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SBASI - ACTUATED PYROTECHNIC TIME DELAY INITIATOR, FINAL REPORT

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16. Abstract

A precision pyrotechnic time delay initiator for missile staging has been developed and tested. Incorporated in the assembly is a Single Bridgewire Apollo Standard Initiator (SBASI) for initiation, a Through-Bulkhead-Initiator to provide isolation of the SBASI output from the delay, the pyrotechnic delay,and an output charge. A delay of 6.0 seconds from ignition of the SBASI to ignition of the output charge was desired, as well as demonstrating a post-fire leakage of less than 1×10^{-5} cc/sec of helium at 5000 psi. The design, development, and testing of this delay initiator was approached with a systematic attempt to control both primary and secondary variables affecting functional performance, as well as incorporating design and functional limit exploration to establish tolerance levels on manufacturing and assembling operations. The test results have demonstrated a coefficient of variation of about 2% at any one temperature and overall coefficient of variation of 2.7% throughout the temperature range of 30 to 120°F. The unit has been tested over this temperature range at simulated operational altitude from sea level to 200,000 feet, following exposure to non-operating environments of acceleration, shock, vibration, and temperature shock.

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SBASI ACTUATED PYROTECHNIC TIME DELAY INITIATOR

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SUMMARY

A precision pyrotechnic time delay initiator for missile staging has been developed and tested. Incorporated in the assembly is a Single Bridgewire Apollo Standard Initiator (SBASI) for initiation, a Through-Bulkhead-Initiator for isolation of the SBASI output from the delay, the pyrotechnic delay and an output charge.

A delay from initiation of the SBASI to ignition of the output charge of 6.0 seconds with a coefficient of variation (COV) test to test of 3% was required with a further target of 2% COV desired.

The design process embodied a systematic attempt to control both primary and secondary variables affecting delay variability. The design concepts tested and evaluated included:

1. Sealed delay column vent cavity for minimum variation of delay cavity pressure test to test.

2. Sealed delay output barrier to prevent premature output ignition from gas percolation down the delay column.

3. Delay output thermal barriers to prevent premature heating and ignition of output charge due to heat transfer.

4. A delay mixture of tungsten, potassium perchlorate, barium chromate and diatomaceous earth.

5. Use of Al A as a low gaseous, high heat delay ignitor material.

The combination of requiring the SBASI actuation (high gaseous output) and the minimum delay variation along with stringent post fire leakage requirements led to the utilization of the Through Bulkhead Initiation (TBI) fire transfer technique where shock transfer through a solid bulkhead from a donor charge to an acceptor charge is used. An additional design feature is the sealed output charge combining a high gas producer ($BKNO_3$) with a high heat producer (Al A) for reliable ignitor initiation under vacuum conditions.

The test results have demonstrated a COV of about 2% at any one temperature and overall COV of 2.7% throughout the entire temperature range. The unit has been tested over the temperature range of 30°F to 120°F, simulated operational altitude from sea level to 200,000 ft. and non-operating environments of acceleration, shock, vibration and temperature shock.

A feature of the test series was the incorporation of design limit exploration to establish tolerance levels on manufacturing and assembling operations.

INTRODUCTION

Certain NASA solid propellant rocket missions require the delayed ignition of stage motors to accomplish proper sequencing of mission events. Under NASA Contract NAS 1-10988, MBAssociates has undertaken to design, test and demonstrate a precision pyrotechnic time delay to provide this function. The actuation of the delay unit is provided by a Single-Bridgewire Apollo Standard Initiator (SBASI), the unit output is designed to initiate a standard pyrogen motor ignitor.

Delay Elements as Pyrotechnic Components

Almost any condensed phase pyrotechnic composition that exhibits a reasonably reproducible burn rate can be used to provide a delay in an energy transfer process. A very readable historical overview of pyrotechnic delays as well as examples of elements in use is provided by Ellern, Reference 1. Additional technical and performance data are contained in Reference 2.

Both reference works highlight the fact that a number of basic and process-dependent parameters can affect accuracy and reliability of a pyrotechnic delay. Among these are:

- Composition and quantity of charge
- External Pressure
- External Temperature
- Terminal Charge
- Partical Size
- Ignition

- Column Diameter
- Loading Pressure
- Housing Material
- Acceleration
- Storage
- Processing

Because of the pressure dependence of burn rate the greatest reproducibility under varying ambient pressure is achieved by delay columns which are sealed ("obturated" in ordnance parlance) and provide a venting space to contain the gaseous products of reaction. This same consideration leads to common usage of the so-called gasless delay mixes (actual very low theoretical gas producers). The most common compositions are mixtures of powdered metal (nickel, zironium, boron and tungsten) with an appropriate oxidizer.

Two common fabrication techniques for delay columns are swaging and pressing. Swaged columns are loaded in ductile tubing and then swaged to smaller sizes to provide compaction. Pressed columns are ram-loaded (usually in a series of increments) into a bored housing. The swaged delay lines provided a convenient means for adjusting exact burn time by cutting to length; length adjustment on pressed delays by varying the total load or back cutting is less convenient but routinely done. The problem of interface fire transfer, particularly in sealed columns is significantly greater for cut, swaged columns than for pressed columns.

The delay developed and reported here is an obturated, pressed column delay using tungsten metal mixed with Barium Chromate, Potassium Perchlorate and Diatomaceous Earth. A fundamental investigation of this delay mix is given by Zimmer-Galler, Reference 3. A brief summary of the state-of-the-art of obturated delays including tungsten delays is presented by Valenta, Reference 4.

The tungsten mixture is inherently a low gas producer, is relatively insensitive to ambient temperature and permits a wide variation of burning rate by varying composition and particle size.

Reference 2 states that under controlled laboratory conditions it is possible to obtain coefficients of variations (standard deviation expressed as a percent of the mean) of less than 3%. Reference 4 reports that an obturated tungsten delay has exhibited a COV of 2% to 5% and a temperature coefficient of burn time of about 0.04% per degree F. The latter reference also notes a good stability of the tungsten mix under high temperature storage.

Program Objectives

The primary objective of the program was to develop the technology base attendant to the production of a SBASI actuated pyrotechnic time delay initiator. Corrollary to this prime objective were specific development tasks and goals. These were as follows.

1. Design, fabricate and test an initiator conforming to the stated design requirements;

2. Design for and verify through testing the functional reliability of the initiator under specified non-operating environments;

3. Develop manufacturing and inspection procedures as a technology base for production of accurate, highly reliable delay initiators.

Pursuant to task 1, the stated design requirement are as follows:

- Design Envelope as shown (Figure 1)
  (Design Target of Minimum Size)
- Ignite $BKNO_3$ Pellets in Rocket Motor Ignitor
- $+30^o$ to $+120^oF$ Operational Temperature Range
- Sea Level to 200,000 ft. Simulated Altitude Operational Range
- Autoignition Greater than 400^oF
- Withstand Postfire Static Backpressure of 5000 psi
- Postfire Leak Rate Less than 1×10^{-5} cc/sec Helium at One Atmosphere
  (After Exposure to 5000 psi Backpressure)
- Shelf Life up to 5 Years
  ($0-120^oF$ & RH to 100% Storage)

Under Task 2, the environmental test program was conducted in accordance with the following specification.

- Withstand Acceleration of 35 G's along any Axis
- Withstand Temperature Shock of -40^oF to $+140^oF$ within one minute
- Withstand Vibration shown below along any Axis.

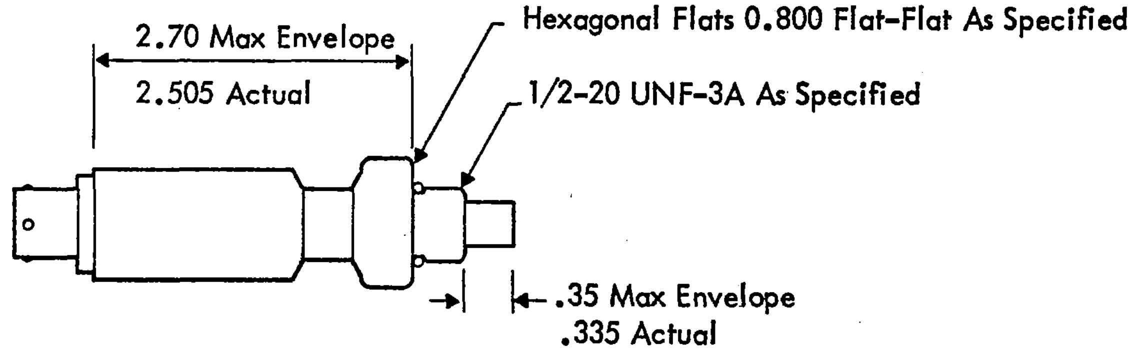


FIGURE 1.
REQUIRED DESIGN ENVELOPE

Test Duration (Sec)	Frequency (cps)		Acceleration		
	Lower	Upper	Random (Grms Ref)	Spectral Density (G^2/cps)	Sine Log Sweep ($\pm$ G)
70	20	100	-	-	18
100	100	1000	-	-	36
30	1000	2000	-	-	9
240	20	2000	11.5	.07	-

In addition to demonstrating overall functional adequacy and reliability a design objective was to demonstrate a coefficient of variation of delay function of 3% (at one temperature) with a goal of achieving less than that value.

Program Structure

The development program was structured to provide an orderly approach to the design goals of demonstrating a functional unit and exploring the relevant technology. Starting from a point design utilizing available information a systematic investigation of identifiable design parameters was undertaken. The program was divided into four major areas of endeavor as follows:

1. Through bulkhead initiation
2. Delay process variability
3. Transfer/output charge
4. Overall assembly and sealing.

The basic approach was to explore design adequacy through limit testing to establish sensitivity to manufacturing tolerances. In addition an attempt was made to specify as accurately as possible the processes and procedures involved.

The remaining sections of this report present details of the design itself, the development procedure and a summary and assessment of the results of the test program.

APPARATUS

This section presents a design description of the final initiator configuration. This description is presented from two standpoints, first a functional summary delineating the physical processes involved and second a material and configuration description of each component. Dimensional details and pertinent process specifications are presented as appendices to this report.

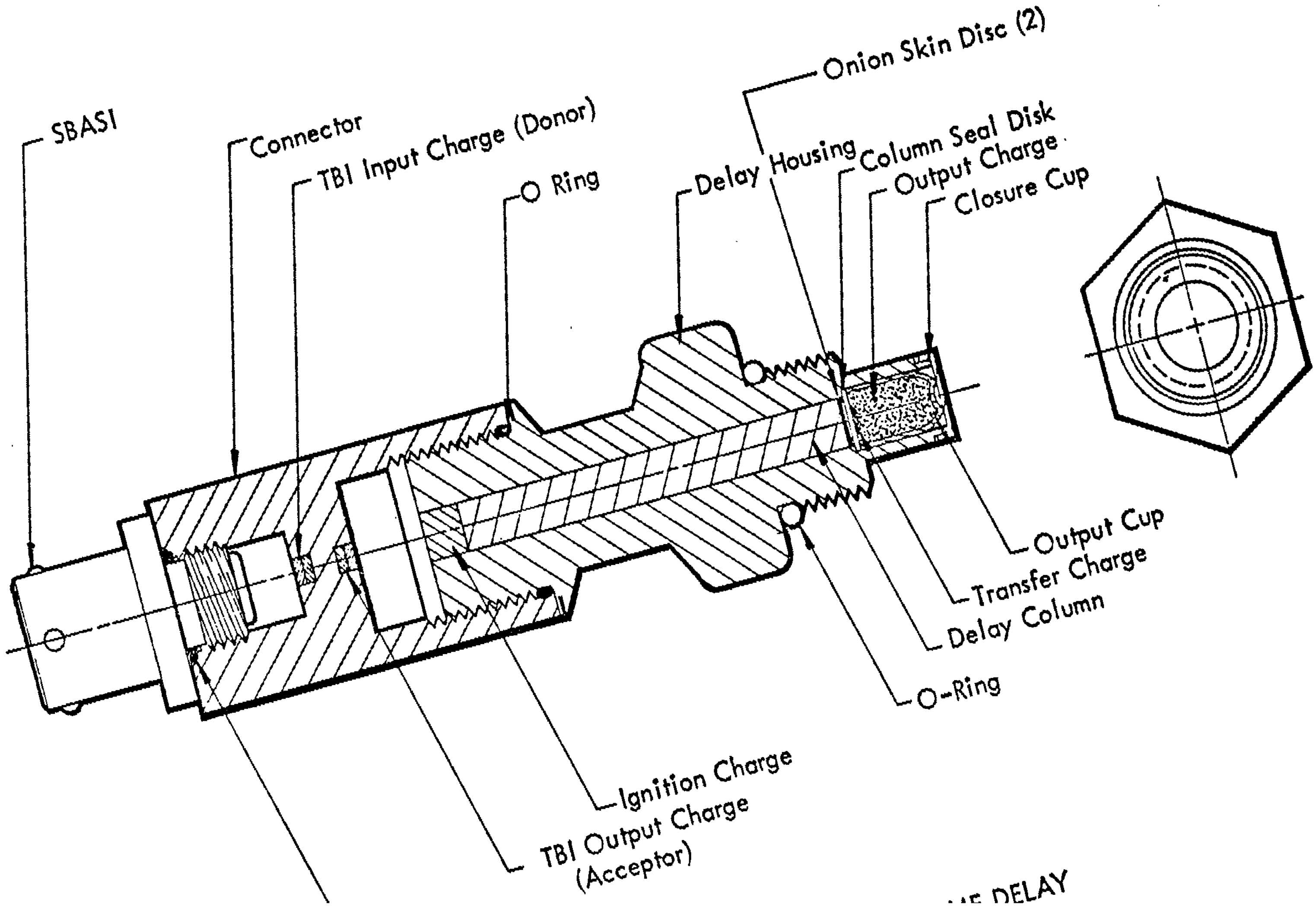
Functional Elements

An overall assembly sketch of the element in cross-section is shown as Figure 2. The fire transfer path is from left to right in the unit as shown. Figure 2a is a photograph of an assembled unit, Figure 2b is a neutron radiograph of an assembly. The various fire-train elements illustrated in Figure 2 can be distinguished. The sequence of functions is as follows.

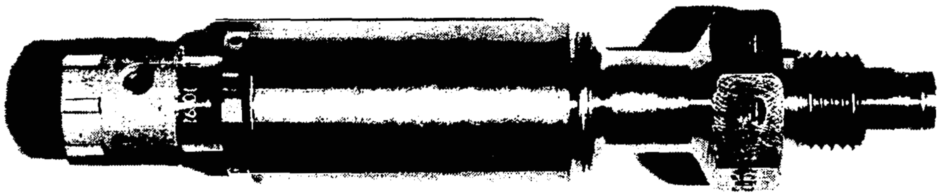
Initiator actuation occurs by firing the SBASI. The SBASI output gases are contained in the input cavity of the connector. The free volume after SBASI fire is about 0.88cc resulting in a peak pressure of approximately 6500 psia.

The SBASI output initiates an input charge for the through-bulkhead-initiation (TBI) function which is pressed into a recessed cavity in the bulkhead. This TBI input charge (lead azide, PbN_6) is the donor of the bulkhead shock wave.

The bulkhead shock wave initiates the TBI output charge which is pressed into a recessed cavity on the output side of the bulkhead and consists of an increment of lead azide (at the base of the recess) and an increment of A1A (pressed on top of the lead azide increment in the recess). This output charge is the acceptor to the bulkhead shock transmission and a donor to the delay ignition charge. The lead azide provides a vigorous output while the A1A provides a hot slag since the primary products of combustion are


SBASI
Connector
TBI Input Charge (Donor)
O Ring
Delay Housing
Onion Skin Disc (2)
Column Seal Disk
Output Charge
Closure Cup
Output Cup
Transfer Charge
Delay Column
O-Ring
Ignition Charge
TBI Output Charge
(Acceptor)

E DELAY



A. Assembled Unit

B. Neutron Radiograph of Assembled Unit

FIGURE 2A., 2B.
INITIATOR ASSEMBLY

condensed phase. The slag provides, through direct thermal transfer, an adequate ignition stimulus to the delay column ignition charge.

The delay column ignition charge is again an increment of Al A, pressed as the last increment in the loading process, into intimate contact with the delay column. This Al A ignition charge is easily ignited by the TBI output charge and does reliably initiate the delay column. The Al A is a fast burning mix (approx. 10 inches per second), low gaseous output hot slag producer (550 calories/gram heat of reaction) which renders the overall function time (delay) insensitive to Al A loading tolerances.

The primary time delay is provided by the pressed delay column itself. The delay selected was a blend of Tungsten, Potassium Perchlorate, Barium Chromate and Diatomaceous Earth. This mixture was selected because of its established characteristics of reproducible burn rates and low temperature sensitivity of burn rate, Reference 4.

The output end is sealed by a 0.003 inch thick stainless disk induction brazed at the base of the output charge cavity. As can be seen in Figure 2 the output cavity is slightly larger in diameter than the column cavity thus providing a shoulder for attachment of the column seal disk.

The output disk performs two functions. It provides structural support for the delay column during the burning event and it serves as a pressure seal to prevent gas percolation from the reaction zone down the unburned column. Both column shift and gas leakage can contribute to erratic burn times so that control here was deemed important to precision delay performance.

Since the delay blend has a high metal content, the thermal conductivity of the unburned column is relatively high. To prevent a premature thermal transfer across the output disk ahead of the flame zone, a thermal barrier consisting of 2 disks of onion skin paper were placed between the base of the delay column and the output disk. These onion skin paper disks are an effective insulator prior to the arrival of the reaction zone but are rapidly decomposed by the flame front itself.

As an aid in achieving reliable fire transfer through the output disk a transfer charge is placed in intimate contact with the outboard side of the output seal disk. This charge is a mixture of KDNBF (potassium 4. 6-dinitro-7-hydroxy-7-hydro benzo furoxan) and diatomaceous earth. This charge, with an auto ignition temperature in the range of 430 to 455^{o}F (221 to 232^{o}C), assists in igniting the main output charge.

The main output charge is a combination of two components both of which are themselves mixtures. The primary gas and energy producer is Boron-Potassium Nitrate mixture ($B\text{-}KNO_3$). A small amount of Al A powder is blended into the output charge. The additional hot slag material exiting with the output charge and actually impinging on the ignition pellets (in the motor ignitor itself) enhances ignition reliability, particularly under high altitude (low ignitor ambient pressure) conditions.

The main output charge (Boron Potassium Nitrate and Al A) is loaded in a soft aluminum cup which is in turn inserted into the output cavity with the open end of the cup oriented towards the delay output seal disc. The output end of the initiator assembly is then hermetically sealed by welding a closure cup over the open end of the housing. By closing and sealing the output charge in this manner the output charge must build sufficient pressure to rupture the seal and thus promote complete ignition of the output charge and subsequently, the motor ignitor pellets in the pyrogen ignitor.

Part and Component Descriptions

An overall pictorial view (exploded) of the initiator parts and components is shown as Figure 3 (detailed machine drawings are shown in the Appendix). Each of the items will be considered in turn following, generally, the fire train.

The SBASI itself is a standard item. No modifications to it are made. Published performance and physical specifications are included in the Appendix to this report.

The connector serves as a transition part between the SBASI and the delay housing. It is machined from Type 304 stainless steel. The connector is threaded to mate with the SBASI at the input side and the delay housing at the output side. The connector serves the primary function of isolating the delay column from the SBASI output by providing the bulkhead barrier. The separation bulkhead is nominally 0. 25 inch thick. Machined in the bulkhead are two 0. 081 inch receptacle holes for the input and output charges for the TBI process. Bulkhead thickness between the charges (hole base to hole base) is nominally 0. 090 inch.

Error

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The TBI input charge consists of a total of 25 mg of lead azide (polyvinyl alcohol-PVA) loaded in two equal increments. Each increment is consolidated at 10, 600 psi.

The TBI output charge consists of 5 mg of lead azide (PVA) pressed into the base of the output cavity at 10, 600 psi. A 10 mg increment of A1A is pressed on top of the azide charge, again at 10, 600 psi.

The delay housing is machined from 304 stainless steel. The input end is threaded to mate with the connector. When assembled to the connector the free volume above the pressed delay column is 0.87 CC and serves to minimize the buildup of pressure behind the burning delay column. The output end of the delay housing mates with the rocket motor ignitor housing.

The delay column hole is drilled on center at 0.188 inches nominal diameter. The output charge cavity is bored out to 0.238 inches and a small lip is machined in the output end of the housing to accommodate the end closure cup.

The delay column is assembled in an inverse order from the fire transfer path, that is, the last increment is loaded first.

The column seal disk, (0.005 inch 304 Stainless) is installed through the output charge bore, seated against the column shoulder and induction brazed in place using a 1195°F melting tin-silver solder. The relatively high melting solder is used to insure no solder failure due to thermal soak in the wall ahead of flame front propagation in the delay column. Use of the onion skin disks provides further insurance against this type of failure mode potential.

The delay mix used in the final test units was composed as follows.

Ingredient	% by Weight	Mean Particle Size
Tungsten	59.5	3.5μ
Barium Chromate	23.15	2μ
Potassium Perchlorate	8.1	20 ± 5μ
Diatomaceous Earth (Super-Flos)	9.25	325 mesh

This mixture yields a mean heat of reaction of 261 cal/gm and is an intrinsically low gas producer (less than 0.5 ml/gm). A summary of measured burn times for tungsten delays of this basic formulation for various mixtures and particle sizes is shown in Figure 4. As installed the reference blend yielded burn times of approximately 3.60 seconds/inch.

The delay column is pressed in 12 equal increments of 300 mg each. Each increment is compacted at 31,600 psi using a cylindrical ram with a one diameter radius convex head. The assembled final column length is controlled with a sizing tool by trimming the final column to 1.66 inch length.

The delay ignition charge, 100 mg of A1A, is pressed as the last increment and the exposed face of that increment is directly across from the TBI output charge.

The transfer charge consists of approximately 20 mg of KDNBF (See Appendix Page 70). It is applied by a "drop-dipping method". A slurry of KDNBF and nitrocellulose lacquer is prepared and one end of a 1/16 diameter wooden dowel is 'wetted' or coated with the slurry until a droplet is formed. The dowel is then inserted, 'wetted' end first, into the output cavity until the slurry comes in contact with the output seal disk. After emplacement the spot charge is oven dried at +130°F for 2 hours. This technique yields excellent adhesion of the transfer charge to the output seal disk.

The output charge is a combination of 150 mg of Boron-Potassium Nitrate granules (20/40 granule size) and 50 mg of A1A weighed out, mixed by hand and dried prior to loading. This blend is placed in the output cup which is drawn from soft (1100 series) aluminum. After installation the loaded output cup is crimped in place by pressing the exposed closed end with a dimpling tool.

Final sealing is provided by installing the closure cup (0.005 inch 304 Stainless) onto the machined shoulder of the output stub. The cup is welded in place by a Tungsten Inert Gas (TIG) process.

Final assembly of the initiator consists of installation of the "o"-rings, which are primary environmental seals, between the SBASI and the connector and between the connector and the delay housing. Both joints are securely seated and assembly is completed by TIG welding the SBASI flange to the connector and the connector to the delay housing.

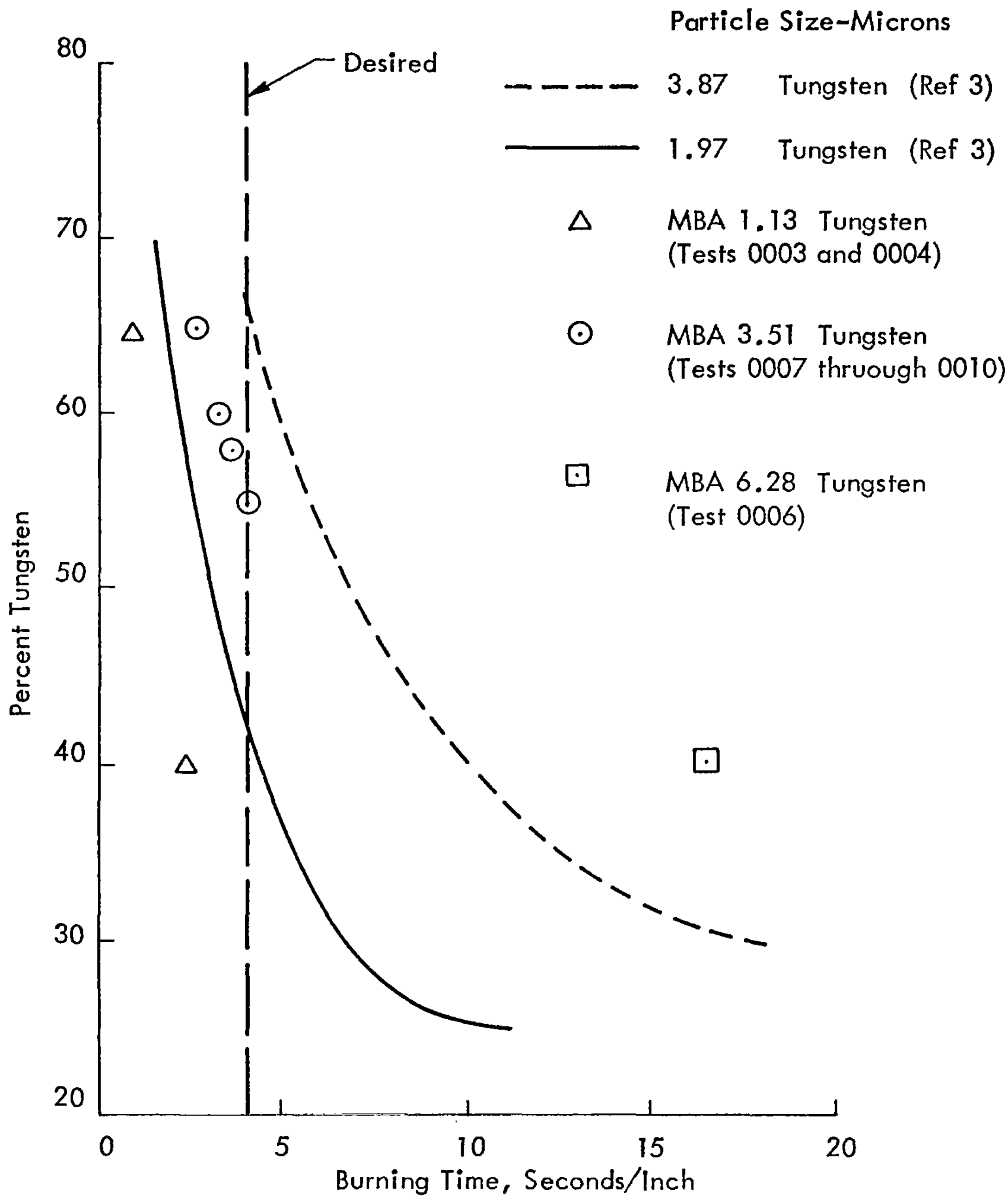


FIGURE 4.
EFFECT OF TUNGSTEN PERCENTAGE ON BURNING TIME
(Data From Reference 3)

The welding process is semi-automatic with both welding current and feed rate programmed to yield a high quality reproducible weld bead. The weld joint between the connector and the delay housing is facilitated by a chamfer on the connector mating face and a small groove around the housing. The dimensional details are provided in Appendix B.

The overall configuration of the assembled initiator conforms to the NASA specified envelope. The major length dimension, SBASI interface to ignitor interface was specified as 2.70 inches maximum, the actual dimension is 2.505 inches. The output stub is specified as 0.35 inch maximum, the actual dimension is 0.335 inch. The assembly hexagonal flats conform to the specified 0.800 inch flat-to-flat constraint.

Assembly Equipment

Delay Housing Assembly Consolidation Press

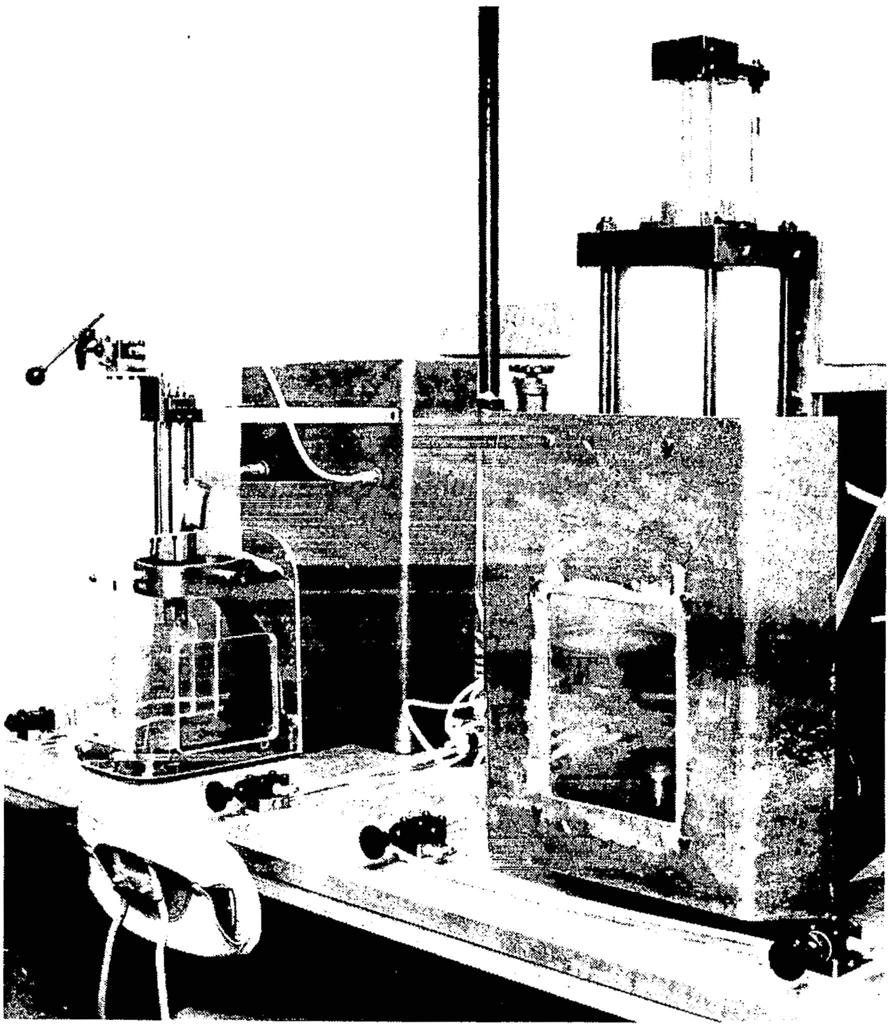
The Delay Consolidation Press, Figure 5b, is a standard Bellows-Valvair Air-Operated Arbor Press Model B271-1002 equipped with ARO and Mead Fluidic Controls (Figure 6). The pressing force is adjustable to two tons and time dwell at pressing pressure is adjustable to 30 sec. max. The press is controlled with two hand actuated valves with an emergency stop and reset hand actuator. The Consolidation Press is equipped with a safety shield which will protect operator from any possible fire or fragments should a pressing malfunction occur.

Connector Subassembly Consolidation Press

TBI Connector Consolidation Press (Figure 5a) is a standard Bellows-Valvair Air-Operated Arbor Press Model No. B8011-1023 equipped with ARO and Mead Fluidic Controls (Figure 6). Force of the Consolidation Press is adjustable up to 1/2 ton and time dwell at pressing pressure is adjustable up to 30 seconds. The press is controlled with two hand actuated valves and is equipped with a safety shield for operator protection.

Tungsten Inert Gas Welding System

The Hodco Model 172A (TIG) Welder is shown in Figure 7. The Model 172A Control Console (20" x 20" x 13") metal cabinet contains a variable power supply up to 30 amp output, variable motor speed control, adjustable gas flow regulator, solid state programming network, and zero positioning indicator.



(A)
TBI CONNECTOR PRESS

(B)
DELAY PRESS

FIGURE 5.

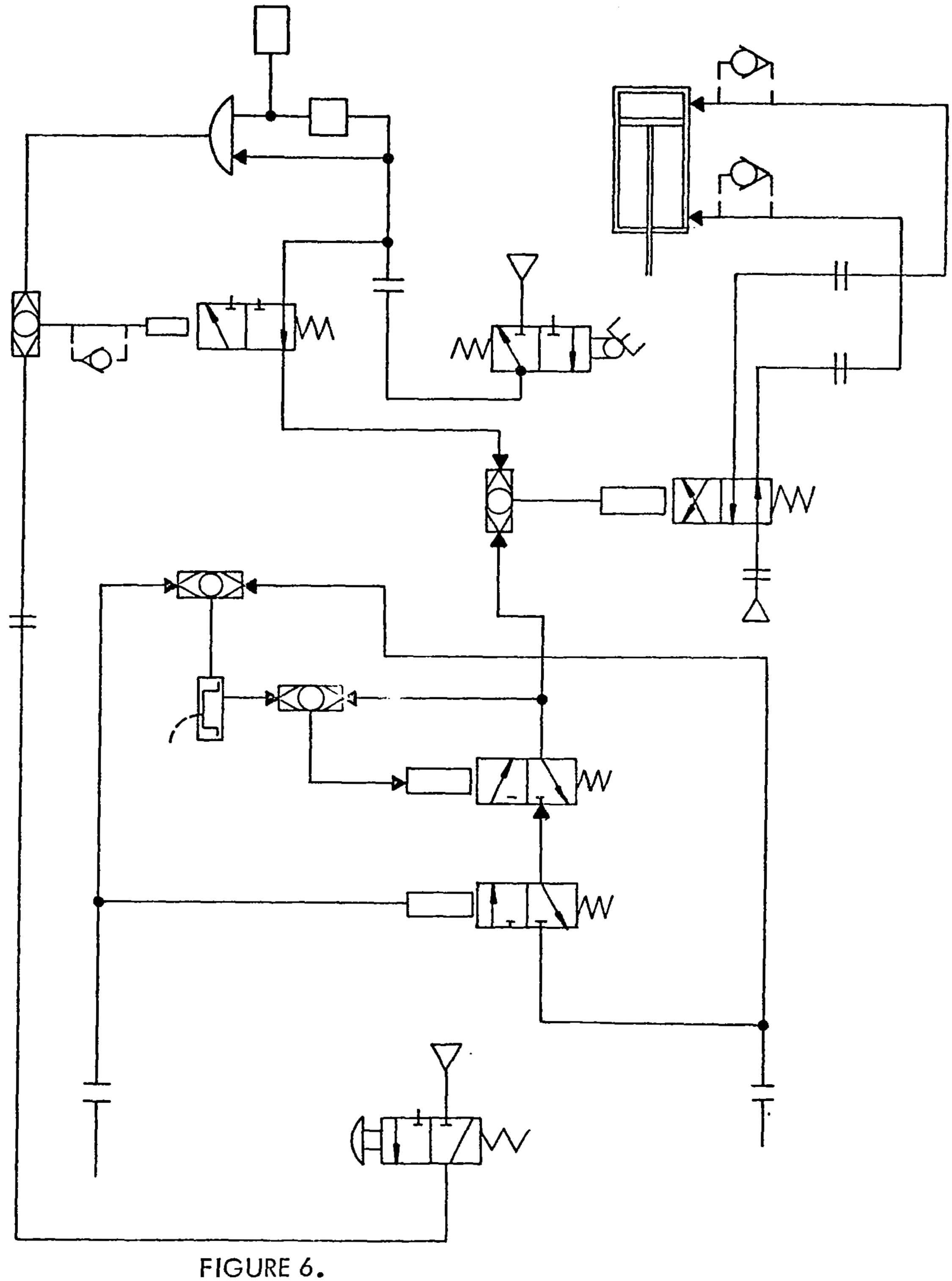


FIGURE 6.
FLUID PRESS CONTROLS SCHEMATIC

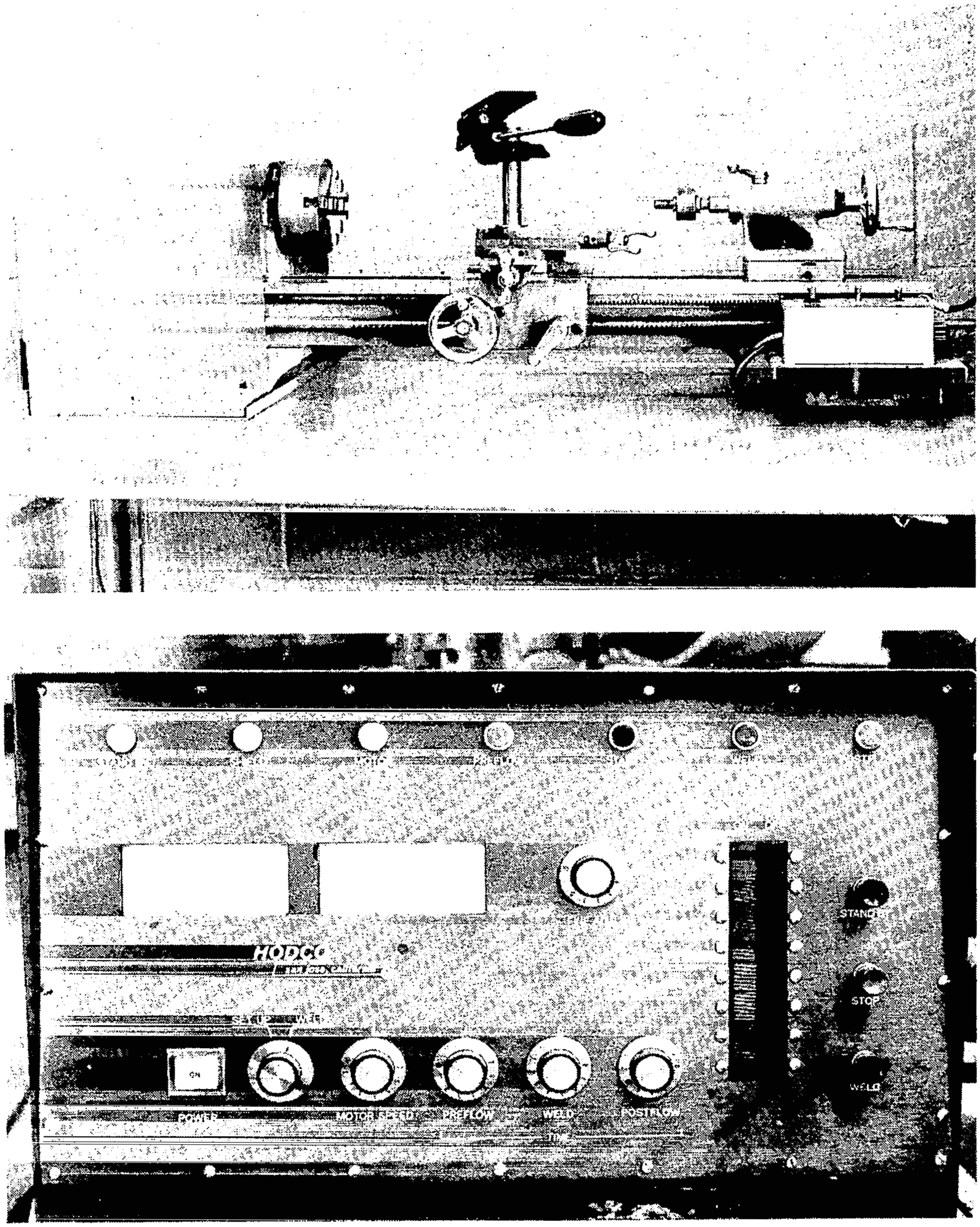


FIGURE 7.
TUNGSTEN INERT GAS WELDING SYSTEM

The Positioning Device (8" x 16" x 33") consists of a steel frame and carriage supporting a universal torce adjustable to .001". The steel base contains a gear reduction box, drive motor, spindle and a three jaw holding chuck. The positioning device can be used in either the vertical or horizontal position.

Induction Heating Generator

A Model 200A, 2.5 KW, Taylor Winfield Ther-Monic Induction Heating Generator rated for continuous duty was used to solder the column seal in place. It was manufactured by Taylor Winfield Corporation, Warren, Ohio 44482 (Figure 8).

The heating coil used on the induction heating generator was designed and manufactured by L. C. Miller Company, Monterey Park, California 91754.

Test Fixtures

Delay Assembly Testing

Delay Assembly Tests were conducted in MBA's two (2) foot diameter by four (4) foot long test stand utilizing existing clamps and fixtures and existing instrumentation hookups.

The test procedure was as follows. Each SBASI Actuated Pyrotechnic Time Delay Initiator Assembly unit was visually inspected for damage and/or anomalies. Then a pressure transducer (Kistler Model 6235F) and/or the thermocouple (Iron-Constantine with micro second response) was installed on the delay assembly. The test specimen was then installed in a test fixture and the SBASI initiator bridgewire resistance was recorded. The test fixture was then oriented so that a light sensitive photo cell was 90° from the path of the ignition output charge (Figure 9). After completion of the test, each unit was inspected and any anomalies, such as bulging, gas leak or initiator blow outs were recorded on test data sheets.

Ignition Evaluation Testing

The test specimen configuration of the Pyrogen Igniter (Figure 10), with an inert Pyrogen propellant grain, was mounted on a test fixture in MBA's two (2) foot diameter by four (4) foot long horizontal test stand, using existing clamps and fixtures. The set up duplicated the actual Pyrogen Igniter.

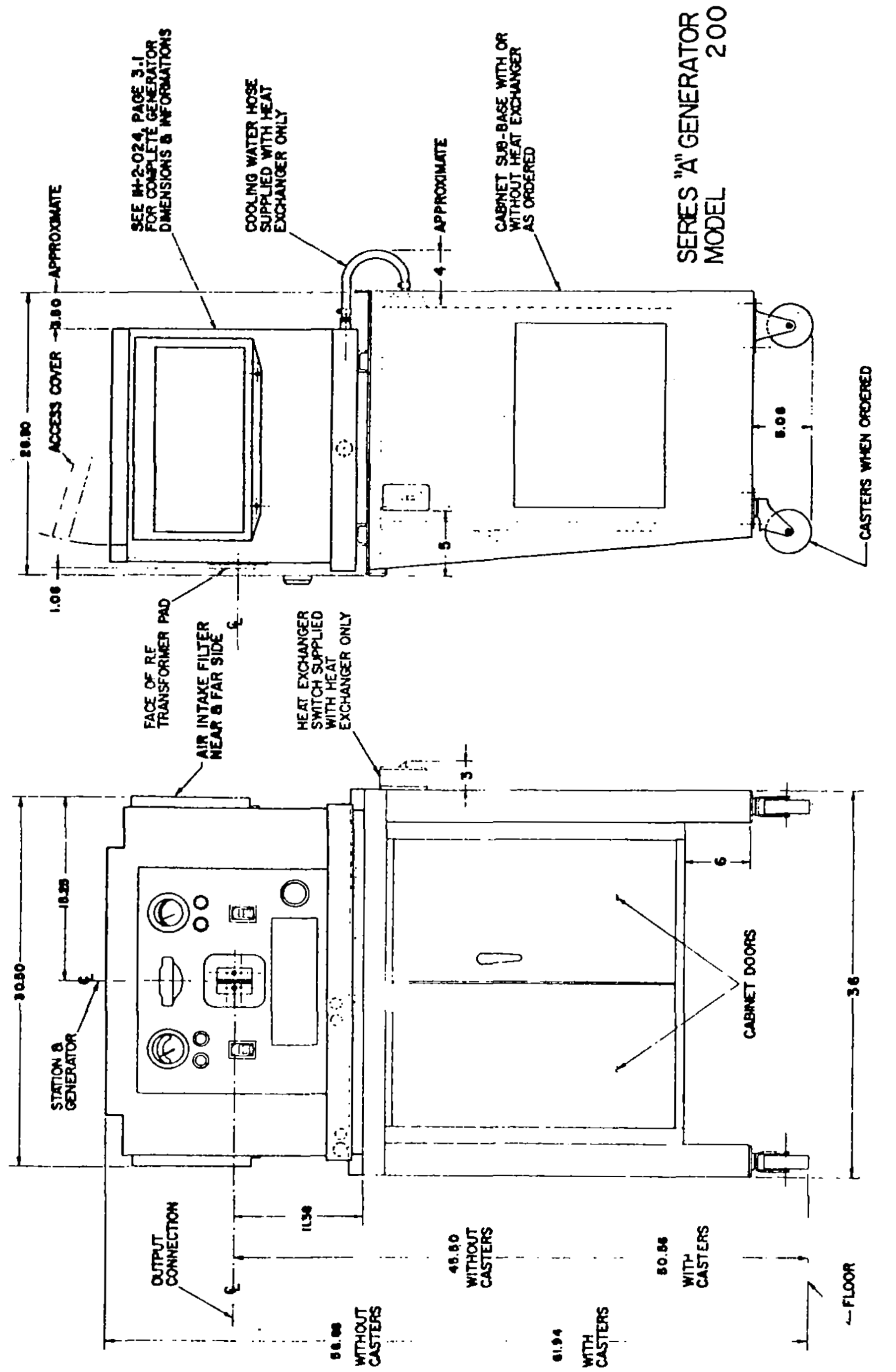


FIGURE 8.
INDUCTION HEATING GENERATOR

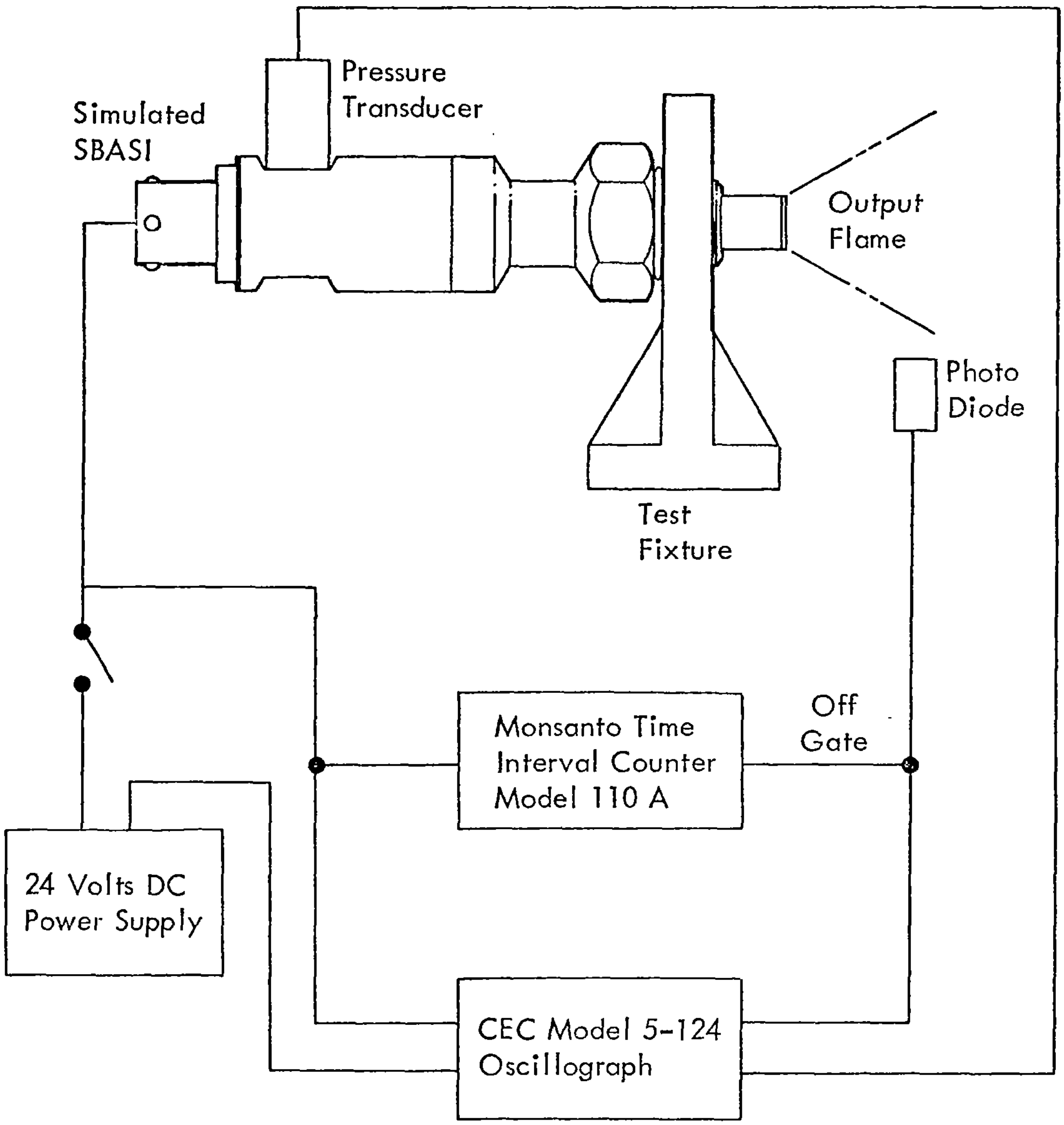


FIGURE 9.
TEST SETUP FOR TIME DELAY EVALUATION

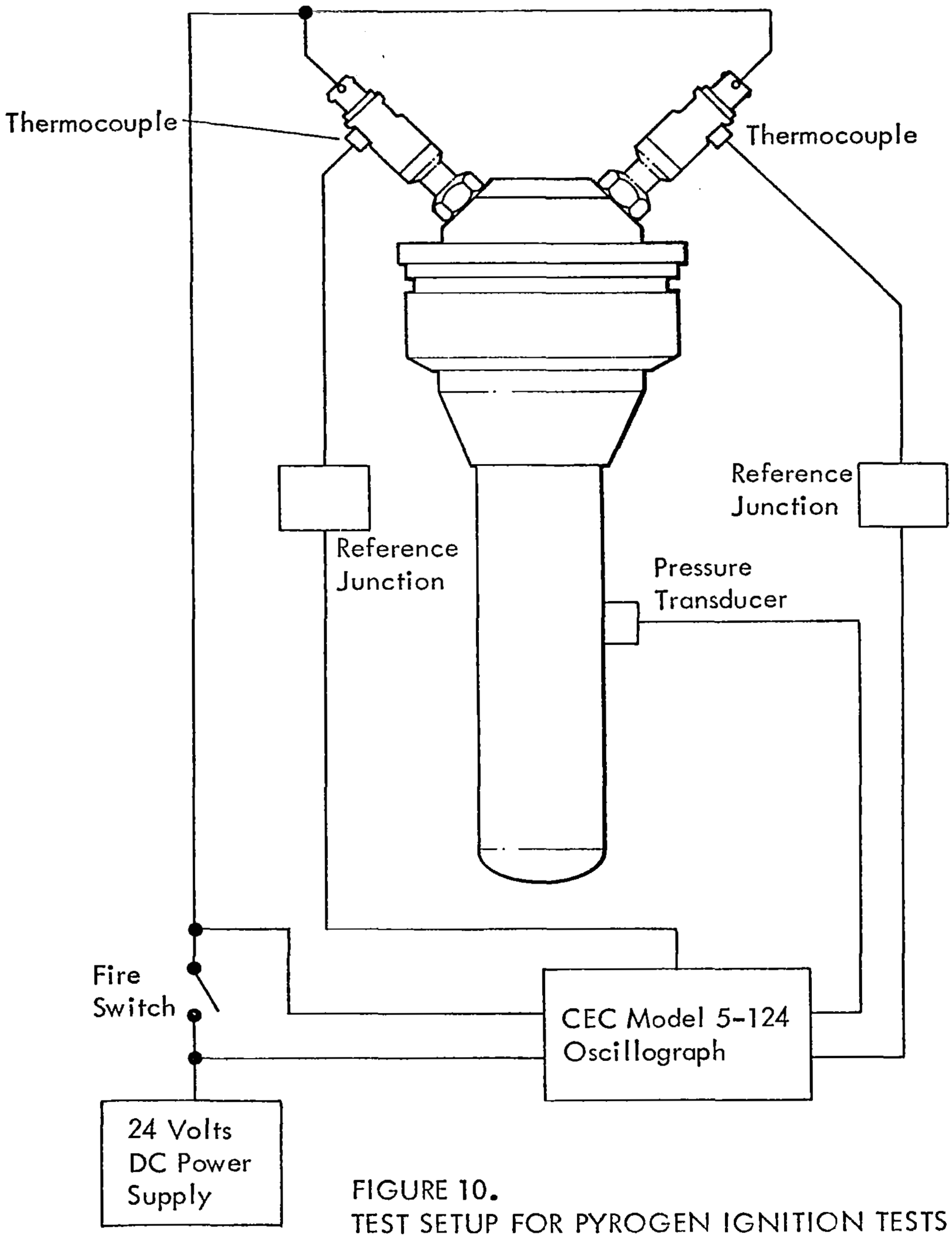


FIGURE 10.
TEST SETUP FOR PYROGEN IGNITION TESTS

The test procedure for each ignition evaluation test was as follows: Each unit was visually inspected for correct ignition pellet bag configuration (P/N B01789-01-01) and installation. Correct diaphragm installation was verified. The pressure tap orifice was checked to be sure it was clear before the pressure transducer (Kistler Model 6235F) was installed.

The Pyrogen igniter was then installed in the test fixture. The SBASI actuated pyrotechnic time delay initiator assemblies were installed in the igniter to a torque of 130 to 150 in. lbs.

After the test specimen assembly was installed in the test stand, the instrumentation leads for the pressure transducer and thermocouple (Figure 10) were connected.

After the test unit was installed in the test stand and all instrumentation hookups completed, the SBASI shunts were removed and the firing leads were connected.

After completion of each test, all hardware was inspected for any anomalies. They were recorded on a test data sheet.

Data reduction and analysis consisted of a review of the oscillograph records and test firing data. The following data were recorded:

1. Total time from fire switch to function
2. D. C. firing voltage
3. D. C. firing current
4. Ambient temperature
5. Specimen temperature
6. Pyrogen pressure
7. SBASI pre-fire bridgewire resistance
8. SBASI post-fire bridgewire resistance

The data from the tests were analyzed for compliance with the design goals.

DEVELOPMENT PROCEDURE

This section presents a brief overview of the major steps in the design, development and demonstration leading to the final configuration of the initiator, including the approaches and design elements into the separate major categories of the study.

Through Bulkhead Initiation

The initial design for the TBI input charge utilized two separate materials, incrementally pressed into the donor cavity: a five milligram initiation charge of lead azide and a ten milligram donor charge of HNS (hexanitrostilbene). This design produced unreliable propagation, possibly due to the small quantity of lead azide not achieving detonation or a sufficient level to initiate the HNS. The input charge design was then changed to two ten milligram increments of lead azide used for a majority of the development tests, and finally to 25 milligrams to reduce the sensitivity to loading and assembly errors.

Three types of limit tests (totaling 140) were conducted: varying input charge using a reference design bulkhead thickness (0.040 inch), thin bulkheads (0.015 to 0.080 inch), and thick bulkheads (0.105 to 0.107 inch).

The TBI output charge of five milligrams of lead azide and 15 milligrams of AlA has remained unchanged throughout the development program, proving its reliability.

Delay Assembly

As noted in the introduction, control of the process variables that affect delay variability is important and isolation of the process variables can be a formidable task. The variables investigated in this study were:

1. Delay formulation, dimensions and blending
2. Delay column increments and consolidation pressure
3. Column protection and retention screen
4. Column bore wall finish
5. Column output/initiator output interface

Output Charge

The first phase of testing used only $BKNO_3$ as the output charge. A limited test series proved it entirely reliable in achieving actuation of the stage ignitor. NASA experience with unreliable ignition of stage ignitors with solely a $BKNO_3$ flame, particularly under low pressure conditions, prompted the inclusion of 25% by mass of AlA into the output charge. Limit testing was conducted with the complete cartridge in a simulated pyrogen ignitor as shown in Figure 10, at ambient, at high and low temperature, and under sea level and vacuum conditions.

Structural Seal Technique

The primary leakage seals at two interface points, SBASI to Connector and Connector to Delay Housing, are provided by internal O-rings installed in accordance with established standards. A secondary environmental seal and structural seal preventing disassembly is effected by TIG welding, externally, these two metal-to-metal joints. The initiator output seal (a stainless cup) was accomplished in the same manner. The primary seals were pressure checked after firing.

Non-Operating Environmental Tests

Fifty complete units of the fired design were subjected to the environments shown on pages 4 and 5, and test fired in the simulated pyrogen ignitor, Figure 10. Further, five units were subjected to an auto-ignition (400^{o}F/one hour) exposure.

RESULTS

TBI Limit Results

As noted in the previous section, the approach taken for establishing design adequacy of the through bulkhead initiation technique was limit testing to explore the effects of off-design conditions on the reliability of shock transmission. Initial tests conducted with an input charge of HNS and lead azide, however, were unsuccessful. This led to the elimination of HNS and utilizing an input charge of only lead azide.

A summary of the nominal bulkhead (0.090 inches) tests with variations to the input charge of lead azide is as follows:

Input Wt. Milligrams	Temp. ^{o}F	Success	Failure	Total
30	120	1	0	1
25	30	25	0	25
25	ambient	33	0	33
25	120	24	0	24
20	30	2	0	2
20	ambient	20	0	20
20	120	2	0	2
16.8	ambient	1	0	1
14.8	ambient	15	4	19
12.8	ambient	0	2	2

The likely value for the 50% fire point is between 12.8 and 14.8 mg PbN_6 input charge. No apparent dependence of temperature on TBI reliability at the higher loadings is evident.

The reference design value for input charge is 25 mg, which should be safely conservative. The 24 successes at 20 mg loading gives a statistical reliability of 0.9 at 90% confidence. The aggregate test sample of all loadings in excess of 20 mg (107 tests) yields 0.98 reliability at 90%. Note that 50 of these tests were conducted after environmental conditioning.

Further limit testing used TBI bulkheads which were deliberately modified to be off-design, either thicker than nominal or thinner than nominal. A summary table of these results is as follows:

Input Wt. Milligrams	Bulkhead	Temp. ^{o}F	Success	Failure	Total
30	thin	ambient	3	0	3
25	thin	ambient	2	0	2
20	thin	ambient	1	0	1
25	thick	ambient	1	0	1
20	thick	ambient	3	0	3
18	thick	ambient	1	0	1
15	thick	ambient	0	1	1

The "thin" bulkheads were 0.075 to 0.080 inches between hole bases, the "thick" bulkheads were 0.105 to 0.107 inches. Based on drawing tolerance specifications, a maximum deviation on bulkhead thickness (tolerances additive in one direction) is ±.014 inches; a probable maximum (root-mean-square of maximum tolerances) is ±0.0077 inches. Taking as representative of manufacturing standards the lot of 50 units supplied for environmental testing, the mean bulkhead thickness was 0.0911 inches with a standard deviation of 0.0021 inches. Accordingly, the limits used for the bulkhead extreme tests is a 7 σ extreme and would be expected less than once in 10^6 units.

In addition to the propagation/no propagation data, the thin bulkhead units were disassembled and inspected for bulkhead damage. No evidence of actual damage nor incipient damage was noted in any units. Since only about 32 mg can physically be loaded into the maximum tolerance input cavity without extending above the bulkhead face, a visual inspection should preclude overloads sufficient to suggest bulkhead rupture. A 20% overload in a thick bulkhead did not stop propagation in a 3-unit sample. Accordingly, the reference load of 25 mg should provide an ample margin for both machining tolerances and loading errors.

Delay Assembly

The major objective of the development effort in this area was to demonstrate a tight tolerance (small coefficient of variation) of the burn time of the delay column itself. To achieve this objective, a number of exploratory tests were conducted on the known variables followed by 97 tests on the finalized design approach. The variables explored were: 1) delay formulation, dimensions and blending; 2) delay column increments and consolidation pressure; 3) column protection and retention screen; 4) column bore wall finish; and 5) column output/initiator output interface.

Delay Formulation, Dimensions and Blending

A literature search revealed the excellent past history and repeatability of the tungsten/barium chromate/potassium perchlorate/ diatomaceous earth mixtures (see Reference 3). Further, this search indicated a delay column diameter of approximately 0.2 inch (final design is 0.188 inch) to be optimum.

The tungsten percentage and particle size was the final decision of the formulation. Particle size influence is presented in Figure 4, showing a large negative slope so that variations in percentage and particle size create only small variations in resultant burn times. A tungsten percentage of 59.5 with a mean particle size of 3.5 microns yielded a burning time of 3.6 seconds/inch, and an optimum column length of 1.55 inches.

Thorough blending of the formulation assures even distribution of the ingredients and intimate contact of particles. The blending method, encompassing a blend time of thirty minutes is described in detail in Appendix C - Manufacturing Specification.

Delay Column Increments and Consolidation Pressure

The establishment of these variables again included a literature search, as well as in-house experience. Increment size of 300 milligrams was selected to yield a length to diameter ratio of approximately one. The consolidation pressure was established in preliminary investigations with pressures ranging from 10,000 to 40,000 psi to be optimum at 31,600 psi; pressures below this level yielded height variations and above, ignition insensitivity.

Column Protection and Retention Screen

The intent of this screen was to provide protection against damage due to impact of the TBI output charge, and to retain the ash column produced in burning. However, the screen proved very susceptible to ash clogging, and the resultant imperviousness to gas passage (generated during burning of the delay column) actually contributed to column fracture and ash movement, and variability in delay times. Subsequent testing without the screen and only the Al A ignition charge indicated that sufficient column protection was provided. Therefore, this screen was eliminated from the final design.

Column Bore Wall Finish

In an effort to evaluate and control this parameter, the column bores were nickel plated and honed. The "as received" columns had a finish of approximately 32 microns rms. Plating and honing yielded a surface of approximately 4 microns rms. However, these smooth bores, while more reproducible from a machining standpoint, permitted ash migration during burn, resulting in inconsistent burn times. The "as received" internal surface exhibited little post-fire evidence of delay column shifting and resulted in reproducible burn times.

Column Output/Initiator Output Interface

To provide a positive interface between the delay column and the initiator's output, the column bore was positively sealed by induction soldering a 0.005-inch stainless steel disc. Two onion skin discs were placed against the delay column side of the disc, then Al A mix was pressed against the onion skin as a transfer charge, and a "spot" of KDNBF was placed on the outboard side of the disc. The stainless steel disc was applied to stop any advance percolation of gases down the column during combustion. This prevented ignition of the transfer charge. The onion skin was applied to allow a thermal isolation against advanced heat soaking down the column. The Al A transfer charge, however, was omitted, since it introduced considerable time delay variations due to "dusting" (minute quantities adhering to the bore) during installation, causing the combustion front to flash ahead. Further, the advance gas percolation could easily initiate the Al A.

In the 108 tests performed, no instances were observed where fire transfer between the delay column and the output charge did not occur. Since minor variation in column length (1.60 to 1.66 inches) was made and tests at different unit temperatures were done (which causes mean burn time shift), the various discrete groups should be considered separately. The results are summarized below.

Test Series	T-sec.	COV - %	Temp. °F	Number
Delay Variation (1.60-inch column)	5.817	1.98	62	11
Ambient Motor Ignition	6.021	1.59	66	7
Cold Motor Ignition	5.977	2.28	30	10
Hot Motor Ignition	5.727	1.79	120	10
Production Sample	5.914	2.29	70	10
Demonstration Tests				
Ambient	5.770	2.67	70	19
Cold	5.873	2.23	30	15
Hot	5.724	1.81	120	15
			Total	97

All tests after the first series above used 1.66-inch column length. All demonstration test units were subjected to the environmental test series specified in Appendix E.

A weighted aggregate rms value for coefficient of variation for the 97 tests is 2.17%. If we take just the environmentally conditioned units, the aggregate COV is 2.30%.

Observing the mean delay times experienced by the demonstration test units, a temperature coefficient of 0.03% per degree F (total COV of 2.7%) is indicated. This value is in substantial agreement with published data (C.F. Reference 4) and verifies the good temperature stability of the tungsten delay blend.

Throughout the entire test program, no diagnosable instances were observed where TBI propagation had occurred (ignition of the TBI output charge) and the delay failed to ignite and burn completely. Even in cases where column shifting during burn was observed, no column burn failures resulted. Accordingly, the delay column itself has proven very reliable. The 97 tests on the final design configuration permit a statistical inference of 0.976 reliability at 90% confidence. If one includes the 45 earlier tests in which TBI propagation occurred, the delay reliability is 0.985 at 90%.

Transfer/Output Charge

Two separate test series were conducted to evaluate the adequacy of the initiator output charge. As the final step in the fire transfer process, the task of the initiator is to initiate, that is, to ignite reliably the stage pyrogen ignitor. Accordingly, a development test series was conducted to evaluate ignitor initiation at ambient, high, and low temperature conditions under sea level and vacuum conditions. The test fixture used simulates the free volume in the pyrogen ignitor and contains the $BKNO_3$ ignition charge, but not the ignitor propellant grain. A total of 96 tests were conducted using the simulated ignitor (tests 66 through 161 of Appendix A). All of the demonstration tests (49 units) were conducted by firing into the simulated ignitor.

In addition to a qualitative assessment of output flame front during the development tests, pressure rise in the simulated ignitor was recorded on all tests using that device. These data supplement the go/no-go evaluation which is simply "did the initiator ignite the $BKNO_3$ ignitor charge." No ignition failures were observed throughout the test series. This implies a demonstrated statistical reliability of 0.976 at 90% confidence.

The output charge produces a vigorous flame. This is illustrated by Figure 11 which presents photographs of the output charge recorded on tests 45 and 46. The vertical background grid is layed out on a 2-inch spacing. As can be seen, the flame front spreads 6 to 8 inches along the test chamber wall which is approximately 12 inches from the output cup. In particular, the photograph of test 45 shows distinctly the presence of condensed phase material issuing from the output charge.

Measured cavity pressures in the simulated ignitor consistently reached 500 to 800 psi (both sea level and vacuum conditions) with a rise time of under 2 milliseconds. The ignitor initiation charge used is 25 gms of pelletized $BKNO_3$ retained in a 1 mil thick polyethylene bag.

Limit testing on the adequacy of the delay output charge was performed by packaging the ignitor initiation charge in a 2.5 mil thick bag (3 tests) and in a 4.0 mil thick bag (8 tests). Successful ignition occurred in all cases and there were no discernible differences in either peak pressure or rise time compared to the 1 mil bags.

Non-Operating Environmental Tests

A lot of 50 units was subjected to the environmental test sequence as delineated in Appendix D. The basic tests were:

- Sinusoidal and random vibration
- Shock
- Temperature shock
- Constant acceleration load

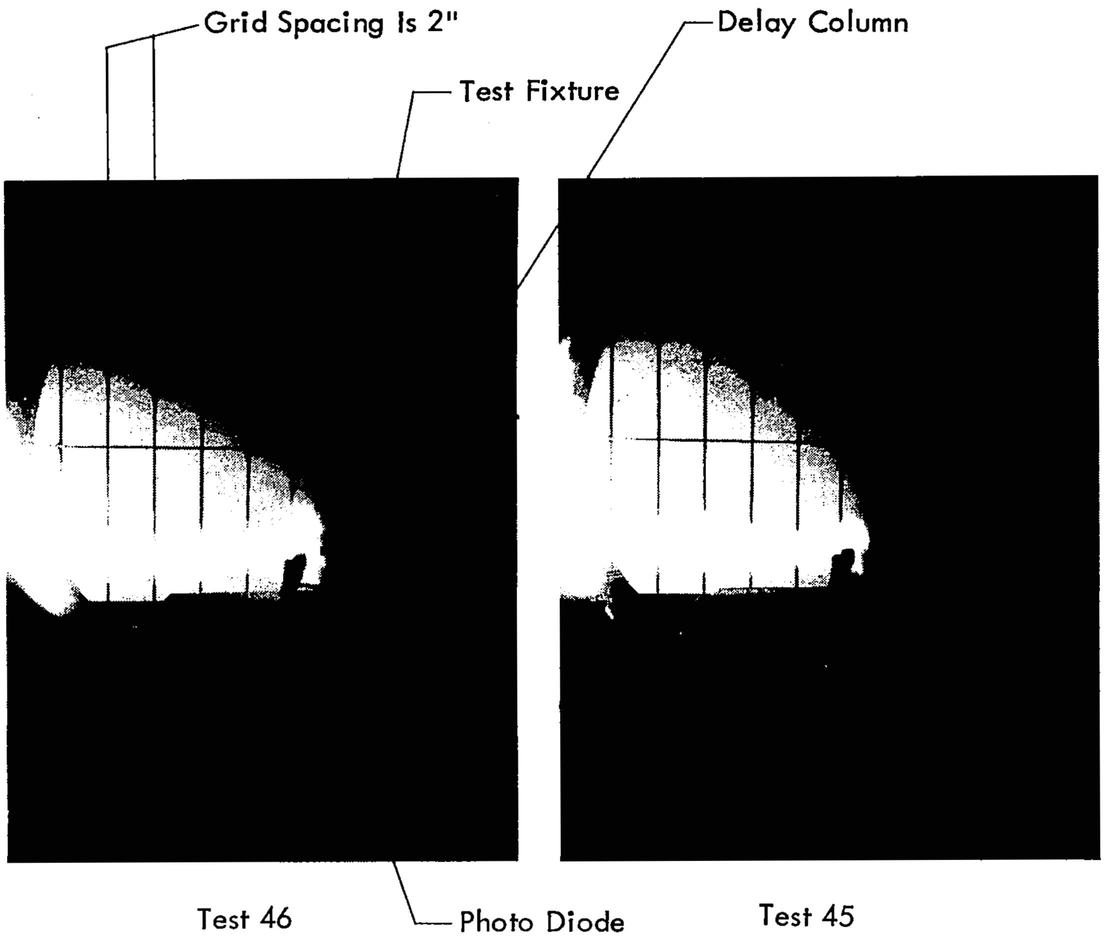


FIGURE 11.
INITIATOR OUTPUT FLAME,
SEA LEVEL FIRING

These units were utilized for the demonstration motor ignition tests previously discussed(Tests 112 to 161 in the test matrix presented as Appendix A). With one exception all units functioned normally and initiated the ignition charge in the simulated pyrogen ignitor. The tests were conducted at ambient conditions and at the temperature extremes of 30°F and 120°F. The tests were run under vacuum conditions with the simulated ignitor seal punctured so that internal pressures on the test unit were those at the pre-set altitude (200 K-ft).

As noted in the summary of delay column test results the only discernible performance difference between the environmentally conditioned units and the control units selected from the same production lot was a slight (about 3%) decrease in mean burn time.

The one exception to complete functioning was observed in Test 112. In that test no output was produced. Neutron radiographs of that unit and a standard unit are shown as Figure 12. The cause of the failure is immediately evident, the entire output charge was omitted during loading! The distortion of the output seal cup indicates that the fire sequence through to the KDNBF transfer charge occurred, but generated insufficient pressure to rupture the seal. This error suggests that radiographic examination be included as a post assembly quality insurance inspection since the discrepant condition is readily apparent.

A control sample of 5 units drawn from the production lot was subjected to an auto ignition test as follows. An environmental oven was preconditioned to 400°F. The test units were inserted and held for 1 hour after oven temperature was re-established.

No auto ignition was experienced on any of the units. Post test attempts to fire the units were unsuccessful. Post test sectioning and inspection suggest that lead azide deterioration resulted in failure of the TBI propagation.

Seal Test Results

A total of 80 test units (31 development units and all 49 demonstration units) were subjected to post-line leak rate testing. The test, as specified, involves pressurization to the output cup end of 5000 psi for 30 seconds, then checking the helium leak rate under 1 atmospheric pressure differential. The performance specification calls for a measured leak rate of less than 10^{-5} cc/sec.

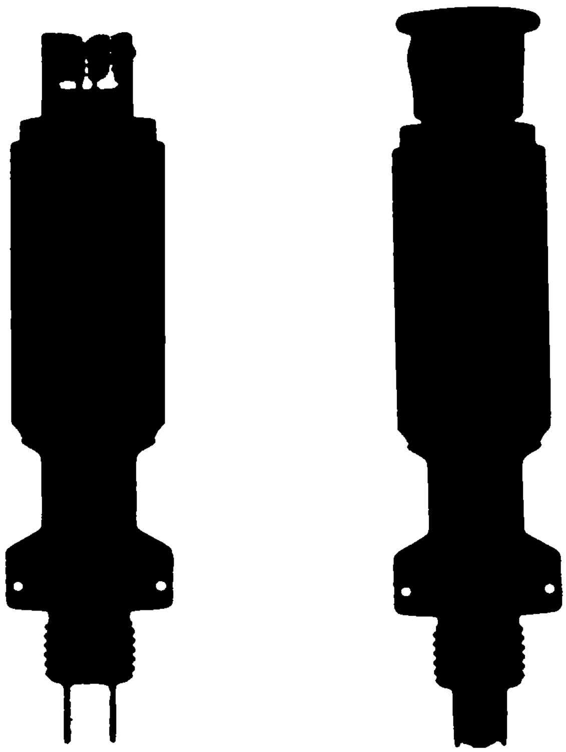


FIGURE 12.
NEUTRON RADIOGRAPHIC INSPECTION OF INIATORS.
DISCREPENT UNIT LEFT (NO OUTPUT CHARGE),
STANDARD UNIT RIGHT.

All the measured leak rates were less than 10^{-6} cc/sec with many as low as 10^{-9} cc/sec. Accordingly the effectiveness of the combination of "O"-ring primary seals and welded closures has proven to provide a very reliable unit seal.

CONCLUSIONS

Through Bulkhead Initiator

The reference design values (cavity dimensions, charge sizes, loading technique) for the through bulkhead initiator have demonstrated a reliable propagation process. In particular, the limit testing has established a high confidence in design tolerance. This series has shown that input charge loading errors of $\pm 25\%$ would not affect the reliability to propagate or cause structural failure of the thinnest possible bulkhead. The reference TBI configuration has been tested a total of 85 times throughout the temperature extremes (excluding the limit testing) without a failure to propogate the proper shock wave. Including the limit test series the TBI has been tested 110 times with propagation failure occurring only after an off loading of greater than 25% of the input charge. Based upon this test experience the reference TBI design has been found to be very satisfactory.

Delay Column

The ignition and complete burning of the delay column has been demonstrated to occur in every instance where the TBI output charge ignited (a total of 147 tests). This has lead to the conclusion that the delay ignition system of the TBI output charge and the pressed delay ignition increment as well as the delay blend itself is a more than adequately reliable system in terms of overall function.

The achievement of an aggregate COV of 2.17% was considered to have been satisfactory since the required COV was 3% or less. Still however a COV approaching 2% or less should be achievable in moderate production lots.

Two aspects of achieving both a precise mean burn time and minimum COV require a greater statistical base than that generated under this program. These are:

1. Lot to lot variations in the tungsten delay mix itself
2. Long term effects of storage, under various conditions, on burn time and COV.

As may be noted from the average delay times a small but distinct (about 3%) decrease in delay was evidenced by the units which experienced environmental conditioning. Since all units were subjected to the same conditioning sequence an exact diagnosis cannot be stated. A possible cause, however, is storage aging. The production sample was tested shortly after assembly while the demonstration test units were tested about 60 days later. The temperature shock conditioning included in the test series may contribute by accelerating solid state diffusion processes which result in burn time modification.

As discussed in Reference 2, aging effects depend not only on the specific blend of delay but also on conditions of storage. Specific data on storage aging effects on the Tungsten delay mix are not known to MBA. Reference 2 reports that dry surveillance of Boron-Barium Chromate mixtures results in a slight decrease in burn time after 8 weeks dry storage. In both cases the effects were of the same order of magnitude (3 to 5% change) as observed with the reference design mix. Additional empirical data on storage effects are needed to establish these trends for the Tungsten blend.

Transfer/Output Charge

The same total aggregate of delay tests (147) can be invoked to attest to reliable energy transfer to and ignition of the output charge. The limit testing verifying motor ignitor initiation through additional barriers provides evidence of substantial design margin. The AlA ingredient should enhance motor ignition reliability under low pressure conditions, however, ignition was achieved in a limited test sample using just B-KNO_3 as the output charge.

Sealing Techniques

Consistent post fire leak rates at least an order of magnitude lower than specification requirements have been demonstrated. The TIG welding of interface joints provides a structurally sound redundant seal and, further, unlike brazing, is readily inspectable for imperfections.

Overall Performance

The reference (or final) design configuration was utilized in 81 consecutive successful firings without failure. The demonstrated reliability was then 0.972 at 90% confidence. In a redundant installation such as that used for stage ignition a functional reliability of 0.99922 can be calculated.

It is felt that the actual reliability is much higher than that demonstrated and items built in conformance with the reference design requirements should have reliability levels greater than 0.9999 at 95% confidence. The verification of this assessment naturally requires a larger data base for demonstration.

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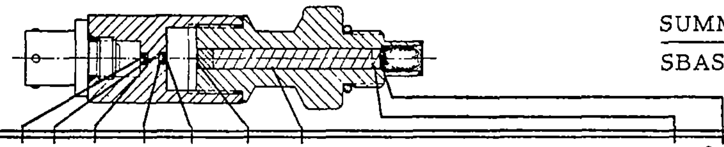
APPENDIX A

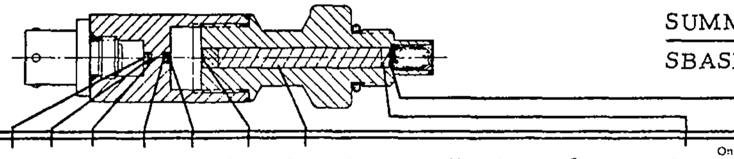
TEST RESULTS



SUMMARY OF TEST RESULTS

SBASI Actuated Pyrotechnic Time Delay Initiator

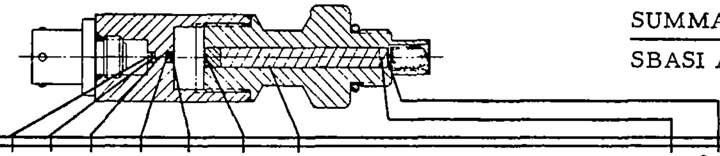
Test #	Test Date	SL/ VAC	Test Temp	Input HNS	Input PbN_6	Blkhd Thkns	Output PbN_6	Output AIA	Ign. Screen	Delay Form.	Comp. Press	# of Incr.	Wt. / Incr.	Dwell Time	RH @ Pressing	Delay Length	Trans Chg	Onion Skin Disks	Flt/Cont Ram	Delay Time	
1	12-30	SL	68°	5 mg	5 mg	.09	5 mg	20 mg	Yes	A	27.9	12	300 mg	5 sec	36	1.606	50 mg	-	F	-	No TBI Transfer'
2	12-30	SL	70°	-	18	.09	5	15	Yes	A	27.9	12	300	5	36	1.606	50	-	F	1.6	(Delay column from Test #1 used)
3	1-20	SL	66°	9	5	.09	5	20	Yes	A	28.9	12	300	5	54	1.606	50	-	F	1.6	
4	1-25	SL	66°	9.2	5	.09	5	15	Yes	B	29.7	9	250	5	48	1.606	50	-	F	4.0	
5	2-1	SL	67°	9.2	5	.09	5	15	Yes	C	29.7	10	250	5	50	1.606	50	-	F	-	No TBI Transfer
6	2-1	SL	70°	-	20	.09	5	15	Yes	C	29.7	10	250	5	50	1.606	50	-	F	27.6	(Delay column from Test #5 used)
7	2-9	SL	70°	-	20	.09	5	15	Yes	A	32.6	16	250	5	35	1.606	50	-	F	4.60	
8	2-10	SL	67°	-	20	.09	5	15	Yes	D	32.6	12	275	5	30	1.606	50	-	F	7.00	
9	2-11	SL	70°	-	20	.09	5	15	Yes	E	31.6	13	300	5	36	1.606	50	-	F	5.50	
10	2-15	SL	72°	-	20	.09	5	15	Yes	F	31.6	13	275	5	40	1.606	50	-	F	6.14	
11	3-24	SL	70°	-	20	.106	5	10	Yes	F	31.6	13	275	5	38	1.606	50	-	F	6.32	
12	3-24	SL	68°	-	15	.106	5	10	Yes	F	41.5	13	285	5	35	1.606	50	-	F	-	No TBI Transfer
13	3-27	SL	70°	-	18	.105	5	10	Yes	F	41.5	13	285	5	34	1.606	50	-	F	6.24	
14	3-27	SL	70°	-	20	.106	5	10	Yes	F	41.5	13	285	5	35	1.606	50	-	F	6.26	(Delay column from Test #12 used)
15	3-27	SL	70°	-	20	.106	5	10	Yes	G	31.6	12	290	5	34	1.606	50	-	F	6.02	
16	3-28	SL	70°	-	30	.075	5	10	Yes	G	31.6	12	280	5	35	1.606	50	-	F	5.97	
17	3-28	SL	70°	-	20	.073	5	10	Yes	G	41.5	13	290	5	35	1.606	50	-	F	6.41	
18	4-26	SL	80°	-	25	.081	5	10	Yes	G	31.6	12	286	5	31	1.606	50	-	F	6.07	
19	4-26	SL	80°	-	25	.081	5	10	Yes	G	31.6	12	284	5	31	1.606	50	-	F	6.08	
20	4-26	SL	80°	-	25	.089	5	10	Yes	G	31.6	13	280	5	36	1.606	50	-	F	5.48	
21	4-26	SL	80°	-	25	.09	5	10	Yes	G	31.6	13	280	10	30	1.606	50	-	F	5.66	
22	5-9	SL	66°	-	25	.09	5	10	Yes	G	31.6	12	290	10	38	1.606	50	-	F	5.96	
23	5-9	SL	120°	-	20	.09	5	10	Yes	G	31.6	12	290	10	38	1.606	50	-	F	6.25	(Note 5)
24	5-9	SL	120°	-	20	.09	5	15	Yes	G	31.6	12	290	10	38	1.606	50	-	F	6.11	(Note 5)
25	5-9	SL	66°	-	20	.09	5	15	Yes	G	31.6	12	290	10	36	1.606	50	-	F	6.31	(Note 6)
26	5-9	SL	66°	-	20	.09	5	15	Yes	G	31.6	12	290	10	33	1.606	50	-	F	6.50	(Note 6)
27	5-24	SL	68°	-	20	.09	5	10	Yes	G	31.6	12	290	10	34	1.606	50	-	F	6.00	(Note 5)
28	5-24	SL	68°	-	20	.09	5	10	Yes	G	31.6	12	290	10	34	1.606	50	-	F	5.40	(Note 6)
29	6-2	SL	30°	-	20	.105	5	10	Yes	G	31.6	12	290	[illegible]	22	1.606	50	-	F	5.93	(Delay column bore cleaned after AIA installation)
30	6-2	SL	30°	-	20	.108	5	10	Yes	G	31.6	12	290	10	22	1.606	50	-	F	5.57	(Delay column bore cleaned after AIA installation)
31	6-14	SL	30°	-	20	.09	5	10	Yes	G	31.6	12	290	10	38	1.606	-	-	F	5.30	
32	6-14	SL	30°	-	20	.104	5	10	Yes	G	31.6	12	290	10	38	1.606	-	-	F	5.02	
33	6-14	SL	30°	-	20	.09	5	10	Yes	G	31.6	12	290	10	38	1.606	50	-	F	5.70	(Notes 5 & 7) (Delay column bore cleaned after AIA installation)
34	6-15	SL	30°	-	20	.087	5	10	Yes	G	31.6	12	290	10	20	1.606	50	-	F	5.76	(Note 6) (Delay column bore cleaned after AIA installation)
35	10-26	SL	64°	-	14.8	.093	5	10	Yes	G	31.6	12	290	10	30	1.606	-	1	F	-	(No TBI Transfer) (Note 4)
36	10-26	SL	64°	-	14.8	.09	5	10	Yes	G	31.6	12	290	10	30	1.606	-	1	F	5.50	
37	10-26	SL	64°	-	16.8	.09	5	10	Yes	G	31.6	12	290	10	30	1.606	-	1	F	5.90	
38	10-27	SL	58°	-	12.8	.09	5	10	Yes	G	31.6	12	291	10	26	1.606	-	1	F	-	(No TBI Transfer) (Note 4)



SUMMARY OF TEST RESULTS

SBASI Actuated Pyrotechnic Time Delay Initiator

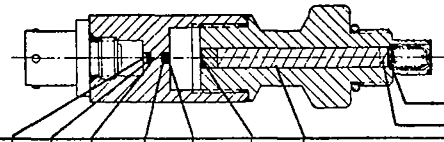
Test #	Test Date	SL/ VAC	Test Temp	Input HNS	Input PbN_6	Blkhd Thkns	Output PbN_6	Output AlA	Ign. Screen	Delay Form.	Comp. Press	# of Incr.	Wt./ Incr.	Dwell Time	RH @ Pressing	Delay Length	Trans Chg	Onion Skin Paper	Flt/Cont Ram	Delay Time	
39	10-27	SL	58°	-	14.8	.09	5	10	Yes	G	31.6	12	291	10	26	1.606	-	1	F	5.70	
40	10-27	SL	60°	-	14.8	.09	5	10	Yes	G	31.6	12	291	10	26	1.606	-	1	F	5.90	(Delay column from Test #38 used) (Note 4)
41	11-2	SL	68°	-	14.8	.09	5	10	Yes	G	31.6	12	291	10	28	1.606	-	1	F	6.01	(Note 4)
42	11-2	SL	68°	-	12.8	.09	5	10	Yes	G	31.6	12	291	10	28	1.606	-	1	F	-	(No TBI Transfer) (Note 4)
43	11-2	SL	66°	-	14.8	.09	5	10	Yes	G	31.6	12	291	10	28	1.606	-	1	F	5.65	(Note 4)
44	11-2	SL	66°	-	14.8	.09	5	10	Yes	G	31.6	12	291	10	28	1.606	-	1	F	5.20	(Delay column from Test #42 used) (Note 4)
45	11-2	SL	67°	-	14.8	.09	5	10	Yes	G	31.6	12	291	10	30	1.606	-	1	F	5.46	
46	11-2	SL	57°	-	14.8	.09	5	10	Yes	G	31.6	12	291	10	30	1.606	-	1	F	5.56	(Note 4)
47	12-1	SL	64°	-	20	.09	5	10	No	G	31.6	12	291	10	30	1.595	-	2	C	5.65	
48	12-1	SL	64°	-	20	.09	*	*	No	G	31.6	12	291	10	30	1.593	-	2	C	-	(No TBI transfer - discrepant loading of output chgs.)
49	12-1	SL	64°	-	20	.09	5	10	No	G	31.6	12	292	10	30	1.583	-	2	C	5.72	
50	12-1	SL	64°	-	20	.09	5	10	No	G	31.6	12	292	10	31	1.589	-	2	F	5.70	
51	12-1	SL	64°	-	20	.09	5	10	No	G	31.6	12	292	10	31	1.591	-	2	F	5.62	
52	12-1	SL	64°	-	20	.09	5	10	No	G	31.6	12	292	10	31	1.590	-	2	F	5.72	
53	12-1	SL	64°	-	20	.09	5	10	No	G	31.6	12	291	10	30	1.593	-	2	C	5.67	Delay column from Test #48 used
54	12-8	SL	62°	-	20	.09	5	10	No	G	31.6	12	293	10	30	1.600	-	2	C	5.78	(Note 6)
55	12-8	SL	62°	-	20	.09	5	10	No	G	31.6	12	293	10	30	1.598	-	2	C	5.74	(Note 6)
56	12-8	SL	62°	-	20	.09	5	10	No	G	31.6	12	293	10	30	1.604	-	2	C	5.93	(Note 6)
57	12-8	SL	62°	-	20	.09	5	10	No	G	31.6	12	293	10	30	1.598	-	2	C	6.05	(Note 6)
58	12-8	SL	62o	-	20	.09	5	10	No	G	31.6	12	293	10	30	1.602	-	2	C	5.92	(Note 6)
59	12-8	SL	62°	-	20	.09	5	10	No	G	31.6	12	293	10	31	1.596	-	2	C	5.74	(Note 6)
60	12-8	SL	62°	-	20	.09	5	10	No	G	31.6	12	293	10	30	1.595	-	2	C	5.70	(Note 6)
61	12-8	SL	62°	-	20	.09	5	10	No	G	31.6	12	293	10	30	1.597	-	2	C	5.71	(Note 6)
62	12-8	SL	62°	-	20	.09	5	10	No	G	31.6	12	293	10	30	1.603	-	2	C	5.90	(Note 6)
63	12-8	SL	62°	-	20	.09	5	10	No	G	31.6	12	293	10	30	1.599	-	2	C	5.85	(Note 6)
64	12-8	SL	62°	-	20	.09	5	10	No	G	31.6	12	293	10	31	1.656	-	2	C	5.94	(Note 6)
65	12-8	SL	62°	-	~15	.09	5	10	No	G	31.6	12	293	10	31	1.656	-	2	C	5.94	(Note 6)
66	1-23	VAC	66°	-	~15	.09	5	10	No	G	31.6	12	293	10	30	1.669	-	2	C	-	(No TBI Transfer) Discrepant loading of input chg. (Note 4)
67	1-23	VAC	66°	-	~15	.09	5	10	No	G	31.6	12	293	10	30	1.665	-	2	C	6.00	Discrepant loading of input chg. (Note 4)
68	1-23	VAC	66°	-	~15	.09	5	10	No	G	31.6	12	293	10	31	1.665	-	2	C	6.09	Discrepant loading of input chg. (Note 4)
69	1-23	VAC	66°	-	~15	.09	5	10	No	G	31.6	12	293	10	30	1.665	-	2	C	6.20	Discrepant loading of input chg. (Note 4)
70	1-23	VAC	66°	-	~15	.09	5	10	No	G	31.6	12	293	10	30	1.665	-	2	C	6.06	Discrepant loading of input chg. (Note 4)
71	1-23	VAC	66°	-	~15	.09	5	10	No	G	31.6	12	293	10	30	1.662	-	2	C	-	(No TBI Transfer) - Discrepant loading of input chg. (Note 4)
72	1-23	VAC	66°	-	~15	.09	5	10	No	G	31.6	12	293	10	31	1.665	-	2	C	6.06	Discrepant loading of input chg. (Note 4)
73	1-23	VAC	66°	-	~15	.09	5	10	No	G	31.6	12	293	10	30	1.665	-	2	C	5.86	Discrepant loading of input chg. (Note 4)
74	1-23	VAC	66°	-	~15	.09	5	10	No	G	31.6	12	293	10	31	1.665	-	2	C	5.97	Discrepant loading of input chg. (Note 4)
75	1-23	VAC	66°	-	~15	.09	5	10	No	G	31.6	12	293	10	30	1.661	-	2	C	-	(No TBI Transfer) Discrepant loading of input chg. (Note 4)
76	1-31	SL	62°	-----No TBI -----							------No Delay ---------									-	Simultaneous ign. of 2 output chgs. in one basket
77	1-31	VAC	62o	-----No TBI -----							------No Delay ---------									-	Simultaneous ign. of 2 output chgs. in one basket



SUMMARY OF TEST RESULTS

SBASI Actuated Pyrotechnic Time Delay Initiator

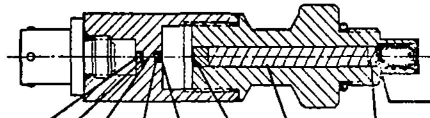
Test #	Test Date	SL/ VAC	Test Temp	Input HNS	Input PbN_6	Blkhd Thkns	Output PbN_6	Output AlA	Ign. Screen	Delay Form.	Comp. Press	# of Incr.	Wt./ Incr.	Dwell Time	RH @ Pressing	Delay Length	Trans Chg	Onion Skin Paper	Flt/Cont Ram	Delay Time	
78	1-31	VAC	62°	-	-----No TBI ----------						---------No Delay ---------										Simultaneous Ign. of 2 output chgs. in one basket (Note 4)
79	1-31	VAC	30°	-	25	.092	5	10	No	G	31.6	12	293	10	30	1.665	-	2	C	6.08	
80	1-31	VAC	30°	-	25	.092	5	10	No	G	31.6	12	293	10	31	1.665	-	2	C	5.95	
81	1-31	VAC	30°	-	25	.093	5	10	No	G	31.6	12	293	10	30	1.665	-	2	C	5.87	
82	1-31	VAC	30°	-	25	.091	5	10	No	G	31.6	12	293	10	30	1.666	-	2	C	5.89	
83	1-31	VAC	30°	-	25	.092	5	10	No	G	31.6	12	293	10	30	1.665	-	2	C	6.14	
84	1-31	VAC	30°	-	25	.089	5	10	No	G	31.6	12	293	10	31	1.666	-	2	C	5.98	
85	1-31	VAC	30°	-	25	.090	5	10	No	G	31.6	12	293	10	31	1.666	-	2	C	5.73	
86	1-31	VAC	30°	-	25	.089	5	10	No	G	31.6	12	293	10	30	1.667	-	2	C	6.20	
87	1-31	VAC	30°	-	25	.089	5	10	No	G	31.6	12	293	10	30	1.665	-	2	C	6.06	
88	1-31	VAC	30°	-	25	.084	5	10	No	G	31.6	12	293	10	30	1.665	-	2	C	5.85	
89	2-1	VAC	120°	-	25	.09	5	10	No	G	31.6	12	293	10	30	1.669	-	2	C	5.74	
90	2-1	VAC	120°	-	25	.090	5	10	No	G	31.6	12	293	10	30	1.665	-	2	C	5.71	
91	2-1	VAC	120°	-	25	.089	5	10	No	G	31.6	12	293	10	31	1.667	-	2	C	5.75	
92	2-1	VAC	120°	-	25	.090	5	10	No	G	31.6	12	293	10	30	1.660	-	2	C	5.80	
93	2-1	VAC	120°	-	25	.090	5	10	No	G	31.6	12	293	10	30	1.668	-	2	C	5.67	
94	2-1	VAC	120°	-	25	.095	5	10	No	G	31.6	12	293	10	30	1.665	-	2	C	5.88	
95	2-1	VAC	120°	-	25	.09	5	10	No	G	31.6	12	293	10	30	1.661	-	2	C	5.65	
96	2-1	VAC	120°	-	25	.090	5	10	No	G	31.6	12	293	10	31	1.666	-	2	C	5.88	
97	2-1	VAC	120°	-	25	.097	5	10	No	G	31.6	12	293	10	30	1.661	-	2	C	5.53	
98	2-1	VAC	120°	-	30	.092	5	10	No	G	31.6	12	293	10	31	1.665	-	2	C	5.66	
99	2-9	VAC	58°	-	30	.080	5	10	No	G	31.6	12	293	10	30	1.662	-	2	C	5.92	
100	2-9	VAC	58°	-	30	.077	5	10	No	G	31.6	12	293	10	30	1.665	-	2	C	5.78	
101	2-9	VAC	53°	-	25	.107	5	10	No	G	31.6	12	293	10	30	1.662	-	2	C	5.77	
102	3-14	SL	70°	-	25	.094	5	10	No	G	31.6	12	293	10	<35	1.663	-	2	C	6.13	
103	3-14	SL	70°	-	25	.091	5	10	No	G	31.6	12	293	10	<35	1.662	-	2	C	5.69	
104	3-14	SL	70°	-	25	.091	.5	10	No	G	31.6	12	293	10	<35	1.663	-	2	C	6.10	
105	3-14	SL	70°	-	25	.09	5	10	No	G	31.6	12	293	10	<35	-	No	2	C	5.92	
106	3-14	SL	70°	-	25	.092	5	10	No	G	31.6	12	293	10	<35	1.665	No	2	C	5.82	
107	3-14	SL	70°	-	25	.091	5	10	No	G	31.6	12	293	10	<35	1.662	No	2	C	6.00	
108	3-14	SL	70°	-	25	.091	5	10	No	G	31.6	12	293	10	<35	1.666	No	2	C	5.79	
109	3-14	SL	70°	-	25	.091	5	10	No	G	31.6	12	293	10	<35	1.664	No	2	C	5.80	
110	3-14	SL	70°	-	25	.069	5	10	No	G	31.6	12	293	10	<35	1.663	No	2	C	5.89	
111	3-14	SL	70°	-	25	.090	5	10	No	G	31.6	12	293	10	<35	1.665	No	2	C	6.00	
112	4-10	VAC	75°	-	25	.090	5	10	No	G	31.6	12	293	10	<35	1.661	No	2	C	-	No ignition of delay (Note 10)
113	4-10	VAC	74°	-	25	.089	5	10	No	G	31.6	12	293	10	<35	1.663	No	2	C	6.01	(Note 11)
114	4-10	VAC	76°	-	25	.091	5	10	No	G	31.6	12	293	10	<35	1.661	No	2	C	5.73	
115	4-10	VAC	76°	-	25	.089	5	10	No	G	31.6	12	293	10	<35	1.662	No	2	C	5.86	
116	4-10	VAC	76°	-	25	.090	5	10	No	G	31.6	12	293	10	<35	1.662	No	2	C	5.87	



SUMMARY OF TEST RESULTS

SBASI Actuated Pyrotechnic Time Delay Initiator

Test #	Test Date	SL/ VAC	Test Temp	Input HNS	Input PbN_6	Blkhd Thkns	Output PbN_6	Output AIA	Ign. Screen	Delay Form.	Comp. Press	# of Incr.	Wt. / Incr.	Dwell Time	RH @ Pressing	Delay Length	Trans Chg	Onion Skin Disks	Flt/Cont Ram	Delay Time			
117	4-10	VAC	76°	-	25	.090	5	10	No	G	31.6	12	293	10	<35	1.662	No	2	C	6.01	(Note 11)		(Note 7)
118	4-10	VAC	76°	-	25	.094	5	10	No	G	31.6	12	293	10	<35	1.665	No	2	C	5.66			
119	4-10	VAC	77°	-	25	.093	5	10	No	G	31.6	12	293	10	<35	1.659	No	2	C	5.75			
120	4-10	VAC	77°	-	25	.092	5	10	No	G	31.6	12	293	10	<35	1.663	No	2	C	5.55			
121	4-10	VAC	77°	-	25	.091	5	10	No	G	31.6	12	293	10	<35	1.663	No	2	C	5.84			
122	4-10	VAC	77°	-	25	.092	5	10	No	G	31.6	12	293	10	<35	1.660	No	2	C	5.66			
123	4-10	VAC	78°	-	25	.090	5	10	No	G	31.6	12	293	10	<35	1.662	No	2	C	5.82			
124	4-10	VAC	78°	-	25	.091	5	10	No	G	31.6	12	293	10	<35	1.661	No	2	C	5.64			
125	4-10	VAC	78°	-	25	.090	5	10	No	G	31.6	12	293	10	<35	1.662	No	2	C	5.55			
126	4-10	VAC	78°	-	25	.090	5	10	No	G	31.6	12	293	10	<35	1.660	No	2	C	6.12			
127	4-10	VAC	78°	-	25	.094	5	10	No	G	31.6	12	293	10	<35	1.664	No	2	C	5.66		(Note 8)	
128	4-10	VAC	76°	-	25	.092	5	10	No	G	31.6	12	293	10	<35	1.662	No	2	C	5.59		(Note 8)	
129	4-10	VAC	75°	-	25	.088	5	10	No	G	31.6	12	293	10	<35	1.664	No	2	C	5.81		(Note 8)	
130	4-10	VAC	74°	-	25	.088	5	10	No	G	31.6	12	293	10	<35	1.662	No	2	C	5.73			
131	4-10	VAC	74°	-	25	.093	5	10	No	G	31.6	12	293	10	<35	1.664	No	2	C	5.79			
132	4-12	VAC	120°	-	25	.092	5	10	No	G	31.6	12	293	10	<35	1.663	No	2	C	5.79			
133	4-12	VAC	120°	-	25	.088	5	10	No	G	31.6	12	293	10	<35	1.663	No	2	C	5.78			
134	4-12	VAC	120°	-	25	.093	5	10	No	G	31.6	12	293	10	<35	1.660	No	2	C	5.72			
135	4-12	VAC	120°	-	25	.090	5	10	No	G	31.6	12	293	10	<35	1.661	No	2	C	5.78			
136	4-12	VAC	120°	-	25	.093	5	10	No	G	31.6	12	293	10	<35	1.667	No	2	C	5.63	(Note 11)		(Note 7)
136	4-12	VAC	120°	-	25	.087	5	10	No	G	31.6	12	293	10	<35	1.661	No	2	C	5.68			
138	4-12	VAC	120°	-	25	.093	5	10	No	G	31.6	12	293	10	<35	1.656	No	2	C	5.76			
139	4-12	VAC	120°	-	25	.088	5	10	No	G	31.6	12	293	10	<35	1.662	No	2	C	5.52			
140	4-12	VAC	120°	-	25	.089	5	10	No	G	31.6	12	293	10	<35	1.662	No	2	C	5.82			
141	4-12	VAC	120°	-	25	.090	5	10	No	G	31.6	12	293	10	<35	1.662	No	2	C	5.86			
142	4-12	VAC	120°	-	25	.088	5	10	No	G	31.6	12	293	10	<35	1.661	No	2	C	5.89			
143	4-12	VAC	120°	-	25	.092	5	10	No	G	31.6	12	293	10	<35	1.664	No	2	C	5.74			
144	4-12	VAC	120°	-	25	.094	5	10	No	G	31.6	12	293	10	<35	1.661	No	2	C	5.72			
145	4-12	VAC	120°	-	25	.091	5	10	No	G	31.6	12	293	10	<35	1.663	No	2	C	5.62			
146	4-12	VAC	120°	-	25	.091	5	10	No	G	31.6	12	293	10	<35	1.662	No	2	C	5.55			
147	4-12	VAC	30°	-	25	.091	5	10	No	G	31.6	12	293	10	<35	1.661	No	2	C	6.10			
148	4-12	VAC	30°	-	25	.090	5	10	No	G	31.6	12	293	10	<35	1.665	No	2	C	5.82			
149	4-12	VAC	30°	-	25	.092	5	10	No	G	31.6	12	293	10	<35	1.[illegible]63	No	2	C	5.88			
150	4-12	VAC	30°	-	25	.090	5	10	No	G	31.6	12	293	10	<35	1.661	No	2	C	5.89			
151	4-12	VAC	30°	-	25	.092	5	10	No	G	31.6	12	293	10	<35	1.663	No	2	C	6.06			
152	4-12	VAC	30°	-	25	.091	5	10	No	G	31.6	12	293	10	<35	1.665	No	2	C	5.78			
153	4-12	VAC	30°	-	25	.094	5	10	No	G	31.6	12	293	10	<35	1.662	No	2	C	5.96			
154	4-12	VAC	30°	-	25	.089	5	10	No	G	31.6	12	293	10	<35	1.665	No	2	C	5.99			



SUMMARY OF TEST RESULTS

SBASI Actuated Pyrotechnic Time Delay Initiator

Test #	Test Date	SL/ VAC	Test Temp	Input HNS	Input PbN_6	Blkhd Thkns	Output PbN_6	Output AIA	Ign. Screen	Delay Form.	Comp. Press	# of Incr.	Wt. / Incr.	Dwell Time	RH @ Pressing	Delay Length	Trans Chg	Onion Skin Disks	Flt/Cont Ram	Delay Time			
155	4-12	VAC	30°	-	25	.099	5	10	No	G	31.6	12	293	10	<35	1.662	No	2	C	5.89	(Note 11)	(Note 8)	(Note 7)
156	4-12	VAC	30°	-	25	.093	5	10	No	G	31.6	12	293	10	<35	1.661	No	2	C	5.80		(Note 8)	
156	4-12	VAC	30°	-	25	.090	5	10	No	G	31.6	12	293	10	<35	1.661	No	2	C	5.75		(Note 8)	
158	4-12	VAC	30°	-	25	.092	5	10	No	G	31.6	12	293	10	<35	1.661	No	2	C	5.99			
159	4-12	VAC	30°	-	25	.092	5	10	No	G	31.6	12	293	10	<35	1.663	No	2	C	5.57			
160	4-12	VAC	30°	-	25	.093	5	10	No	G	31.6	12	293	10	<35	1.661	No	2	C	5.74			
161	4-12	VAC	30°	-	25	.090	5	10	No	G	31.6	12	293	10	<35	1.664	No	2	C	5.90			

NOTES:

(1) Delay Letter

	A	B	C	D	E	F	G
Tungsten (%)	65	40	40	55	60	58.2	59.5
Barium Chromate (%)	20	34.3	34.3	25.8	22.8	23.9	23.15
Potassium Perchlorate (%)	7	17	12	9	8	8.4	8.1
Diatomaceous Earth (%)	8	8	13.7	10.2	9.2	9.5	9.25

(2) Delay ignition increment was 100 mg on all tests except # 1 & 2 which had 150 mg AIA.

(3) Delay and Connector housings for Tests #1-21 were nickel plated.

(4) Delay column bore honed to a finish of ^{5} to ^{7} for tests 35-46 (all others as machined- approx. ^{32}

(5) SBASI/TBI cavity pressure measured on Tests #23, 24, 27 & 33.

(6) TBI/delay cavity pressure measured on Tests #25, 26, 28, 34 & 54-65.

(7) Delay assembled to a loaded ignitor basket and ignitor pressure spike method on Tests 33, 34 and 66-161

(8) Ignitor bag thickness increased to 2.5 mils for Tests 127, 128 and 155 and to 4.0 mils for Tests 129, 130, 156 and 157 (Nominal is 1 mil)

(9) Output charge for Tests 1-40 was 20 mg KDNBF and 390 mg BPN (12/20 granulation)
Output charge for Tests 41-161 was 20 mg KDNBF, 150 mg BPN (12/20 granulation) and 50 mg AIA

(10) Postfire examination revealed the output TBI AIA increment had been omitted.

(11) Hardware for Tests 113 to 161 subjected to environmental tests at NASA-Langley prior to functional test and after functional test were subjected to a backpressure greater than 5,000 psi and then subjected to a helium leak check with all units exhibiting a leak rate less than 1×10^{-6} std cc/sec helium.

APPENDIX B

DESIGN DETAILS

DRAWINGS

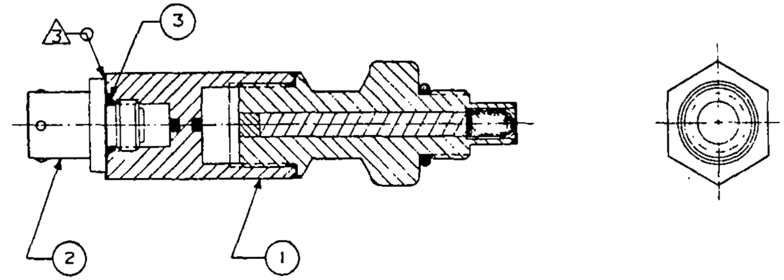
Part Number	Sheet Number	Description
011333-500	1	SBASI Actuated Pyrotechnic Time Delay Initiator Assy.
011137-500	1	Pyrotechnic Delay Assy.
011147-500	1	Connector Subassy.
011150-500	1	Delay Housing and Powder Assy.
011131-1	1	Connector
011149-500	1	Delay Housing Subassy.
012091-1	1	Closure Cup
011135-1	1	Output Cup
011132-1	1	Delay Housing
011134-1	1	Disk
	1	Onion Skin Paper Disk
T01146	1 & 2	Loading Press Connector - TB7
T01153	1	Connector, Ram Holder and Ram Details - Delay Body Loading Press
T01148	1	Loading Press Delay Body - SBASI
T01155	1	Loading Press Connector - TBI

NOTES:

1. INTERPRET DRAWING PER MIL-D-1000.
2. PROCESS PER MBA SPECIFICATION P52005.
3. T.I.G. WELD PER BEST COMMERCIAL PRACTICE.

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	EO 052-3 11-1-71 JLS		
	B	EO 052-7 12-6-71 JLY	12-9-71	
	C	EO 052-25 5-1-73 VDT		



—PYROTECHNIC—
TO BE HANDLED BY AUTHORIZED PERSONNEL ONLY

QTY REQD -500	SYM	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	UNIT WT	ZONE	ITEM NO.
1			NAS1593-009	PACKING, PREFORMED					3
1		21356	SLB2610 0052	SINGLE BRIDGEWIRE APPOLLO STANDARD INITIATOR (SBASI)					2
1			01137-500	PYROTECHNIC DELAY ASSEMBLY					1

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ANGULAR
DO NOT SCALE DRAWING

TREATMENT

FINISH

SIMILAR TO | ACT WT | CALC WT

FINAL

PART DASH NO | NEXT ASSY | FINAL QTY REQD PER ASSY | NEXT ASSY | USED ON | APPLICATION

		DATE
DRAWN	G. LEWIS	10-19-71
CHECK		
DESIGN		

DESIGN ACTIVITY APPD

MBA Associates
SCIENCE AND ENGINEERING

TITLE
SBASI ACTUATED PYROTECHNIC TIME DELAY INITIATOR ASSY
SBASI

DWG SIZE	CODE IDENT NO	DWG NO
C	27934	011333

SCALE 2/1 | RELEASE DATE | SHEET

C 011333

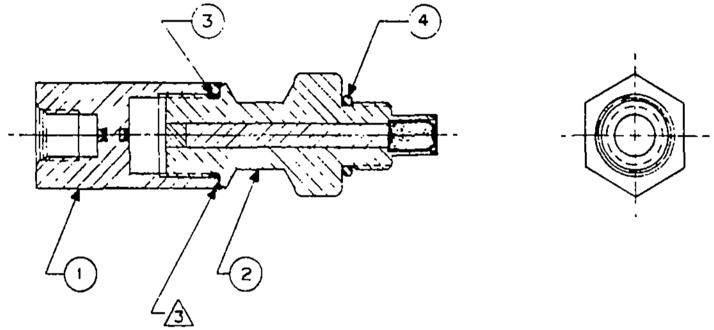
[redacted]

NOTES:

1. INTERPRET DRAWING PER MIL-D-1000.
2. PROCESS PER MBA SPECIFICATION P52003.
3. SOLDER ITEM 1 TO ITEM 2 USING 0.010 DIAMETER SOLID CORE TIN-SILVER SOLDER PER QQ-S-571 (SN96WS). USE SOLDER FLUX CONFORMING TO OF-506 TYPE 2.

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	EO 052-4 11-1-71 JLS		
	B	EO 052-9 12-3-71 JLY		
	C	EO 052-21 5-2-73 VDT		



—PYROTECHNIC—
TO BE HANDLED BY AUTHORIZED PERSONNEL ONLY

QTY REQD -500	SYM	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	UNIT WT	ZONE	ITEM NO
AR				SOLDER WIRE		3			5
1			NAS 1595-5	PACKING, PREFORM					4
1			MS 9068 -014	PACKING, PREFORM					3
1			011150-500	DELAY HOUSING & POWDER ASSY					2
1			011147-500	CONNECTOR SUBASSY					1

LIST OF MATERIALS

PART DASH NO	QTY REQD PER ASSY NEXT	QTY REQD PER ASSY FINAL	APPLICATION NEXT ASSY	APPLICATION USED ON
500	1		011333	011333

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS .XX ± — .XXX ± — ANGULAR ± —
DO NOT SCALE DRAWING

TREATMENT

FINISH

SIMILAR TO | ACT WT | CALC WT

DRAWN J L YODER 9-3-71
CHECK 9-23-71
DESIGN 10-20-71
DESIGN ACTIVITY APPD

MBA MBAssociates SCIENCE AND ENGINEERING

TITLE PYROTECHNIC DELAY ASSY
SBASI

DWG SIZE C | CODE IDENT NO 27934 | DWG NO 011137

SCALE 2/1 | RELEASE DATE | SHEET

011137 C

49

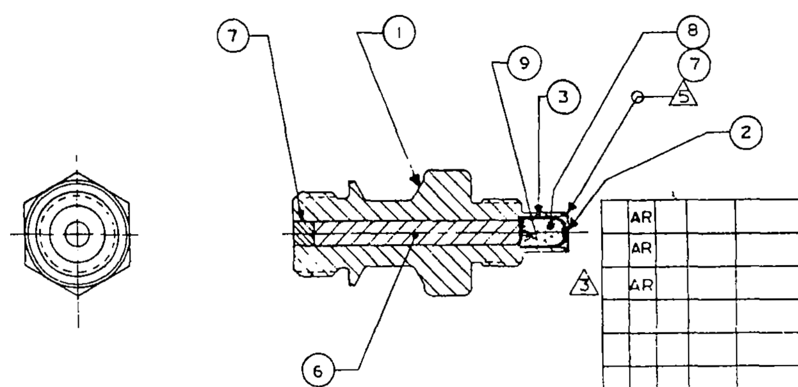
50

[redacted]

NOTES:

1. INTERPRET DRAWING PER MIL-D-1000.
2. PROCESS PER MBA SPECIFICATION P52002.
3. INDICATED QUANTITIES ARE IN MILLIGRAMS.
4. ITEM 4 MUST BE FLUSH TO .010 BELOW SURFACE OF ITEM 1 AFTER ASSEMBLY.
5. T.I.G. WELD PER BEST COMMERCIAL PRACTICE.

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	EO 052-10 12-2-71 JLY		
	B	EO 052-20 5-2-73 VDT		



—PYROTECHNIC—
TO BE HANDLED BY
AUTHORIZED
PERSONNEL ONLY

QTY REQD (500)	SYM	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	UNIT WT	ZONE	ITEM NO
AR					KDNBF	MIL-P-50486			9
AR					BORON POTASSIUM NITRATE	M52004			8
AR					A1A POWDER	MIL-P-22264			7
					DELAY POWDER				6
									5
									4
1			011135-1	OUTPUT CUP					3
1			012091-1	CLOSURE CUP					2
1			01149-500	DELAY HOUSING SUBASSY					1

LIST OF MATERIALS

PART DASH NO	NEXT QTY REQD	FINAL PER ASSY	NEXT ASSY	USED ON
500	1		01137	C-1333

APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS ANGULAR .XX ± — ± — .XXX ± —
DO NOT SCALE DRAWING

TREATMENT

FINISH

SIMILAR TO | ACT WT | CALC WT

		DATE
DRAWN	G. NISKALA	7-28-71
CHECK		7-23-71
DESIGN		10-20-71

DESIGN ACTIVITY APPD

MBA — M B Associates, SCIENCE AND ENGINEERING

TITLE: DELAY HOUSING & POWDER ASSY

SBAS1

DWG SIZE C | CODE IDENT NO 27934 | DWG NO C [illegible]

SCALE 2/1 | RELEASE DATE | SHEET

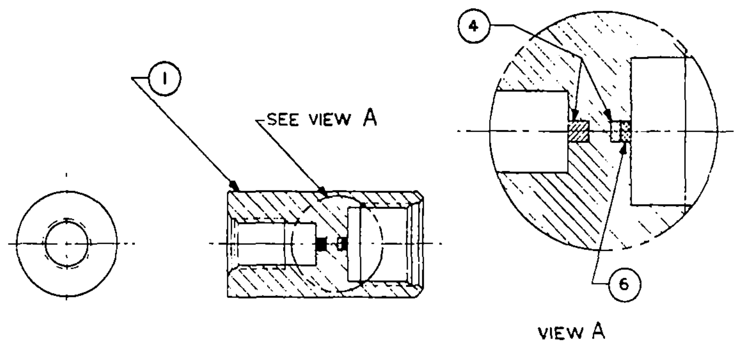
01115C B

NOTES:

1. INTERPRET DRAWING PER MIL-D-1000.
2. PROCESS PER MBA SPECIFICATION P52001.

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	B	EO 052-8 (REDRAWN) 12-6-71 JLY		
	C	EO 052-24 5-2-73 VDT		
	D	EO 052-31 8-10-73 VDT		



VIEW A

—PYROTECHNIC—
TO BE HANDLED BY
AUTHORIZED
PERSONNEL ONLY

QTY REQD	SYM	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	UNIT WT	ZONE	ITEM NO.
AR					AIA	MIL-P-22264			6
									5
AR					LEAD AZIDE	MIL-L-3055 TYPE I			4
									3
									2
1			011131-1	CONNECTOR					1
-500									

LIST OF MATERIALS

PART DASH NO.	QTY REQD PER ASSY	NEXT / FINAL	NEXT ASSY	USED ON
-500	1		011137	011333

APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ANGULAR
.XX ± — ± —
.XXX ± —
DO NOT SCALE DRAWING

TREATMENT

FINISH

SIMILAR TO | ACT WT | CALC WT

		DATE
DRAWN	J.L. YODER	9-2-71
CHECK	J. STEWART	9-23-71
DESIGN	S. SALTER	10-20-71

DESIGN ACTIVITY APPD

MBA — MBAssociates — SCIENCE AND ENGINEERING

TITLE: CONNECTOR SUBASSY

SBASI

DWG SIZE	CODE IDENT NO.	DWG NO.
C	27934	011147

SCALE 2/1 | RELEASE DATE EAC 10-21-71 | SHEET

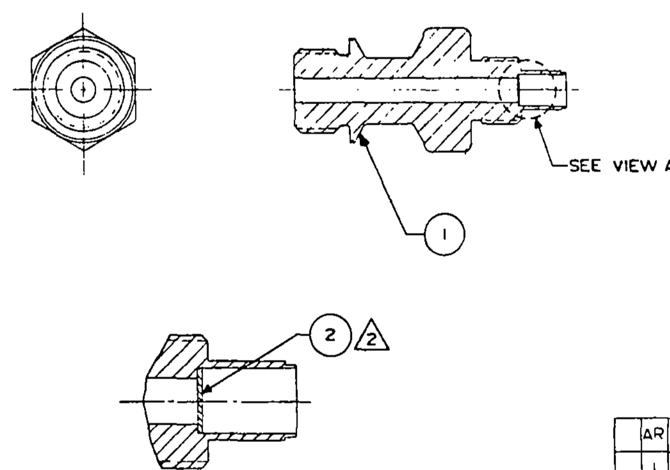
D 011147

NOTES:

1. INTERPRET DRAWING PER MIL-D-1000.
2. SOLDER ITEM 2 TO ITEM 1 USING 0.010 DIAMETER SOLID CORE TIN-SILVER SOLDER PER QQ-S-571 (SN96WS). USE SOLDER FLUX CONFORMING TO OF-506 TYPE 2.
3. NICKEL PLATE ALL SURFACES PER MIL-C-26074, CLASS 1, GRADE B, AFTER SOLDERING.

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	EO 052-11 12-2-71 JLY	12-9-71	
	B	EO 052-15 5-4-72 GEL		
	C	EO 052-23 5-2-73 VDT		



QTY REQD -500	SYM	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	UNIT WT	ZONE	ITEM NO
AR				SOLDER WIRE		2			3
1			011134-4	DISK					2
1			011132-1	DELAY HOUSING					1

LIST OF MATERIALS

PART DASH NO.	NEXT	FINAL	NEXT ASSY	USED ON
500	1		011150	011333
	QTY REQD PER ASSY		APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS .XX ± — .XXX ± — ANGULAR ± —
DO NOT SCALE DRAWING

TREATMENT

FINISH 3

SIMILAR TO | ACT WT | CALC WT

		DATE
DRAWN	G. NISKALA	7-26-71
CHECK		9-21-71
DESIGN		

DESIGN ACTIVITY APPD

MBA Associates
SCIENCE AND ENGINEERING

TITLE

DELAY HOUSING SUBASSY

SBAS1

DWG SIZE	CODE IDENT NO	DWG NO.
C	27934	011149

SCALE 2/1 | RELEASE DATE | SHEET

011149 C

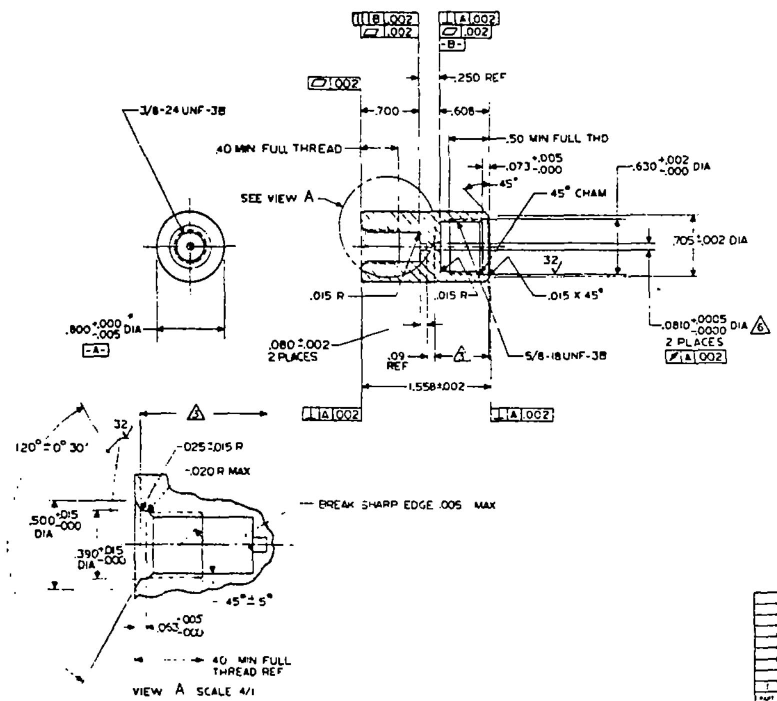
[redacted]

NOTES.

1. INTERPRET DRAWING PER MIL-D-1000.
2. △ NICKEL PLATE ALL SURFACES EXCEPT INDICATED PER MIL-C-26074, CLASS 1, GRADE B.
3. △ PLATING NOT REQUIRED TO BE APPLIED TO INTERNAL FEATURES WITHIN INDICATED LENGTH.
4. REMOVE ALL BURRS AND BREAK SHARP EDGES .010 R MAX.
5. 63/ ALL SURFACES UNLESS OTHERWISE SPECIFIED.
6. UNLESS OTHERWISE SPECIFIED, ALL DIAMETERS TO BE CONCENTRIC WITHIN ONE HALF THE SUM OF THEIR TOLERANCES.

REVISIONS

LTR	DESCRIPTION		
A	EO 052-6 (REDRAWN)	11-16-71	JLS
B	EO 052-13	12-3-71	JLY
C	EO 52-17	5-25-72	S.M
D	EO 52-18	6-20-72	S Am
E	EO 052-22	5 2-73	VDY



-1		CRES 304 COND A .375 DIA ROD	QQ-S-763		

LIST OF MATERIALS

DRAWN NISKALA 7-22-71
CHECK HEIER 7-26-71
DESIGN SALTER 10-20-71

MBA Associates

CONNECTOR

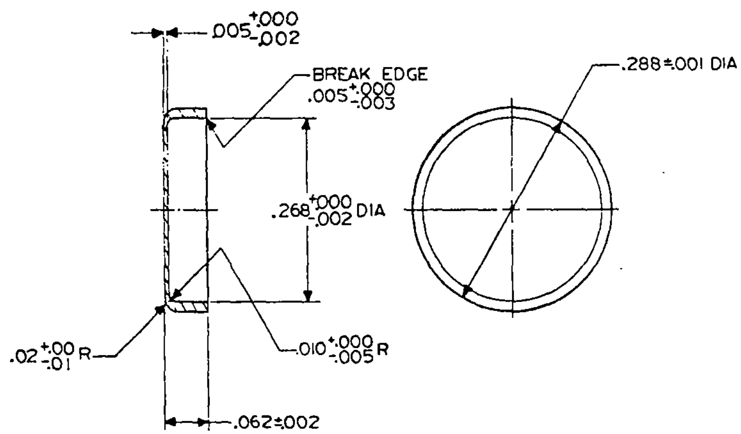
D 27934 011131

[redacted]

NOTES:
1. INTERPRET DRAWING PER MIL-D-1000.
2. PART TO BE FREE OF BURRS AND SHARP EDGES.

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
B3	A	REMOVED OD DIMENSION OF .263 +.003 -.000 DIA	11 Jan 73	McConagal
B3		ADDED ID DIMENSION OF .265 +.000 -.002 DIA		
A4		IS: .025 +.000 -.005 WAS: .020 +.000 -.005 GEL. 1-10-73		
	B	REVISED 3-21-73 G.N.	26 Mar 73	McConagal



QTY REQD			SYM	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	UNIT WT	ZONE	ITEM NO
					-1		CRES, CLASS 304, COND A	QQ-S-766			

LIST OF MATERIALS

PART DASH NO.	NEXT	FINAL	NEXT ASSY	USED ON
-1	1		011150	011333
	QTY REQD PER ASSY		APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ANGULAR
.XX ± — ± —
.XXX ± —
DO NOT SCALE DRAWING

TREATMENT

FINISH

SIMILAR TO | ACT WT | CALC WT

		DATE
DRAWN	TRUJILLO	1-2-73
CHECK		1-2-73
DESIGN		5 Jan 73

DESIGN ACTIVITY APPD

MBA — M B Associates, San Ramon, Calif. — Science and Engineering

TITLE: CLOSURE CUP

DWG SIZE	CODE IDENT NO.	DWG NO.
C	27934	012091

SCALE 10/1 | RELEASE DATE | SHEET

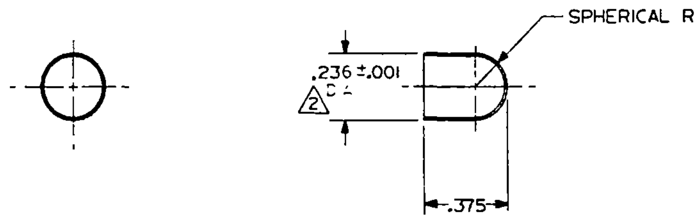
B 012091

[redacted]

NOTES:

1. INTERPRET DRAWING PER MIL-D-1000.
2. (△) INDICATED DATA APPLIES WHEN PART IS IN A RESTRAINED CONDITION.
3. PART TO BE FREE OF BURRS AND SHARP EDGES.

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



011135

QTY REQD		SYM	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	UNIT WT.	ZONE	ITEM NO
				-1		AL 1100-0 .005 THK	QQ-A-250/1			

LIST OF MATERIALS

PART DASH NO.	NEXT	FINAL	NEXT ASSY	USED ON
-1	1		011150	011333

QTY REQD PER ASSY — APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS .XX ± .XXX ±.005 ANGULAR ± —
DO NOT SCALE DRAWING

TREATMENT

FINISH

SIMILAR TO | ACT WT | CALC WT

		DATE
DRAWN	D. HEIER	7-22-71
CHECK		7-23-71
DESIGN		7-26-71

DESIGN ACTIVITY APPD

MBA — M B Associates — SAN RAMON, CALIF. — SCIENCE AND ENGINEERING

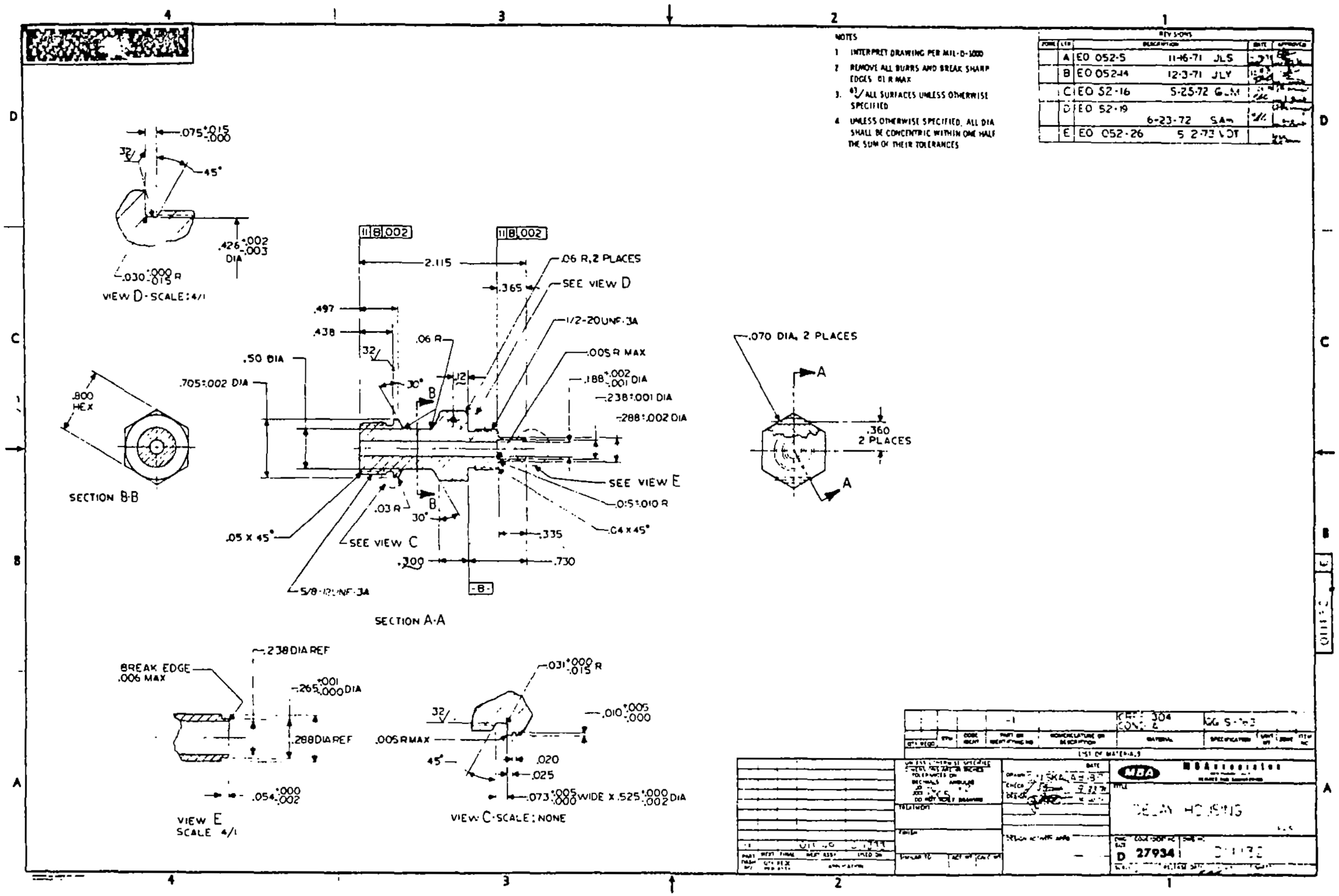
TITLE

OUTPUT CUP

SBASI

DWG SIZE	CODE IDENT NO.	DWG NO.
C	27934	011135

SCALE 4/1 | RELEASE DATE | SHEET

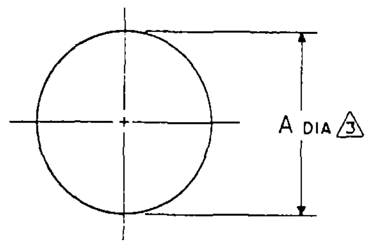

NOTES
1 INTERPRET DRAWING PER MIL-D-1000
2 REMOVE ALL BURRS AND BREAK SHARP EDGES .01 R MAX
3. 63/ ALL SURFACES UNLESS OTHERWISE SPECIFIED
4 UNLESS OTHERWISE SPECIFIED, ALL DIA SHALL BE CONCENTRIC WITHIN ONE HALF THE SUM OF THEIR TOLERANCES
REVISIONS
A EO 052-5 11-16-71 JLS
B EO 052-14 12-3-71 JLY
C EO 52-16 5-25-72
D EO 52-19 6-23-72
E EO 052-26
VIEW D - SCALE: 4/1
.426 +.002 -.003 DIA
.030 +.000 -.015 R
.075 +.015 -.000
45°
.800 HEX
SECTION B-B
2.115
.06 R, 2 PLACES
SEE VIEW D
1/2-20UNF-3A
.005 R MAX
.188 +.002 -.001 DIA
.238±.001 DIA
.288±.002 DIA
.497
.438
.365
.06 R
.50 DIA
.705±.002 DIA
30°
.12
SEE VIEW E
.015±.010 R
.04 X 45°
.03 R
.05 X 45°
SEE VIEW C
.335
.300
.730
5/8-18UNF-3A
-B-
SECTION A-A
.070 DIA, 2 PLACES
.360 2 PLACES
.238 DIA REF
BREAK EDGE .006 MAX
.265 +.001 -.000 DIA
.288 DIA REF
.054 +.000 -.002
VIEW E SCALE 4/1
.031 +.000 -.015 R
.010 +.005 -.000
.005 R MAX
.020
.025
.073 +.005 -.000 WIDE X .525 +.000 -.002 DIA
VIEW C - SCALE: NONE
LIST OF MATERIALS
D 27934

[redacted]

NOTES:

1. INTERPRET DRAWING PER MIL-D-1000.
2. EDGE OF PART TO BE FREE OF BURRS.
3. (triangle) DIAMETER INDICATED APPLIES WHEN PART IS RESTRAINED FLAT WITHIN .010.

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	EO 052-2	11-1-71 JLS	



PART DASH NUMBER	A DIA
-3	.280±.005
-4	$.227^{+.000}_{-.003}$

011134

QTY REQD	SYM	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	UNIT WT	ZONE	ITEM NO
			-4		NICKEL 200 .005 THK	MIL-N-46025			2
			-3		CRES 302, FULL HARD, .002 THK	MIL-S-5059			1

LIST OF MATERIALS

PART DASH NO	NEXT QTY REQD	FINAL QTY PER ASSY	NEXT ASSY	USED ON
-4			011149	
-3			011150	
			APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ANGULAR
.XX ± — ± —
.XXX ± —
DO NOT SCALE DRAWING

TREATMENT

FINISH

SIMILAR TO | ACT WT | CALC WT

		DATE
DRAWN	STEWART	7-22-71
CHECK	J. Stewart	7-23-71
DESIGN		

DESIGN ACTIVITY APPD

MBA — M B Associates — SCIENCE AND ENGINEERING

TITLE

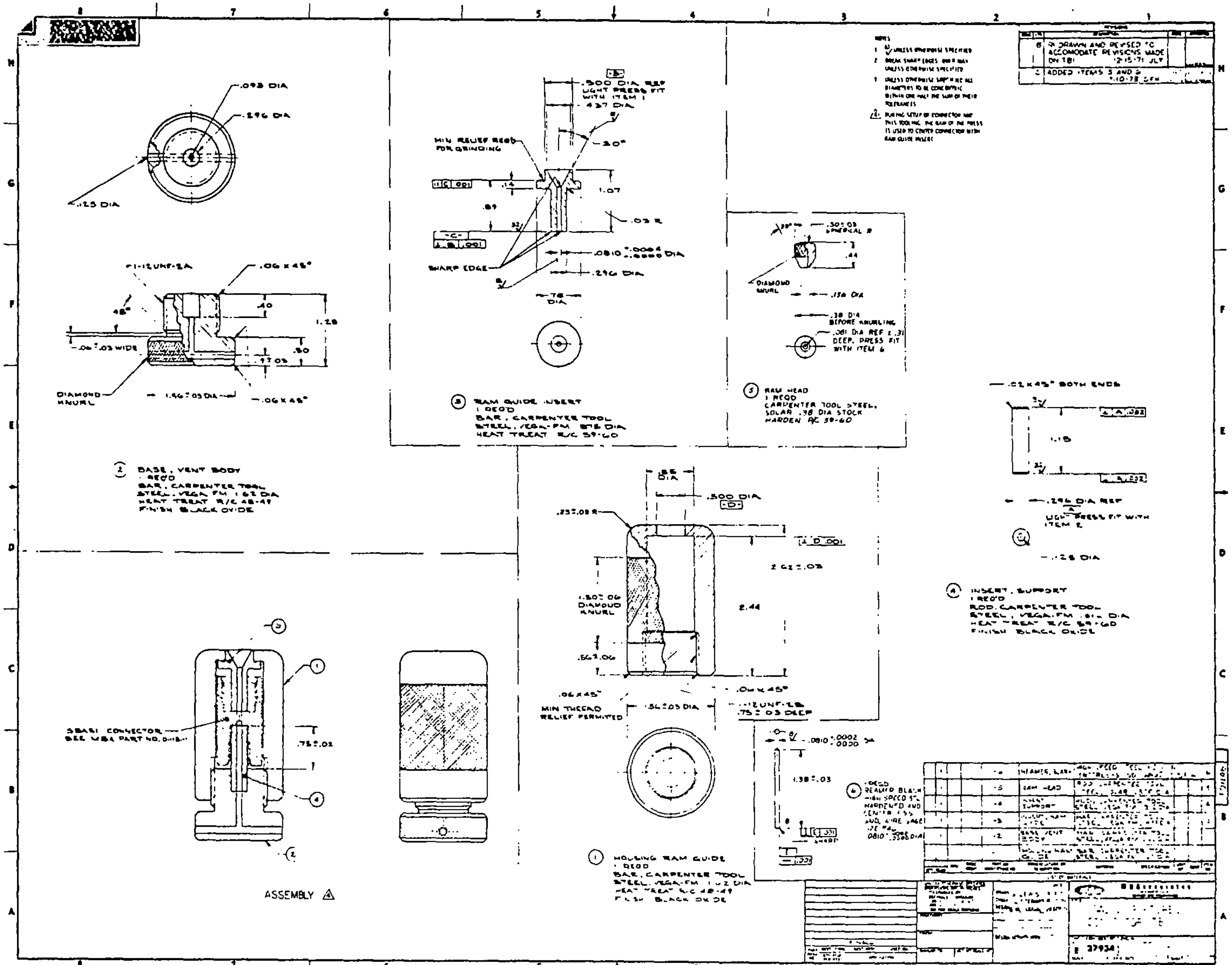
DISK

56AS1

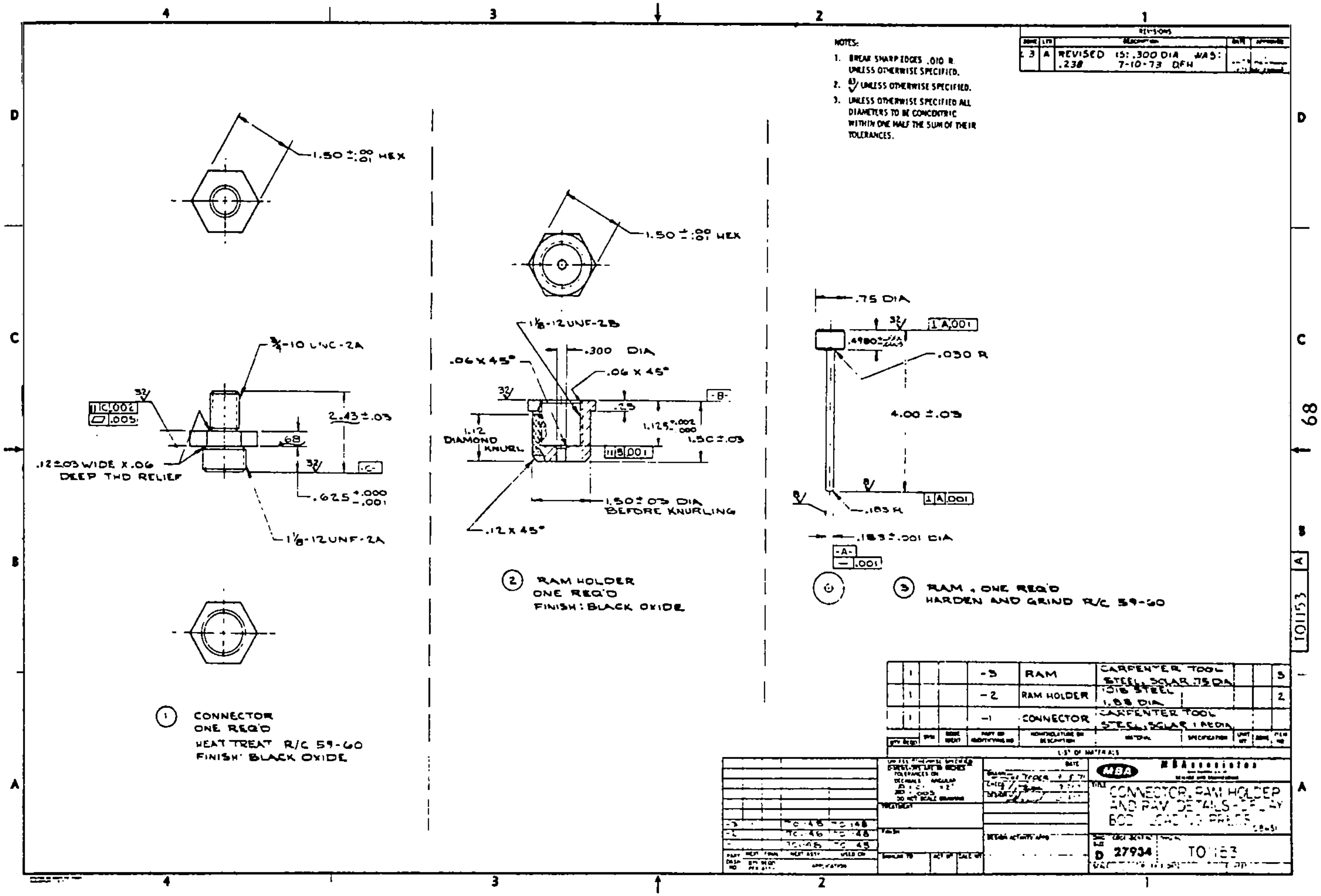
DWG SIZE: C | CODE IDENT NO.: 27934 | DWG NO.: 011134

SCALE: NONE | RELEASE DATE | SHEET

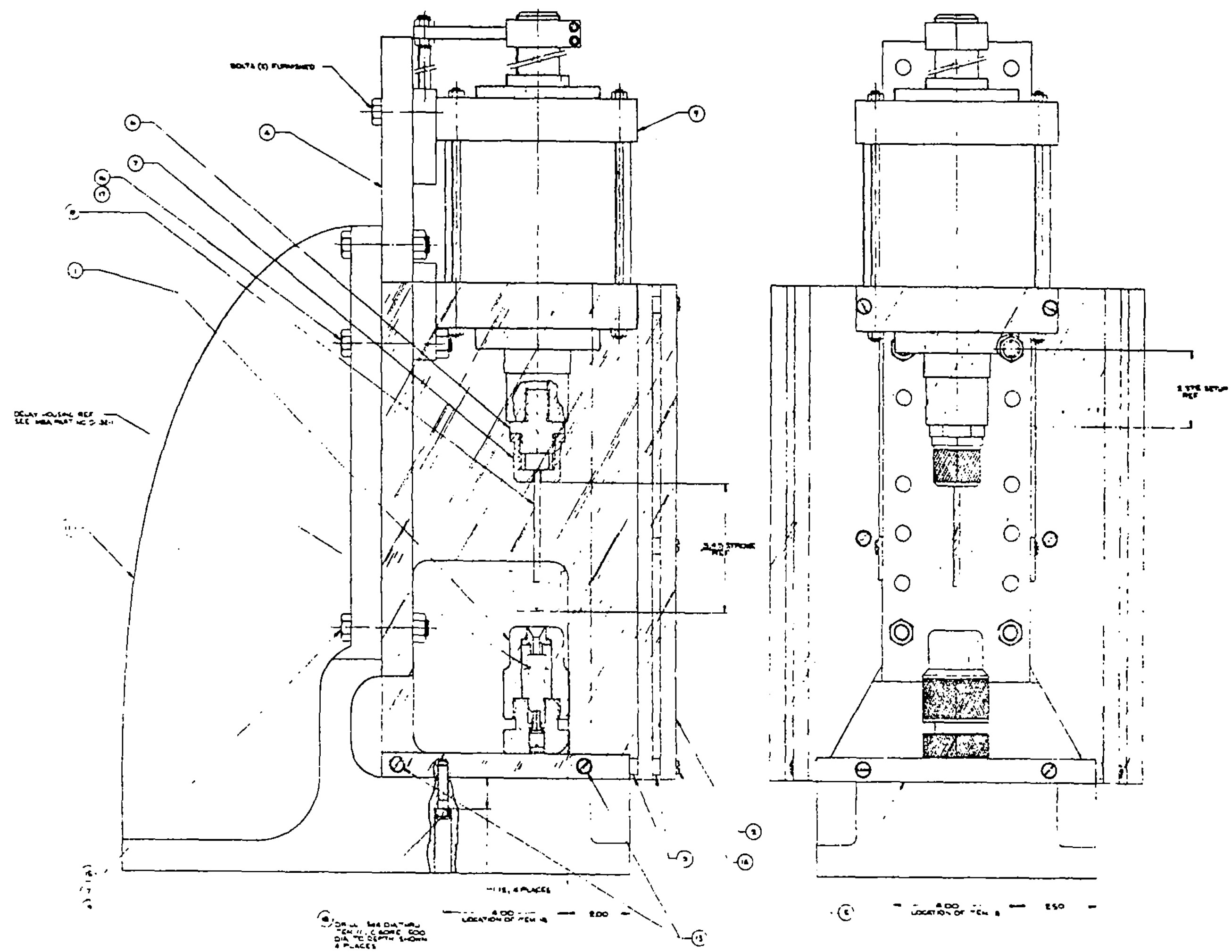
57

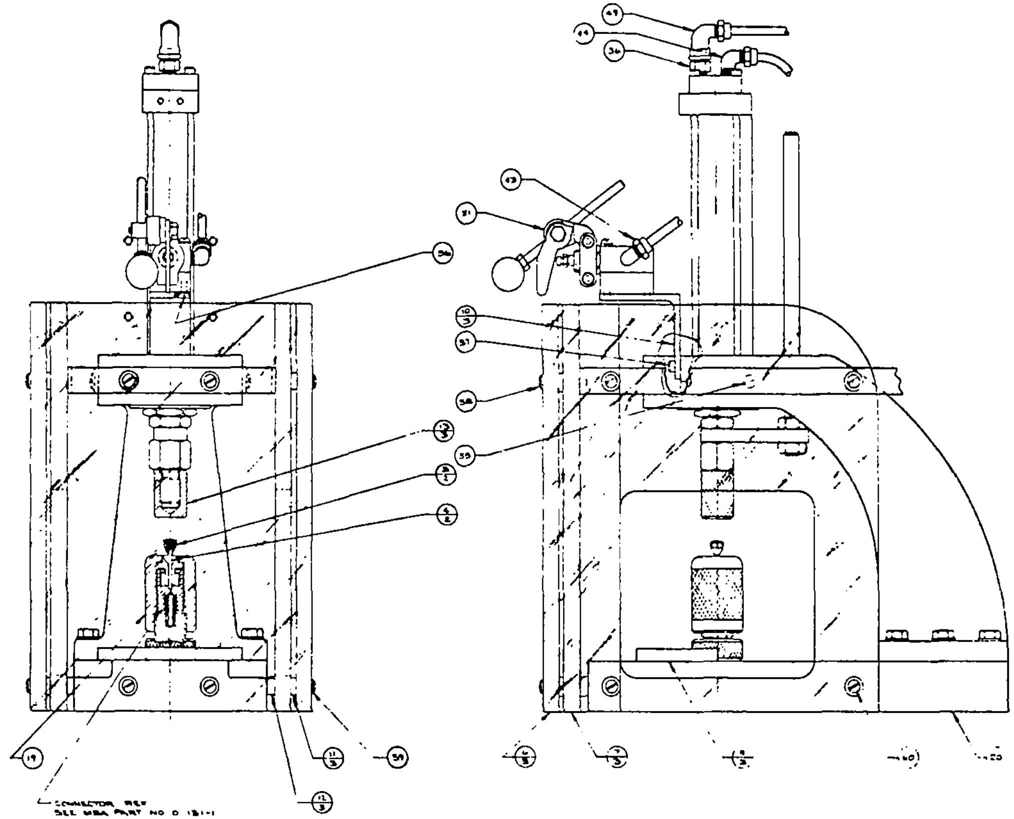


.093 DIA
.296 DIA
.125 DIA
DIAMOND KNURL
.06 X 45°
② BASE, VENT BODY
1 REQ'D
BAR, CARPENTER TOOL STEEL, VEGA-FM 1.62 DIA
HEAT TREAT R/C 48-49
FINISH BLACK OXIDE
.500 DIA REF
LIGHT PRESS FIT WITH ITEM 1
.437 DIA
MIN RELIEF REQD FOR GRINDING
30°
SHARP EDGE
.296 DIA
③ RAM GUIDE INSERT
1 REQ'D
BAR, CARPENTER TOOL STEEL, VEGA-FM
HEAT TREAT R/C 59-60
DIAMOND KNURL
.38 DIA BEFORE KNURLING
DEEP, PRESS FIT WITH ITEM 6
⑤ RAM HEAD
1 REQD
CARPENTER TOOL STEEL, SOLAR .38 DIA STOCK
HARDEN RC 59-60
.02 X 45° BOTH ENDS
.296 DIA REF
LIGHT PRESS FIT WITH ITEM 2
.125 DIA
④ INSERT, SUPPORT
1 REQ'D
ROD, CARPENTER TOOL STEEL, VEGA-FM
HEAT TREAT R/C 59-60
FINISH BLACK OXIDE
.500 DIA
DIAMOND KNURL
2.44
.06 X 45°
MIN THREAD RELIEF PERMITTED
SSASI CONNECTOR
ASSEMBLY
① HOUSING RAM GUIDE
1 REQD
BAR, CARPENTER TOOL STEEL, VEGA-FM
HEAT TREAT R/C 48-49
FINISH BLACK OXIDE
⑥ REAMER BLANK
HIGH SPEED STL
HARDENED AND
ADDED ITEMS 3 AND 6
REDRAWN AND REVISED TO ACCOMODATE REVISIONS MADE
37934



NOTES:
1. BREAK SHARP EDGES .010 R. UNLESS OTHERWISE SPECIFIED.
2. 63 UNLESS OTHERWISE SPECIFIED.
3. UNLESS OTHERWISE SPECIFIED ALL DIAMETERS TO BE CONCENTRIC WITHIN ONE HALF THE SUM OF THEIR TOLERANCES.
REVISIONS
3 A REVISED 15: .300 DIA WAS: .238 7-10-73 DFH
1.50 +.00 -.01 HEX
3/4-10 UNC-2A
2.43 ±.03
.68
.12±.03 WIDE X .06 DEEP THD RELIEF
.625 +.000 -.001
1 1/8-12UNF-2A
1 CONNECTOR ONE REQ'D HEAT TREAT R/C 59-60 FINISH: BLACK OXIDE
1 1/8-12UNF-2B
.300 DIA
.06 X 45°
.25
1.125 +.002 -.000
1.50 ±.03
1.12 DIAMOND KNURL
1.50 ±.03 DIA BEFORE KNURLING
.12 X 45°
2 RAM HOLDER ONE REQ'D FINISH: BLACK OXIDE
.75 DIA
.030 R
4.00 ±.03
.183 R
.183 ±.001 DIA
3 RAM, ONE REQ'D HARDEN AND GRIND R/C 59-60
-3 RAM CARPENTER TOOL STEEL, SOLAR .75 DIA 3
-2 RAM HOLDER 1018 STEEL 1.88 DIA 2
-1 CONNECTOR CARPENTER TOOL STEEL, SOLAR 1 REQ'D
LIST OF MATERIALS
MBA
CONNECTOR, RAM HOLDER AND RAM DETAILS
D 27934 TO1153
68


4 PLACES
4.00
2.00
4 PLACES
2.50


CONNECTOR, REF
SEE MBA PART NO D 1311-1

APPENDIX C

MANUFACTURING SPECIFICATION

APPENDIX C

Manufacturing Specification

SCOPE

This document describes the materials, equipment, and procedures required to assemble the SBASI Actuated Pyrotechnic Time Delay Initiator MBA 011333-500.

APPLICABLE DOCUMENTS

The following documents of the latest issue in effect or as specified by MBAssociates (MBA) form a part of this section to the extent specified herein.

SPECIFICATIONS

FEDERAL

QQ-S-763	Stainless Steel
QQ-B-00655a	Silver Brazing Alloy
O-F-499c	Flux, Brazing
TT-B-838	Butyl Acetate

MILITARY

MIL-L-3055A	Lead Azide R/A Type 1
MIL-P-22264(WEP)	Composition A-1A
MIL-W-8611A	Welding, Metal Arc and Gas, Steels and Corrosion and Heat Resistant Alloys; Process for
MIL-N-5538	Nitrocellulose, Technical
MIL-P-50486(MU)	Potassium Dinitro-Hydroxy Hydro-Benzofuroxan (for use in ammunition)
MIL-T-23132(WEP)	Tungsten Delay Composition

MISC

FND 60005, Rev. A	Boron Potassium Nitrate Pellets 2L Configuration
PA-PD-3056	Tungsten, Powder (for Pyrotechnics)

The Through Bulkhead Initiator (TBI) P/N 01131-1 is loaded with Loading Tooling P/N TO1146 (Figure 1) on TBI press (Figure 2).

The part is inspected per latest drawing.

The parts are cleaned using TF Grade Freon in an ultrasonic cleaner for a minimum of 10 minutes.

Parts are handled after cleaning with care to insure cleanliness throughout loading operations.

Prior to loading, Connector Tooling (T)1146) is cleaned to eliminate all possible traces of oil and dus .

The procedure is as follows:

1. Calibrate the TBI press, maintaining a pressing pressure between 14,900 and 15,100 psi on a 0.080 in. dia. ram.

2. Verify and record dwell of press at pressing pressure, at 7 to 10 sec.

3. Install TBI connector in loading tooling, using Ram (P/N T)1146-6) to align cavity to be loaded and then hand torque tooling together.

4. Obtain lead azide PVA Type 1 per MIL-L-3055a and verify moisture content to be not more than .02%.

5. Obtain gasless ignition powder per MIL-P-22264 (WEP) Amend. 2 Composition A-1A and verify moisture content to be not more than .02%.

6. Weigh two 12.5 milligram increments of lead azide. Press each increment separately into the input side of connector. Measure actual explosive column height and record on data sheet.

7. Disassemble TBI connector loading tooling and reverse TBI connector in tooling. Then reassemble tooling aligning output cavity in tooling with pressing ram while hand torqueing tooling together.

8. Weigh one 5 milligram increment of lead azide and press into the connector output cavity. Measure column height and record on data sheet.

9. Weigh two 5 milligram increments of A-1A gasless ignition composition and press in separate increments into output side of connector. Measure A-1A column height and record on data sheet.

10. After donor and acceptor pressing operations are complete, bag and identify, then store in desiccator until next assembly operation.

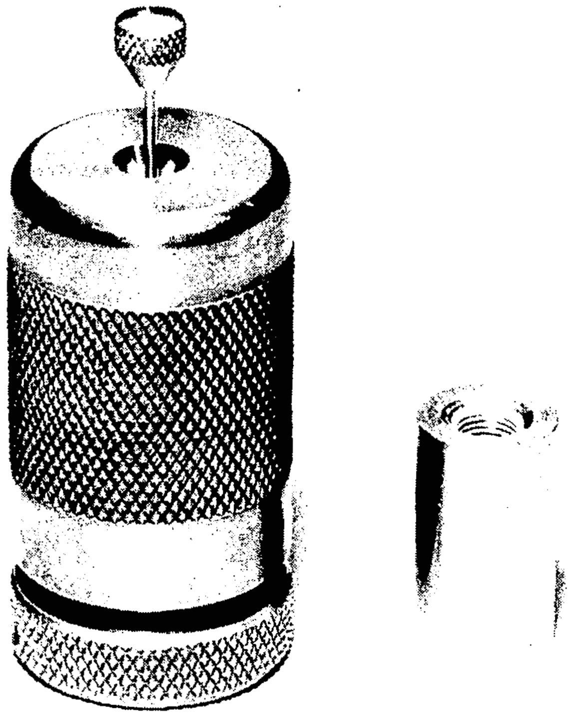


FIGURE 1.
THROUGH BULKHEAD INITIATOR TOOLING

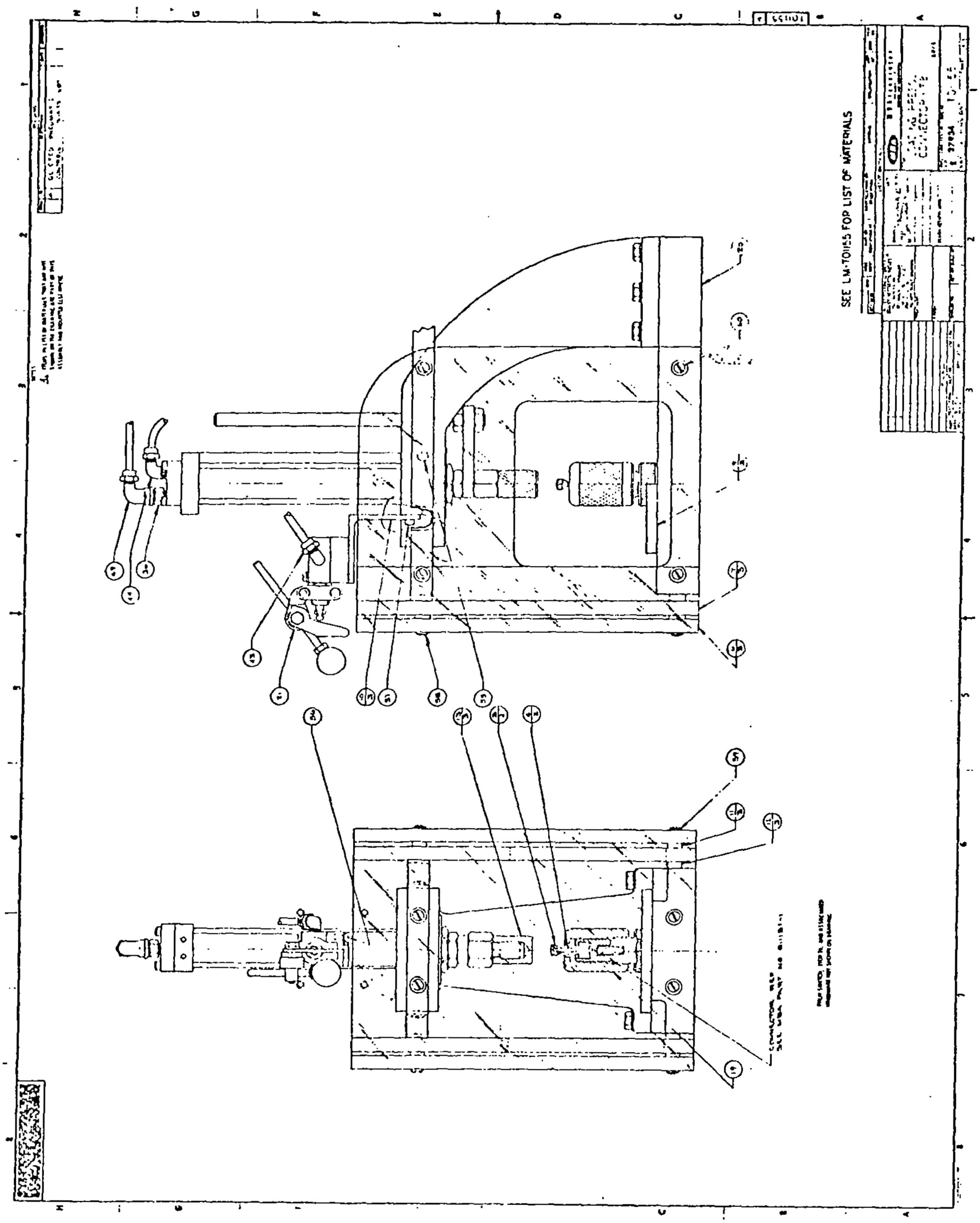


FIGURE 2.
TBI PRESS

Delay Housing Subassembly P/N 01149 - This subassembly is an operation joining a stainless foil closure over bottom of delay column cavity. Materials required for this assembly are:

Delay Housing P/N 011132

Disk P/N 011134

Preform, Brazing P/N 912424

Flux, Silver Brazing

Verify that all applicable parts and materials have been properly inspected and identified before use.

Applicable parts are to be ultrasonically cleaned for a minimum of 10 min. in clean TF Grade Freon solvent. After removing the parts from the ultrasonic cleaner allow them to dry before bagging and identifying for use.

Note: All parts are to be handled after cleaning so as to insure cleanliness for next assembly or loading operation.

Flux is applied to circular flat area in delay housing where disk is to be brazed into position. Flux should be applied to only this area and only sparingly. Disk is placed in position with brazing preform on top of disk. The subassembly is then induction brazed while holding disk in position against delay column end to prevent the disk from floating excessively or tilting slightly.

After brazing, the delay housing to subassembly is thoroughly cleaned to remove any brazing flux and foreign material.

Delay subassembly is then inspected for proper filet configuration, then bagged and identified for next assembly operation.

Delay Housing and Powder Assembly P/N 011150 - Calibrate Delay Press TO1148, maintaining pressing pressure at 850 $lbs_f \pm 25\ lbs_f$ (Figure 3).

Verify that delay press is dwelling 10 ± 1 sec. at pressing pressure and record on data sheet.

Verify that Delay Housing Subassembly has been cleaned and inspected per Drawing #011149 Rev. C.

Install two Onion Skin Paper Disks at bottom of Delay Housing Subassembly P/N 011149 Rev. C prior to pressing first delay increment. Verify after installing each paper disk that it is flat and seated properly.

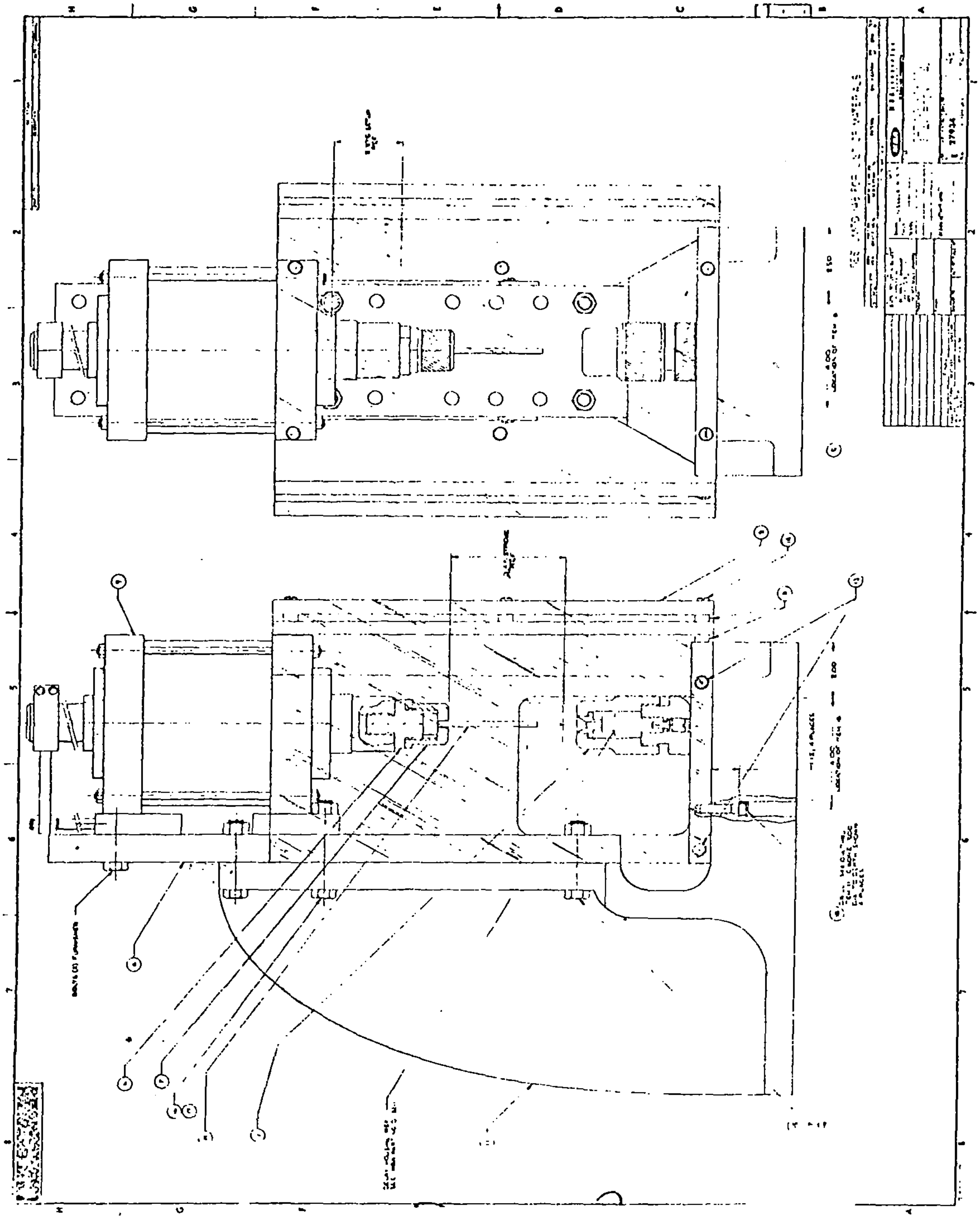


FIGURE 3
DELAY PRESS

Delay Composition Blending

Blend in five pound batches, percentage composition by weight is:

Ingredient	% By Weight	Mean Particle Size
Tungsten	59.5	3.5 micron
Barium Chromate	23.15	2 micron
Potassium Perchlorate	8.1	20 ± 5 micron
Diatomaceous Earth	9.25	325 mesh

The ingredients shall be blended in the following process (blend time in minutes):

a. Barium chromate (by itself) - 10 minutes.
b. Add tungsten - 10 minutes.
c. Mix potassium perchlorate and diatomaceous earth in 500 ml of acetone.
d. Add mixture in "C" - 10 minutes.
e. Remove and dry, as per MIL-T-23132 (WEP).
f. Screen through several coarse screens to break up expected caking during drying process.

Blender used - Lancaster Counter-Current, Type LWD.

Loading Fixture, Delay Housing, P/N T01147 (Figure 4)

Verify that loading fixture is clean and free of oil and foreign material.

Verify and/or align loading tooling (T01147) with delay press (TO1148) and that tooling detents are secure to press base.

Loading of delay assembly and storage shall be accomplished in controlled production area of 45% max. Relative humidity at 80°F max. temperature.

Secure delay composition and verify that moisture content of composition of time of loading does not exceed .2%.

Delay column shall be consolidated in twelve increments of approximately 290 milligrams each of delay composition.

At top of delay column there will be consolidated one increment of 100 milligrams composition ignition (A1A).

Actual delay column length is to be adjusted after verification by testing.

Install delay housing loaded with onion skin paper discs, P/N 912416-1 into loading fixture using an assembly tool, P/N T01453-6 to align delay cavity with loading fixture and hand tightening tool together. After tightening tool P/N T01147-2 together with tool P/N T01147-1, tool P/N T01147-5 is to be torqued to a torque of 6 in. lb. ± 1 in. lb. so that tool P/N T01147-4 is supported against delay column seal (Figure 4).

After consolidation of ignition materials, the column shall be flush to .040 below delay housing.

Preparation of materials for application of KDNBF nitrocellulose (N/C) lacquer. The N/C lacquer shall be formulated as follows:

N/C Lacquer	% By Weight
Camphor, USP	0.85
N/C, MIL-N-5538, 0.5 sec. vis	2.26
N/C, Commercial, 60-80 sec. vis	1.21
Butyl Acetate, TT-B-838	19.31
Ethanol, 3A Denatured	58.87
Toluene, ACS Grade	17.50

KDNBF Transfer Charge Mixture

The KDNBF transfer charge mixture shall be formulated as follows: 71.72% by weight of N/C lacquer and 28.28% by weight of KDNBF.

Weigh out KDNBF in a 10 milliliter teflon beaker. Add the correct amount of nitorcellulose lacquer. Stir with a small wooden dowel (wooden applicator of stick-test type) using a slow circular motion until a smooth lump-free suspension is formed.

Apply transfer charge mixture of approximately 20 milligrams to the output side of delay column disc seal and allow transfer charge mixture to air dry for one (1) hour and then dry in a vacuum dryer at 50 ± 5°C for a minimum of four (4) hours. Remove delay housing and cool in a desiccator.

After delay housing with transfer charge has cooled, identify and store under desiccated condition until next operation.

Installation of Output Charge

The material is boron potassium nitrate (BPN) 20/40 granulation in accordance with end specification 75005. Gasless ignition powder A1A is per specification MIL-P-22264 (WEP).

Verify that BPN and A1A are inspected per specification and that moisture content on both compositions at time of loading do not exceed .2%.

Output Cup, P/N 011135

Output Cup, P/N 011135 shall be ultrasonically cleaned for a minimum of 10 minutes in TF grade freon solvent. Allow output cup to dry after cleaning, then bag and identify for use on next assembly, P/N 011150, Rev. B.

TBI/Delay Housing Assembly, P/N 011137-500, (Figure 5)

Assemble packing preform to delay housing assembly P/N 011150-500 (P/N NAS 1595-5) with packing preform assembly tool P/N T01453-4. Then torque connector subassembly P/N 011147 to delay housing assembly P/N 011150-500 to a torque of 130 ± 10 in. lbs.

Install packing preform NAS 1593-009 with assembly tool P/N T01453-2 to SBASI NASA P/N SEB26100001, then install SBASI to TBI connector subassembly P/N 011147-500 with a torque of 130 ± 10 in. lbs.

Next place the closure cap P/N 012901 to delay housing assembly P/N 011150-500, Rev. B.

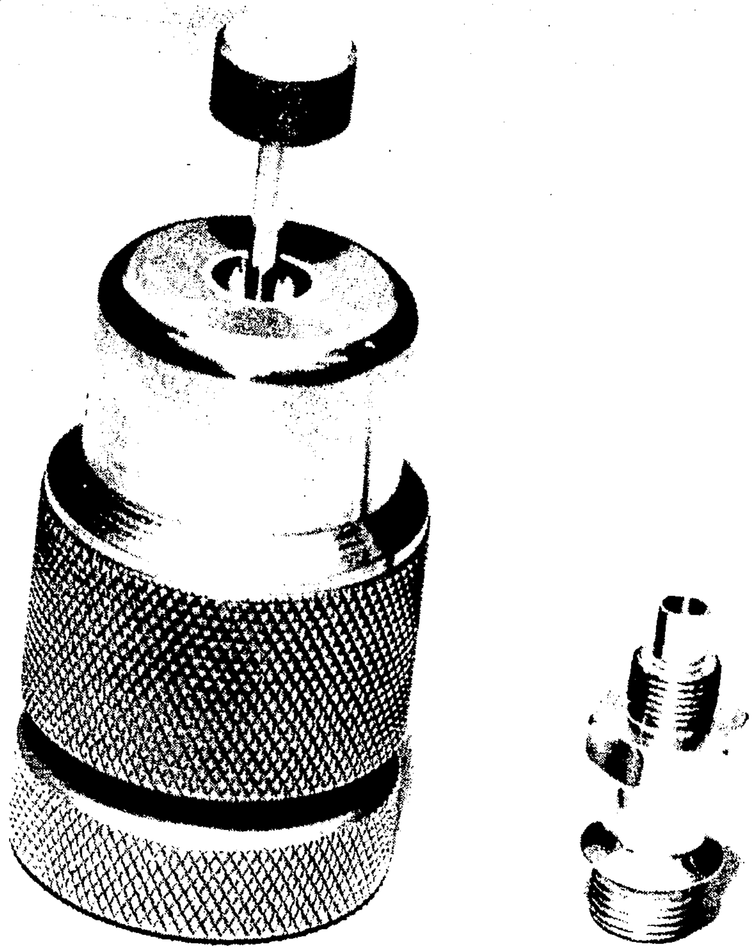


FIGURE 4.
DELAY HOUSING LOADING FIXTURE

TIG weld closure cup P/N 012091-1 to delay housing assembly P/N 011150-500, Rev. B.

TIG weld SBASI NASA P/N SEB26100001 to TBI connector assembly P/N 011147-500.

TIG weld TBI connector assembly P/N 011147-500 to delay housing assembly P/N 011150-500.

<u>Gas Tungsten-Arc Weld Operation (TIG)</u>

Turn valve on gas bottle full on, verify gas bottle quantity.

Press On-Off switch On (indicator light on).

Verify gas flow (should be from (6) to (10) CFG).

Note: 1. Flow meter now on bottle should read 10 at top of ball.

2. At optimum point of gas flow there is no noise at weld head while welding is in progress.

3. Reduce gas flow to lower point where welds are satisfactory.

Switch selector to set-up mode.

Set pre-flow.

Set weld-time control to match surface speed of positioner.

Note: For optimum results, electrode tip should be finished in (sodium nitrate).

Place work piece in positioner and adjust top to no more than .0003 maximum for optimum weld uniformity.

Adjust electrode angle adjust clearance.

Note: Make electrode adjustment while work piece is stationary in positioner.

While in set-up mode, move electrode set at proper angle slowly toward work piece while observing weld voltage meter. When voltage drops to zero, electrode is in contact with work piece.

While still in set-up mode, start positioner and observe weld voltage, weld voltage should remain fairly constant unless electrode is touching work piece at some point while work piece is in motion.

<u>X-RAY ALL UNITS TO VERIFY PROPER ASSEMBLY.</u>

APPENDIX D

MANUFACTURING COST ESTIMATE

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MANUFACTURING COST ESTIMATE

The cost estimate delineated below is based upon the following assumptions:

1) the current MBA G&A and Overhead Rates
2) SBASI's are GFP
3) procurement quantity of 50 units
4) similar inspection and test requirements as experienced on current program.

SUMMARY OF COSTS

(Details on following pages)

Direct Labor	$ 3,116
Direct Materials	6,445
Total Burden G&A and Overhead	6,859
Total Cost	$16,420

Unit Cost $328.40 each.

LABOR SUMMARY

Program Control				
Engineer/Scientist	E-4	100 hrs. @ $7.19	$719	
Document Aide	DA	20 hrs. @ $3.15	63	
				$ 782
Manufacturing				
Engineer/Scientist	E-5	15 hrs. @ $5.67	$ 85	
Ordnance Technician	OT	164 hrs. @ $4.07	667	
				$ 752
Quality Assurance				
Engineer/Scientist	E-4	20 hrs. @ $7.19	$144	
Chief Inspector	IC	60 hrs. @ $6.78	407	
Receiving Inspection	IR	60 hrs. @ $4.17	250	
Line Inspection	IL	48 hrs. @ $2.67	128	
				$ 929
Test				
Engineer/Scientist	E-4	70 hrs. @ $7.19	$503	
Test Technician	TT	40 hrs. @ $3.75	150	
				$ 653
				$3,116

Operations

Blend Delay Mix	16 hrs. OT
PAAR Analysis of all Pyrotechnics	24 hrs. OT
Press TBI	32 hrs. OT
Press Delay	48 hrs. OT
Solder Disc	12 hrs. OT
Load Output Cup and Install	8 hrs. OT
Weld TBI/SBASI	8 hrs. OT
Weld TBI/Delay	8 hrs. OT
Weld Output Cup	8 hrs. OT
	164 hrs. OT

Materials

	Total Cost
Connector (011131)	$1,600/lot
Delay Housing (011132)	1,495/lot
Disk (011134)	50
Output Cup (011135)	400
Closure Cup (012091)	150
A1A	100
Boron Potassium Nitrate	300
Lead Azide	400
KDNBF	1,500
Tungsten	75
Barium Chromate	50
Potassium Perchlorate	50
Diatomaceous Earth	75
Miscellaneous (O-rings, solder, acetone, etc.)	200
	$6,445