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EVALUATION
OF A HIGH RESPONSE
ELECTROHYDRAULIC DIGITAL CONTROL VALVE
BERTEA DOCUMENT NUMBER 224200-7

EVALUATION OF A HIGH RESPONSE ELECTROHYDRAULIC DIGITAL CONTROL VALVE

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TITLE DIGITAL CONTROL VALVE EVALUATION

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FOREWORD

This report was prepared by the Bertea Corporation, Irvine, California under NASA Contract NAS 8-28379. The report describes the evaluation of a unique electrohydraulic digitally controlled servo actuator.

The evaluation contract was sponsored by the George C. Marshall Space Flight Center, National Aeronautics and Space Administration, Marshall Space Flight Center, Alabama 35812. The contracting officer's technical representative was P. T. Golley, Astrionics Laboratory.

The work was performed by members of the Engineering Department of Bertea Corporation, Irvine, California 92664. The principle investigator was R. L. Anderson with assistance from J. W. Blanton, W. E. Cover, and P. Chin. Work on the contract was performed between February 29, 1972 and February 28, 1973.

1.0 SUMMARY

This final report describes the application of a digital control valve on an electrohydraulic servo actuator. The report discusses the digital control problem in general as well as the design and evaluation of a breadboard actuator.

The evaluation of the digital control valve revealed a number of problems associated with matching the DART Valve to a hydraulic load. The problems were related to lost motion resulting from bulk modulus and leakage. These problems were effectively minimized in the breadboard actuator by maintaining a 1000 psi back pressure on the DART Valve circuit and thereby improving the effective bulk modules.

In general the test results obtained from the breadboard were impressive and tend to indicate that satisfactory performance may be obtained using the DART Valve electrohydraulic interface. It is recommended that further testing be performed using a hydraulic load which would be designed from the test data collected on the breadboard actuator. It is also recommended that the DART Valve be evaluated on a secondary actuator driving a hydromechanical actuator.

2.0 INTRODUCTION

Contemporary flight control systems rely on a variety of design techniques to establish an interface between electronic signals and hydraulic actuators. The simplest techniques employ solenoid actuated valves to control the flow of fluid to a hydraulic actuator.

For more demanding applications the electrohydraulic interface must be capable of proportional control. Where frequency response requirements are not severe the interface is typically accomplished using an electromagnetic torque motor which drives a slide valve through a combination of gears and linkage. For higher response requirements the torque motor may drive the slide valve indirectly using a hydraulic preamplifier.

In each case, as the performance requirements become more demanding the intrinsic reliability of the hardware is reduced as the number of failure modes increase in proportion to the number of components. At the crux of the problem are the "sensitive" components which form the electromechanical interface. The reliability of these components is typically compromised to achieve specified performance requirements. This compromise

2.0 INTRODUCTION (Continued)

often takes the form of marginal meachanical design in terms of susceptibility to contamination, limited design life, or reliance upon critical assembly and maintenance techniques.

Two approaches are available to the designer who is faced with both high performance requirements and high reliability requirements. The first approach is to design the interface to accommodate redundant elements for the least reliable components. This approach increases the reliability of the control system in terms of the probability of safely completing a mission. However, the probability of failure from a maintenance standpoint is greatly increased due to the addition of the redundant components and redundancy management sub-systems.

A second approach to achieving the required reliability requirement is to design a single channel interface using ultrareliable components. This is actually a feasible approach within existing technology. However,

2.0 INTRODUCTION (Continued)

the cost of these components greatly exceeds the cost of using redundant components. Therefore, this approach has been limited in its application.

The basic attractiveness of the single channel reliability approach is so great that in recent years Bertea has initiated an in-house program to investigate approaches to improving single channel reliability without incurring the costs associated with the use of conventional ultrareliable hardware. The result of this effort has been the development of a digital electrohydraulic interface using a Bertea developed electrohydraulic valve called the DART Valve. The DART Valve has been developed to eliminate basic problems such as contamination sensitivity and critical assembly techniques and thereby improve electrohydraulic interface reliability. The DART Valve promises not only a reduction in failure modes but also an improvement in failure effects. A key factor in the development of the DART Valve has been to greatly reduce the number of failure modes which result in hardover failures.

2.0 INTRODUCTION (Continued)

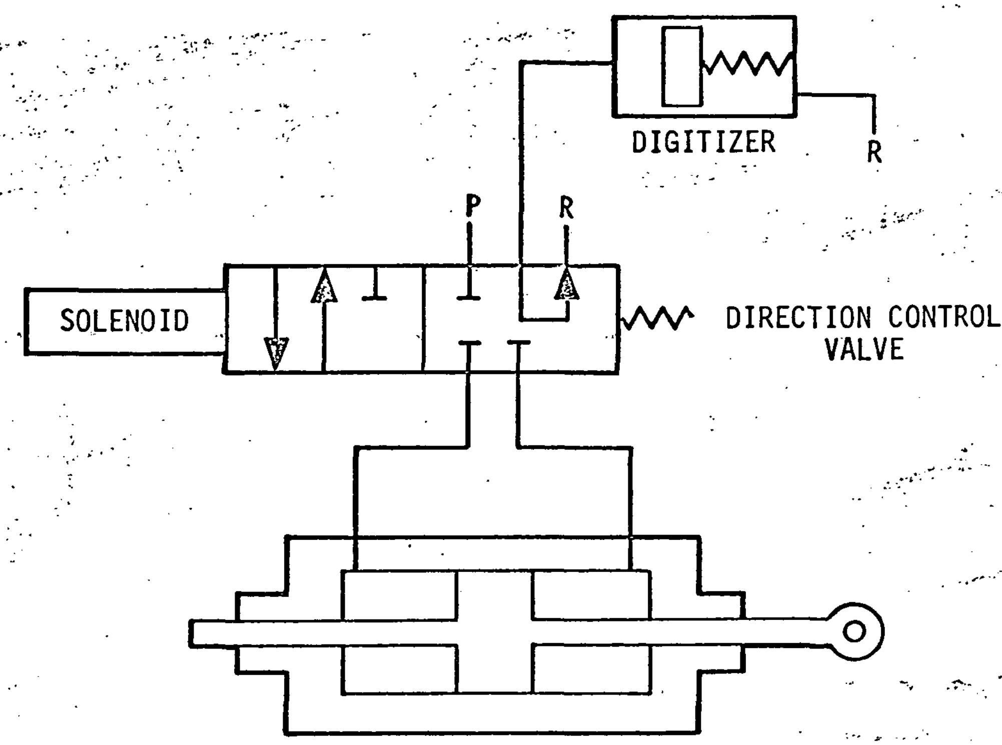
This report describes the application of a second generation DART Valve, referred to as the Microdrift DART Valve, as used to position the slide valve in a electrohydraulic servo actuator.

3.0 DIGITAL CONTROL TECHNIQUE

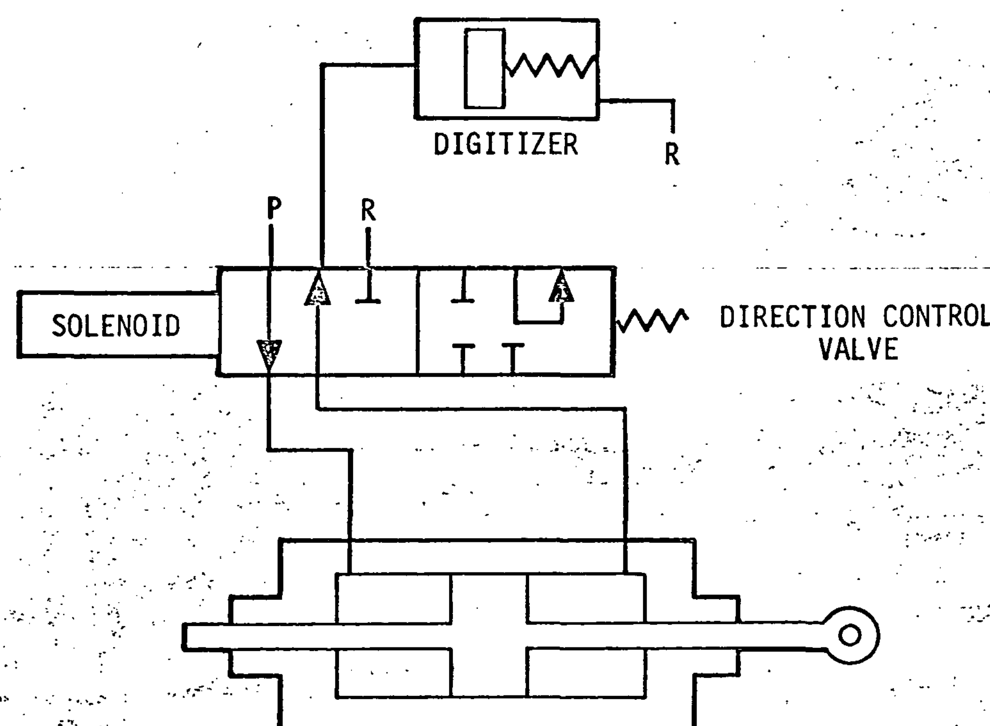
There are two basic approaches for mechanizing a digital actuator: binary commanded and pulse commanded.

Typically binary digital actuators have less attractive failure modes than pulse commanded actuators. For example, a failure of the most significant bit in a binary actuator will produce a 50% transient at the actuator output. Pulse commanded actuators may be designed such that each pulse will command a limited actuator stroke and thereby prevent hardover failures.

Pulse commanded actuators may be of either the pulse rate or pulse width type. Pulse width actuators receive information at a fixed frequency with variable pulse width. Pulse rate actuators receive information with a fixed pulse form but at variable pulse frequency. For hydromechanical applications a pulse rate command is more desirable than a pulse width command. Over a given period of time the pulse rate command will result in fewer mechanical cycles and therefore less mechanical wear.



SOLENOID DE-ENERGIZED
FIGURE 1a



SOLENOID ENERGIZED
FIGURE 1b

3.0 DIGITAL CONTROL TECHNIQUE (Continued)

3.1 DESCRIPTION OF PULSE RATE ACTUATOR

The pulse rate actuator utilizes a stepper motor which positions the output one increment for each pulse command. The output position is the algebraic sum of plus and minus pulse commands. The hydraulic mechanization of a stepper motor may be represented schematically as shown in Figure 1. The hydraulic stepper motor contains three basic components: a direction control valve, a digitizer to restrict the fluid flow to a predefined volume, and an actuator to sum the individual hydraulic steps. In actual practice, the direction control valve may be duplicated to provide control in both directions (plus and minus commands).

The hydraulic stepper will cause the actuator to advance one "step" each time the solenoid is sequenced through an on-off-on cycle. Figure la illustrates the steady state (or rest) condition of the stepper.

3.0 DIGITAL CONTROL TECHNIQUE (Continued)

3.1 DESCRIPTION OF PULSE RATE ACTUATOR (Continued)

In this position both actuator ports are blocked so that the actuator can not move. The digitizer is ported to return pressure and therefore is in the (spring) extend position. Figure 1b shows the direction control valve in the solenoid energized position. Supply pressure is ported to one side of the actuator. The opposite side of the actuator is ported to the digitizer. Fluid will flow into the actuator from the pressure supply and out of the actuator to the digitizer until the digitizer piston bottoms (spring compressed). The digitizer volumetric displacement defines the actuator displacement for each step. The cycle is complete when the solenoid has been deenergized and the digitizer piston allowed to return to the full extend position.

The hydraulic stepper may be meachanized to have either a locked or bypass failure mode. If the hydraulic stepper, shown in Figure 1, were to loose electrical power it would

3.0 DIGITAL CONTROL TECHNIQUE (Continued)

3.1 DESCRIPTION OF PULSE RATE ACTUATOR (Continued)

lock the actuator in its last commanded position. However, if the function of the solenoid were to be reversed such that the solenoid were normally energized the hydraulic stepper would fail to a bypass position. If this revised design were to experience a loss of electric power the direction control valve would assume the position shown in Figure 1b. If there were two direction control valves (one for each direction) then both sides of the actuator would be connected to pressure and the actuator thereby bypassed.

There is also a second option to consider in the mechanization of the hydraulic stepper. The digitizer may operate at either return or supply pressure level. The digitizer shown in Figure 1 operates at return pressure. In the rest position it is depressurized. The reverse mechanization may also be considered in which the digitizer is referenced to supply pressure. For this case the direction control valve would port one side of the actuator to return and allow the digitizer to supply the fluid required

3.0 DIGITAL CONTROL TECHNIQUE (Continued)

3.1 DESCRIPTION OF PULSE RATE ACTUATOR (Continued)

to move the actuator. This approach has the disadvantage that the actuator is left at "return" pressure at the end of the stroke and therefore is not as stiff as the actuator configuration shown in Figure 1.

3.2 APPLICATION OF THE HYDRAULIC STEPPER

The practical application of the hydraulic stepper depends upon the ability to achieve both fine control (small steps) and high speed response (large steps). The limitation on achieving both of the requirements simultaneously is the stepping speed. Currently a stepping rate of 50 steps/second is achievable and a 100 steps/second may be achieved in the near future.

An example of the effects of this stepping rate limitation is given below. Assume that the fine control or resolution requirement defines the smallest step size as 0.2% of full stroke. Using this step size at 50 steps/second it will take 10 seconds for the actuator to go from full extend to full retract. For many applications this is too slow.

3.0 DIGITAL CONTROL TECHNIQUE (Continued)

3.2 APPLICATION OF THE HYDRAULIC STEPPER (Continued)

A technique for improving the response of the hydraulic stepper would be to have a large and a small step size available. These two step sizes could then be used individually, summed, or subtracted to provide as many as four step sizes. This technique would extend the capability of the hydraulic stepper such that it would fulfill a great many applications. Referring to the above example, a nine to one improvement in actuator speed would result from the use of hydraulic steppers which have a .8% and 1.0% step size. The actuator will now have a .2%, .8%, 1.0%, and 1.8% step size capability. At fifty steps per second the actuator will go from full extend to full retract in 1.11 seconds. The minimum step size of .2% is preserved by cycling the 1.0% step valve in one direction and the .8% step valve in the opposite direction. This differential step must be sequenced so that both sides of the actuator are not connected to the pressure port at the same time. If the stepper valves were not sequenced in this manner the actuator would be bypassed each time a .2% step is commanded.

3.0 DIGITAL CONTROL TECHNIQUE (Continued)

3.3 APPLICATIONS REQUIRING LARGE ACTUATORS

The majority of the digital valve developmental work has been directed toward small (1 gpm) actuators. The application of digital valve techniques to large actuators requires special consideration of the pulsing effect of the hydraulic stepper. As a minimum, an accumulator must be inserted into the supply and return passages to isolate the pulsation from the main hydraulic system. In addition, it may be required that larger valves be cycled at a lower stepping rate than the 50 or more steps per second used for the smaller valves. This reduction in stepping rate may require the addition of a damping device to attenuate actuator response at the valve stepping frequency.

A more conventional approach to the large actuator problem is to allow a digital actuator to drive a large servo valve, either directly or indirectly. The direct approach is to port the "steps" of hydraulic fluid into end chambers of the servo valve. The end chambers will integrate the individual steps and thereby position the servo valve. The digital valve command must therefore be a function of the difference between actuator command and actuator output.

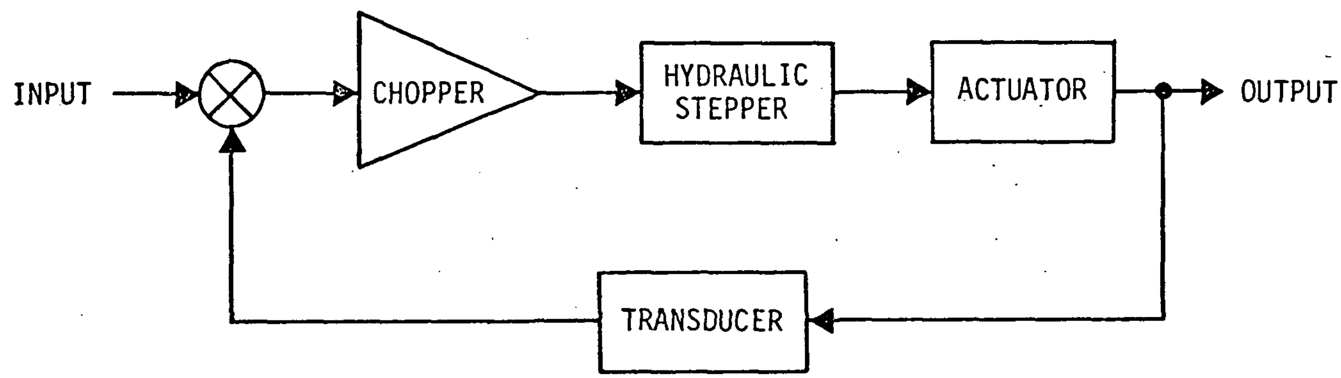
3.0 DIGITAL CONTROL TECHNIQUE (Continued)

3.3 APPLICATIONS REQUIRING LARGE ACTUATORS (Continued)

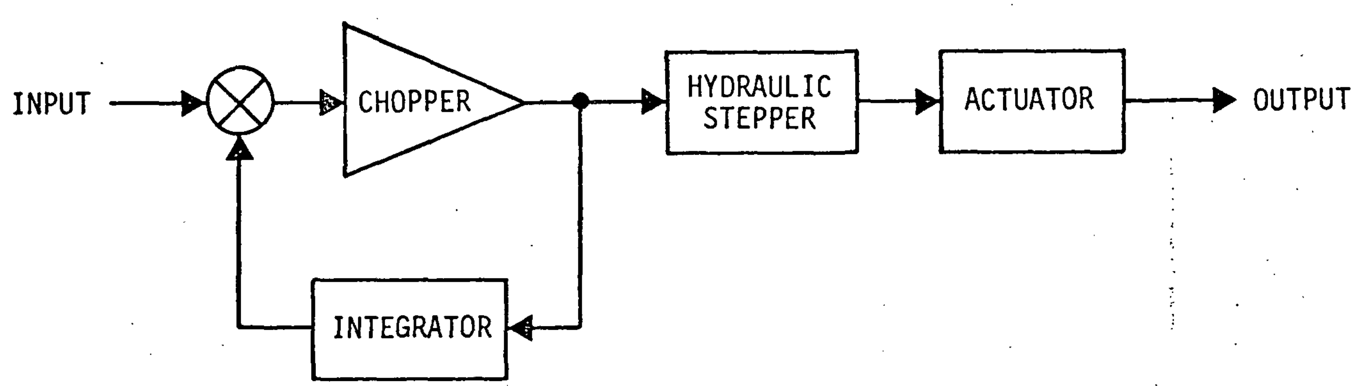
The indirect approach to driving a large servo valve is to use a small digital actuator to supply position inputs to a large hydromechanical servo actuator. This approach greatly simplifies the electronic logic in that the digital signal is a function of the position command only.

3.4 OPEN LOOP CONTROL

The hydraulic stepper may be used in either an open loop or closed loop control system. Figure 2 illustrates the closed loop approach. The command and output are compared at a summing junction. A digital amplifier-chopper drives the hydraulic stepper in response to error signals at the summing junction. For a simple hydraulic stepper the digital amplifier-chopper is simply a direction sensitive relay which drives the hydraulic stepper whenever the summing junction error exceeds a preset threshold. For a multiple step hydraulic stepper the digital amplifier-chopper must contain the logic to drive various combinations of hydraulic steppers in response to two or more threshold levels.



CLOSED LOOP STEPPER
FIGURE 2



OPEN LOOP STEPPER
FIGURE 3

3.0 DIGITAL CONTROL TECHNIQUE (Continued)

3.4 OPEN LOOP CONTROL (Continued)

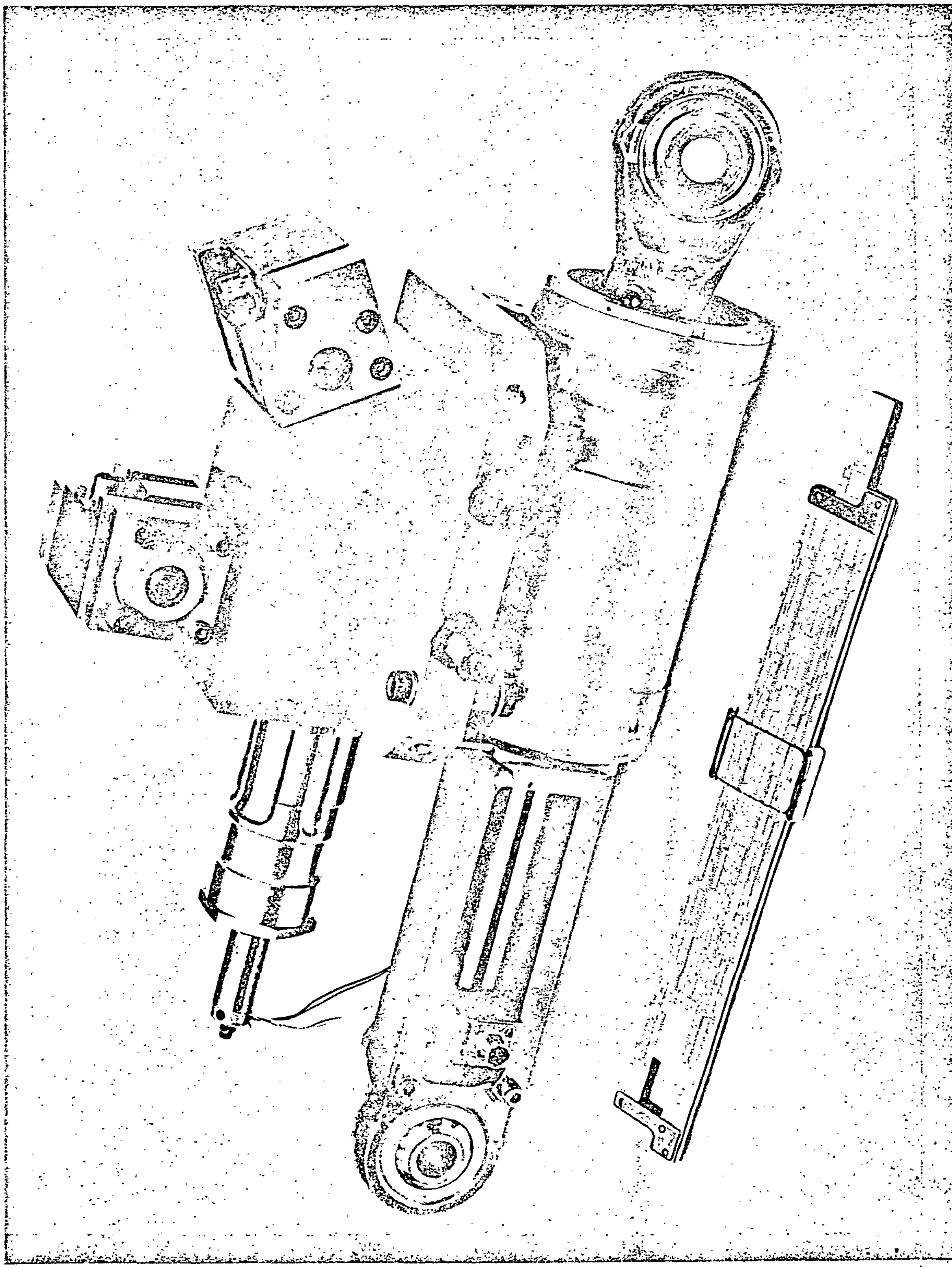
The hydraulic stepper may also be operated open loop as shown in Figure 3. In this configuration an electronic up-down counter or integrator is used to sum hydraulic stepper commands. The output of this integrator is combined with the input at a summing junction. In operation the digital amplifier-chopper will respond to an input by continuously stepping until the integrator cancels the input command. The open loop technique is attractive when it is desirable to eliminate feedback from the hydraulic equipment to the electronic. Elimination of this feedback may be desired to improve reliability or to decrease weight or cost. The disadvantages of open loop control are inaccuracies due to drift (leakage) and/or abnormal step sizes.

When the open loop technique is used it is necessary to isolate the digital amplifier-chopper from the summing junction by using data sampling techniques. This procedure is necessary to prevent the step size selector from changing command outputs in the middle of a step with a resulting loss in step calibration.

3.0 DIGITAL CONTROL TECHNIQUE (Continued)

3.4 OPEN LOOP CONTROL (Continued)

A hybird approach is also possible in which the hydraulic stepper transmits a step verification command to the electronic logic after every step. These signals may then be integrated and applied to the summing junction. A second use of a step verification signal would be for monitoring. A fault would be indicated if there was a disagreement between a step verification signal integrator and a digital amplifer-chopper integrator.



DIGITAL CONTROL ACTUATORS

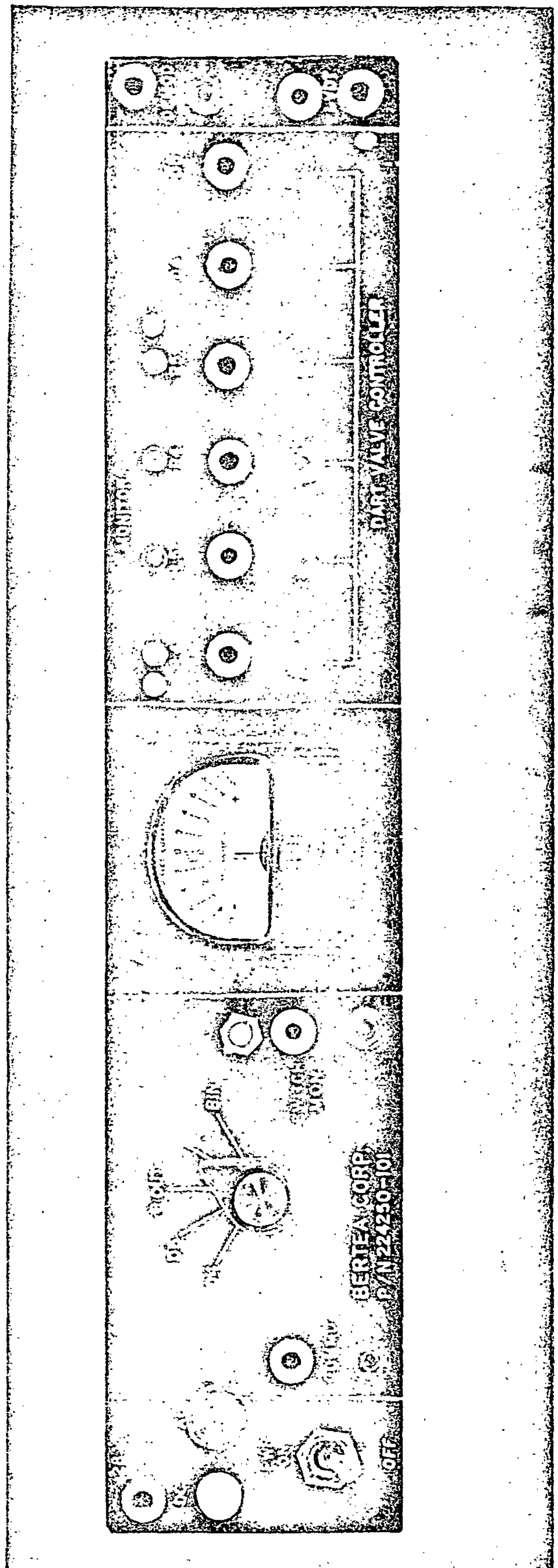
FIGURE 4

4.0 BREADBOARD ACTUATOR

The breadboard actuator assembly is shown in Figure 4. Two Dart Valves are used to position a mechanical servo valve. The mechanical servo valve controls the flow of fluid to the hydraulic cylinder. Linear position transducers are attached to both the servo valve slide and cylinder piston. These transducer signals are electrically compared to the position command in the DART Valve Controller shown in Figure 5. The error signal resulting from this comparison is processed by a digital step selector which in turn control the DART Valves. A block diagram for the controller and actuator is shown in Figure 6.

The output of the first summing junction is nonlinearized as illustrated by the curve shown over the nonlinear amplifier in Figure 6. The effect of this nonlinearity is to increase error sensitivity for small summation errors. This increased sensitivity improves actuator resolution in that it reduces the summation error required to activate the digital step selector.

The inner control loop shown in Figure 6 accepts the nonlinearized input and positions a slide valve in



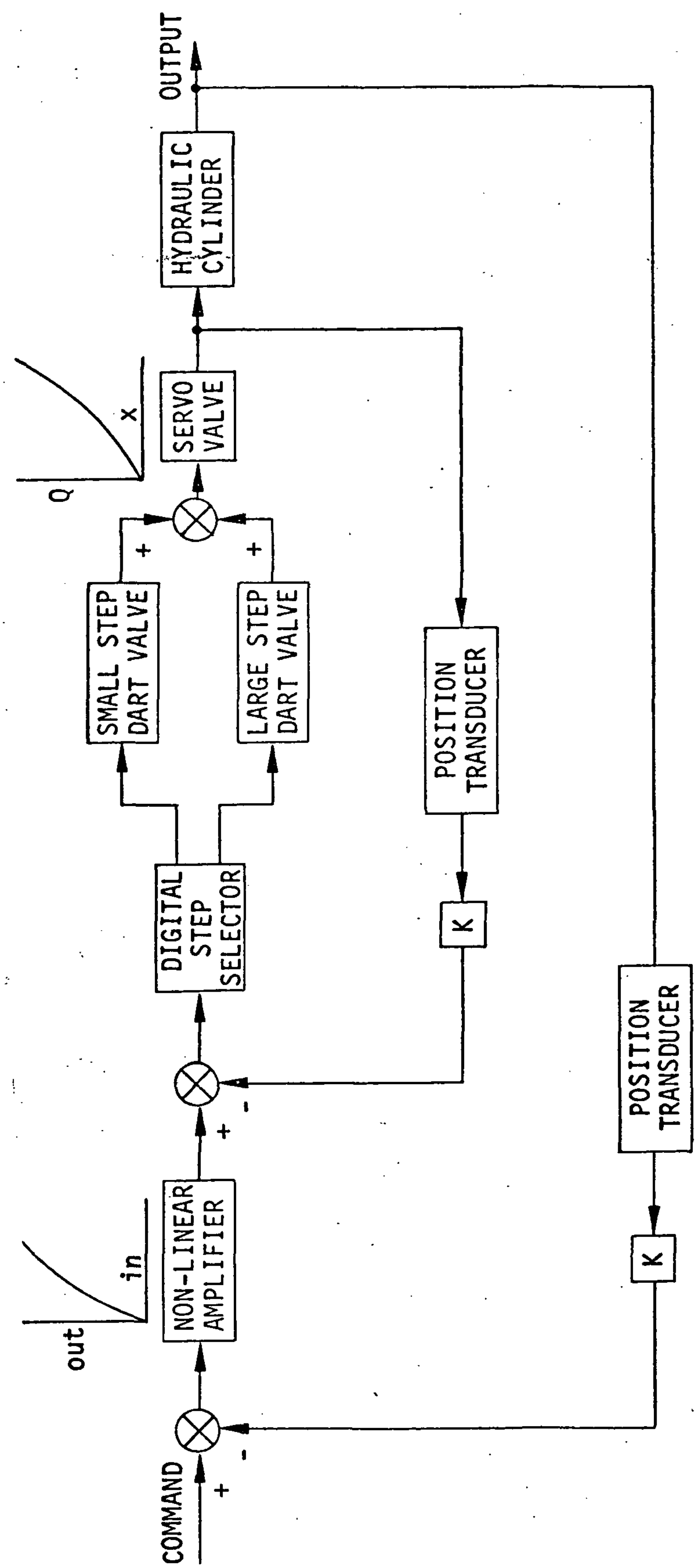
DART VALVE CONTROLLER

FIGURE 5

4.0 BREADBOARD ACTUATOR (Continued)

response to this input. The digital step selector causes the small step DART Valve to cycle when it's input exceeds 3% of full error signal at the second summing junction. The large step DART Valve is cycled when the second summing junction error signal exceeds 15% of full error signal. The DART Valves meter a digital step of fluid to the servo valve end chambers such that the servo valve slide is displaced either 3% or 15% of it's stroke for each digital command. A linear position transducer is attached to the servo valve slide to feedback slide position. Thus, the inner loop repeats the nonlinearized error signal from the first summing junction.

The servo valve metering port has a triangular opening such that flow gain is a function of valve stroke. This metering slot produces a stroke/flow curve as shown over the servo valve block on Figure 6. This stroke/flow curve is the inverse of the curve shown over the non-linear amplifier. The net result of these complementary nonlinearities is a linear flow output in response to error signals at the first summing junction. The purpose



DIGITAL CONTROL BLOCK DIAGRAM

FIGURE 6

4.0 BREADBOARD ACTUATOR (Continued)

of the nonlinear design is two fold. First, the actuator resolution capability is improved by a factor of approximately 10 times. Second, the digital step size appears as a function of the error signal's absolute valve. Both of these effects improve smoothness of operation in the low velocity region.

The following list of constants apply to the breadboard actuator.

Hydraulic Cylinder	8.73 in^2 area 3.98 in stroke
Servo Valve	±20 GPM flow ±.175 stroke
DART Valve	Small Step .0055 in Large Step .027 in 32 small steps = .175 in 27 steps/sec with 1000 psi back pressure
Inner Loop Gain	±10 VDC at first summing junction will produce ±.175 inch at servo valve
Outer Loop Gain	±10 VDC at command will produce ±1.99 inch cylinder stroke

4.0 BREADBOARD ACTUATOR (Continued)

If the inner loop were assumed to have a zero time constant the outer loop open loop gain may be found as follows:

$$G = \left(\frac{.175 \text{ IN}}{10 \text{ VDC}}\right)\left(\frac{20 \text{ GPM}}{.175 \text{ IN}} \times 3.85 \frac{\text{IN}^3/\text{SEC}}{\text{GPM}}\right)\left(\frac{1}{8.73 \text{ IN}^2}\right)\left(\frac{10 \text{ VDC}}{1.99 \text{ IN}}\right)$$

$$G = 4.43 \quad \text{SEC}^{-1}$$

This gain was selected to accommodate the large phase lag associated with the nonlinear digital control scheme. The stepping rate of the DART Valve produces a lag in the response inner loop. The low hydraulic gain of the servo valve around center produces proportionally longer time lags for smaller amplitudes. It was empirically found that the outer loop time constant of .23 seconds was required to eliminate all low amplitude oscillations.

5.0 BREADBOARD TESTING

The breadboard testing was divided into three phases. The first phase of testing was accomplished using an existing DART Valve on Bertea P/N 221400, Active Standby Actuator Assembly. The purpose of this test was to demonstrate the feasibility of closed loop control as shown on Figure 6. One of the significant problems uncovered during this first phase of testing was related to the data sampling technique used in the digital step selector. For subsequent test phases a sample and hold technique was used for data sampling.

Following the first phase of testing a manifold was designed and fabricated to interconnect two Microdrift Dart Valves to a nonlinear servo valve and hydraulic cylinder as shown in Figure 4. An electronic controller was also designed and packaged as shown in Figure 5. For phase two testing the block diagram (Figure 6) was modified to eliminate the feedback transducer on the servo valve. The inner loop was closed using an up - down counter to simulate the action of the DART Valve, servo valve, and position transducer. The output of the up - down counter was then used as a pseudofeedback to close the inner loop. This modified

5.0 BREADBOARD TESTING (Continued)

scheme was subjected to an intensive development program which attempted to align step sizes and limits between the electronic counter and hydromechanical integrator. This approach was finally abandoned as not being feasible with the existing mechanization.

Following termination of the phase two effort the hardware was modified to facilitate studying the major performance problem, the ability to produce precise hdyromechanical steps. These modifications and the third phase of testing were not originally scheduled for the program and accounted for a substantial slip in the scheduled completion of the program.

The third phase of testing proved successful and acceptable closed loop performance was obtained. The test procedure and results appearing in Appendix A and B define the third phase of testing in detail. The results of phase three testing indicated two problem areas which require further developmental effort. The first is step size inaccuracies and the second is limited frequency response.

5.0 BREADBOARD TESTING (Continued)

5.1 EFFECT OF LEAKAGE

The step size problems may be divided into two categories: leakage and fluid compressibility. Leakage may effect the step size by either causing steady state drift or dynamic drift. Steady state drift will result when fluid is allowed to leak from a source of pressure into one or both DART Valve control lines. The Microdrift DART Valve used for phase three testing eliminated internal steady state leakage through the use of a Microseal poppet to isolate the control lines from the source of pressure. Testing of the DART Valve indicated that this technique effectively reduced internal steady state leakage to zero.

Steady state drift may also be caused by leakage from the pressure source into the DART Valve control lines within the servo valve. The servo valve used for phase three testing eliminated all lap leakage into the control lines by venting control line lap leakage to return.

Fluid compressibility may affect step size if the control line experiences a change in pressure during the execution of a step. An increase in pressure will cause the

5.0 BREADBOARD TESTING (Continued)

5.1 EFFECT OF LEAKAGE (Continued)

fluid to compress and thereby increase the step size. The effect of fluid compressibility becomes a significant problem if leakage is allowed to reduce the fluid pressure step commands. In the hardware used for phase three testing, this effect resulted in a servo valve slide displacement equal to the desired "small" step. Therefore, the "small" step digitizer had to be reduced to zero stroke in order to achieve the desired "small" step size. This situation is most undesirable in that the "small" step size is now a function of control line pressure and leakage. In the extreme case the control line will bleed down to the extent that a "small" step command will not result in any slide valve displacement. In this case the summation error will accumulate until a "large" step threshold is exceeded. This effect may be observed in the test data presented in Appendix A.

The fluid compressibility problem is further complicated by the servo valve centering springs. These springs detent the valve to neutral and thereby cause the actuator to lock in it's last commanded position in

5.0 BREADBOARD TESTING (Continued)

5.1 EFFECT OF LEAKAGE (Continued)

the event of a loss of fluid pressure. However, when the servo valve is at neutral the detenting action of the springs degrades the performance of the "small" step function. It is suggested that further development work investigate the trade offs associated with lap leakage, step sizes, and detent springs.

5.2 EFFECT OF NONLINEARITY

Section 4.0 of this report described the nonlinear inner loop technique used to achieve fine resolution at the actuator output. This technique did improve resolution as predicted but had a detrimental effect on inner loop frequency response for small amplitude signals. This frequency response limitation is related to the finite stepping rate of the DART Valve. Since the servo valve flow gain is very low around neutral, several digital steps may be required to achieve a commanded flow rate. As each step requires 38 milliseconds to execute, the inner loop phase lag may be quite large. This inner loop phase lag limits the allowable outer loop gain and hence the over-all frequency response of the servo actuator.

5.0 BREADBOARD TESTING (Continued)

5.2 EFFECT OF NONLINEARITY (Continued)

The nonlinear inner loop is in some ways self-defeating as a technique for improving actuator resolution. As noted above, the nonlinear inner loop requires a lower outer loop gain that may be used with a linear inner loop. This reduced outer loop gain effectively increases the actuator displacements required to cycle the "small" step DART Valve. Further analyses are required to determine the optimum nonlinearity for a given application.

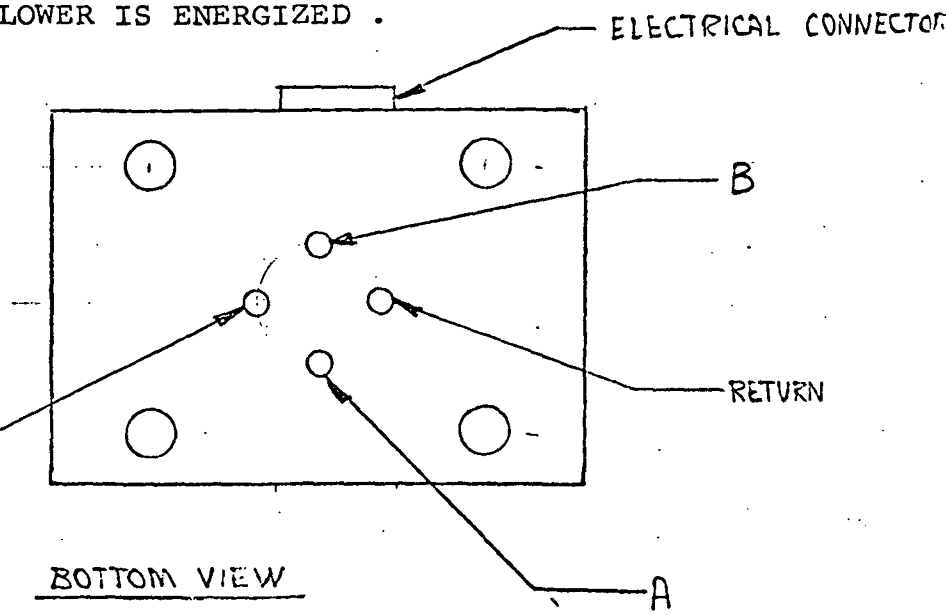
An alternate approach to improving the actuator frequency response would be to drive a hydromechanical actuator with a digital secondary actuator. This application of the digital valve does not require the high response inner loop characteristics of the application defined in this report. Also, the hydromechanical actuator will act as a filter on the output of the secondary digital actuator. It is suggested that the secondary actuator approach be considered for any further development work.

APPENDIX A

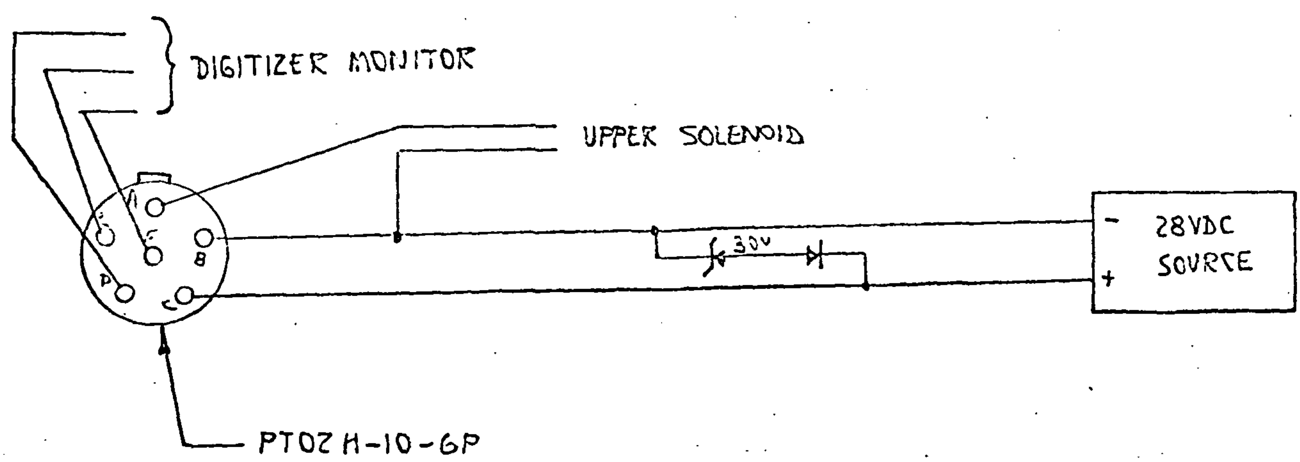
TEST RESULTS

1. TEST ALL 228200 DART VALVES TO THIS PROCEDURE.
2. TEST VALVE SLIDES TO 228212-T.
3. USE MIL-H-5606 FLUID AT 80 $\pm$ 20°F, 3000 PSI.
4. PERFORM TESTS IN ORDER NOTED.
5. RECORD RESULTS ON A COPY OF THIS PROCEDURE.
6. FLOW IS OUT OF B PORT WHEN ONLY THE UPPER SOLENOID IS ENERGIZED; OUT A WHEN ONLY LOWER IS ENERGIZED .

PORT LOCATIONS (REF)



BOTTOM VIEW



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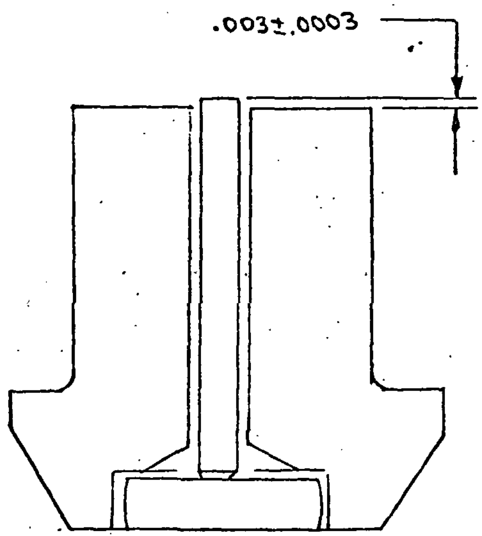
PRODUCTION TEST PROCEDURE

DRAWN BY RJa DATE

CHECK BY DATE

TEST		PROCEDURE	REQUIREMENT
1.	SOLENOID TRIM		UPPER SOLENOID .003 LOWER SOLENOID .003
2.	RESISTANCE	MUST BE 50-60 OHMS BETWEEN A-B OR B-C MUST BE 550-650Ω BETWEEN D-E OR E-F	A-B ✓ Ω B-C ✓ Ω D-E ✓ Ω E-F ✓ Ω
3.	SOLENOID TIME CONSTANT	RECORD PULL-IN AND DROP-OUT VOLTAGE AND CURRENT. 3 MS MAX PULL-IN, 4 MS MAX DROP-OUT. SET SUPPLY PRESSURE AT 3000 PSI	NO ARC SUPPRESSION PULL-IN UPPER 5 MS LOWER 5 MS DROP-OUT UPPER 1 MS LOWER 1 MS
4.	INTERNAL LEAKAGE	APPLY 28VDC TO BOTH SOLENOIDS. MEASURE LEAKAGE AT A, B, AND R, 10 CC/MIN MAX EACH PORT	A 0 CC/MIN B 0 CC/MIN R 25 CC/MIN OK RJa

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PG. 2 OF

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PRODUCTION TEST PROCEDURE

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5.	ORIFICE SIZE	APPLY 28VDC TO UPPER SOLENOID. FLOW AT A MUST BE 1650 TO 2000 CC/MIN. REPEAT FOR B.	A 1950 CC/MIN B 1950 CC/MIN
6.	SWITCH POINT	APPLY 28VDC TO UPPER SOLENOID. RESTRICT FLOW AT A. MEASURE BACK PRESSURE FOR 1200 CC/MIN.	A 1500 PSI B 1155 PSI
7.	INTER-FLOW	MEASURE FLOW FROM R DURING ABOVE TEST. REFERENCE ONLY.	(A) 1350 CC/MIN (B) 1350 CC/MIN

CONNECT DART VALVE ASSEMBLY TO SK 51772 RESPONSE ACTUATOR. USE 228240-101 HARNESS TO CONNECT DART VALVE TO 224250 CONTROLLER TEST CONTROLLER PER 228250T BEFORE USE.

CYLINDER BORE .500 IN, ROD ——, AREA .196 IN²

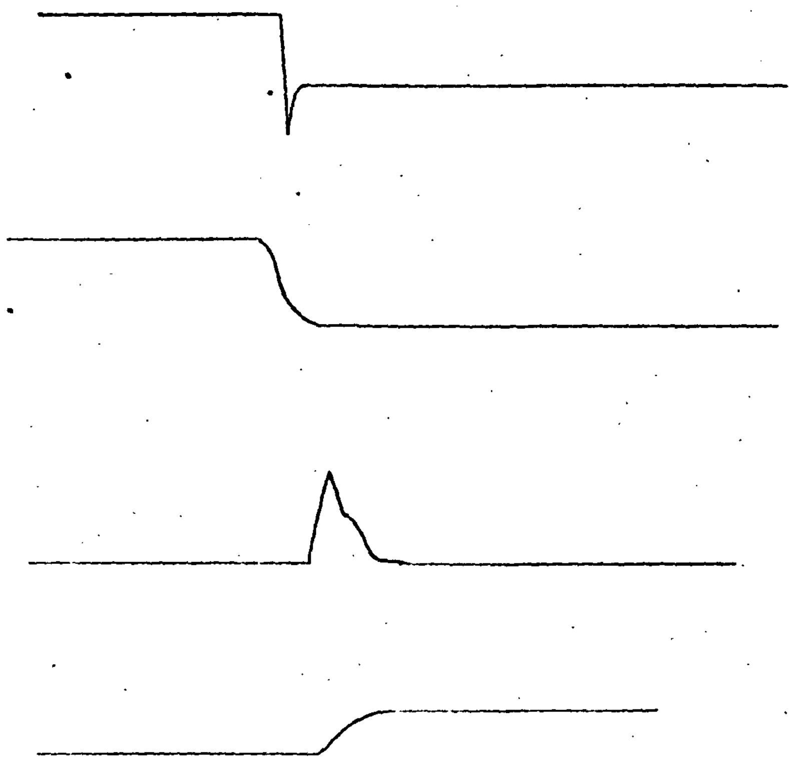
8.	DIGITIZER LEAKAGE	APPLY 300 PSI TO P WITH ONLY LOWER SOLENOID ENERGIZED. MEASURE CHANGE IN LEAKAGE AT R WHEN 2000 PSI IS APPLIED AT A. REPEAT FOR LOWER VALVE.	A 1.5 CC/MIN B 5.0 CC/MIN

S/N 100

228200T

9.	DRIFT	ENERGIZE BOTH SOLENOIDS. MEASURE ACTUATOR DRIFT RATE.	0 IN/SEC

10. APPLY 3000 PSI TO PRESSURE PORT. MONITOR VELOCITY TRANSDUCER ON OSCILLOGRAPH. WITH UPPER SOLENOID ENERGIZED RECORD TURN-ON AND TURN-OFF FOR LOWER SOLENOID. REPEAT WITH LOWER ENERGIZE. RECORD SOLENOID VOLTAGE AND CURRENT, VELOCITY AND POSITION OF RESPONSE ACTUATOR. (180 MV/IN/SEC/.196IN^2 = 920 MV/IN^3/SEC = 1 MV/CC/MIN) ATTACH RECORDING TO TEST RESULTS. IDENTIFY AS NOTED BELOW.



SOLENOID VOLTAGE

SOLENOID CURRENT

VELOCITY TRANSDUCER

POSITION TRANSDUCER

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PRODUCTION TEST PROCEDURE

DRAWN BY R?C? DATE

CHECK BY DATE

11.	DIGITIZER TRIM	TRIM DIGITIZER STOPS TO OBTAIN NOTED STEP SIZES. AT 40 STEPS/SEC.	UPPER .0104 IN^3 LOWER .0110 IN^3

S/N	COUNT	SIZE
001	~~2~~ 4	~~.00137~~
002	5	.00684

MUST AGREE WITH ±10%

.053 x .196 = .0104
.056 x .196 = .0110

BERTEA CORPORATION IRVINE • CALIFORNIA

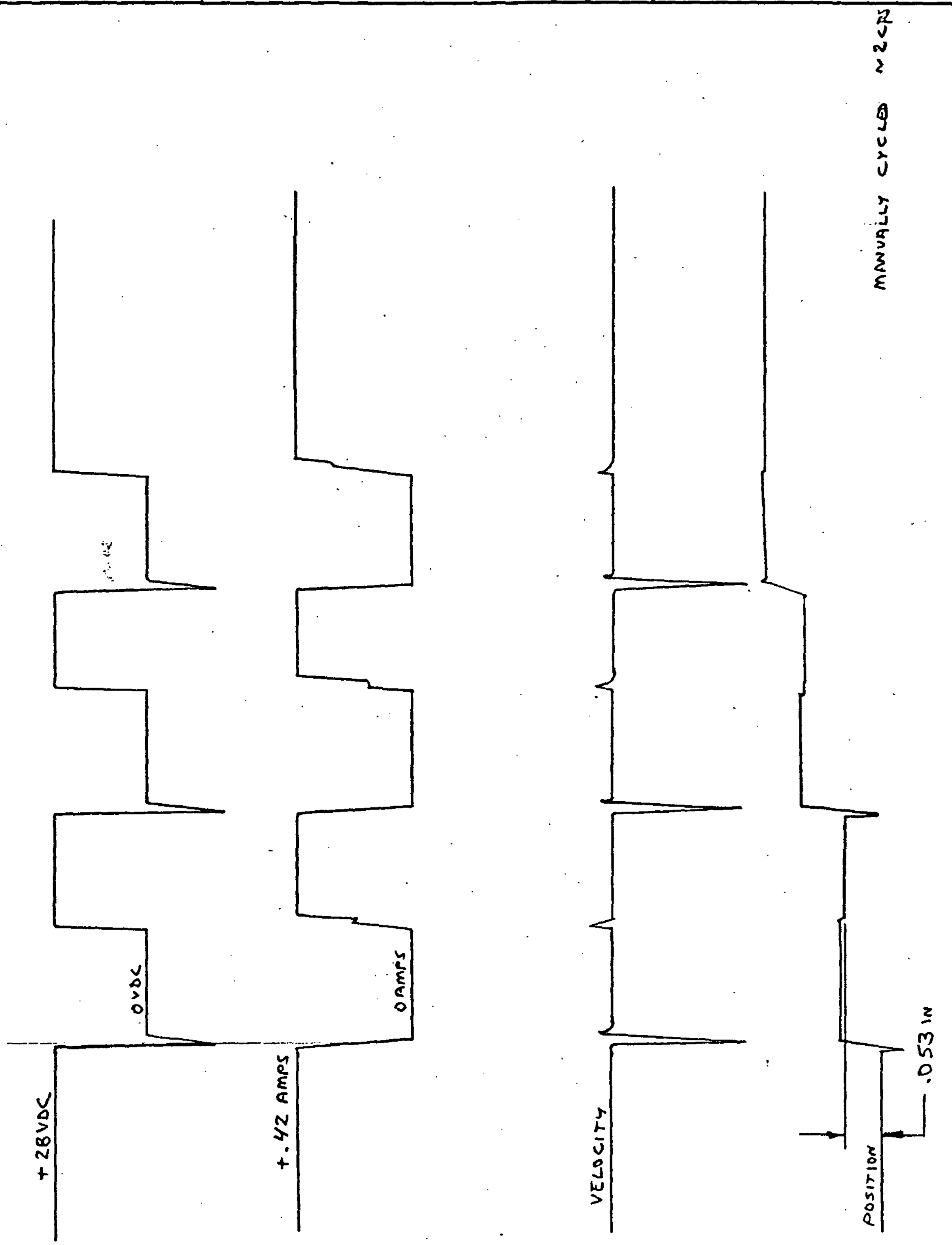
PRODUCTION TEST PROCEDURE

DRAWN BY ______ DATE ______

CHECK BY DATE

PART NO: 228200	SERIAL NO: 001	VALVE NO: UPPER	DATE: 1-9-73
IBM NO:	PART NAME DART VALVE		INSP: DW

TEST	REQUIREMENTS	RESULTS	ACC.	REJ.



TEST 10

PG. OF

228200T

BERTEA CORPORATION IRVINE • CALIFORNIA

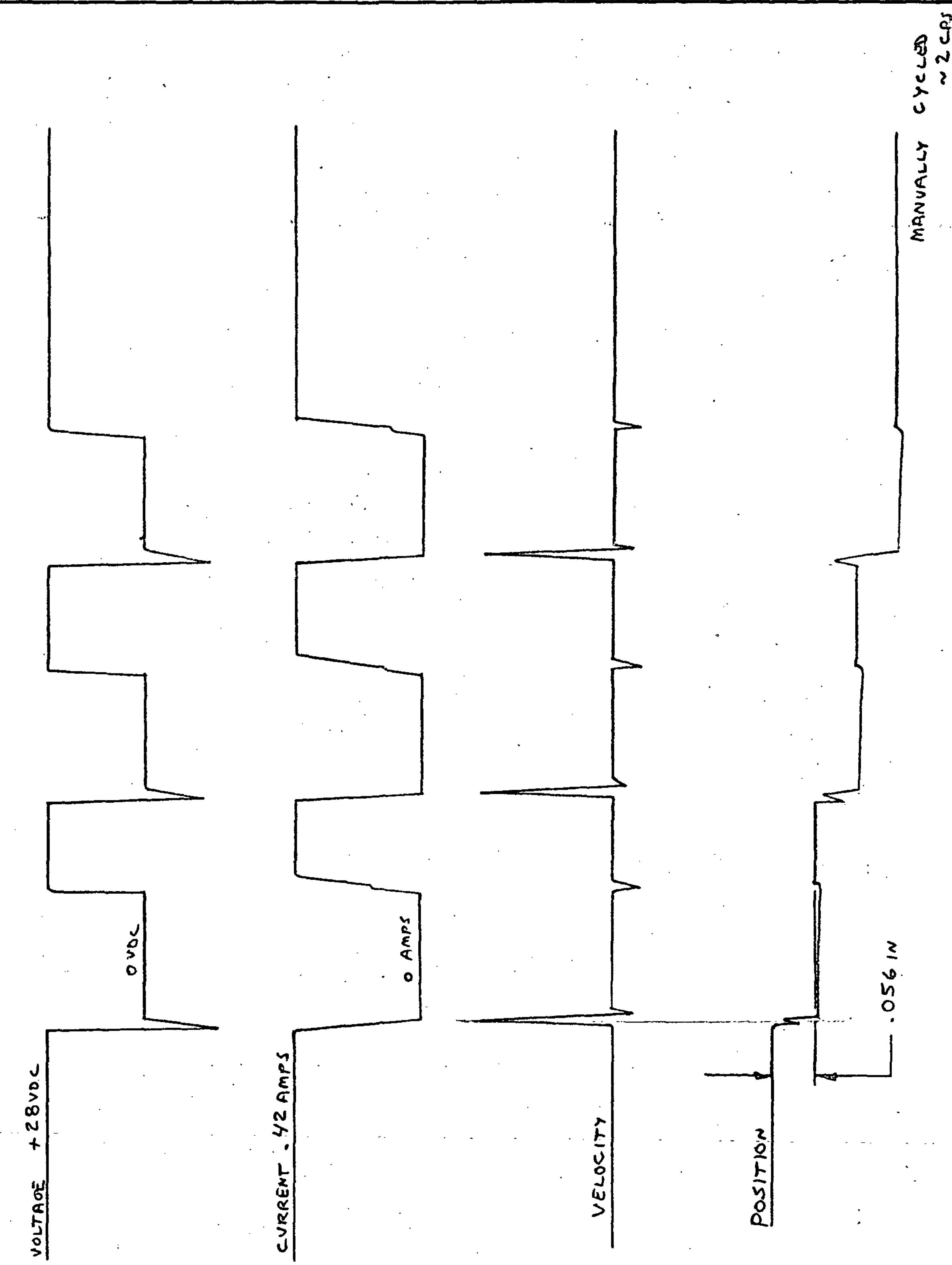
PRODUCTION TEST PROCEDURE

DRAWN BY ______________ DATE ________

CHECK BY DATE

PART NO: 228200	SERIAL NO: 001	VALVE NO: Lower	DATE: 1-9-73
IBM NO:	PART NAME: DART VALVE		INSP: DW

TEST	REQUIREMENTS	RESULTS	ACC.	REJ.



228200T

PG. OF

TEST 10

BERTEA CORPORATION IRVINE • CALIFORNIA

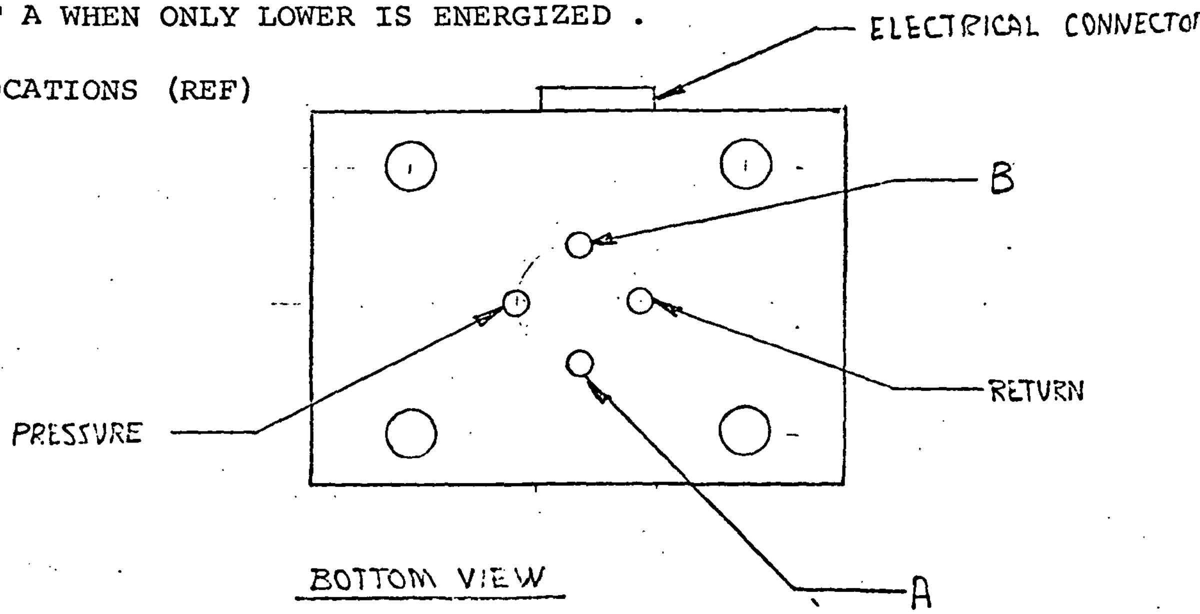
PRODUCTION TEST PROCEDURE

DRAWN BY Rda DATE

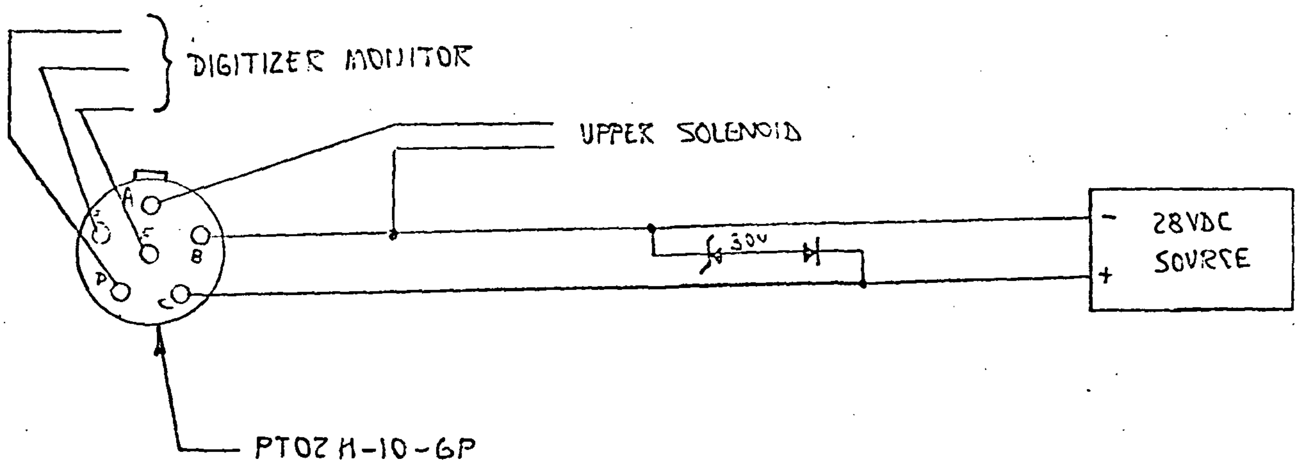
CHECK BY DATE

1. TEST ALL 228200 DART VALVES TO THIS PROCEDURE.
2. TEST VALVE SLIDES TO 228212-T.
3. USE MIL-H-5606 FLUID AT 80 $\pm$ 20^{o}F, 3000 PSI.
4. PERFORM TESTS IN ORDER NOTED.
5. RECORD RESULTS ON A COPY OF THIS PROCEDURE.
6. FLOW IS OUT OF B PORT WHEN ONLY THE UPPER SOLENOID IS ENERGIZED; OUT A WHEN ONLY LOWER IS ENERGIZED .

PORT LOCATIONS (REF)



BOTTOM VIEW

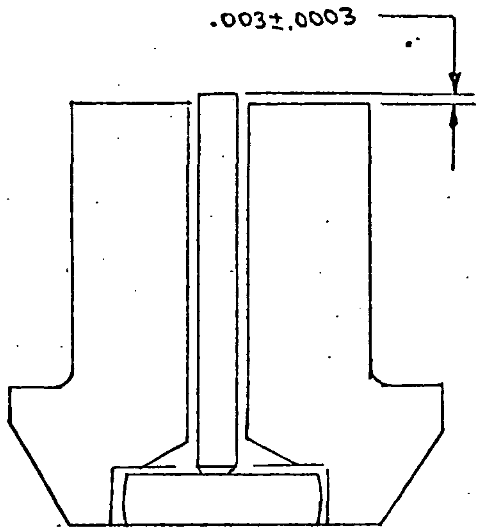


BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY RJa DATE

CHECK BY DATE

	TEST	PROCEDURE	REQUIREMENT
1.	SOLENOID TRIM		UPPER SOLENOID .003 LOWER SOLENOID .003
2.	RESISTANCE	MUST BE 50-60 OHMS BETWEEN A-B OR B-C MUST BE 550-650Ω BETWEEN D-E OR E-F	A-B ✓ Ω B-C ✓ Ω D-E ✓ Ω E-F ✓ Ω
3.	SOLENOID TIME CONSTANT	RECORD PULL-IN AND DROP-OUT VOLTAGE AND CURRENT. 3 MS MAX PULL-IN, 4 MS MAX DROP-OUT. SET SUPPLY PRESSURE AT 3000 PSI	NO ARC SUPPRESSION PULL-IN UPPER 6 MS LOWER 5 MS DROP-OUT UPPER 1 MS LOWER 1 MS
4.	INTERNAL LEAKAGE	APPLY 28VDC TO BOTH SOLENOIDS. MEASURE LEAKAGE AT A, B, AND R, 10 CC/MIN MAX EACH PORT	A 0 CC/MIN B 0 CC/MIN R 1.5 CC/MIN

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BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY RJa DATE
CHECK BY DATE

5.	ORIFICE SIZE	APPLY 28VDC TO UPPER SOLENOID. FLOW AT A MUST BE 1650 TO 2000 CC/MIN. REPEAT FOR B.	A 1950 CC/MIN B 2000 CC/MIN
6.	SWITCH POINT	APPLY 28VDC TO UPPER SOLENOID. RESTRICT FLOW AT A. MEASURE BACK PRESSURE FOR 1200 CC/MIN.	A 1950 PSI B 1155 PSI
7.	INTER-FLOW	MEASURE FLOW FROM R DURING ABOVE TEST. REFERENCE ONLY.	(A) 1300 CC/MIN (B) 1300 CC/MIN

CONNECT DART VALVE ASSEMBLY TO SK 51772 RESPONSE ACTUATOR. USE 228240-101 HARNESS TO CONNECT DART VALVE TO 224250 CONTROLLER TEST CONTROLLER PER 228250T BEFORE USE.

CYLINDER BORE .500 IN, ROD —, AREA .196 IN^2

8.	DIGITIZER LEAKAGE	APPLY 300 PSI TO P WITH ONLY LOWER SOLENOID ENERGIZED. MEASURE CHANGE IN LEAKAGE AT R WHEN 2000 PSI IS APPLIED AT A. REPEAT FOR LOWER VALVE.	A .8 CC/MIN B 1.0 CC/MIN

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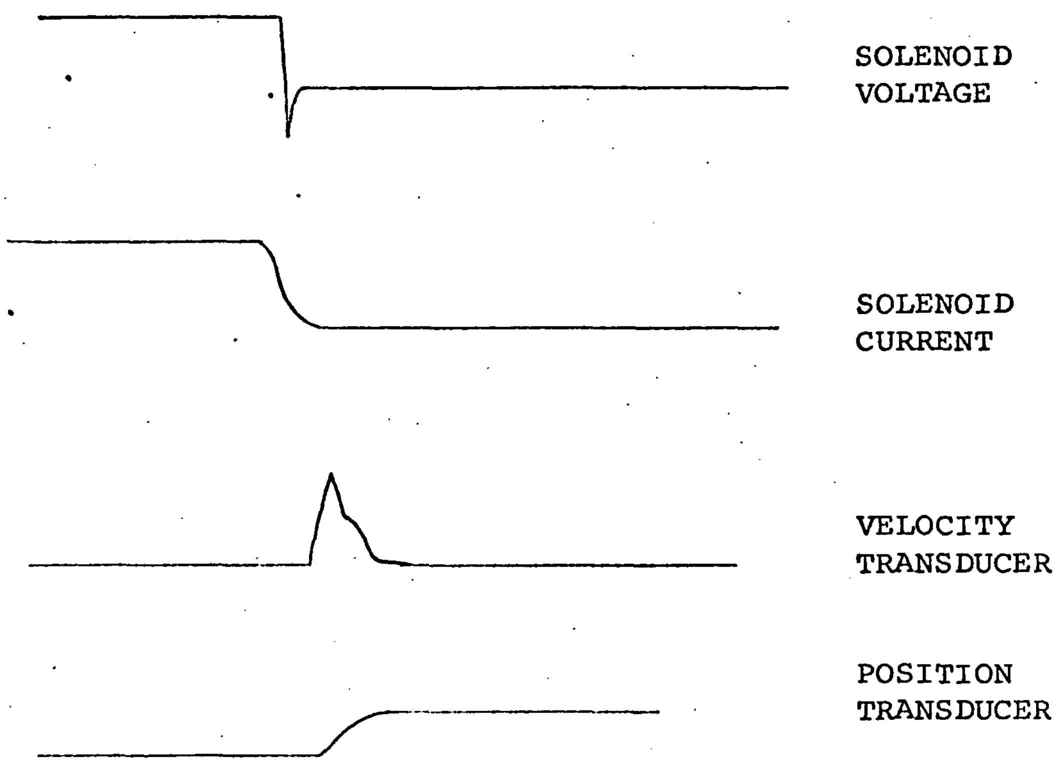
S/N 002

228200T

9.	DRIFT	ENERGIZE BOTH SOLENOIDS. MEASURE ACTUATOR DRIFT RATE.	0 IN/SEC

10. APPLY 3000 PSI TO PRESSURE PORT. MONITOR VELOCITY TRANSDUCER ON OSCILLOGRAPH. WITH UPPER SOLENOID ENERGIZED RECORD TURN-ON AND TURN-OFF FOR LOWER SOLENOID. REPEAT WITH LOWER ENERGIZE. RECORD SOLENOID VOLTAGE AND CURRENT, VELOCITY AND POSITION OF RESPONSE ACTUATOR. ($180\ MV/IN/SEC/.196IN^2 = 920\ MV/IN^3/SEC = 1\ MV/CC/MIN$) ATTACH RECORDING TO TEST RESULTS. IDENTIFY AS NOTED BELOW.



BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY RYCA DATE

CHECK BY DATE

11.	DIGITIZER TRIM	TRIM DIGITIZER STOPS TO OBTAIN NOTED STEP SIZES. AT 40 STEPS/SEC. S/N — COUNT — SIZE 001 — 1 — .00137 002 — 5 — .00684 MUST AGREE WITH ±10%	UPPER .0127 IN^3 LOWER .0116 IN^3 .065 x .196 = .0127 .059 x .196 = .0116

S/N 002

228200T

BERTEA CORPORATION IRVINE • CALIFORNIA

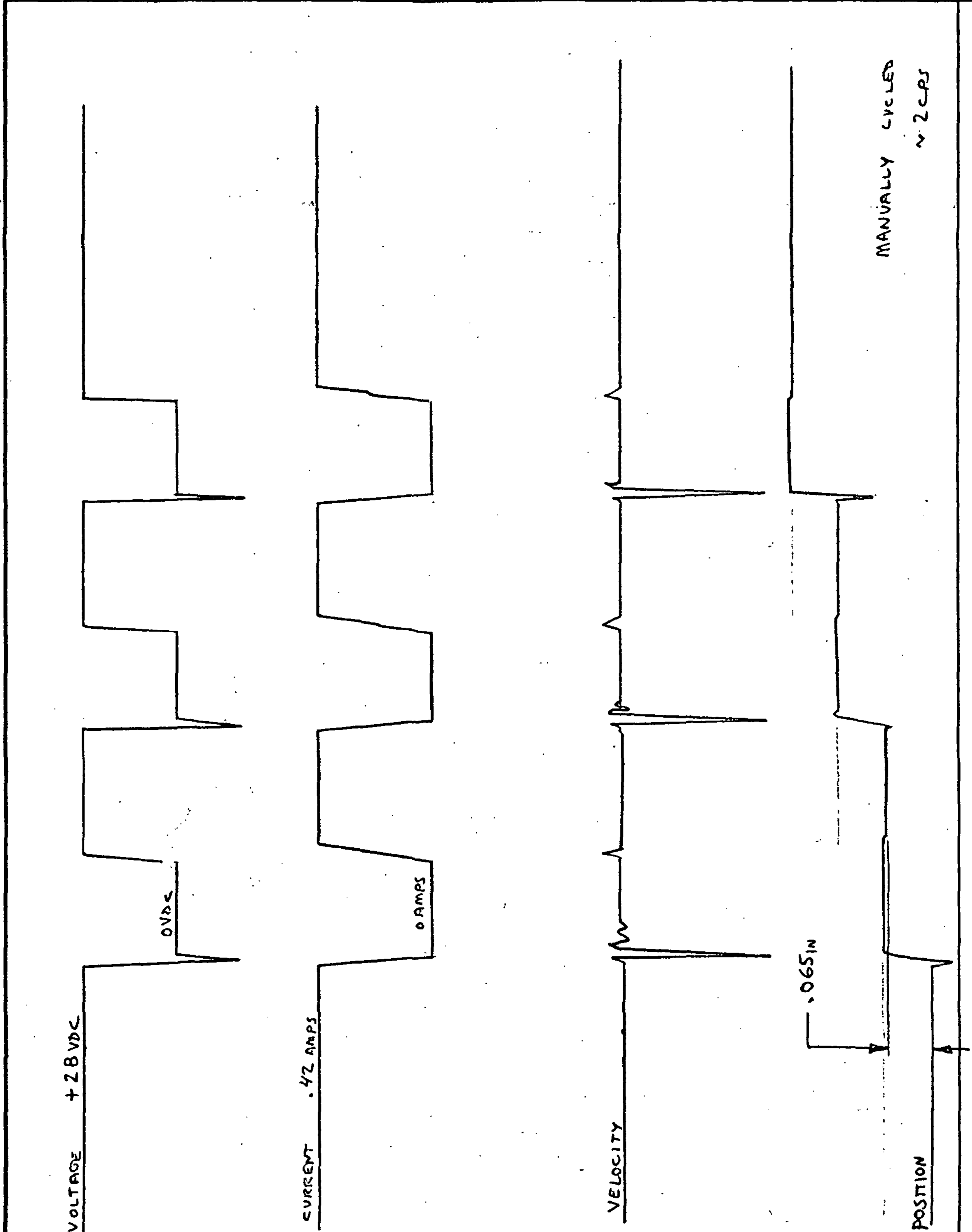
PRODUCTION TEST PROCEDURE

DRAWN BY ______ DATE ______

CHECK BY ______ DATE ______

PART NO: 228200	SERIAL NO: 002	VALVE NO: UPPER	DATE: 1-9-73
IBM NO:	PART NAME DART VALVE		INSP: DW

TEST	REQUIREMENTS	RESULTS	ACC.	REJ.



228200T PG. OF TEST 10

BERTEA CORPORATION IRVINE • CALIFORNIA

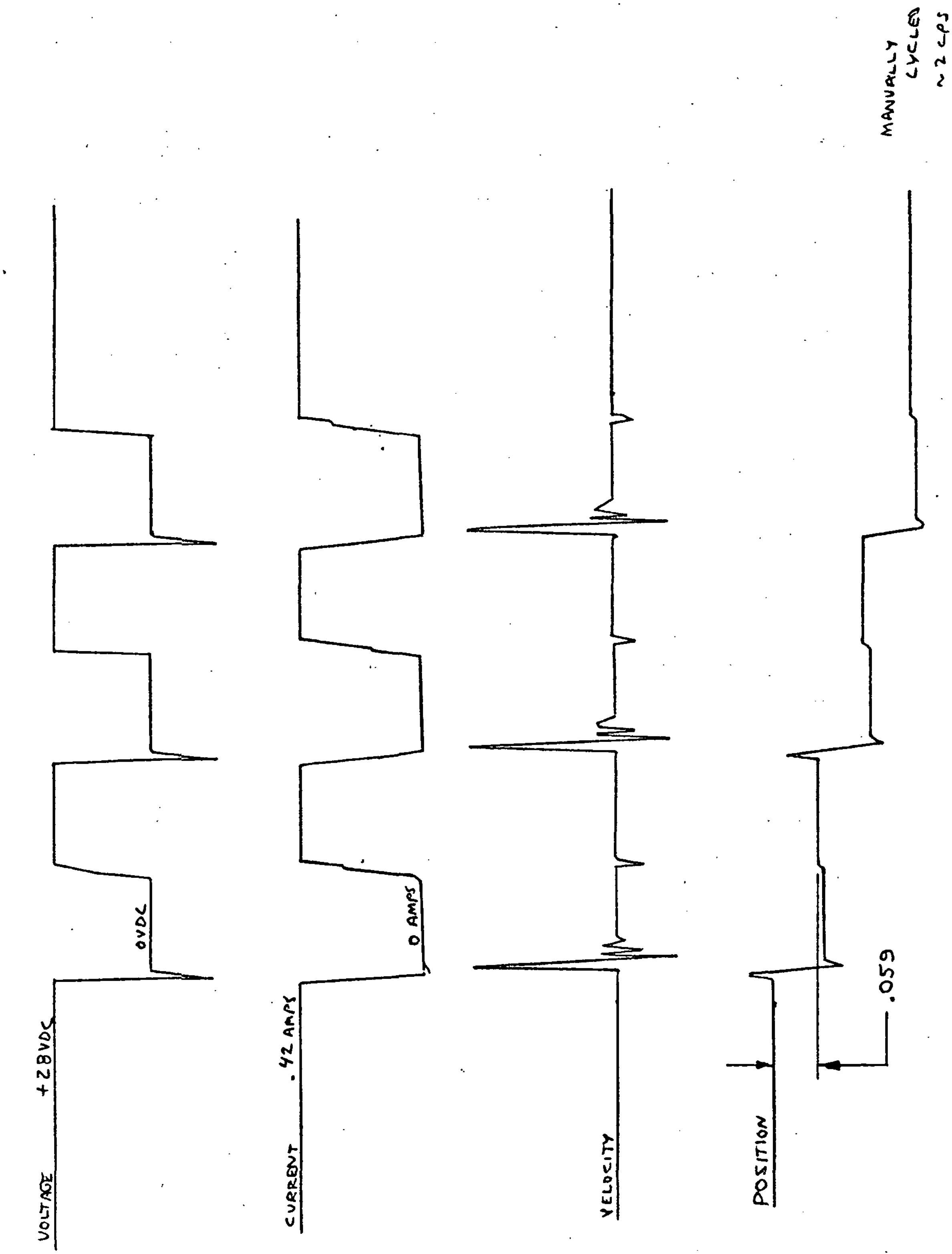
PRODUCTION TEST PROCEDURE

DRAWN BY ____________ DATE ________

CHECK BY DATE

PART NO: 228200	SERIAL NO: 002	VALVE NO: LOWER	DATE: 1-9-73
IBM NO:	PART NAME DART VALVE		INSP: DW

TEST	REQUIREMENTS	RESULTS	ACC.	REJ.



228200T

PG. OF

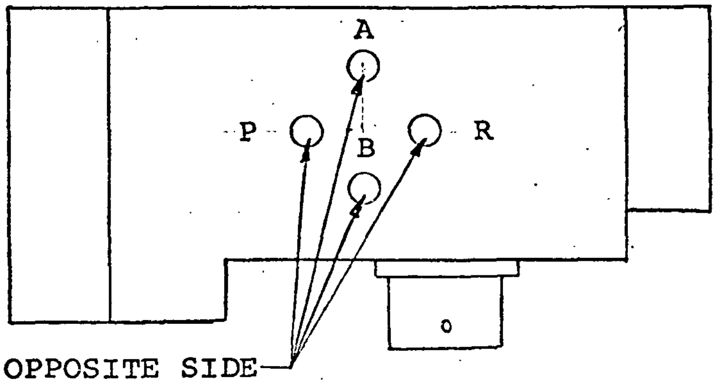
TEST 10

DART VALVE SLIDE TEST

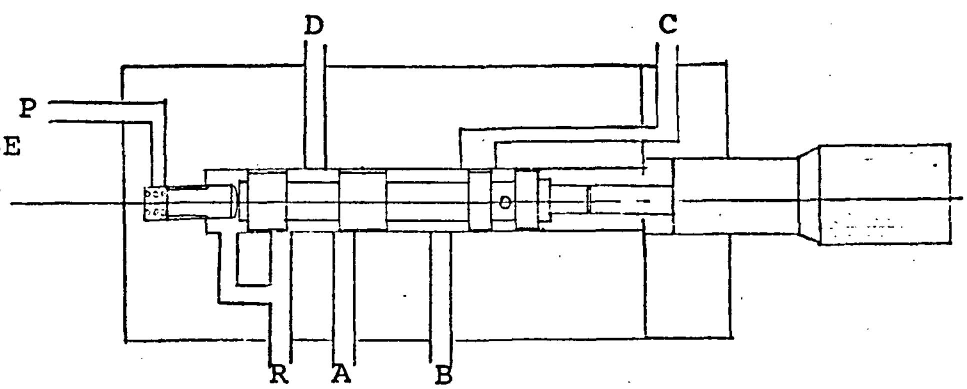
1. TEST BOTH UPPER AND LOWER LAP ASSEMBLIES TO THIS PROCEDURE.
2. TEST DIGITIZER ASSEMBLIES PER 228220-T BEFORE INSTALLING IN VALVE HOUSING.
3. USE MIL-H-5606 FLUID AT $80^{\circ} \pm 20^{\circ}F$. DO NOT APPLY MORE THAN 1500 PSI TO TEST FIXTURE.
4. RECORD TEST RESULTS ON A COPY OF THIS PROCEDURE.

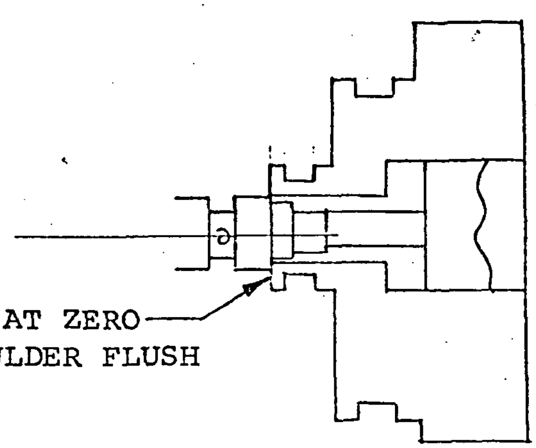
TOP VIEW

PORT LOCATION



UPPER VALVE PORTING (REVERSE A & B FOR LOWER VALVE)





SET MICROMETER AT ZERO WITH SLIDE SHOULDER FLUSH WITH THIS FACE

BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY ________ DATE ________

CHECK BY ________ DATE ________

LOWER VALVE (MAINTAIN UPPER SOLENOID ENERGIZED)

1. MEASURE VALVE STROKE TO "+" AND "-" STOPS. MUST BE .090 ± .003 IN PLUS DIRECTION.
RECORD READING +.090 INCHES
-— INCHES

2. APPLY 700 PSI TO B. VENT P, R, A, AND C.

EXTEND VALVE SLIDE AND MONITOR 2WDT OUTPUT. RECORD VALVE POSITION WHICH CAUSES DIGITIZER PISTON TO BOTTOM. RETRACT VALVE SLIDE AND RECORD POSITION WHICH ALLOWS DIGITIZER PISTON TO RESET. (TO AVOID LEAKAGE INTERFERENCE, THE RECORDED SLIDE POSITIONS SHOULD CAUSE THE DIGITIZER TO EXTEND OR RETRACT IN LESS THAN 1 SECOND.) MUST AGREE WITH FIGURE 1.

.036 IN TO BOTTOM DIGITIZER .040 IN TO RESET

3. APPLY 200 PSI TO C. VENT P, R, B, AND A.

EXTEND VALVE SLIDE AND RECORD POSITION FOR APPROXIMATELY .1, .2, .3, .4, .5, 1, AND 2 GPM AT A OR R. MUST AGREE WITH FIGURE 1.

FLOW AT R

.018	IN	0	GPM
.021	IN	.1	GPM
.024	IN	.2	GPM
.028	IN	.3	GPM
.033	IN	.4	GPM
.041	IN	.5	GPM
.090	IN	.52	GPM

FLOW AT A

.040	IN	0	GPM
.037	IN	.1	GPM
.035	IN	.2	GPM
.032	IN	.3	GPM
.030	IN	.4	GPM
.022	IN	.6	GPM
.017	IN	.7	GPM
-.002		.75	

4. APPLY 200 PSI AT P. RECORD LEAKAGE AT R FOR VALVE SLIDE FULLY RETRACTED AND FULLY EXTENDED. RECORD FLOW AT C.

— CC/MIN AT "+" STOP — CC/MIN AT "-" STOP
— CC/MIN AT C

5. APPLY 1500 PSI AT B. RECORD LEAKAGE AT R AND A FOR VALVE SLIDE AT "+" STOP.

— CC/MIN AT R — CC/MIN AT A

6. APPLY 1500 PSI AT A. RECORD LEAKAGE AT R AND B FOR VALVE SLIDE AT "+" STOP.

— CC/MIN AT R — CC/MIN AT B

BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY ______ DATE ______
CHECK BY ______ DATE ______

LOWER VALVE (Continued)

7. WITH VALVE AT "-" STOP. RECORD PRESSURE AT B TO MOVE DIGITIZER PISTON.

INCREASING — PSI TO START — PSI TO BOTTOM
DECREASING — PSI TO START — PSI TO RESET

UPPER VALVE (MAINTAIN LOWER SOLENOID ENERGIZED)

8. MEASURE VALVE STROKE TO "+" AND "-" STOPS. MUST BE .090 ± .003 IN PLUS DIRECTION.

RECORD READING + .091 INCHES
− .040 INCHES

9. APPLY 700 PSI TO A. VENT P, R, B, AND C.

EXTEND VALVE SLIDE AND MONITOR 2WDT OUTPUT. RECORD VALVE POSITION WHICH CAUSES DIGITIZER PISTON TO BOTTOM. RETRACT VALVE SLIDE AND RECORD POSITION WHICH ALLOWS DIGITIZER PISTON TO RESET. (TO AVOID LEAKAGE INTERFERENCE, THE RECORDED SLIDE POSITIONS SHOULD CAUSE THE DIGITIZER TO EXTEND OR RETRACT IN LESS THAN 1 SECOND.) MUST AGREE WITH FIGURE 1.

.035 IN TO BOTTOM DIGITIZER .037 IN TO RESET

10. APPLY 200 PSI TO C. VENT P, R, A, AND B. EXTEND VALVE SLIDE AND RECORD POSITION FOR APPROXIMATELY .1, .2, .3, .4, .5, 1, AND 2 GPM AT B OR R. MUST AGREE WITH FIGURE 1.

FLOW AT R		FLOW AT B	
.018 IN	0 GPM	.037 IN	.1 GPM
.022 IN	.1 GPM	.035 IN	.2 GPM
.024 IN	.2 GPM	.033 IN	.3 GPM
.027 IN	.3 GPM	.030 IN	.4 GPM
.032 IN	.4 GPM	.027 IN	.5 GPM
.040 IN	.5 GPM	.022 IN	.6 GPM
.056 IN	.52 GPM	.017 IN	.7 GPM
		.000	.74

11. APPLY 200 PSI AT P. RECORD LEAKAGE AT R FOR VALVE SLIDE FULLY RETRACTED AND FULLY EXTENDED. RECORD AT C.

1 CC/MIN AT "+" STOP 1 CC/MIN AT " " STOP
0 CC/MIN AT C

228212-T PG. 3 OF S/N 001 228212-T

UPPER VALVE (Continued)

12. APPLY 1500 PSI AT A. RECORD LEAKAGE AT R AND B FOR VALVE SLIDE AT "+" STOP.

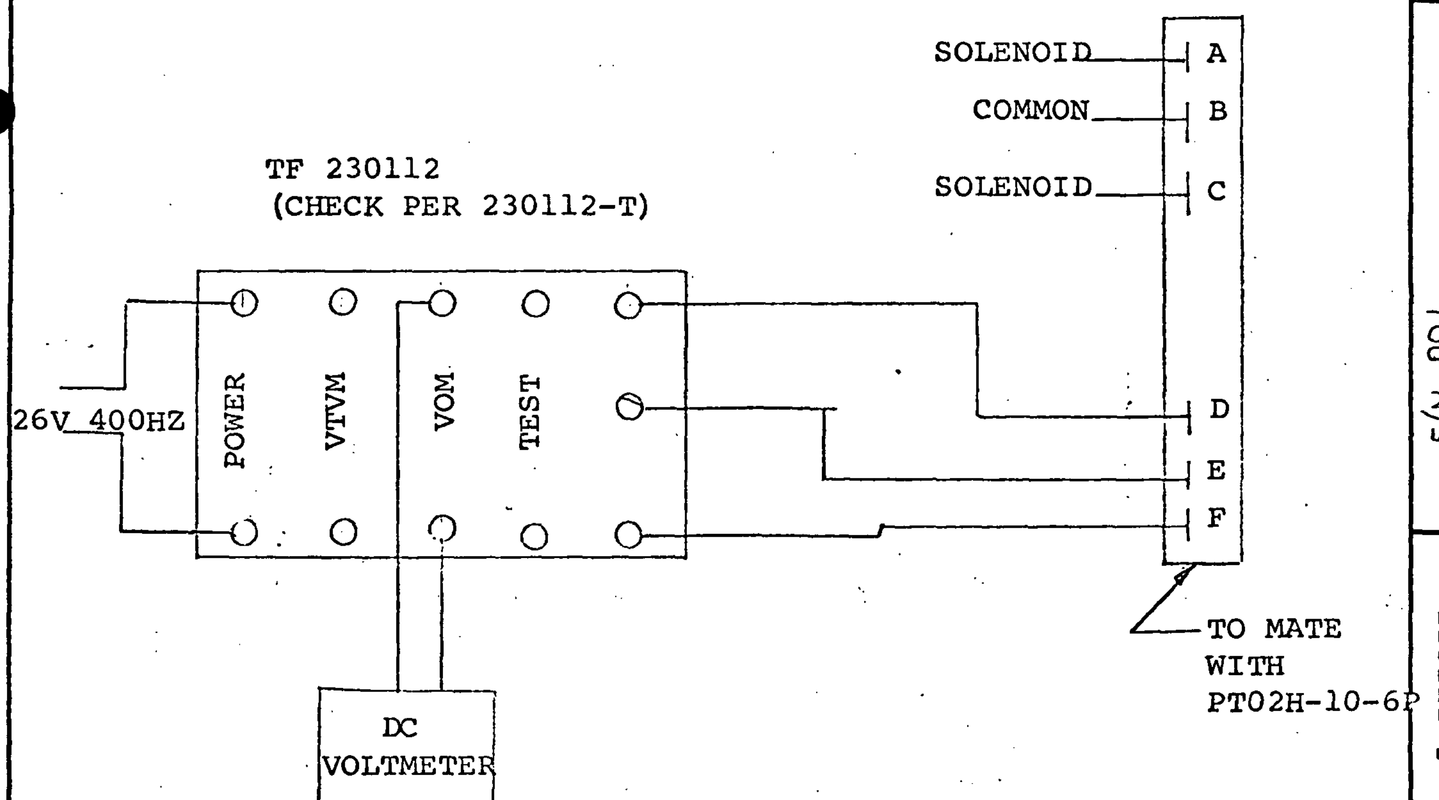
3 CC/MIN AT R 4 CC/MIN AT B

13. APPLY 1500 PSI AT B. RECORD LEAKAGE AT R AND A FOR VALVE SLIDE AT "+" STOP.

3 CC/MIN AT R 5 CC/MIN AT A

14. WITH VALVE AT "-" STOP RECORD PRESSURE AT A TO MOVE DIGITIZER PISTON.

INCREASING 550 PSI TO START 800 PSI TO BOTTOM
DECREASING — PSI TO START — PSI TO RESET



BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY ______________ DATE ________

CHECK BY DATE

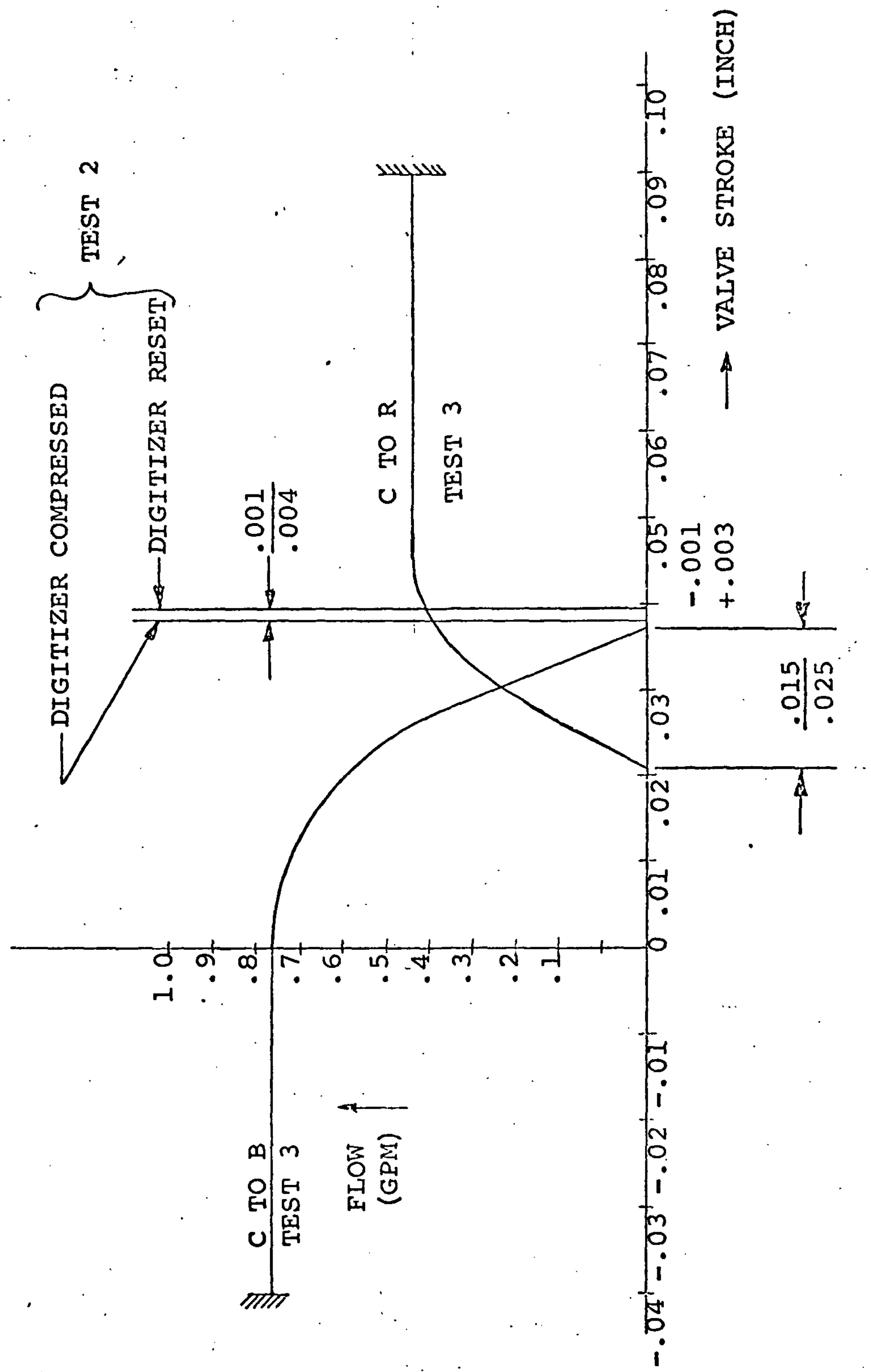


FIGURE I

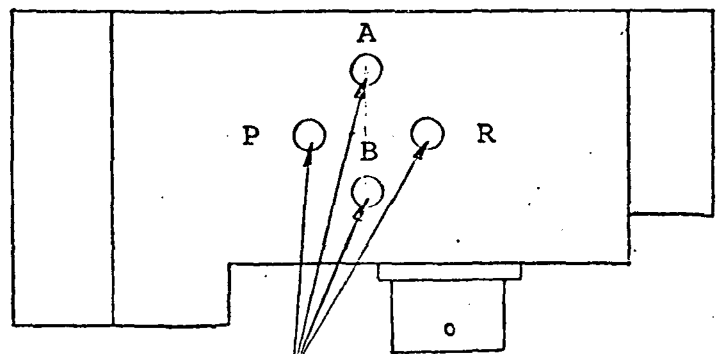
228212-T

DART VALVE SLIDE TEST

1. TEST BOTH UPPER AND LOWER LAP ASSEMBLIES TO THIS PROCEDURE.
2. TEST DIGITIZER ASSEMBLIES PER 228220-T BEFORE INSTALLING IN VALVE HOUSING.
3. USE MIL-H-5606 FLUID AT $80^{\circ} \pm 20^{\circ}F$. DO NOT APPLY MORE THAN 1500 PSI TO TEST FIXTURE.
4. RECORD TEST RESULTS ON A COPY OF THIS PROCEDURE.

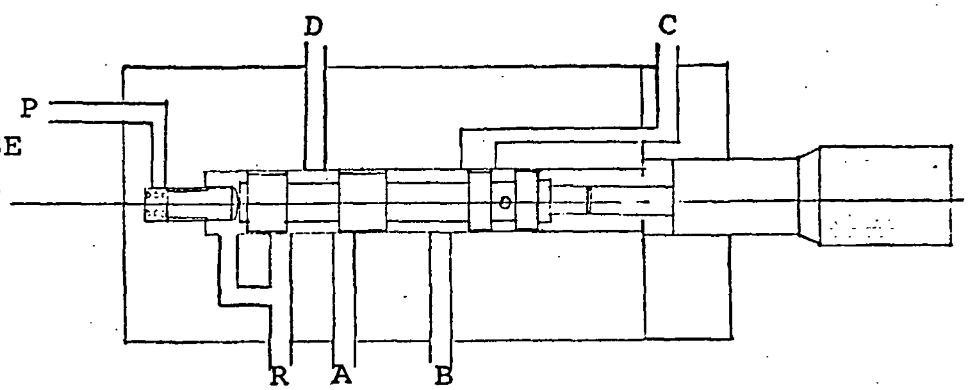
TOP VIEW

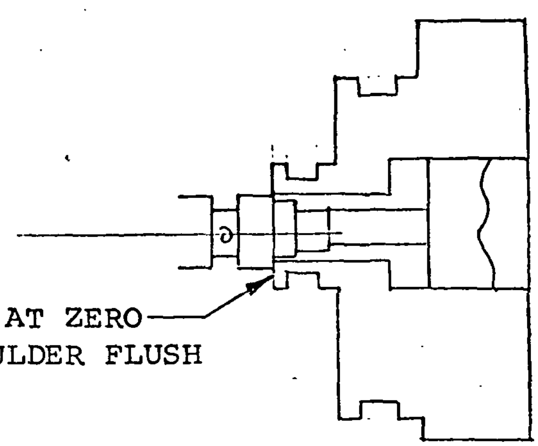
PORT LOCATION



OPPOSITE SIDE

UPPER VALVE PORTING (REVERSE A & B FOR LOWER VALVE)





SET MICROMETER AT ZERO WITH SLIDE SHOULDER FLUSH WITH THIS FACE

BERTEA CORPORATION IRVINE • CALIFORNIA | PRODUCTION TEST PROCEDURE | DRAWN BY ______ DATE ______ CHECK BY DATE

LOWER VALVE (MAINTAIN UPPER SOLENOID ENERGIZED)

1. MEASURE VALVE STROKE TO "+" AND "-" STOPS. MUST BE .090 ± .003 IN PLUS DIRECTION.
RECORD READING + .089 INCHES
- — INCHES

2. APPLY 700 PSI TO B. VENT P, R, A, AND C.

EXTEND VALVE SLIDE AND MONITOR 2WDT OUTPUT. RECORD VALVE POSITION WHICH CAUSES DIGITIZER PISTON TO BOTTOM. RETRACT VALVE SLIDE AND RECORD POSITION WHICH ALLOWS DIGITIZER PISTON TO RESET. (TO AVOID LEAKAGE INTERFERENCE, THE RECORDED SLIDE POSITIONS SHOULD CAUSE THE DIGITIZER TO EXTEND OR RETRACT IN LESS THAN 1 SECOND.) MUST AGREE WITH FIGURE 1.

.036 IN TO BOTTOM DIGITIZER   OUT OF REQUIREMENTS / OK RLA   .044 IN TO RESET

3. APPLY 200 PSI TO C. VENT P, R, B, AND A.

EXTEND VALVE SLIDE AND RECORD POSITION FOR APPROXIMATELY .1, .2, .3, .4, .5, 1, AND 2 GPM AT A OR R. MUST AGREE WITH FIGURE 1.

FLOW AT R				FLOW AT A			
+.020	IN	0	GPM	+.045	IN	0	GPM
+.024	IN	.1	GPM	.043	IN	.1	GPM
.027	IN	.2	GPM	.041	IN	.2	GPM
.033	IN	.3	GPM	.038	IN	.3	GPM
.039	IN	.4	GPM	.035	IN	.4	GPM
.047	IN	.5	GPM	.032	IN	.5	GPM
.057	IN	.52	GPM	.027 / 0	IN	.6 / .75	GPM

4. APPLY ~~80~~ 3000 PSI AT P. RECORD LEAKAGE AT R FOR VALVE SLIDE FULLY RETRACTED AND FULLY EXTENDED. RECORD FLOW AT C.

10 CC/MIN AT "+" STOP   5 CC/MIN AT "-" STOP
— CC/MIN AT C

5. APPLY 1500 PSI AT B. RECORD LEAKAGE AT R AND A FOR VALVE SLIDE AT "+" STOP.

— CC/MIN AT R   — CC/MIN AT A

6. APPLY 1500 PSI AT A. RECORD LEAKAGE AT R AND B FOR VALVE SLIDE AT "+" STOP.

— CC/MIN AT R   — CC/MIN AT B

LOWER VALVE (Continued)

7. WITH VALVE AT "-" STOP. RECORD PRESSURE AT B TO MOVE DIGITIZER PISTON.

INCREASING — PSI TO START — PSI TO BOTTOM
DECREASING — PSI TO START — PSI TO RESET

UPPER VALVE (MAINTAIN LOWER SOLENOID ENERGIZED)

8. MEASURE VALVE STROKE TO "+" AND "-" STOPS. MUST BE .090 ± .003 IN PLUS DIRECTION.

RECORD READING + .091 INCHES
− — INCHES

9. APPLY 700 PSI TO A. VENT P, R, B, AND C.

EXTEND VALVE SLIDE AND MONITOR 2WDT OUTPUT. RECORD VALVE POSITION WHICH CAUSES DIGITIZER PISTON TO BOTTOM. RETRACT VALVE SLIDE AND RECORD POSITION WHICH ALLOWS DIGITIZER PISTON TO RESET. (TO AVOID LEAKAGE INTERFERENCE, THE RECORDED SLIDE POSITIONS SHOULD CAUSE THE DIGITIZER TO EXTEND OR RETRACT IN LESS THAN 1 SECOND.) MUST AGREE WITH FIGURE 1.

.037 IN TO BOTTOM DIGITIZER .040 IN TO RESET

10. APPLY 200 PSI TO C. VENT P, R, A, AND B. EXTEND VALVE SLIDE AND RECORD POSITION FOR APPROXIMATELY .1, .2, .3, .4, .5, 1, AND 2 GPM AT B OR R. MUST AGREE WITH FIGURE 1.

FLOW AT R (IN)	FLOW AT R (GPM)	FLOW AT B (IN)	FLOW AT B (GPM)
+.019	0	+.040	0
+.023	.1	+.036	.1
+.026	.2	+.034	.2
+.029	.3	+.032	.3
+.033	.4	+.030	.4
+.041	.5	+.025	.6
+.061	.52	+.016	.8
		0	.86

11. APPLY ~~200~~ 3000 PSI AT P. RECORD LEAKAGE AT R FOR VALVE SLIDE FULLY RETRACTED AND FULLY EXTENDED. RECORD AT C.

10 CC/MIN AT "+" STOP
13 CC/MIN AT "-" STOP
— CC/MIN AT C

UPPER VALVE (Continued)

12. APPLY 1500 PSI AT A. RECORD LEAKAGE AT R AND B FOR VALVE SLIDE AT "+" STOP.

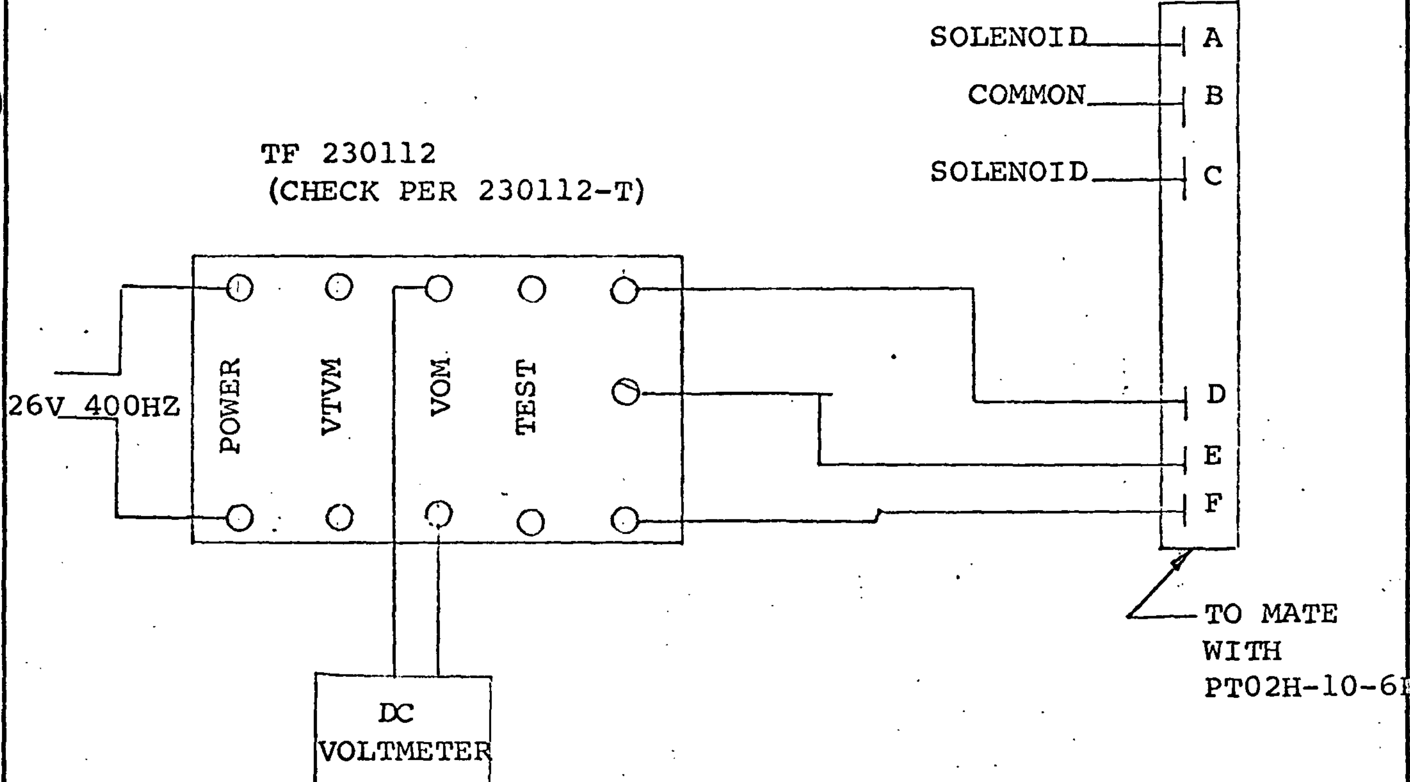
— CC/MIN AT R — CC/MIN AT B

13. APPLY 1500 PSI AT B. RECORD LEAKAGE AT R AND A FOR VALVE SLIDE AT "+" STOP.

— CC/MIN AT R — CC/MIN AT A

14. WITH VALVE AT "-" STOP RECORD PRESSURE AT A TO MOVE DIGITIZER PISTON.

INCREASING 450 PSI TO START 725 PSI TO BOTTOM
DECREASING — PSI TO START — PSI TO RESET



BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY ______________ DATE ______

CHECK BY DATE

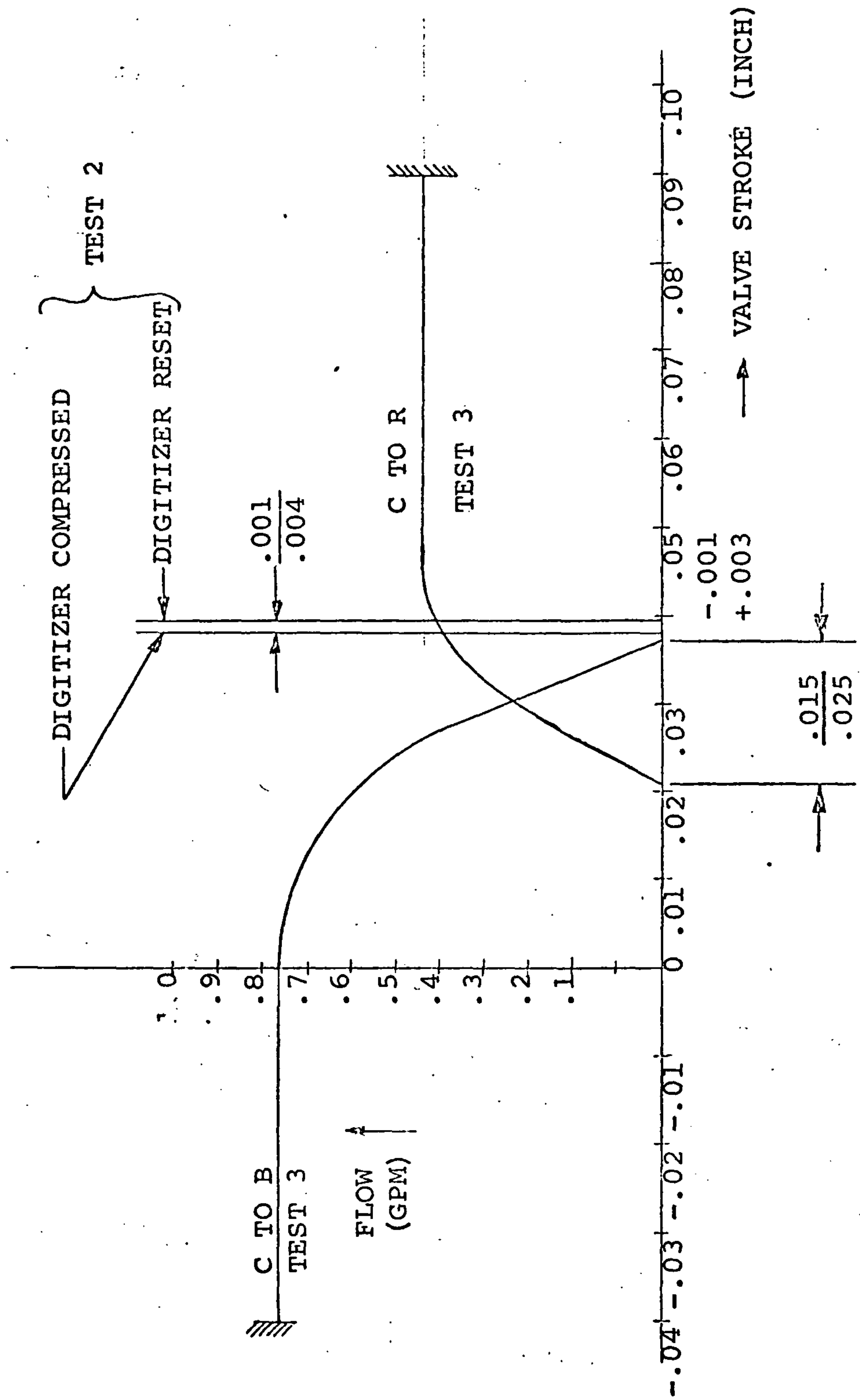


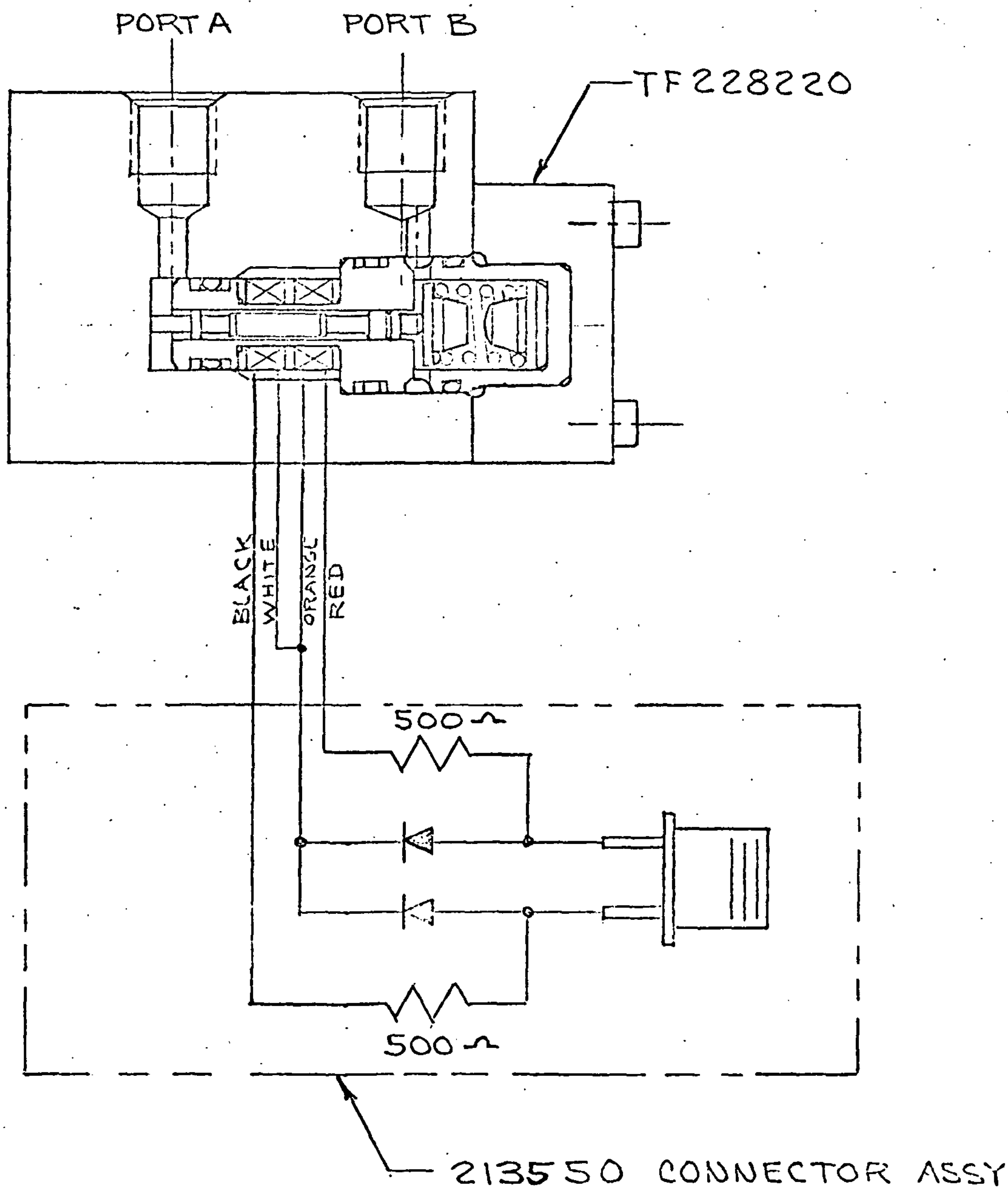
FIGURE I

228220 DIGITIZER

1) FLUID: MIL-H-5606 AT 80° ± 20° F

2) ASSEMBLE 228220 VALVE ASSEMBLY INTO TF228220 USING 228226 CAP, 93360 SPRING, 228228 SEAT AND 228230 STOP.

3) RECORD RESULTS ON DATA SHEET, SEND ONE COPY WITH UNIT AND FILE ONE COPY



TEST		PORT A	PORT B	REQUIREMENT
1	PROOF	4500 PSI	OPEN	NO EXTERNAL LEAKAGE IN 2 MINUTES
		OPEN	3000 PSI	
2	LEAKAGE	3000 PSI	OPEN	2 CC/MIN MAXIMUM
3	COIL RESISTANCE			650±50 OHMS PER COIL
CONNECT COIL LEADS TO 213550 CONNECTOR ASSY. ATTACH TO TF213500				
4	EXCITATION CURRENT			MEASURE AC (RMS) CURRENT AT THE EXCITATION TERMINALS OF TF213500. 50 MA MAX.
5	PRESSURE SETTING	AS REQD	OPEN	RECORD PRESSURE VS VOLTAGE 0 TO 1000 PSI (SEE SHEET 4 OF 213500-T)
6	DIELECTRIC STRENGTH			APPLY 500 VAC (60 HZ) NO ARCING OR INSULATION BREAKDOWN IN ONE MINUTE.
7	INSULATION RESISTANCE			100 MEGOHMS MINIMUM WITH 500VDC BETWEEN COILS AND HOUSING.

INSPECTION TEST RESULTS

TEST		RESULTS	ACC.	REJ
1	PROOF	A	✓	
		B	✓	
2	LEAKAGE	0 [illegible]	✓	
3	COIL RESISTANCE	650 OHMS	✓	
4	EXCITATION CURRENT	22 MA	✓	
5	PRESSURE SETTING		✓	
6	DIELECTRIC STRENGTH			
7	INSULATION RESISTANCE	______ KOHMS ______ KOHMS		

228220T

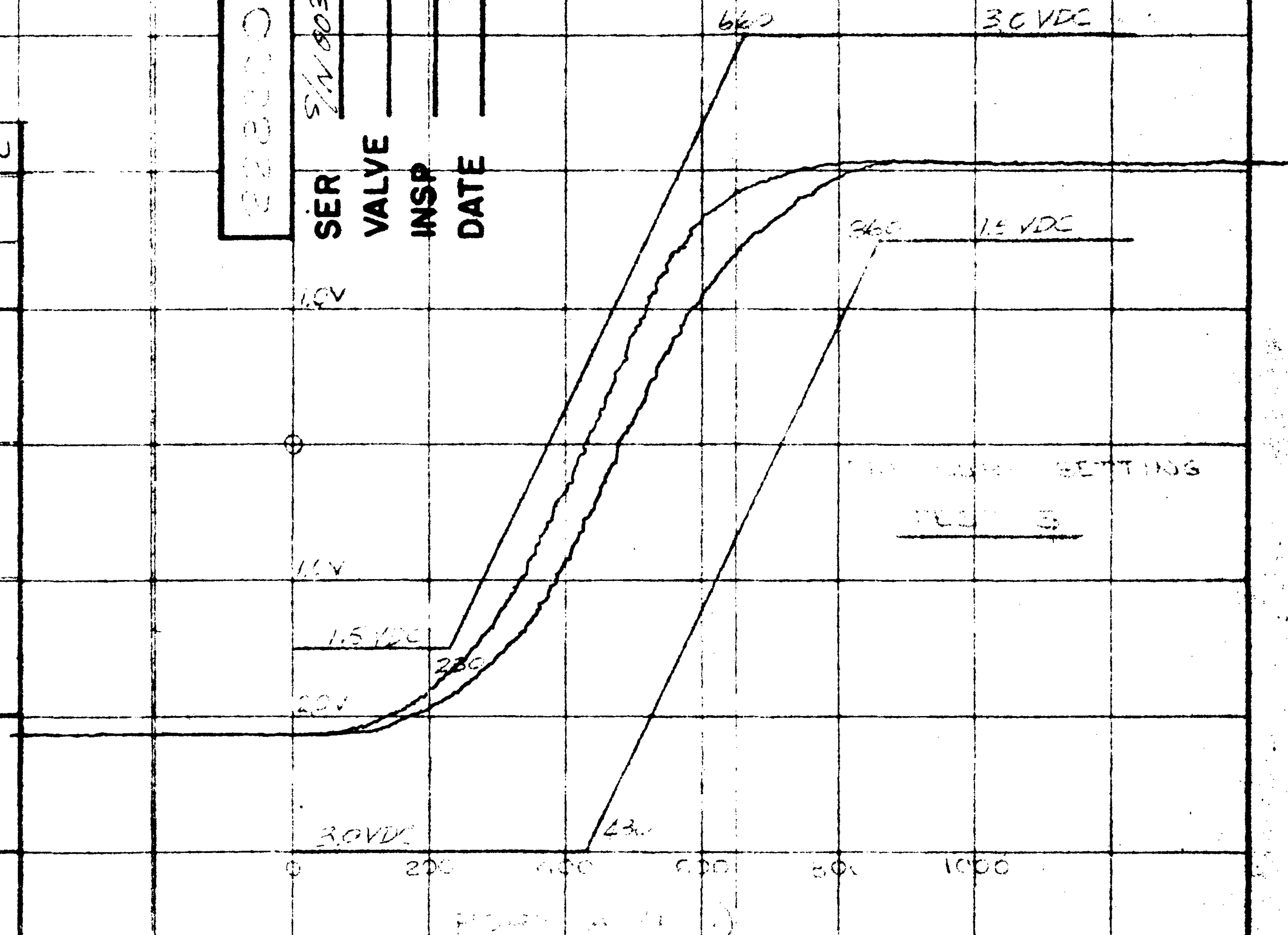
S/N 803

SER

VALVE

INSP

DATE



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PG 3 OF 3

228220T

INSPECTION TEST RESULTS

TEST		RESULTS	ACC	REJ
1	PROOF	A	✓	
		B	✓	
2	LEAKAGE	0 CC/MIN	✓	
3	COIL RESISTANCE	650 OHMS	✓	
4	EXCITATION CURRENT	205 MA	✓	
5	PRESSURE SETTING		✓	
6	ELECTRICAL TEST			
7	INSULATION RESISTANCE	____ KOHMS ____ MOHMS		

22820T

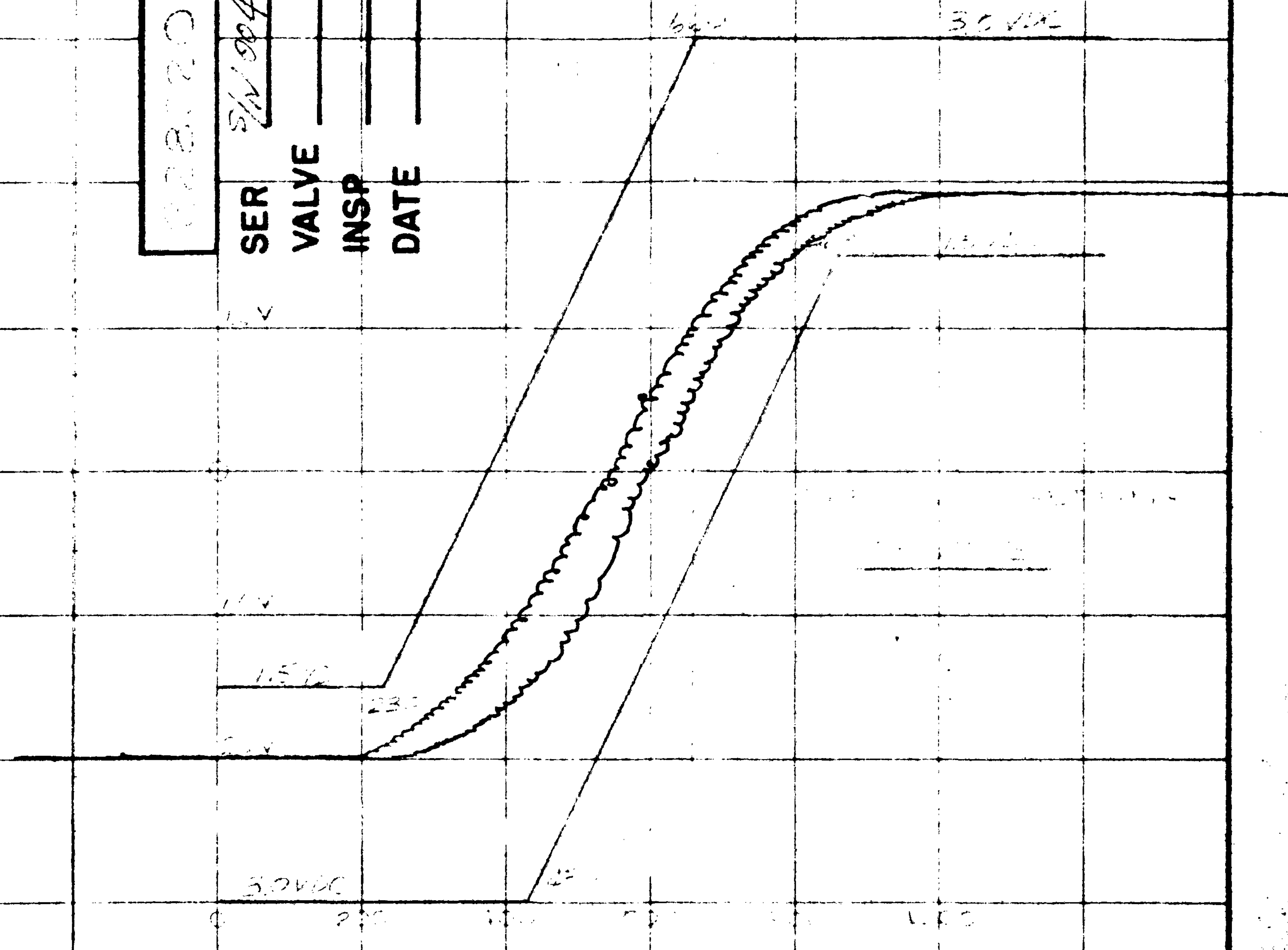
S/N 904

SER

VALVE

INSP

DATE



BERTEA CORPORATION
IRVINE · CALIFORNIA

22820T

Form 1072

BERTEA CORPORATION
IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY ______ DATE ______
CHECK BY DATE

224200-T

1) TEST ALL 224200-T SERVO ACTUATOR TO THIS PROCEDURE.

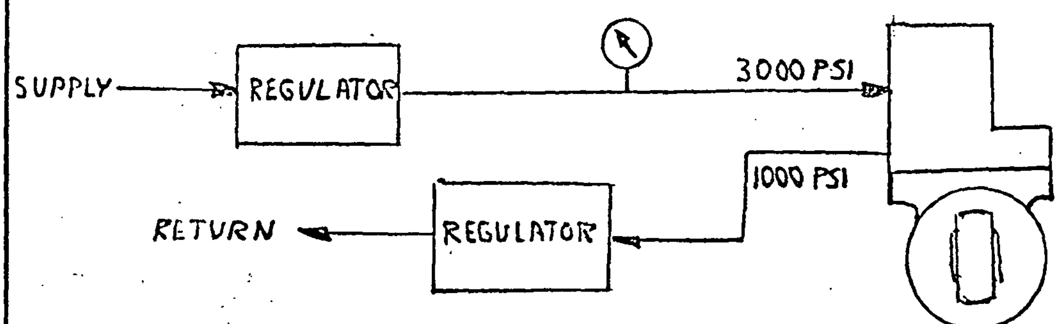
2) BEFORE ASSEMBLING ACTUATOR ASSEMBLY PRETEST THE FOLLOWING COMPONENTS AS NOTED:

DART VALVES	228200T
SERVO VALVE	224210T
CONTROLLER	224250T

3) USE MIL-H-5606 FLUID AT $80^{\circ} \pm 20^{\circ}F$.

4) RECORD RESULTS ON A COPY OF THIS PROCEDURE.

5) CONNECT TO HYDRAULIC SUPPLY USING ½ INCH LINES AS NOTED BELOW:



6) CONNECT TO 224250 CONTROLLER AS NOTED BELOW:

a) 115 VAC, 400 HZ TO THREE PRONG RECEPTACLES ON BACK OF CONTROLLER.

b) 28 VDC, (2 AMP MINIMUM) TO DUAL RECEPTACLE ON BACK OF CONTROLLER

6) (Continued)

c) CONNECT .0015μ ACROSS "EXT C" ON BACK OF CONTROLLER.

d) CONNECT BOTH ACTUATOR AND SERVO VALVE LVDT PRIMARIES (EXCITATION) TO 26 VAC DUAL RECEPTACLE ON BACK OF CONTROLLER.

e) CONNECT SERVO VALVE LVDT SECONDARY (SIGNAL) TO "SECONDARY" DUAL RECEPTACLE ON BACK OF CONTROLLER.

f) CONNECT ACTUATOR LVDT SECONDARY (SIGNAL) TO "LVDT" DUAL RECEPTACLE ON FRONT OF CONTROLLER. OBSERVE COLOR CODING ON WIRING HARNESS.

g) CONNECT DART VALVE WIRING HARNESSES USING LABELS AS CONNECTORS:

1. PLUG LABLED 001 TO -001 DART VALVE
2. PLUG LABLED 002 TO -002 DART VALVE
3. L4, L5, R4, R5 TO LIKE LABLED RECEPTACLES ON FRONT OF CONTROLLER. NOTE ALL GROUND CONNECTION ON PLUGS MUST BE CONNECTED TO BLACK SIDE OF DUAL RECEPTACLE.

h) ENERGIZE CONTROLLER BY TURNING POWER SWITCH TO "ON". BOTH AC AND DC POWER LIGHTS SHOULD BE ON. MONITOR LIGHTS L4, L5, R4, R5 SHOULD BE ON.

BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY ______ DATE ______

CHECK BY DATE

PART NO:	SERIAL NO:	VALVE NO:	DATE:
IBM NO:	PART NAME		INSP:

	TEST	REQUIREMENTS	RESULTS	ACC.	REJ.
1	OPEN LOOP	a) DISCONNECT PLUGS L4, L5, R4, R5 FROM FRONT OF CONTROLLER AND APPLY 28 VDC TO ALL PLUGS. INTERRUPT POWER TO L5 (OR R5) SUCH AS TO PRODUCE A SERIES OF PULSE COMMANDS TO DART VALVE. ACTUATOR MUST FULLY EXTEND OR RETRACT. VOLTAGE AT LVDT SIGNAL ON REAR OF CONTROLLER MUST BE 3.5±.35 VAC AT EACH END OF THE VALVE STROKE.	ACTUATOR EXTEND 3.5 VAC ACTUATOR RETRACT 3.5 VAC		
		b) CONTINUE TO CYCLE POWER TO L5 (OR R5) AND RECORD VOLTAGE AT LVDT SIGNAL ON FRONT OF CONTROLLER. MUST BE 23.5±2.3 VAC AT EACH END OF ACTUATOR STROKE.	ACTUATOR EXTEND 23 VAC ACTUATOR RETRACT 23 VAC		
2	INNER LOOP	a) RECONNECT PLUGS L4, L5, R4, R5 TO RECEPTACLES ON FRONT OF CONTROLLER. DISCONNECT LVDT SIGNAL FROM FRONT OF CONTROLLER. DEMOD ON BACK OF CONTROLLER MUST READ ZERO VDC FOR NO INPUT COMMAND.	0 VDC		
		b) RECORD VOLTAGE REQUIRED AT COMMAND TO FULLY EXTEND AND RETRACT SERVO VALVE. MUST BE 10±.5 VDC.	ACTUATOR EXTEND 10 VDC ACTUATOR RETRACT 10 VDC		
3	OUTER LOOP	a) RECONNECT ACTUATOR LVDT TO SIGNAL INPUT ON FRONT OF CONTROLLER. MONITOR DEMOD ON FRONT OF CONTROLLER. MUST BE ZERO VDC FOR NO INPUT COMMAND.	0 VDC		

224200-T PG. 3 OF

S/N 001 224200-T

BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

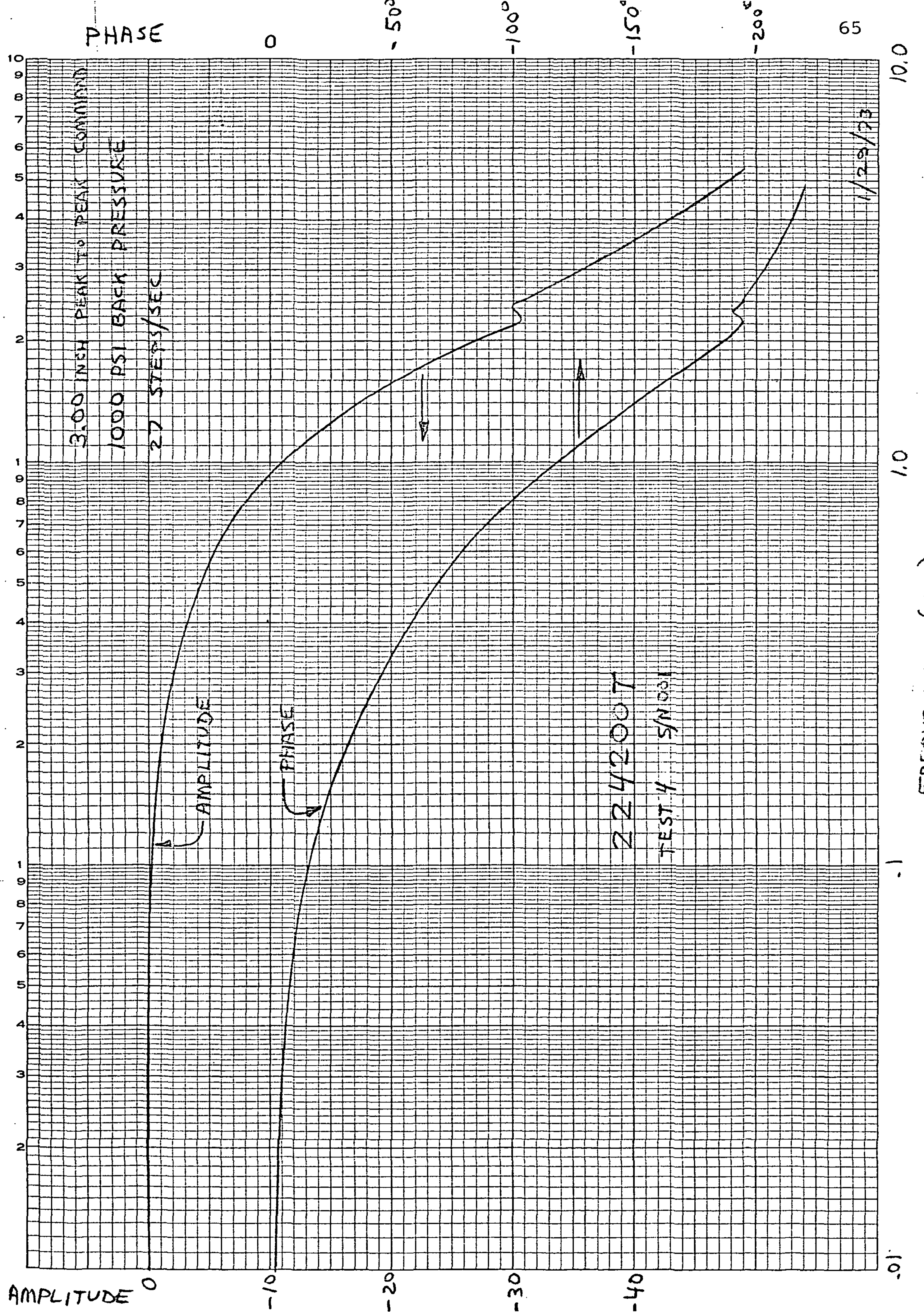
DRAWN BY ______________ DATE ________

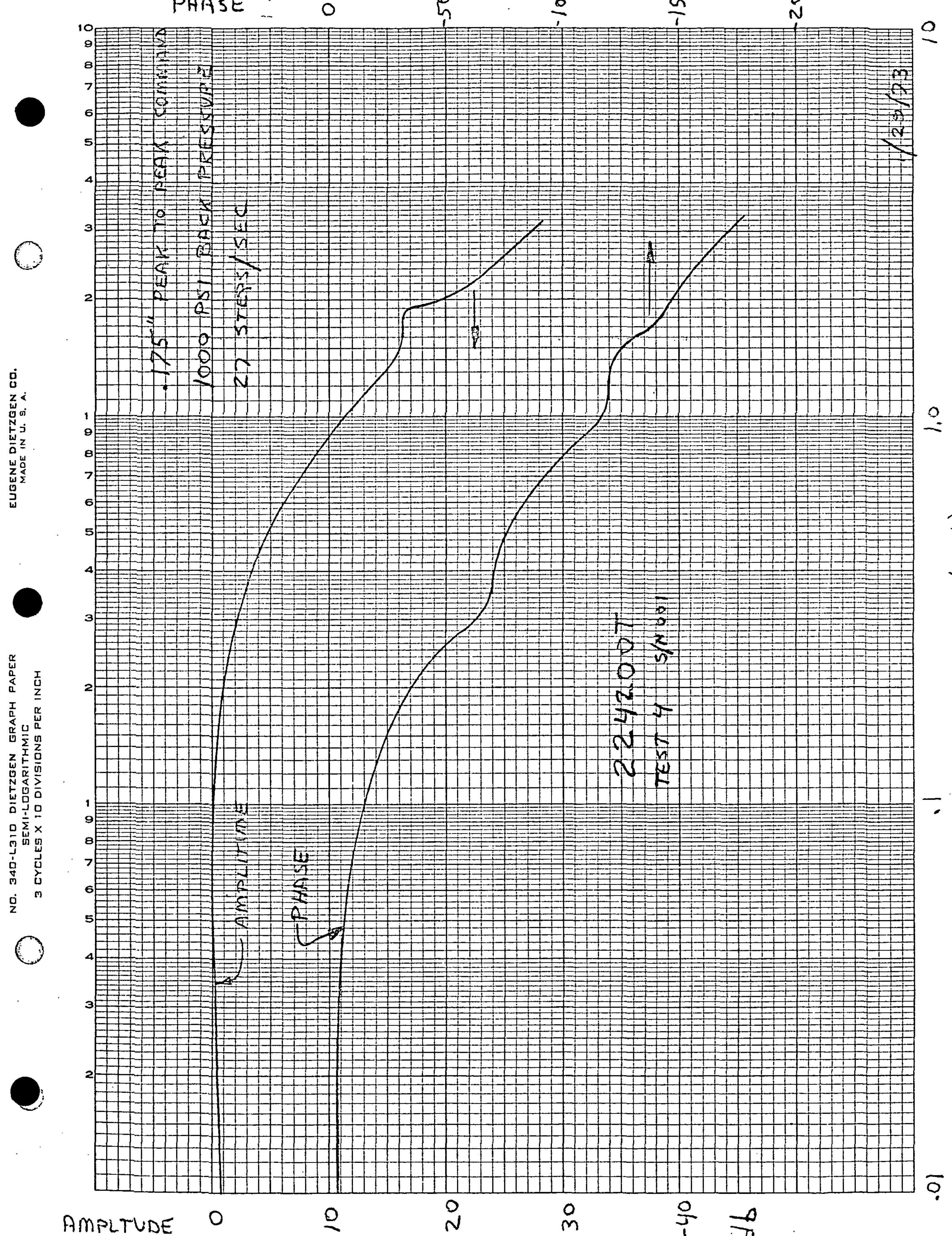
CHECK BY DATE

PART NO:	SERIAL NO:	VALVE NO:	DATE:
IBM NO:	PART NAME		INSP:

	TEST	REQUIREMENTS	RESULTS	ACC.	REJ.
3	(Cont.)	b) RECORD VOLTAGE REQUIRED AT COMMAND TO FULLY EXTEND AND RETRACT ACTUATOR. MUST BE 10$\pm$.5 VDC.	ACTUATOR EXTEND 10 VDC ACTUATOR RETRACT 10 VDC		
4	FREQUENCY RESPONSE	RECORD ACTUATOR AMPLITUDE RATIO AND PHASE LAG USING INPUT COMMANDS OF 7.5 V AND .45 V PEAK TO PEAK.			
5	HYSTERESIS	USING AN X-Y RECORDER PLOT COMMAND VS ACTUATOR POSITION FOR +7.5 V TO -7.5 V TO +7.5 V.	PLOTS		
6	RESOLUTION	USING AN X-Y RECORDER PLOT COMMAND VS ACTUATOR POSITION FOR +.8 V TO -.8 V TO +.8 V.	ATTACHED		
7	STEP	USING AN OSCILLOGRAPH RECORD ACTUATOR RESPONSE TO SQUARE WAVE INPUT OF 2 V PEAK TO PEAK AT .5 CPS. REPEAT FOR 15 V at .1 CPS.			
8	TRACKING	USING AN OSCILLOGRAPH RECORD ACTUATOR OUTPUT IN RESPONSE TO SINE WAVE INPUT OF 2 V PEAK TO PEAK AT .5 CPS AND 15 V AT .1 CPS.	SEE		

224200-T PG. 4 OF SN 100 224200-T


PHASE
0
-50°
-100°
-150°
-200°
AMPLITUDE
0
-10
-20
-30
-40
10.0
1.0
.1
.01
3.00 INCH PEAK TO PEAK COMMAND
1000 PSI BACK PRESSURE
27 STEPS/SEC
1/29/73
224200T
TEST 4 S/N 001
AMPLITUDE
PHASE
EUGENE DIETZGEN CO.
MADE IN U. S. A.
NO. 340-L310 DIETZGEN GRAPH PAPER
SEMI-LOGARITHMIC
3 CYCLES X 10 DIVISIONS PER INCH


PHASE
0
-50°
-100°
-150°
-200°
.175" PEAK TO PEAK COMMAND
1000 PSI BACK PRESSURE
27 STEPS/SEC
224200T
TEST 4 S/N 001
1/29/73
AMPLITUDE
PHASE
AMPLTUDE
0
10
20
30
-40
10
1.0
.1
.01
EUGENE DIETZGEN CO.
MADE IN U. S. A.
NO. 340-L310 DIETZGEN GRAPH PAPER
SEMI-LOGARITHMIC
3 CYCLES X 10 DIVISIONS PER INCH

BERTEA CORPORATION IRVINE • CALIFORNIA

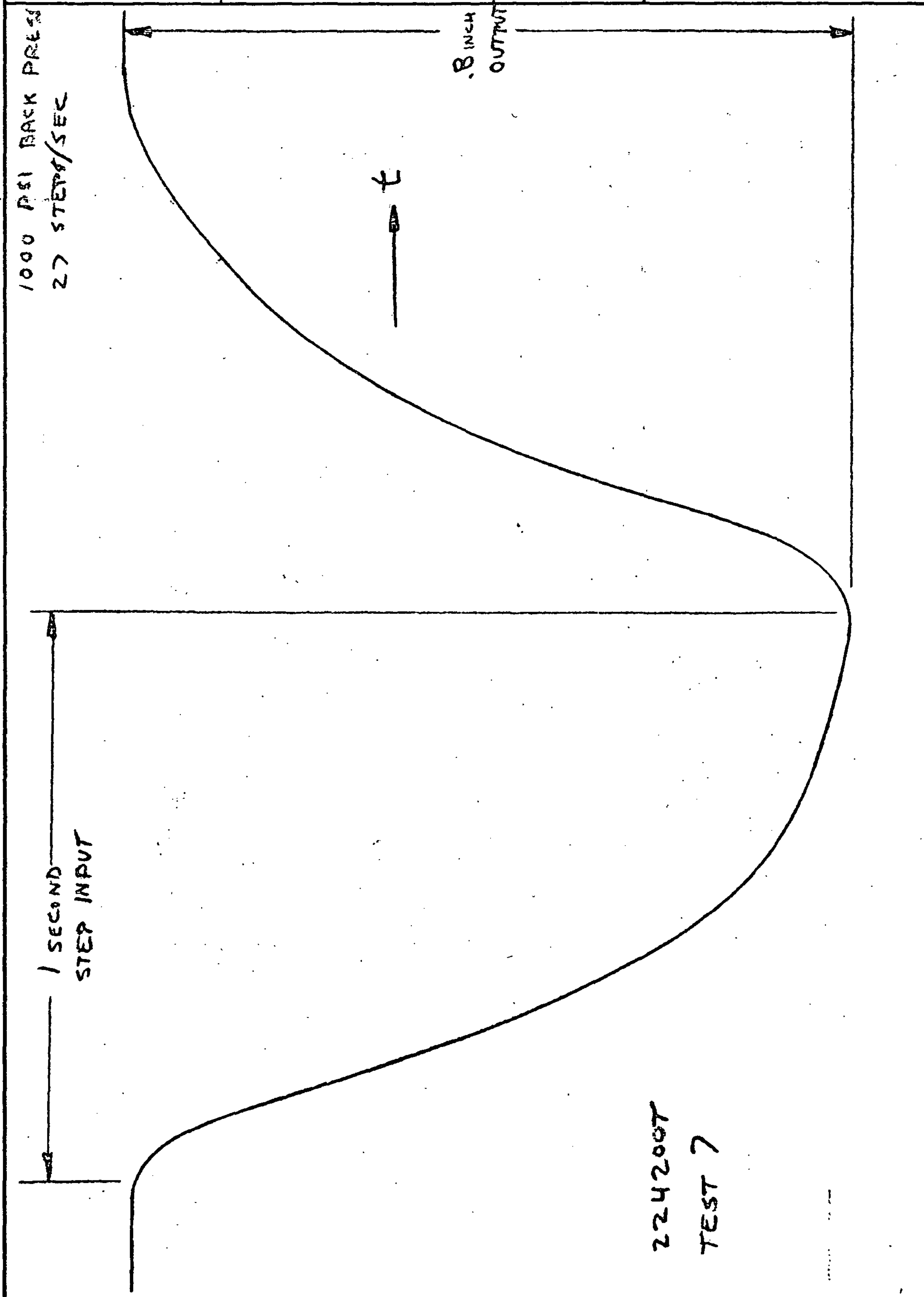
PRODUCTION TEST PROCEDURE

DRAWN BY ______ DATE ______

CHECK BY ______ DATE ______

PART NO: 224200	SERIAL NO: 001	VALVE NO:	DATE:
IBM NO:	PART NAME		INSP:

TEST	REQUIREMENTS	RESULTS	ACC.	REJ.



PG. OF

BERTEA CORPORATION IRVINE • CALIFORNIA

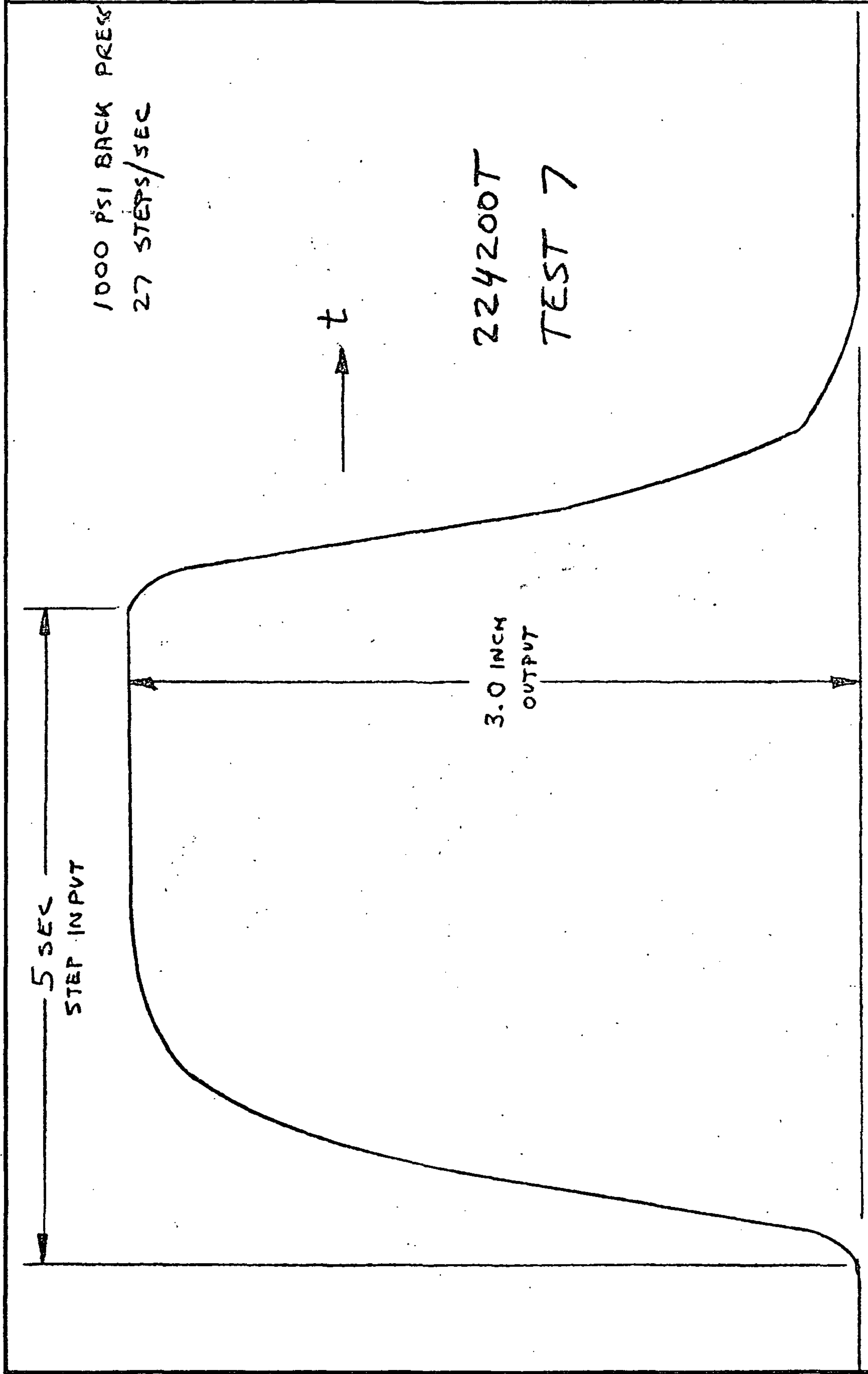
PRODUCTION TEST PROCEDURE

DRAWN BY ______ DATE ______

CHECK BY ______ DATE ______

PART NO: 224200	SERIAL NO: 001	VALVE NO: —	DATE: 1-24-73
IBM NO:	PART NAME		INSP:

TEST	REQUIREMENTS	RESULTS	ACC.	REJ.



PG. OF

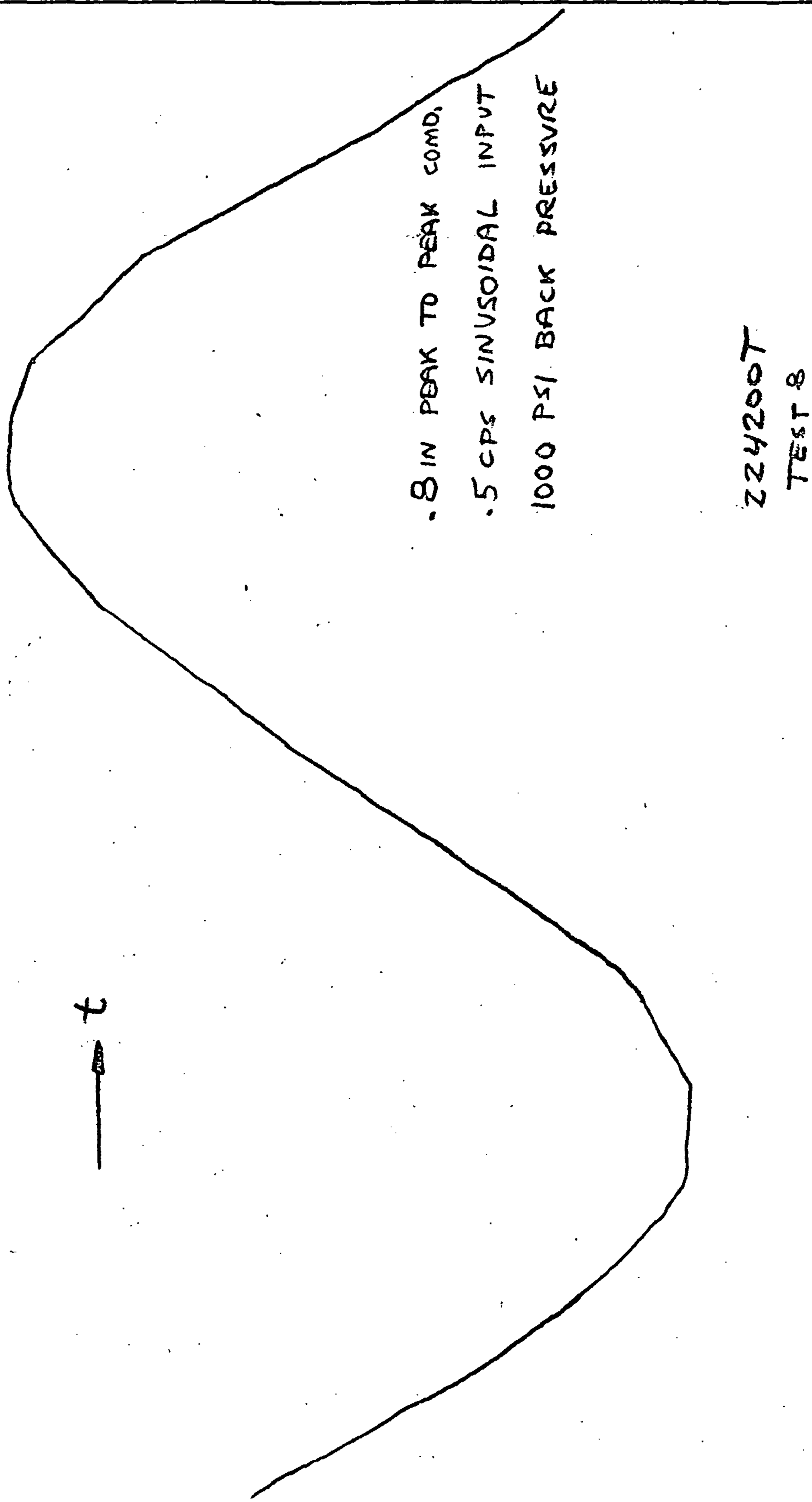
BERTEA CORPORATION
IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY ______ DATE ______
CHECK BY DATE

PART NO: 224200	SERIAL NO: 001	VALVE NO:	DATE:
IBM NO:	PART NAME		INSP:

TEST	REQUIREMENTS	RESULTS	ACC.	REJ.



PG. OF

BERTEA CORPORATION IRVINE • CALIFORNIA

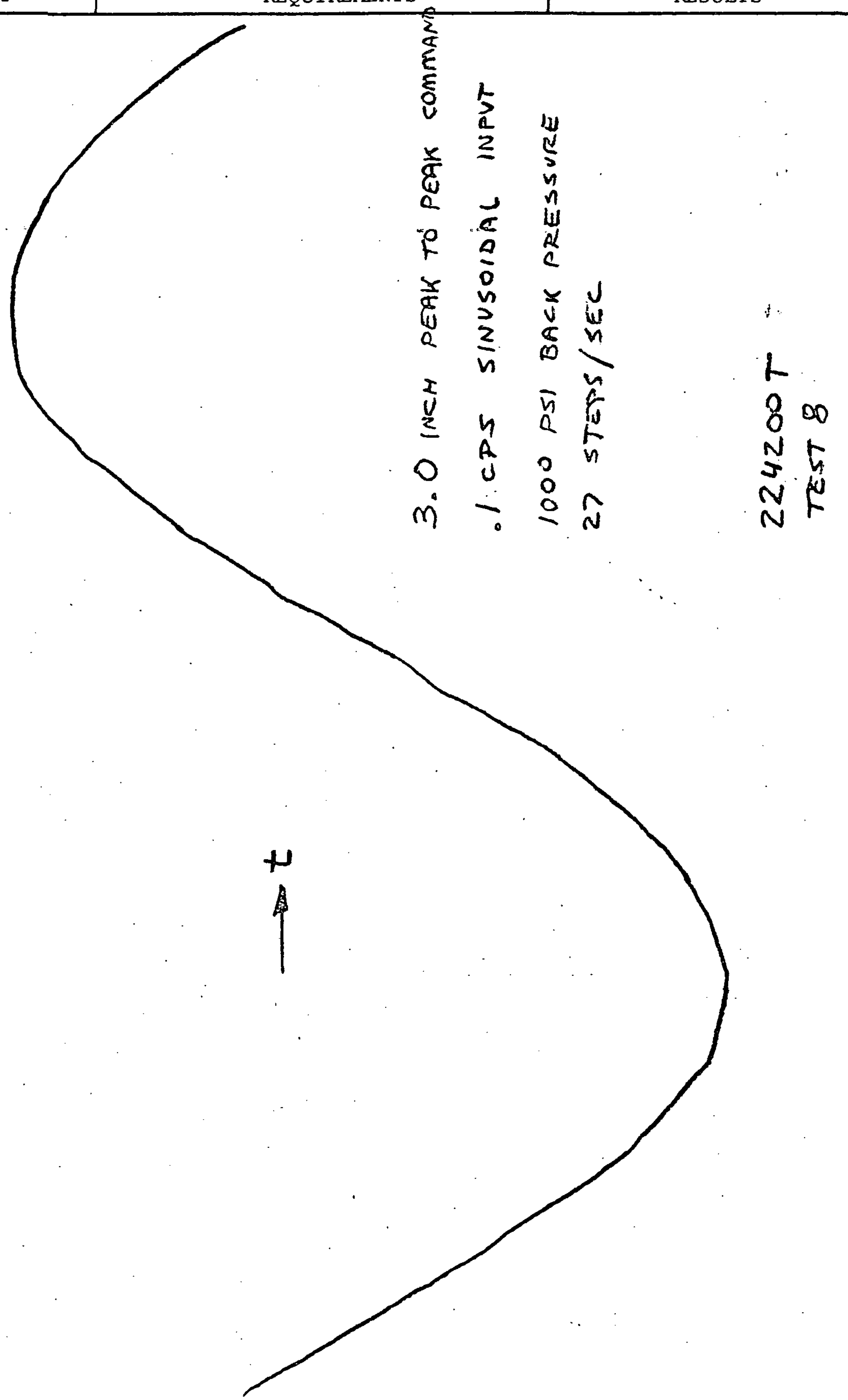
PRODUCTION TEST PROCEDURE

DRAWN BY ______ DATE ______

CHECK BY ______ DATE ______

PART NO: 224200	SERIAL NO: 001	VALVE NO:	DATE: 1-24-73
IBM NO:	PART NAME		INSP:

TEST	REQUIREMENTS	RESULTS	ACC.	REJ.



PG. OF

BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY P. CHIN DATE 10-10-72
CHECK BY DATE

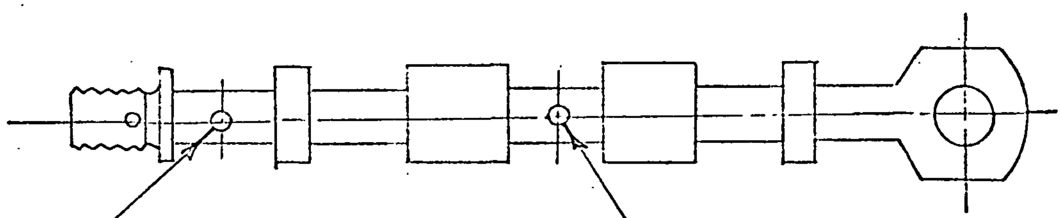
224210T

PG. 1 OF 2

224210 SERVO VALVE

1) FLUID: MIL-H-5606 AT 80°±20°F

2) RECORD RESULTS ON DATA SHEET, SEND ONE COPY WITH UNIT AND FILE ONE COPY.



TEST		PROCEDURE	REQUIREMENTS
1	NEUT. PRESS	SPOOL AT NEUTRAL, 3000 PSI AT PRESS, GAGES IN CYL PORTS	$C_1 = C_2 = \frac{2250}{1000}$ PSI
2	NEUT. FLOW		20 TO 60 C.C./MIN.
3	PRESS GAIN	RECORD CYL PORT PRESS AT .001 INCREMENTS	REF. ONLY
4	FLOW	RECORD FLOW WITH CYL. PORTS INTERCONNECTED. 3000 PSI AT PRESS. PORT. USE 925 PSI FOR ±.020 AND OVER	LIMITS PER SHEET 2 RECORD AT ±.0025 ±.040 ±.005 ±.060 ±.0075 ±.080 ±.010 ±.100 ±.0125 ±.120 ±.140 ±.160 ±.175
5	CYL. PORT PRESS.	RECORD CYL. PRESSURE WITH PORTS INTERCONNECTED	1000 TO 2250 PSI WITH 3000 PSI INLET. RECORD AT ±.010; ±.020; ±.050

PG 2 'B' SIZE

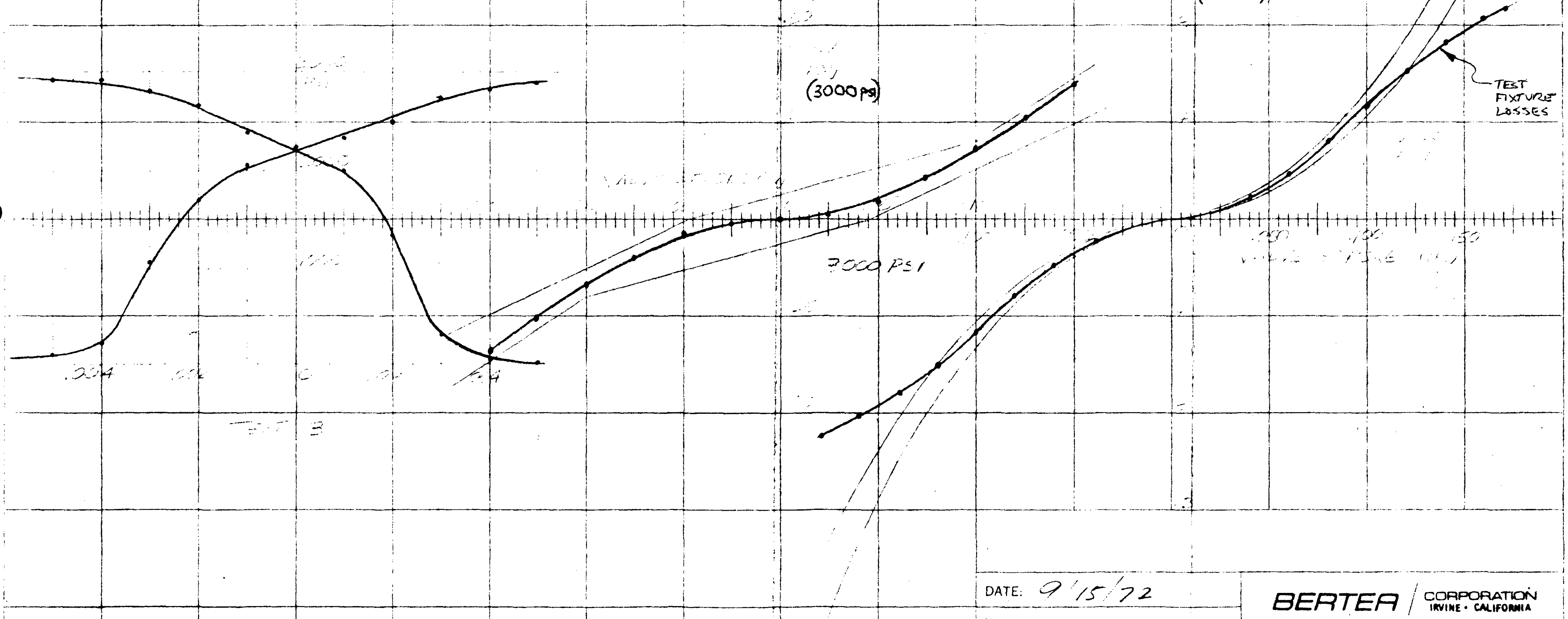
224210T

INSPECTION TEST RESULTS

TEST 1 = 2250
TEST 2 26
TEST 3

.010	1820 PSI	1850
.020	1700	1700
.030	1625	1650

224210T
SERIAL NO: 001



DATE: 9/15/72	BERTEA / CORPORATION IRVINE · CALIFORNIA
INSP:	224210T — REV.
VALVE NO:	
WORK ORDER: 5-1508-0	PROJECT — PAGE 2 OF 2

224250-T

DART VALVE CONTROLLER

1) THE 224250-101 DART VALVE CONTROLLER SHALL MEET THE REQUIREMENTS OF THIS SPECIFICATION.

2) RECORD RESULTS ON A COPY OF THIS PROCEDURE.

3) CONNECT 115 VAC, 400 HZ, AND 28 VDC TO LIKE LABELED CONNECTORS ON THE BACK PANEL OF THE CONTROLLER. REFER TO BERTEA DRAWING NUMBER 224250 FOR PHYSICAL LAYOUT OF CONTROLLER.

BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY [illegible] DATE

CHECK BY DATE

	TEST	SELECTOR SWITCH	PROCEDURE AND REQUIREMENT
1	INPUT GAIN	B_{IN}	A) SHORT CIRCUIT BOTH "LVDT" SECONDARY INPUTS. B) APPLY +10 VDC AT "COMMD". METER MUST READ 10 MA ± .5 MA. C) REPEAT WITH -10 VDC + 10 MA - 10 MA D) WITH "COMMD" SHORTED METER MUST READ LESS THAN .2 MA. .03 MA E) RECORD "COMMD" VS "SWITCH MON" ON X-Y RECORDER.
2	ACTUATOR FEEDBACK GAIN	B_{IN}	A) SHORT CIRCUIT "COMMD" AND LVDT INPUT ON BACK OF BOX. B) APPLY 23.5 VAC (RMS) TO "LVDT" INPUT ON FRONT OF BOX. C) REPEAT WITH 23.5 VAC (RMS) REVERSED. + 10 MA - 10 MA D) WITH "LVDT" INPUT SHORTED THE METER MUST READ LESS THAN .2 MA. .03 MA

BERTEA CORPORATION
IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY RJA DATE ______
CHECK BY DATE

	TEST	SELECTOR SWITCH	PROCEDURE AND REQUIREMENT
3	VALVE FEEDBACK GAIN	B_{OUT}	A) SHORT CIRCUIT "COMMD" AND "LVDT" INPUT ON FRONT OF BOX. B) APPLY 3.5 VAC TO "LVDT" INPUT ON BACK OF BOX. METER MUST READ 10 MA ± .5 MA. C) REPEAT WITH 3.5 VAC REVERSED. + 10.1 MA − 10.1 MA D) WITH "LVDT" INPUT SHORTED METER MUST READ LESS THAN .2 MA. +.025 MA
4	EXCITATION VOLTAGE		A) RECORD VOLTAGE AT "26 VAC" ON BACK OF BOX. MUST BE 26 ± 1 VAC 27.5 VAC OK RJA
5	STEP SIZE	B_{IN}	A) SHORT CIRCUIT BOTH "LVDT" INPUTS. B) RECORD METER READINGS FOR THE FOLLOWING STEPS.

LIGHTS	REQUIREMENT	METER
L5	>1.35 MA	+ 1.55 MA
R4	<.15 MA	+ 0.15 MA
—	0 MA	
L4	<.15 MA	− 0.14 MA
R5	>1.35 MA	− 1.35 MA

224250T

PG. 3 OF

224250T

A

BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

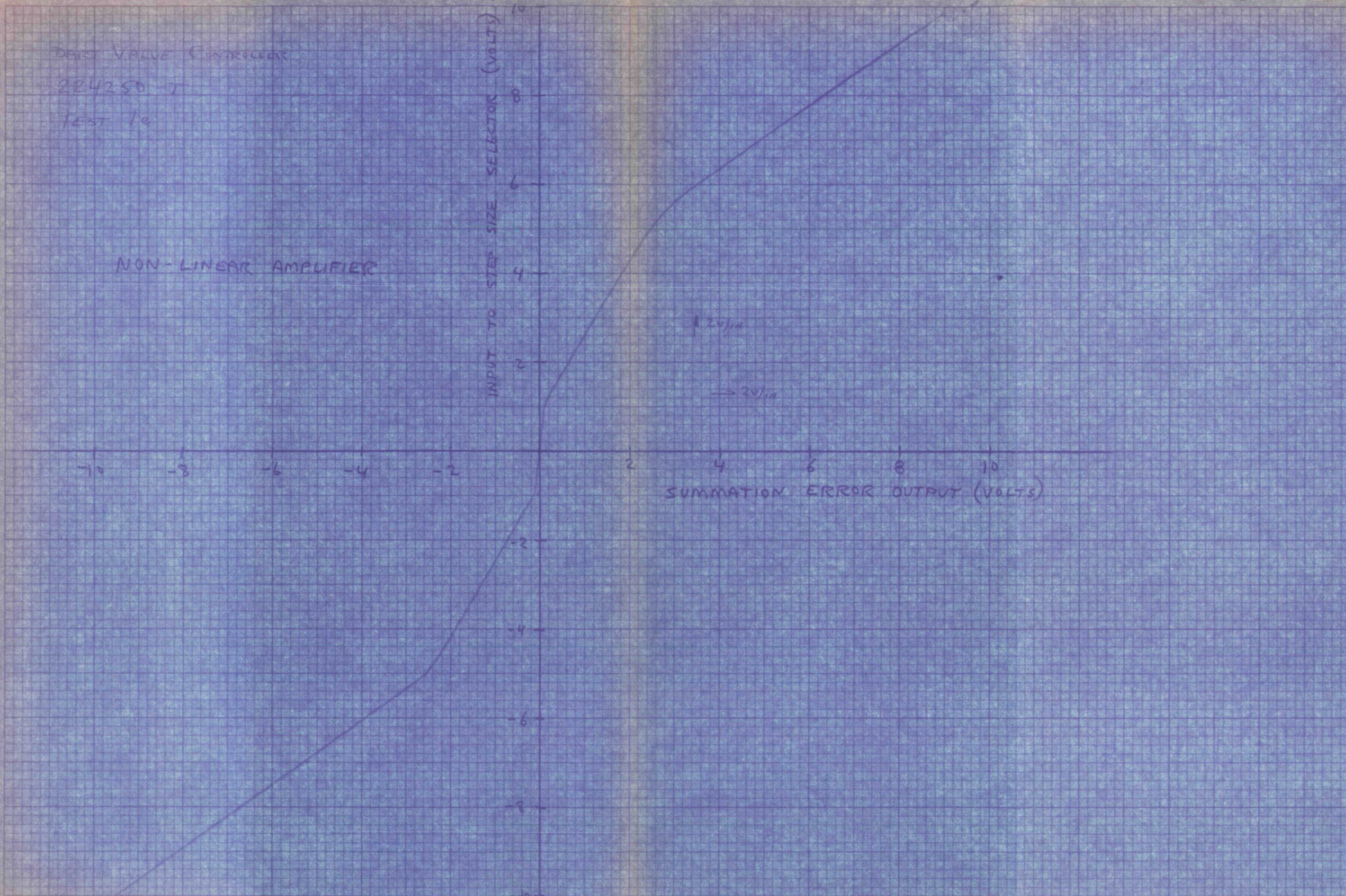
DRAWN BY P.?? DATE

CHECK BY DATE

	TEST	SELECTOR SWITCH	PROCEDURE AND REQUIREMENT
6	STEPPING RATE	—	A) APPLY 10 VDC TO "COMMD". B) RECORD L5 VOLTAGE ON OSCILLOSCOPE. C) SOLENOID MUST BE OFF FOR 12.5 ± 1 MILLISECOND AND ON FOR 12.5 ± 1 MILLISECOND. 12 MS ON 12 MS OFF NOTE: WITH .0015 μ AT "EXT C" 18 ms "ON" or "OFF"

224250T

A


DIGIT VALVE CONTROLLER
224250 J
Test 1a
NON-LINEAR AMPLIFIER
INPUT TO STEP SIZE SELECTOR (VOLTS)
SUMMATION ERROR OUTPUT (VOLTS)
2v/in
2v/in
-10
-8
-6
-4
-2
2
4
6
8
10

APPENDIX B

TEST PROCEDURES

224200-T

1) TEST ALL 224200-T SERVO ACTUATOR TO THIS PROCEDURE.

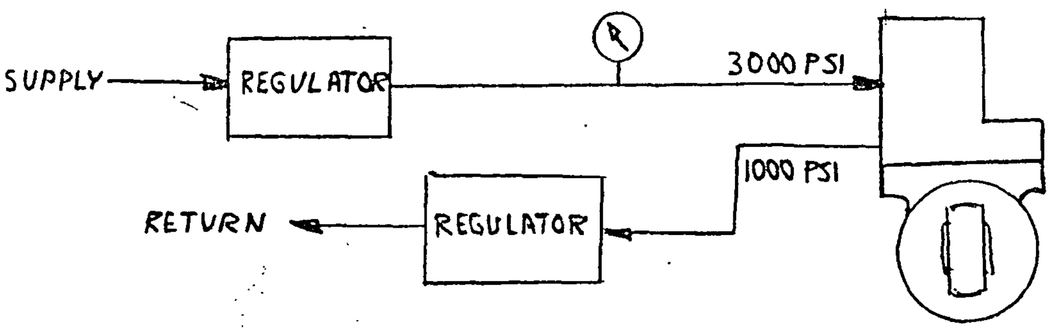
2) BEFORE ASSEMBLING ACTUATOR ASSEMBLY PRETEST THE FOLLOWING COMPONENTS AS NOTED:

DART VALVES	228200T
SERVO VALVE	224210T
CONTROLLER	224250T

3) USE MIL-H-5606 FLUID AT $80^{\circ} \pm 20^{\circ}$F.

4) RECORD RESULTS ON A COPY OF THIS PROCEDURE.

5) CONNECT TO HYDRAULIC SUPPLY USING ½ INCH LINES AS NOTED BELOW:



6) CONNECT TO 224250 CONTROLLER AS NOTED BELOW:

a) 115 VAC, 400 HZ TO THREE PRONG RECEPTACLES ON BACK OF CONTROLLER.

b) 28 VDC, (2 AMP MINIMUM) TO DUAL RECEPTACLE ON BACK OF CONTROLLER

6) (Continued)

c) CONNECT .0015μ ACROSS "EXT C" ON BACK OF CONTROLLER.

d) CONNECT BOTH ACTUATOR AND SERVO VALVE LVDT PRIMARIES (EXCITATION) TO 26 VAC DUAL RECEPTACLE ON BACK OF CONTROLLER.

e) CONNECT SERVO VALVE LVDT SECONDARY (SIGNAL) TO "SECONDARY" DUAL RECEPTACLE ON BACK OF CONTROLLER.

f) CONNECT ACTUATOR LVDT SECONDARY (SIGNAL) TO "LVDT" DUAL RECEPTACLE ON FRONT OF CONTROLLER. OBSERVE COLOR CODING ON WIRING HARNESS.

g) CONNECT DART VALVE WIRING HARNESSES USING LABELS AS CONNECTORS:

1. PLUG LABLED 001 TO -001 DART VALVE
2. PLUG LABLED 002 TO -002 DART VALVE
3. L4, L5, R4, R5 TO LIKE LABLED RECEPTACLES ON FRONT OF CONTROLLER. NOTE ALL GROUND CONNECTION ON PLUGS MUST BE CONNECTED TO BLACK SIDE OF DUAL RECEPTACLE.

h) ENERGIZE CONTROLLER BY TURNING POWER SWITCH TO "ON". BOTH AC AND DC POWER LIGHTS SHOULD BE ON. MONITOR LIGHTS L4, L5, R4, R5 SHOULD BE ON.

BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY ________________ DATE ________

CHECK BY DATE

PART NO:	SERIAL NO:	VALVE NO:	DATE:
IBM NO:	PART NAME		INSP:

TEST		REQUIREMENTS	RESULTS	ACC.	REJ.
1	OPEN LOOP	a) DISCONNECT PLUGS L4, L5, R4, R5 FROM FRONT OF CONTROLLER AND APPLY 28 VDC TO ALL PLUGS. INTERRUPT POWER TO L5 (OR R5) SUCH AS TO PRODUCE A SERIES OF PULSE COMMANDS TO DART VALVE. ACTUATOR MUST FULLY EXTEND OR RETRACT. VOLTAGE AT LVDT SIGNAL ON REAR OF CONTROLLER MUST BE 3.5±.35 VAC AT EACH END OF THE VALVE STROKE.	ACTUATOR EXTEND ________ VAC ACTUATOR RETRACT ________ VAC		
		b) CONTINUE TO CYCLE POWER TO L5 (OR R5) AND RECORD VOLTAGE AT LVDT SIGNAL ON FRONT OF CONTROLLER. MUST BE 23.5±2.3 VAC AT EACH END OF ACTUATOR STROKE.	ACTUATOR EXTEND ________ VAC ACTUATOR RETRACT ________ VAC		
2	INNER LOOP	a) RECONNECT PLUGS L4, L5, R4, R5 TO RECEPTACLES ON FRONT OF CONTROLLER. DISCONNECT LVDT SIGNAL FROM FRONT OF CONTROLLER. DEMOD ON BACK OF CONTROLLER MUST READ ZERO VDC FOR NO INPUT COMMAND.	________ VDC		
		b) RECORD VOLTAGE REQUIRED AT COMMAND TO FULLY EXTEND AND RETRACT SERVO VALVE. MUST BE 10±.5 VDC.	ACTUATOR EXTEND ________ VDC ACTUATOR RETRACT ________ VDC		
3	OUTER LOOP	a) RECONNECT ACTUATOR LVDT TO SIGNAL INPUT ON FRONT OF CONTROLLER. MONITOR DEMOD ON FRONT OF CONTROLLER. MUST BE ZERO VDC FOR NO INPUT COMMAND.	________ VDC		

224200-T

PG. 3 OF

S/N ______

224200-T

BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY ______ DATE ______
CHECK BY DATE

PART NO:	SERIAL NO:	VALVE NO:	DATE:
IBM NO:	PART NAME		INSP:

	TEST	REQUIREMENTS	RESULTS	ACC.	REJ.
3	(Cont.)	b) RECORD VOLTAGE REQUIRED AT COMMAND TO FULLY EXTEND AND RETRACT ACTUATOR. MUST BE 10±.5 VDC.	ACTUATOR EXTEND ______VDC ACTUATOR RETRACT ______VDC		
4	FREQUENCY RESPONSE	RECORD ACTUATOR AMPLITUDE RATIO AND PHASE LAG USING INPUT COMMANDS OF 7.5 V AND .45 V PEAK TO PEAK.			
5	HYSTERESIS	USING AN X-Y RECORDER PLOT COMMAND VS ACTUATOR POSITION FOR +7.5 V TO -7.5 V TO +7.5 V.			
6	RESOLUTION	USING AN X-Y RECORDER PLOT COMMAND VS ACTUATOR POSITION FOR +.8 V TO -.8 V TO +.8 V.			
7	STEP	USING AN OSCILLOGRAPH RECORD ACTUATOR RESPONSE TO SQUARE WAVE INPUT OF 2 V PEAK TO PEAK AT .5 CPS. REPEAT FOR 15 V at .1 CPS.			
8	TRACKING	USING AN OSCILLOGRAPH RECORD ACTUATOR OUTPUT IN RESPONSE TO SINE WAVE INPUT OF 2 V PEAK TO PEAK AT .5 CPS AND 15 V AT .1 CPS.			

BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY P. CHIN DATE 10-10-72

CHECK BY DATE

224210T

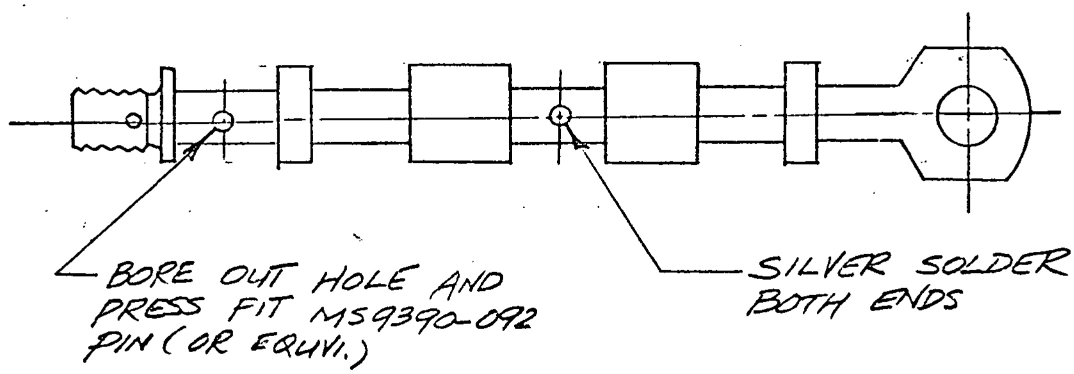
PG. 1 OF 2

(REF 364/733) ADP

224210 SERVO VALVE

1) FLUID: MIL-H-5606 AT 80°±20°F

2) RECORD RESULTS ON DATA SHEET, SEND ONE COPY WITH UNIT AND FILE ONE COPY.



TEST		PROCEDURE	REQUIREMENTS
1	NEUT. PRESS	SPOOL AT NEUTRAL, 3000 PSI AT PRESS, GAGES IN CYL PORTS	$C_1 = C_2 = \frac{2250}{1000}$ PSI
2	NEUT. FLOW		20 TO 60 C.C./MIN.
3	PRESS GAIN	RECORD CYL PORT PRESS AT .001 INCREMENTS	REF. ONLY
4	FLOW	RECORD FLOW WITH CYL. PORTS INTERCONNECTED. 3000 PSI AT PRESS. PORT. USE 925 PSI FOR ±.020 AND OVER	LIMITS PER SHEET 2 RECORD AT ±.0025 ±.040 ±.005 ±.060 ±.0075 ±.080 ±.010 ±.100 ±.0125 ±.120 ±.140 ±.160 ±.175
5	CYL. PORT PRESS.	RECORD CYL. PRESSURE WITH PORTS INTERCONNECTED	1000 TO 2250 PSI WITH 3000 PSI INLET. RECORD AT ±.010; ±.020; ±.050

Pg 2 'B' SIZE

224210T

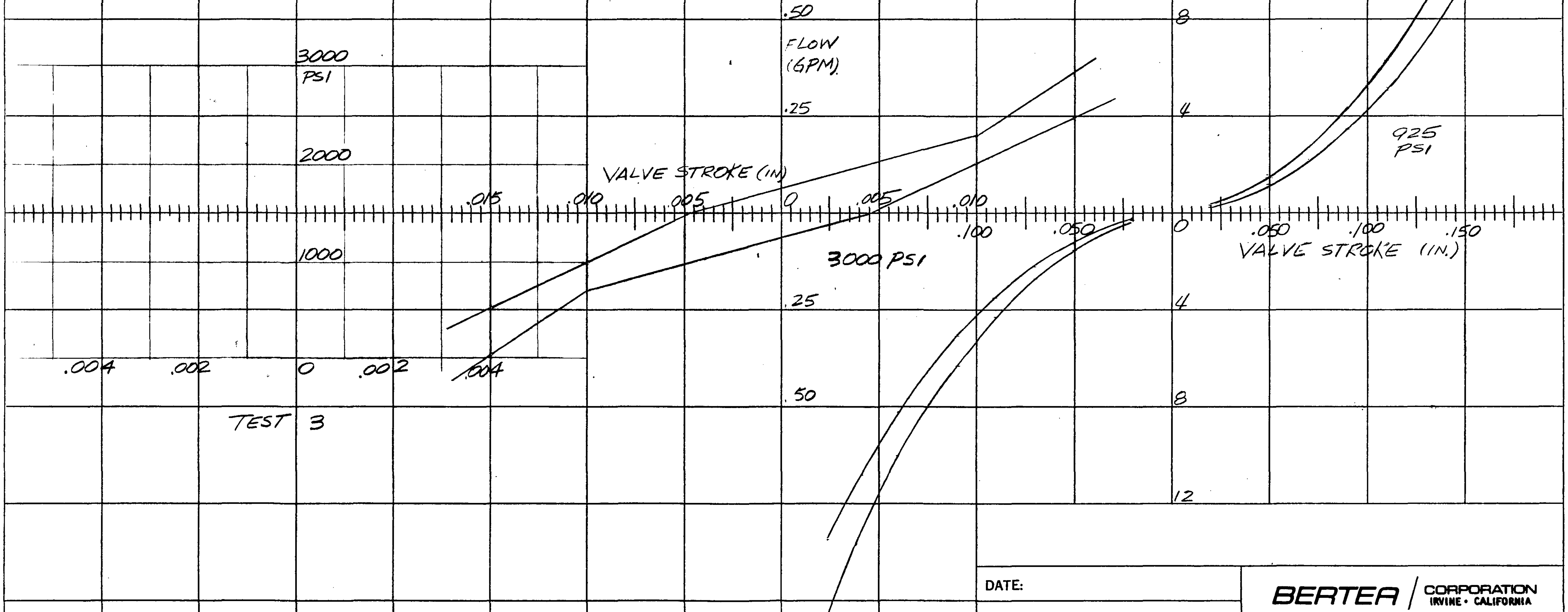
INSPECTION TEST RESULTS

SERIAL NO: 224210T

TEST 1 $C_1 = C_2 =$ ______ PSI
TEST 2 ______ C.C./MIN

TEST 5

	EXT	RET
.010	______ PSI	______ PSI
.020	______ PSI	______ PSI
.050	______ PSI	______ PSI



DATE:	BERTEA / CORPORATION IRVINE • CALIFORNIA
INSP:	224210T — REV.
VALVE NO:	
WORK ORDER:	PROJECT — PAGE 2 OF 2

ADP

224250-T

DART VALVE CONTROLLER

1) THE 224250-101 DART VALVE CONTROLLER SHALL MEET THE REQUIREMENTS OF THIS SPECIFICATION.

2) RECORD RESULTS ON A COPY OF THIS PROCEDURE.

3) CONNECT 115 VAC, 400 HZ, AND 28 VDC TO LIKE LABELED CONNECTORS ON THE BACK PANEL OF THE CONTROLLER. REFER TO BERTEA DRAWING NUMBER 224250 FOR PHYSICAL LAYOUT OF CONTROLLER.

BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY RJQ DATE

CHECK BY DATE

	TEST	SELECTOR SWITCH	PROCEDURE AND REQUIREMENT
1	INPUT GAIN	B_{IN}	A) SHORT CIRCUIT BOTH "LVDT" SECONDARY INPUTS. B) APPLY +10 VDC AT "COMMD". METER MUST READ 10 MA ± .5 MA. C) REPEAT WITH -10 VDC +______MA -______MA D) WITH "COMMD" SHORTED METER MUST READ LESS THAN .2 MA. ______MA E) RECORD "COMMD" VS "SWITCH MON" ON X-Y RECORDER.
2	ACTUATOR FEEDBACK GAIN	B_{IN}	A) SHORT CIRCUIT "COMMD" AND LVDT INPUT ON BACK OF BOX. B) APPLY 3.5 VAC TO "LVDT" INPUT ON BACK OF BOX. METER MUST READ 10 MA ± .5 MA. C) REPEAT WITH 23.5 VAC (RMS) REVERSED. +______MA -______MA D) WITH "LVDT" INPUT SHORTED THE METER MUST READ LESS THAN .2 MA. ______MA

BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY R?A DATE ______

CHECK BY DATE

	TEST	SELECTOR SWITCH	PROCEDURE AND REQUIREMENT
3	VALVE FEEDBACK GAIN	B_{OUT}	A) SHORT CIRCUIT "COMMD" AND "LVDT" INPUT ON FRONT OF BOX. B) APPLY 3.5 VAC TO "LVDT" INPUT ON BACK OF BOX. METER MUST READ 10 MA ± .5 MA. (C) REPEAT WITH 3.5 VAC REVERSED. +______MA −______MA D) WITH "LVDT" INPUT SHORTED METER MUST READ LESS THAN .2 MA.
4	EXCITATION VOLTAGE		A) RECORD VOLTAGE AT "26 VAC" ON BACK OF BOX. MUST BE 26 ± 1 VAC ______VAC
5	STEP SIZE	B_{IN}	A) SHORT CIRCUIT BOTH "LVDT" INPUTS. B) RECORD METER READINGS FOR THE FOLLOWING STEPS.

LIGHTS	REQUIREMENT	METER
L5	>1.35 MA	______MA
R4	<.15 MA	______MA
___	0 MA	
L4	<.15 MA	______MA
R5	>1.35 MA	______MA

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PRODUCTION TEST PROCEDURE

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TEST		SELECTOR SWITCH	PROCEDURE AND REQUIREMENT
6	STEPPING RATE	—	A) APPLY 10 VDC TO "COMMD". B) RECORD L5 VOLTAGE ON OSCILLOSCOPE. C) SOLENOID MUST BE OFF FOR 12.5 ± 1 MILLISECOND AND ON FOR 12.5 ± 1 MILLISECOND. _______MS ON _______MS OFF

224250T

A

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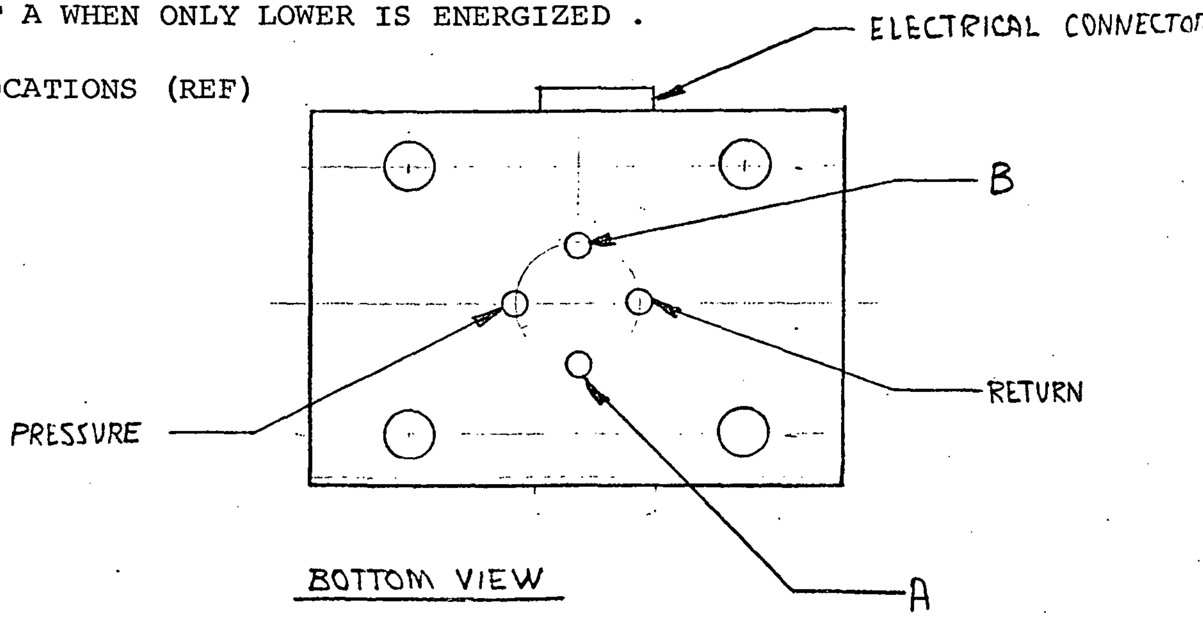
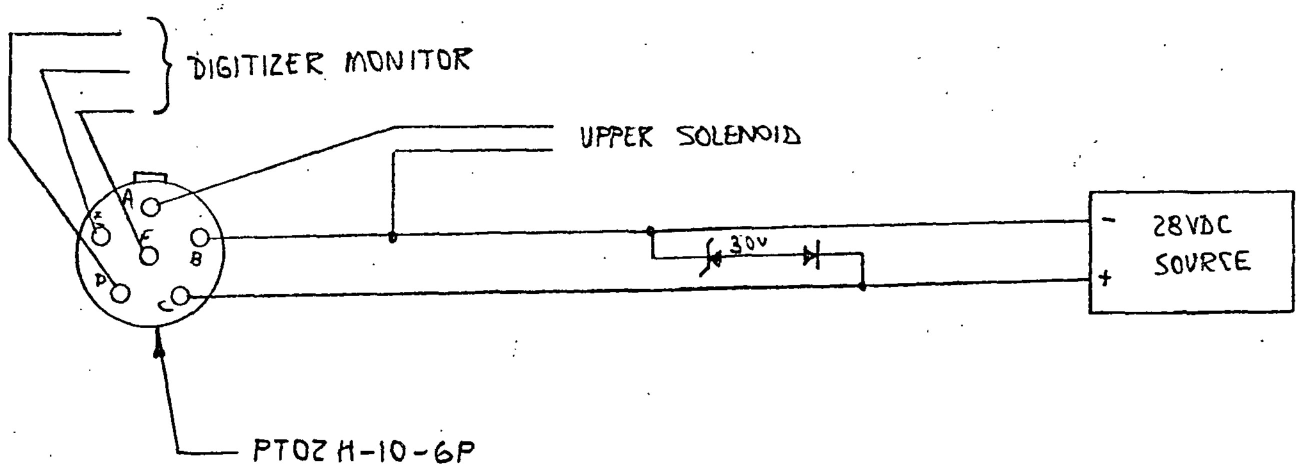
1. TEST ALL 228200 DART VALVES TO THIS PROCEDURE.
2. TEST VALVE SLIDES TO 228212-T.
3. USE MIL-H-5606 FLUID AT 80 $\pm$ 20^{o}F, 3000 PSI.
4. PERFORM TESTS IN ORDER NOTED.
5. RECORD RESULTS ON A COPY OF THIS PROCEDURE.
6. FLOW IS OUT OF B PORT WHEN ONLY THE UPPER SOLENOID IS ENERGIZED; OUT A WHEN ONLY LOWER IS ENERGIZED .

PORT LOCATIONS (REF)



BOTTOM VIEW



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IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

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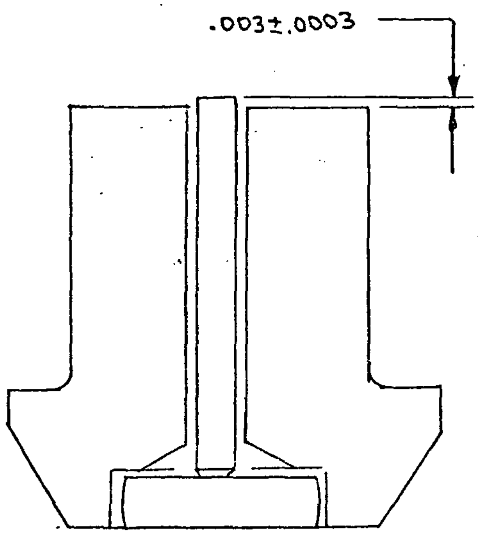
CHECK BY DATE

	TEST	PROCEDURE	REQUIREMENT
1.	SOLENOID TRIM		UPPER SOLENOID ______ LOWER SOLENOID ______
2.	RESISTANCE	MUST BE 50-60 OHMS BETWEEN A-B OR B-C MUST BE 550-650Ω BETWEEN D-E OR E-F	A-B ______Ω B-C ______Ω D-E ______Ω E-F ______Ω
3.	SOLENOID TIME CONSTANT	RECORD PULL-IN AND DROP-OUT VOLTAGE AND CURRENT. 3 MS MAX PULL-IN, 4 MS MAX DROP-OUT. SET SUPPLY PRESSURE AT 3000 PSI	PULL-IN UPPER ______MS LOWER ______MS DROP-OUT UPPER ______MS LOWER ______MS
4.	INTERNAL LEAKAGE	APPLY 28VDC TO BOTH SOLENOIDS. MEASURE LEAKAGE AT A, B, AND R, 10 CC/MIN MAX EACH PORT	A ______CC/MIN B ______CC/MIN R ______CC/MIN

228200T

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S/N ______

228200T

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PRODUCTION TEST PROCEDURE

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5.	ORIFICE SIZE	APPLY 28VDC TO UPPER SOLENOID. FLOW AT A MUST BE 1650 TO 2000 CC/MIN. REPEAT FOR B.	A ____ CC/MIN B ____ CC/MIN
6.	SWITCH POINT	APPLY 28VDC TO UPPER SOLENOID. RESTRICT FLOW AT A. MEASURE BACK PRESSURE FOR 1200 CC/MIN.	A ____ PSI B ____ PSI
7.	INTER-FLOW	MEASURE FLOW FROM R DURING ABOVE TEST. REFERENCE ONLY.	(A) ____ CC/MIN (B) ____ CC/MIN

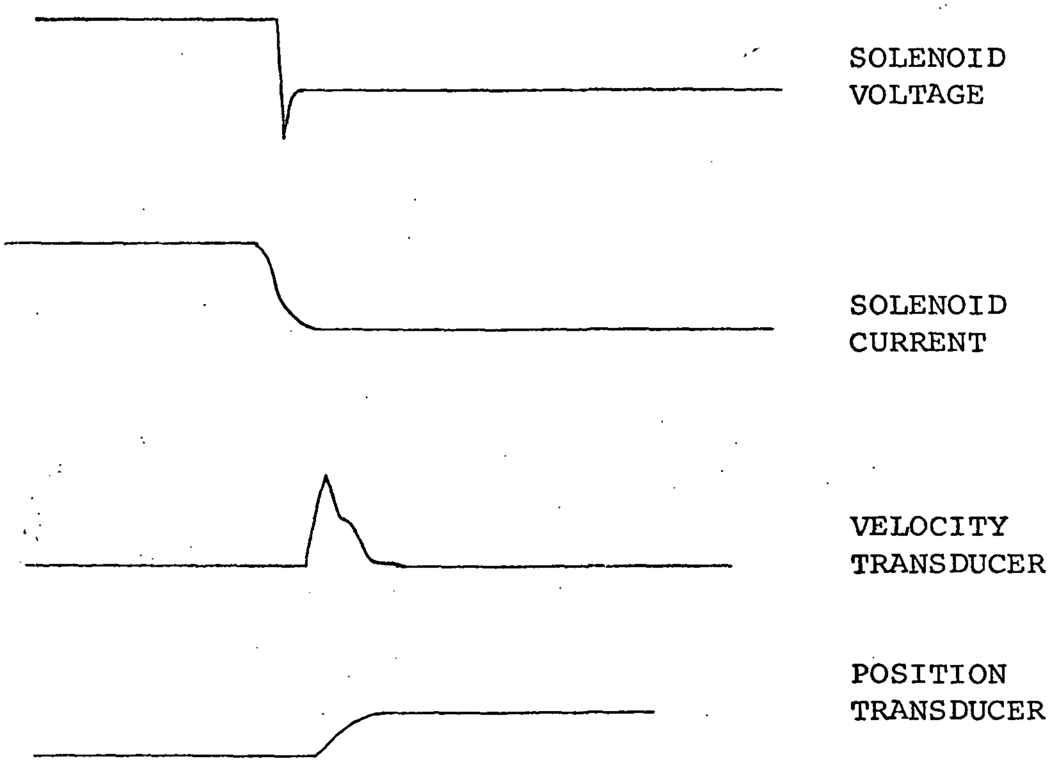
CONNECT DART VALVE ASSEMBLY TO SK 51772 RESPONSE ACTUATOR. USE 228240-101 HARNESS TO CONNECT DART VALVE TO 224250 CONTROLLER TEST CONTROLLER PER 228250T BEFORE USE.

CYLINDER BORE ____, ROD ____, AREA ____

8.	DIGITIZER LEAKAGE	APPLY 300 PSI TO P WITH ONLY LOWER SOLENOID ENERGIZED. MEASURE CHANGE IN LEAKAGE AT R WHEN 2000 PSI IS APPLIED AT A. REPEAT FOR LOWER VALVE.	A ____ CC/MIN B ____ CC/MIN

9.	DRIFT	ENERGIZE BOTH SOLENOIDS. MEASURE ACTUATOR DRIFT RATE.	______________IN/SEC

10. APPLY 3000 PSI TO PRESSURE PORT. MONITOR VELOCITY TRANSDUCER ON OSCILLOGRAPH. WITH UPPER SOLENOID ENERGIZED RECORD TURN-ON AND TURN-OFF FOR LOWER SOLENOID. REPEAT WITH LOWER ENERGIZE. RECORD SOLENOID VOLTAGE AND CURRENT, VELOCITY AND POSITION OF RESPONSE ACTUATOR. ($180\ MV/IN/SEC/.196IN^2 = 920\ MV/IN^3/SEC = 1\ MV/CC/MIN$) ATTACH RECORDING TO TEST RESULTS. IDENTIFY AS NOTED BELOW.



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PRODUCTION TEST PROCEDURE

DRAWN BY R&CA DATE

CHECK BY DATE

11.	DIGITIZER TRIM	TRIM DIGITIZER STOPS TO OBTAIN NOTED STEP SIZES. AT 40 STEPS/SEC. S/N COUNT SIZE 001 1 .00137 002 5 .00684 MUST AGREE WITH ±10%	UPPER ______ IN^3 LOWER ______ IN^3

S/N ____

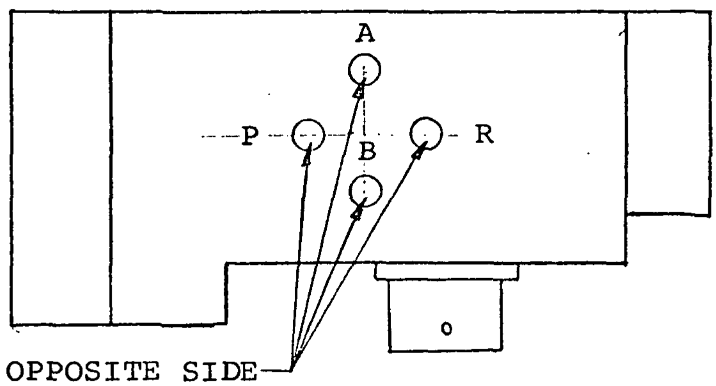
228200T

DART VALVE SLIDE TEST

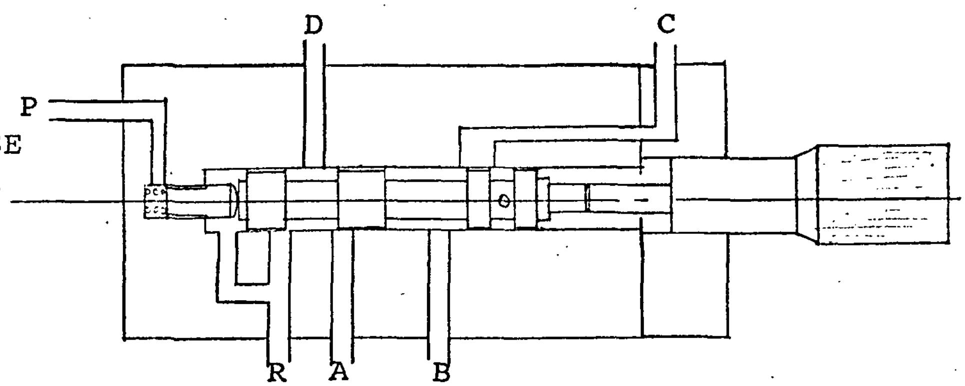
1. TEST BOTH UPPER AND LOWER LAP ASSEMBLIES TO THIS PROCEDURE.
2. TEST DIGITIZER ASSEMBLIES PER 228220-T BEFORE INSTALLING IN VALVE HOUSING.
3. USE MIL-H-5606 FLUID AT $80^{\circ} \pm 20^{\circ}$F. DO NOT APPLY MORE THAN 1500 PSI TO TEST FIXTURE.
4. RECORD TEST RESULTS ON A COPY OF THIS PROCEDURE.

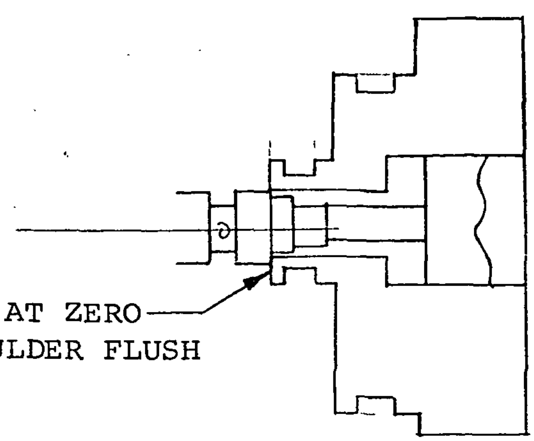
TOP VIEW

PORT LOCATION



UPPER VALVE PORTING (REVERSE A & B FOR LOWER VALVE)





LOWER VALVE (Continued)

7. WITH VALVE AT "-" STOP. RECORD PRESSURE AT B TO MOVE DIGITIZER PISTON.

INCREASING ______PSI TO START ______PSI TO BOTTOM
DECREASING ______PSI TO START ______PSI TO RESET

UPPER VALVE (MAINTAIN LOWER SOLENOID ENERGIZED)

8. MEASURE VALVE STROKE TO "+" AND "-" STOPS. MUST BE .090 ± .003 IN PLUS DIRECTION.

RECORD READING +______INCHES
-______INCHES

9. APPLY 700 PSI TO A. VENT P, R, B, AND C.

EXTEND VALVE SLIDE AND MONITOR 2WDT OUTPUT. RECORD VALVE POSITION WHICH CAUSES DIGITIZER PISTON TO BOTTOM. RETRACT VALVE SLIDE AND RECORD POSITION WHICH ALLOWS DIGITIZER PISTON TO RESET. (TO AVOID LEAKAGE INTERFERENCE, THE RECORDED SLIDE POSITIONS SHOULD CAUSE THE DIGITIZER TO EXTEND OR RETRACT IN LESS THAN 1 SECOND.) MUST AGREE WITH FIGURE 1.

______IN TO BOTTOM DIGITIZER ______IN TO RESET

10. APPLY 200 PSI TO C. VENT P, R, A, AND B. EXTEND VALVE SLIDE AND RECORD POSITION FOR APPROXIMATELY .1, .2, .3, .4, .5, 1, AND 2 GPM AT B OR R. MUST AGREE WITH FIGURE 1.

FLOW AT R		FLOW AT B	
______IN	______GPM	______IN	______GPM
______IN	______GPM	______IN	______GPM
______IN	______GPM	______IN	______GPM
______IN	______GPM	______IN	______GPM
______IN	______GPM	______IN	______GPM
______IN	______GPM	______IN	______GPM
______IN	______GPM	______IN	______GPM

11. APPLY 200 PSI AT P. RECORD LEAKAGE AT R FOR VALVE SLIDE FULLY RETRACTED AND FULLY EXTENDED. RECORD AT C.

______CC/MIN AT "+" STOP ______CC/MIN AT "-" STOP
______CC/MIN AT C

LOWER VALVE (MAINTAIN UPPER SOLENOID ENERGIZED)

1. MEASURE VALVE STROKE TO "+" AND "-" STOPS. MUST BE .090 $\pm$ .003 IN PLUS DIRECTION.
RECORD READING +______INCHES
-______INCHES

2. APPLY 700 PSI TO B. VENT P, R, A, AND C.

EXTEND VALVE SLIDE AND MONITOR 2WDT OUTPUT. RECORD VALVE POSITION WHICH CAUSES DIGITIZER PISTON TO BOTTOM. RETRACT VALVE SLIDE AND RECORD POSITION WHICH ALLOWS DIGITIZER PISTON TO RESET. (TO AVOID LEAKAGE INTERFERENCE, THE RECORDED SLIDE POSITIONS SHOULD CAUSE THE DIGITIZER TO EXTEND OR RETRACT IN LESS THAN 1 SECOND.) MUST AGREE WITH FIGURE 1.

______IN TO BOTTOM DIGITIZER ______IN TO RESET

3. APPLY 200 PSI TO C. VENT P, R, B, AND A.

EXTEND VALVE SLIDE AND RECORD POSITION FOR APPROXIMATELY .1, .2, .3, .4, .5, 1, AND 2 GPM AT A OR R. MUST AGREE WITH FIGURE 1.

FLOW AT R		FLOW AT A	
______IN	______GPM	______IN	______GPM
______IN	______GPM	______IN	______GPM
______IN	______GPM	______IN	______GPM
______IN	______GPM	______IN	______GPM
______IN	______GPM	______IN	______GPM
______IN	______GPM	______IN	______GPM
______IN	______GPM	______IN	______GPM

4. APPLY 200 PSI AT P. RECORD LEAKAGE AT R FOR VALVE SLIDE FULLY RETRACTED AND FULLY EXTENDED. RECORD FLOW AT C.

______CC/MIN AT "+" STOP ______CC/MIN AT "-" STOP
______CC/MIN AT C

5. APPLY 1500 PSI AT B. RECORD LEAKAGE AT R AND A FOR VALVE SLIDE AT "+" STOP.

______CC/MIN AT R ______CC/MIN AT A

6. APPLY 1500 PSI AT A. RECORD LEAKAGE AT R AND B FOR VALVE SLIDE AT "+" STOP.

______CC/MIN AT R ______CC/MIN AT B

UPPER VALVE (Continued)

12. APPLY 1500 PSI AT A. RECORD LEAKAGE AT R AND B FOR VALVE SLIDE AT "+" STOP.

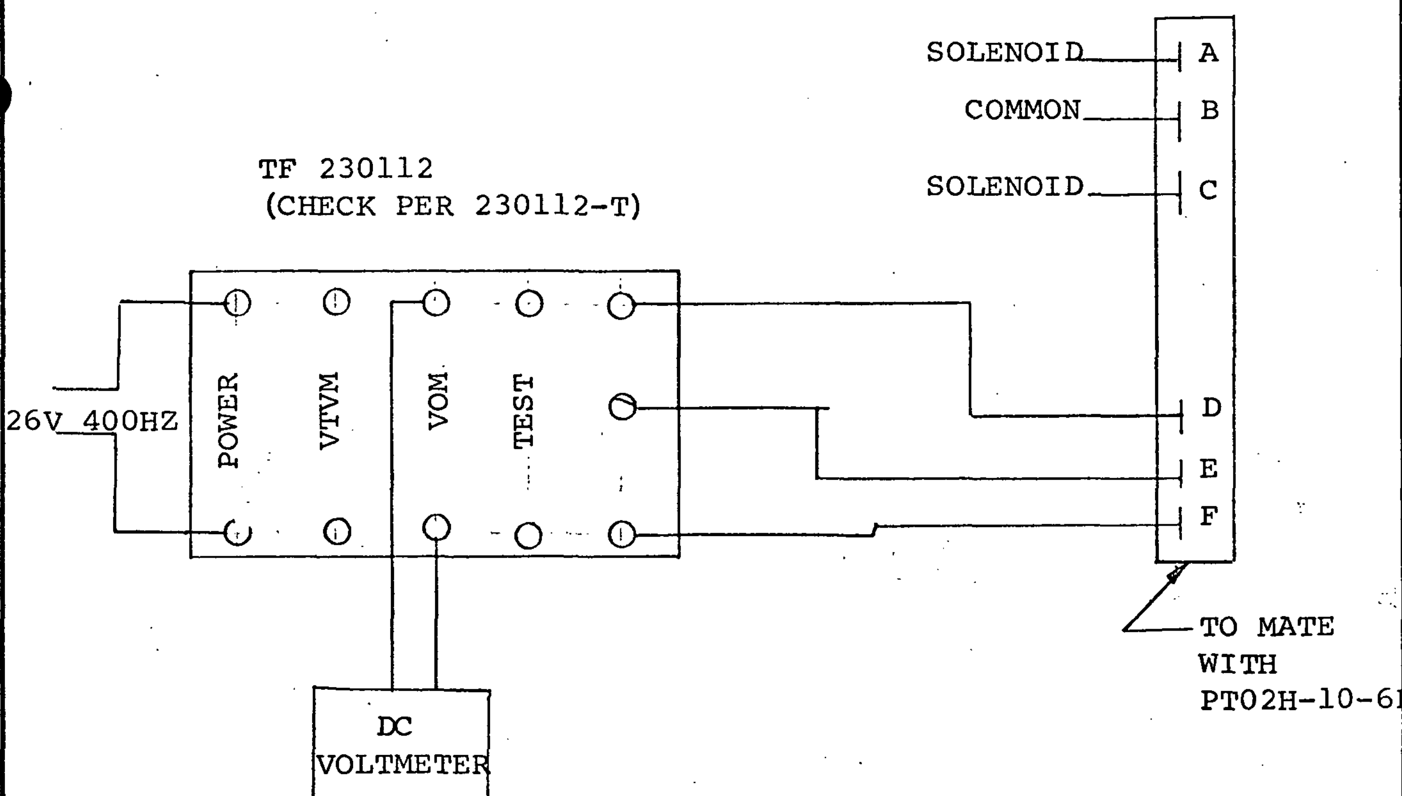
______CC/MIN AT R ______CC/MIN AT B

13. APPLY 1500 PSI AT B. RECORD LEAKAGE AT R AND A FOR VALVE SLIDE AT "+" STOP.

______CC/MIN AT R ______CC/MIN AT A

14. WITH VALVE AT "-" STOP RECORD PRESSURE AT A TO MOVE DIGITIZER PISTON.

INCREASING ______PSI TO START ______PSI TO BOTTOM
DECREASING ______PSI TO START ______PSI TO RESET



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PRODUCTION TEST PROCEDURE

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CHECK BY DATE

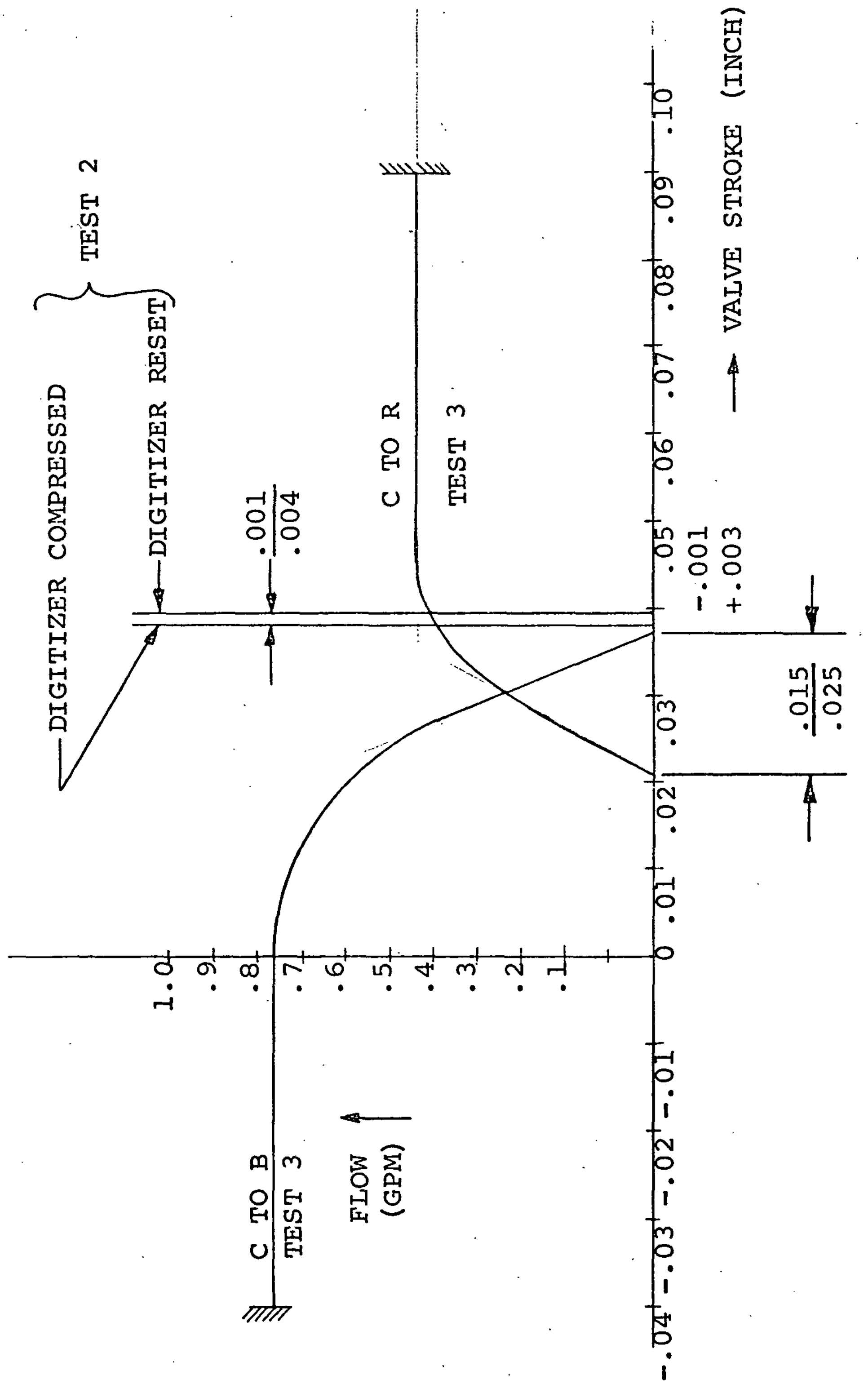


FIGURE I

228212-T

PG. 5 OF

S/N

228212-T

BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

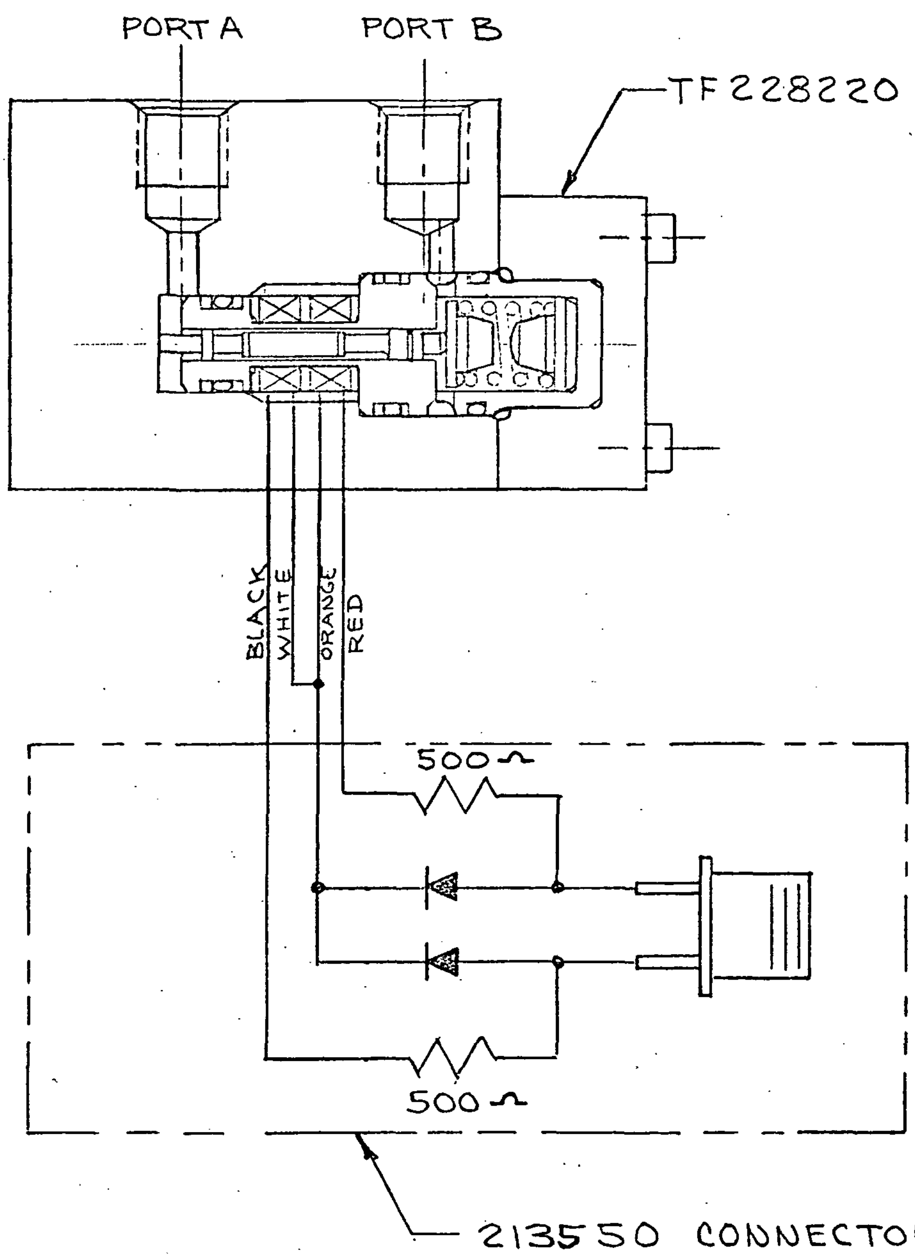
DRAWN BY A. FACKRELL DATE 7-12-72
CHECK BY P. CHIN DATE 10-4-72

228220 DIGITIZER

1) FLUID: MIL-H-5606 AT 80° ± 20° F

2) ASSEMBLE 228220 VALVE ASSEMBLY INTO TF228220 USING 228226 CAP, 93360 SPRING, 228228 SEAT AND 228230 STOP.

3) *RECORD RESULTS ON DATA SHEET, SEND ONE COPY WITH UNIT AND FILE ONE COPY*



BERTEA CORPORATION IRVINE • CALIFORNIA

PRODUCTION TEST PROCEDURE

DRAWN BY A FACKRELL DATE 7-12-72
CHECK BY P. CHIN DATE 10-4-72

TEST		PORT A	PORT B	REQUIREMENT
1	PROOF	4500 PSI	OPEN	NO EXTERNAL LEAKAGE IN 2 MINUTES
		OPEN	3000 PSI	
2	LEAKAGE	3000 PSI	OPEN	2 CC/MIN MAXIMUM
3	COIL RESISTANCE			650 ± 50 OHMS PER COIL
CONNECT COIL LEADS TO 213550 CONNECTOR ASSY. ATTACH TO TF213500				
4	EXCITATION CURRENT			MEASURE AC (RMS) CURRENT AT THE EXCITATION TERMINALS OF TF213500. 50 MA MAX.
5	PRESSURE SETTING	AS REQD	OPEN	RECORD PRESSURE VS VOLTAGE 0 TO 1000 PSI (SEE SHEET 4 OF 213500-T)
6	DIELECTRIC STRENGTH			APPLY 500 VAC (60 HZ) NO ARCING OR INSULATION BREAKDOWN IN ONE MINUTE.
7	INSULATION RESISTANCE			100 MEGOHMS MINIMUM WITH 500 VDC BETWEEN COILS AND HOUSING.

228220T

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PART

228220T

INSPECTION TEST RESULTS

TEST		RESULTS	ACC.	REJ.
1	PROOF	A		
		B		
2	LEAKAGE	______ CC/MIN		
3	COIL RESISTANCE	______ OHMS		
4	EXCITATION CURRENT	______ MA		
5	PRESSURE SETTING			
6	DIELECTRIC STRENGTH			
7	INSULATION RESISTANCE	______ KOHMS ______ KOHMS		

Form 1072

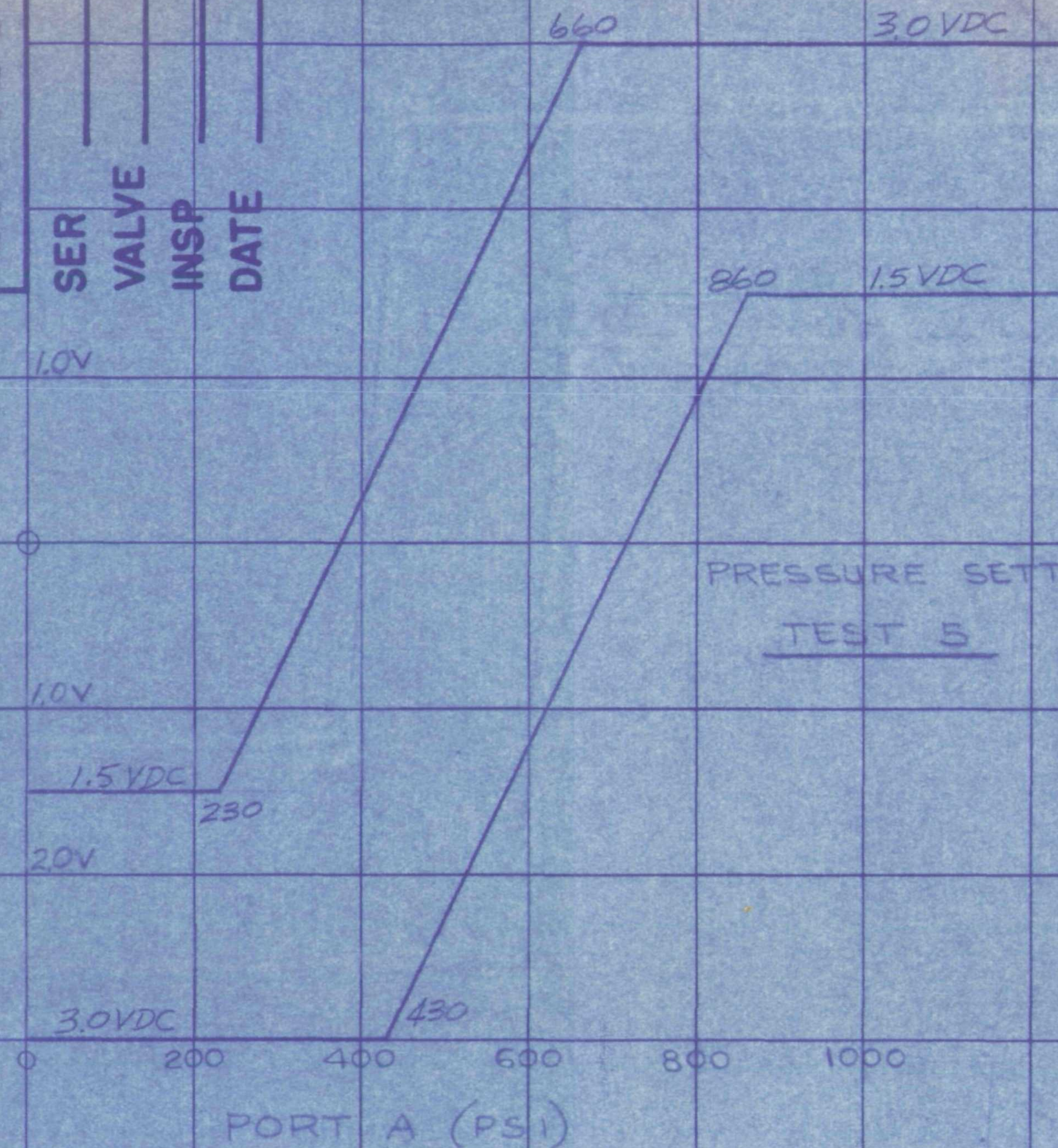
228220T

SER

VALVE

INSP

DATE



PRESSURE SETTING

TEST 5

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228220T

DART