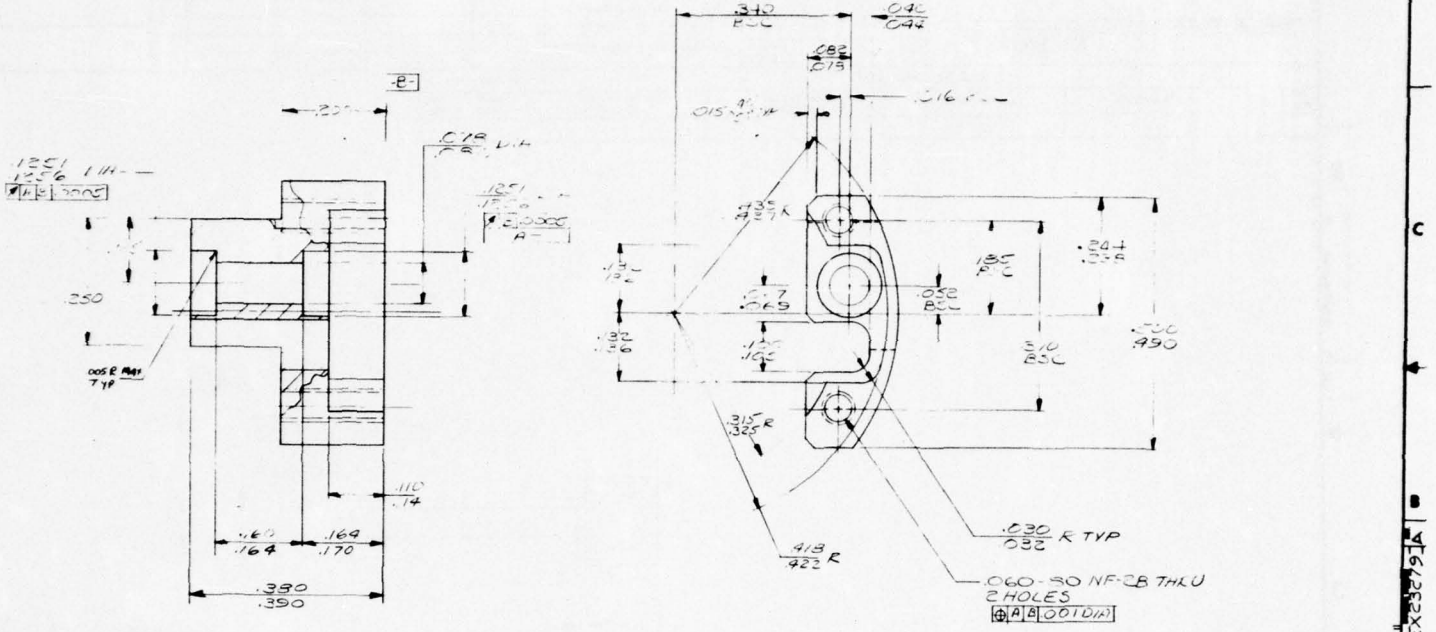
SCALE 10/1 WT SHEET

DO NOT SCALE DRAWING

The Drafthoard Inc

ANODIZE

REVISIONS					
ENGR CHG	ZONE	LTR	DESCRIPTION	DATE	APPROVED



QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
	ASSY NO.	-1		AL 6061-T6			

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER 0663
X ± .03 .XX ± .01 .XXX ± .005
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
FINISH 63
SURFACE ROUGHNESS

CONTR NO
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AMCO SYSTEMS DIVISION

TITLE: BLOCK, BEARING

SIZE	CODE IDENT NO.	DWG NO.
D	04614	EX23279

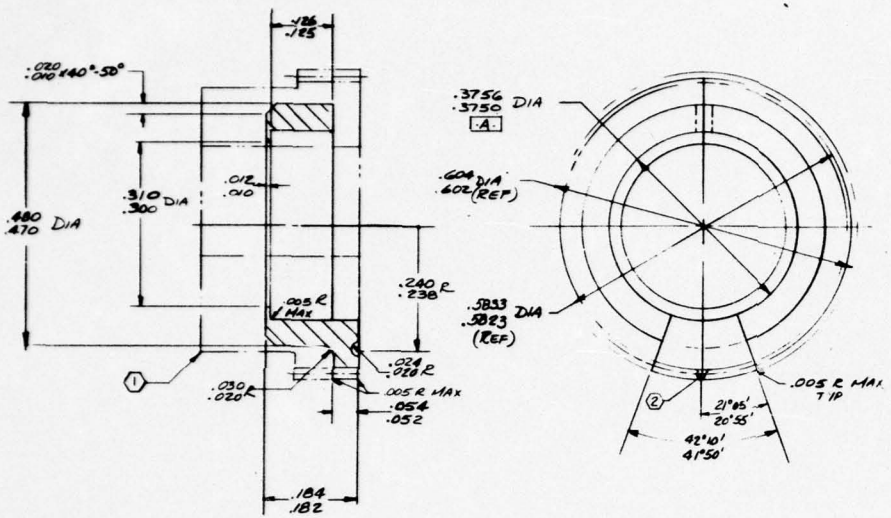
SCALE 10/1 WT SHEET

PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
ASS BY

DWG NO	NEXT ASSY	USED ON	QTY PER ASSY	END ITEM NUMBER	SERIAL NO.
-1	EX23277	SD	1		
	APPLICATION			EFFECTIVITY	

DO NOT SCALE DRAWING

EX23279 A



GEAR DATA (REF)	
PRESSURE ANGLE	20°
PITCH	96
NO. OF TEETH	56
FACE THICKNESS	.187

(3) PASSIVATE
(2) LOCATE CENTERLINE THRU CENTER OF TOOTH
(1) MAKE FROM NORDEX CO. NF 34-56 Q14 OR EQUIVALENT

NOTE

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO
ASSY NO		-1		(1) CRES 303			

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D343
X ± .03 XX ± .01 XXX ± .005
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P 10001
SURFACE ROUGHNESS ✓

CONTR NO
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: SECTOR GEAR

SIZE: D | CODE IDENT NO: 04614 | DWG NO: EX-23280

SCALE 10/1 | WT | SHEET

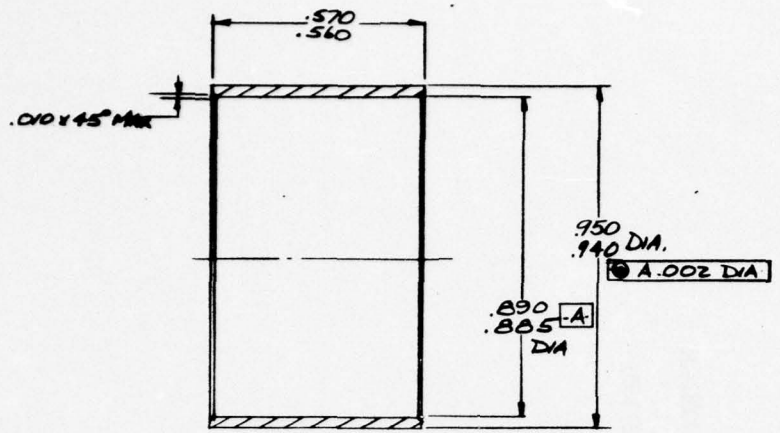
PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
ADC BY: [illegible]

CHGN NO	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO EFFECTIVITY
-1	EA23216	SQ	1		

APPLICATION

DO NOT SCALE DRAWING

DRAWING NUMBER
EX-23281
NOT REQUIRED



ENGR CHG	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
		-1		LUCITE			

ASSY NO.

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001 _____
SURFACE ROUGHNESS ✓

CONTR NO.
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: WINDOW

SIZE	CODE IDENT NO	DWG NO.
C	04614	EX-23282

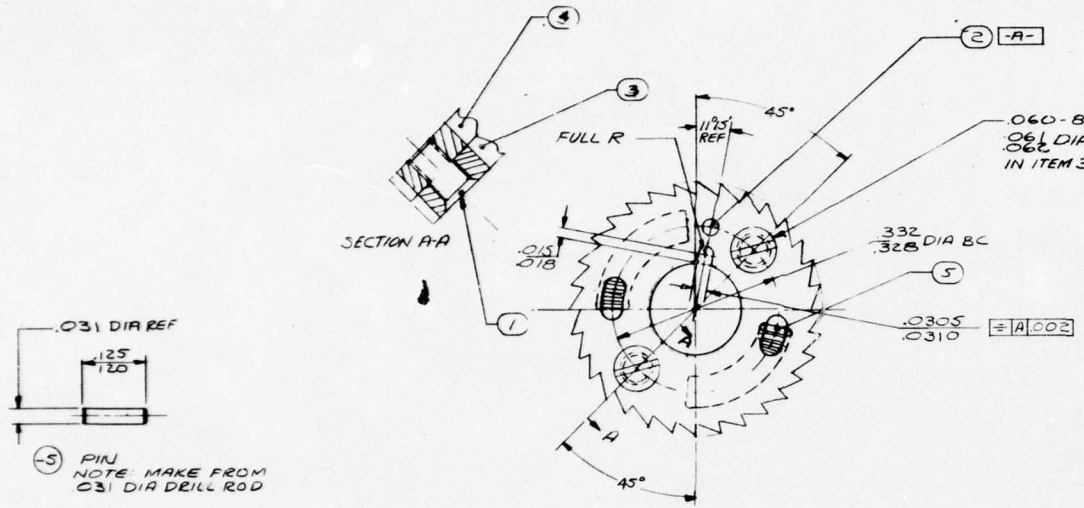
SCALE 5/1 WT SHEET

PART CLASS: UNCLASSIFIED	DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
DWG CLASS: UNCLASSIFIED	-1	LA23216	SD	1		
AGG BY: [signature] 9/21/76	APPLICATION				EFFECTIVITY	

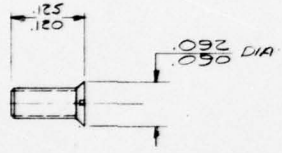
DO NOT SCALE DRAWING

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DRAWING NUMBER
EX-23283
NOT REQUIRED



(-5) PIN
NOTE: MAKE FROM .031 DIA DRILL ROD



(-3) SCREW
NOTE: MAKE FROM 0-80 FH. SCREW

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
2	84830	CL-008A-3	SPRING				4
1		EX23268-3	DRIVE RATCHET				3
1		EX23268-1	DRIVE RATCHET				2
1		-5	PIN				5
2		-3	SCREW				1
-1		ASSY NO.					

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X = .03 XX = .01 XXX = .005
MACHINED ANGLES = 0° 30'
SHEET METAL BEND ANGLES = 2°
FINISH = 40
SURFACE ROUGHNESS

CONTR NO.
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: RATCHET ASSY

SIZE D | CODE IDENT NO. 04614 | DWG NO. EX23284

SCALE 10/1 | WT | SHEET

PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
ASG BY: [illegible] 11/4/74

-1 | 1A2332/6 | SD | 1 | NEXT ASSY | USED ON | QTY PER NHA | END ITEM NUMBER | SERIAL NO. EFFECTIVITY | APPLICATION

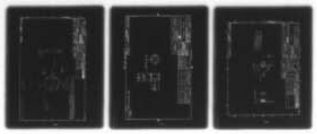
DO NOT SCALE DRAWING

EX23284 -1 DWG

8 7 6 5 4 3 2 1

AD-A032 575 AVCO SYSTEMS DIV WILMINGTON MASS F/G 20/6
SWITCH DRIVER CONCEPT DEVELOPMENT.(U)
NOV 76 M E WOLF DAAA21-76-C-0203
UNCLASSIFIED AVSD-0318-76-RR NL

2 OF 2
AD
A032575



END
DATE
FILMED
1-77

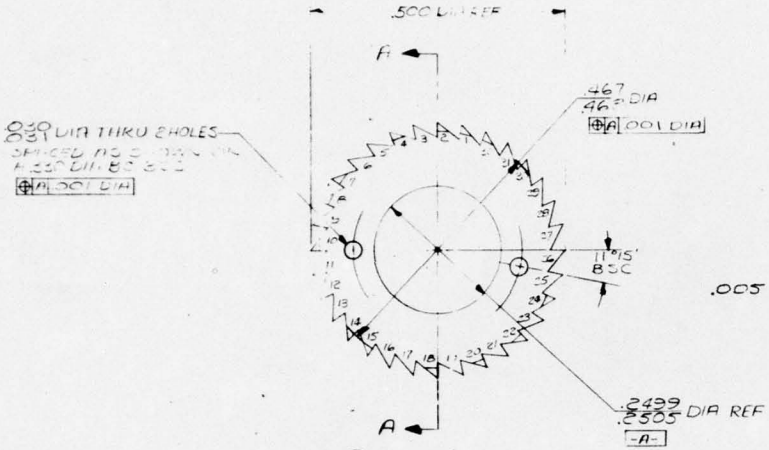
NOTES

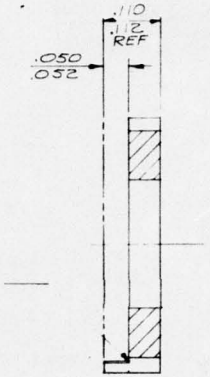
(1) MAKE 1 - .010 EXCESS RATCHET

(2) REMOVE BOSSES PER TABLE I, -2 SAME AS -1 EXCEPT OPPOSITE HAND

MIRRORING VIEW OF -2 REF







SECTION A-A

(-1) AS SHOWN

(-2) OPPOSITE HAND

TABLE I (2)																																
DASH NO	REMOVE BOSSES FROM THE FOLLOWING TEETH TO DEPTH SHOWN																															
-1	3	5	6	9	11	12	13	16	17	19	21	23	25	26	27	28	29	31														
-2	1	2	4	7	8	10	14	15	18	20	22	24	30	32																		

SEE TABLE I

LIST OF PARTS

QTY	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	(1) MATERIAL OR NOTE	SPECIFICATION	ZONE	REV
ASSY NO.							

REVISIONS					
LTR	ZONE	DESCRIPTION	DATE	APPROVED	

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND SYMBOLS INTERPRETATION PER ANSI
X ± .03 XX ± .01 XXX ± .005
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 1°
FINISH 63 ✓
SURFACE ROUGHNESS

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS

TITLE: LOCK, RATCHET

SIZE D | CAGE CODE NO. 04614 | DWG NO. EX23285

SCALE 10/1 | WT | SHEET

-2	4/23/66	SD	1
-1	4/23/66	SD	1

NEXT ASSY | USED ON | APPLICATION | END ITEM NUMBER | SERIAL NO. EFFECTIVITY | QTY PER ASSY

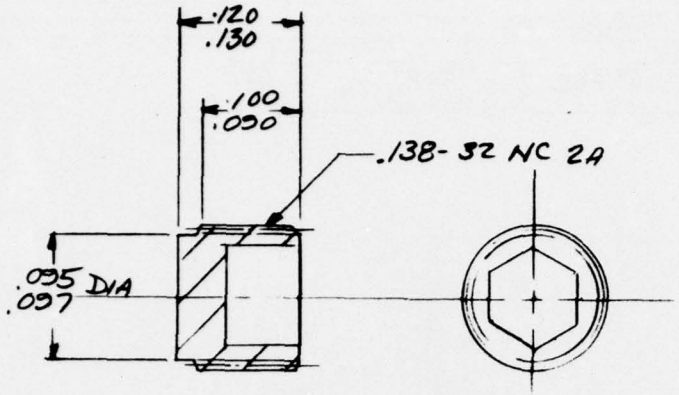
DO NOT SCALE DRAWING

8 7 6 5 4 3 2 1

A-40

EX23285

NOTE
(1) MAKE FROM ALLEN SET SCREW



DRAWING NUMBER | REV

ENGR CHG	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

PART OR IDENTIFYING NO.	MATERIAL OR NOTE	SPECIFICATION
1	(1)	

LIST OF PARTS

DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
-1	LA23216	SD	1		

APPLICATION | EFFECTIVITY

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
.X ± .08 .XX ± .04 .XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001
SURFACE ROUGHNESS ✓

CONTR NO.	
RELEASE	
DWG APPD	
CHECKED	[illegible] 9/17/74
DRAWN	[illegible] 9/17/74
DESIGN APPROVAL	
MANAGER	
SECT CH	
DESIGNER	

AVCO MSD / WILMINGTON, MASSACHUSETTS

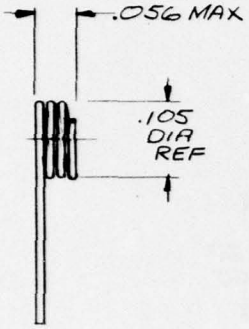
TITLE: RESET PLUG

SIZE	CODE IDENT NO.	DWG NO.
B	04614	EX-23286

SCALE 10/1 | WT | SHEET

DO NOT SCALE DRAWING

ENGR CHG	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED



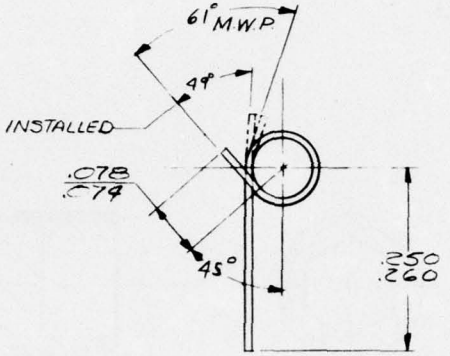


TABLE I	
DASH NO	MAKE FROM LEE SPRING P/N
-1	LT-012A-1L
-2	LT-012A-1R

EX23287

QTY REQD	CODE IDENT / ASSY NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
		SEE TABLE I					

LIST OF PARTS

DASH NO.	NEXT ASSY (APPLICATION)	USED ON (APPLICATION)	QTY PER NHA	END ITEM NUMBER (EFFECTIVITY)	SERIAL NO. (EFFECTIVITY)
-2	LA23216	SD	1		
-1	LA23216	SQ	1		

PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
ASG BY:

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P.1000 - 40
SURFACE ROUGHNESS ✓

CONTR NO		
RELEASE		
DWG APPD		
CHECKED	[signature]	9/1/64
DRAWN	[signature]	9/1/64
DESIGN APPROVAL		
MANAGER		
SECT CH		
DESIGNER		

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE: SPRING

SIZE	CODE IDENT NO.	DWG NO.
C	04614	EX23287

SCALE 10/1 WT SHEET

DO NOT SCALE DRAWING

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