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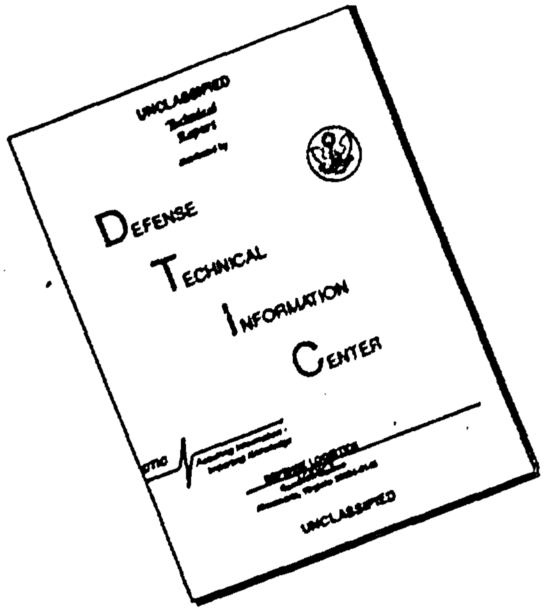

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THE SPIKEDUCER: A TIME-OF-ARRIVAL PIN CONFIGURATION FOR SHOCK WAVE EXPERIMENTS

by
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J. B. BICKLEY
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JUNE 1976

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An epoxy-encapsulated time-of-arrival pin and cable configuration (spikeducer) for use in shock wave experiments is described. The configuration provides a protective cover for a piezoelectric pin and facilitates accurate pin positioning in an experiment. A precision molding fixture has been designed for spikeducer fabrication. The details of fabrication and the application of spikeducers in a shock wave experiment are presented.

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FOREWORD

This report describes an epoxy-encapsulated time-of-arrival pin and cable assembly, called the spikeducer, for use in shock wave experiments.

This work was supported by NAVAIR Task No. A350-3500/004C/6WTW27-001.

This report has been reviewed and approved by C. L. Dettinger, Acting Head, Munitions Division.

Released by:

CDR G. J. FLANNERY
Assistant Head
Military Applications
Armaments Development Department

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INTRODUCTION

Explosive experiments give the experimenter only one chance to record information before the components of a shock assembly are destroyed or severely damaged. For this reason one endeavors to design experiments such that maximum information is obtained from each shot. When piezoelectric or other types of shock time-of-arrival pins are used to provide trigger pulses for oscilloscopes, fast counters, or for other real-time diagnostics, reliable pin operation is essential. These pins are frequently fragile and are sometimes difficult to position accurately in shock assemblies that have dimensions many times larger than that of a pin. A protective cover has been designed for such pins that also facilitates accurate positioning while not interfering with pin operation.

In this report piezoelectric shock time-of-arrival pins are considered (Valpey-Fisher Corp. Pinducers, Part No. VP-1093-1.5, and mating 50 Ω cable assemblies, Part No. VC-1024-A). A pinducer with cable assembly is shown in Figure 1. The pinducer diameter is 2.36 mm, and the length from the connector to the tip is about 38 mm. The pin is basically a small brass tube with a piezoelectric element at one end and a coaxial electrical connector at the other end. One electrode on the element is internally connected to the center conductor. The other electrode is externally connected to the brass tube by a thin conducting film across the end of the tube. This thin film can be easily damaged by abrasion, or the insulating epoxy support for the film can be attacked by common laboratory solvents.

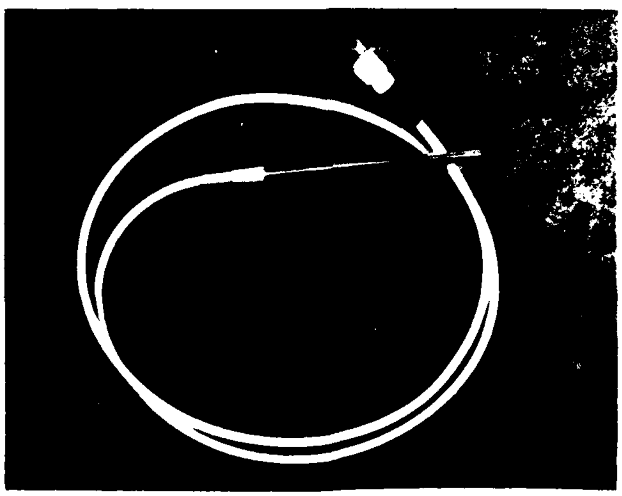


Figure 1. Pinducer Shock Time-Of-Arrival Pin with Attached Coaxial Cable

Certain experimental conditions require the pinducer to be embedded in epoxy materials; an obvious choice for the protective cover material is to use the same epoxy as used in potting the chock assembly. This choice eliminates any additional shock impedance mismatch interfaces in the assembly. The dimensions of the epoxy-pinducer configuration are chosen for convenience of handling and positioning in the shock assembly. This configuration is called the spikeducer. A description of the spikeducer is given in the SPIKEDUCER DETAILS AND FABRICATION section. An example application of the spikeducer is described in the SPIKEDUCER APPLICATION IN SHOCK WAVE EXPERIMENTS section.

SPIKEDUCER DETAILS AND FABRICATION

Figure 2 is a schematic of a spikeducer; the length is approximately 150 mm and the diameter is 6.35 mm. This diameter was chosen so that Swagelok (Crawford Fitting Co.) connectors for 6.35-mm outside diameter tubing could be used as collet clamps for adjustable positioning and support of the spikeducer. The distance from the tip of the spikeducer to the active end of the pinducer is precision gauged during fabrication to account for wave transit time in the epoxy tip. This rugged unit is easily tested prior to potting in an experimental configuration; the spikeducer output is monitored with an oscilloscope, and the tip is tapped lightly to produce a deflection on the oscilloscope screen. This procedure checks both the pinducer and the cable. The spikeducer tip is pointed to aid degassing of the epoxy poured around it in a shock assembly; bubbles are less likely to be trapped at the tip.

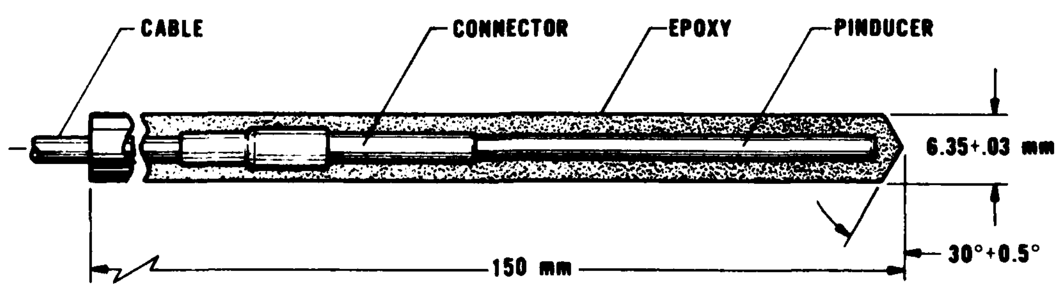


Figure 2. Schematic of Spikeducer

Figure 3 shows three completed spikeducers. These were fabricated with an alumina-filled epoxy (Castall, Inc., No. 300) to be embedded in the same material for an explosively-loaded shock wave assembly.

Figure 3. Completed Spikeducers

The items used for spikeducer fabrication include fixtures for alignment of the pinducer during coating and split molds for casting the epoxy. The alignment fixtures are made from Swagelok reducers, Part No. B-200-R-4, that have been modified to provide adjustable support for the pinducer in the mold. Figure 4 shows a pinducer and a disassembled fixture. From left to right in this figure are the pinducer, modified Swagelok reducer body, pinducer collet (fabricated from a pinducer cable electrical connector and Swagelok front and back ferrules for 3.18-mm diameter tubing), and a Swagelok nut. Figure 5 shows the assembled fixture with pinducer.

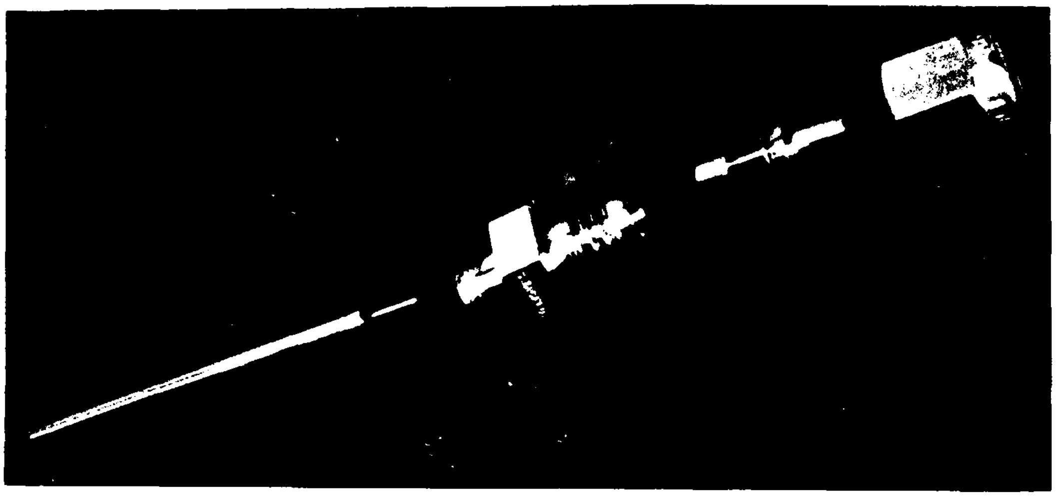


Figure 4. Pinducer with Disassembled Modified Swagelok Collet

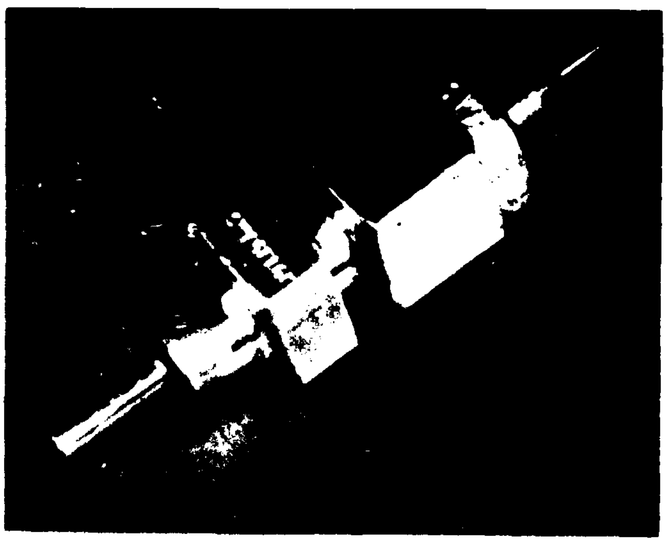


Figure 5. Pinducer and Assembled Collet

Figure 6 shows the fixture and pinducer positioned on one of the split spikeducer mold parts. The mold contains removable cylindrical inserts with concave ends for shaping the spikeducer tips. The tip shape can be varied by changing inserts. The pinducer tip is positioned relative to the tip of the spikeducer by placing a master precision gauge ball (Industrial Tectonics, Inc., 1.5875 mm diameter) in the concave part of the insert. The two halves of the lower split mold are bolted together and supported on a precision granite surface plate. The pinducer is gently lowered until it contacts the ball; the fixture is then tightened to clamp the pinducer in that position. The fixture and pinducer are then removed from the mold as a unit. The gauging ball is also removed. After the mold parts have been coated with fluorocarbon mold release, degassed epoxy is poured into the assembled mold. The tip of the clamped pinducer is dipped in epoxy and then reinserted in the mold. For a 30° angle on the insert (Figure 2) and the 1.5875-mm diameter gauge ball, the distance from the tip of the spikeducer to the end of the pinducer is 1.71 mm. For other angles or gauge ball diameters, this distance can be calculated from

$$H = \frac{d(1+\cos\phi)}{2\cos\phi},$$

where

H is the distance from the spikeducer tip to the pinducer end,
d is the diameter of the gauge ball, and
ϕ is the angle on the tip of the spikeducer.

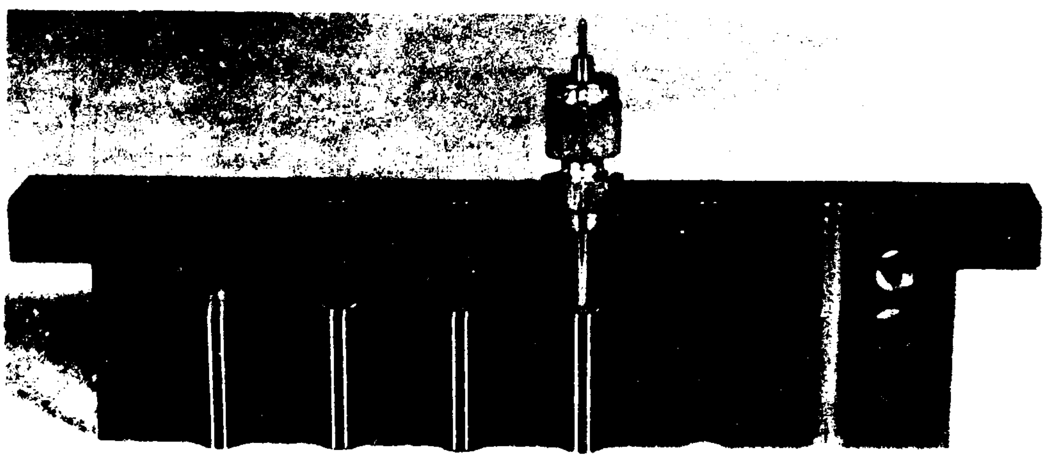


Figure 6. Lower Split Mold Section with Pinducer Collet

Figure 7 shows the lower sections of the mold with six clamped pinducers during epoxy cure. The granite gauging surface keeps the lower ends of all the inserts flush with the base of the mold. The cylindrical surface of each insert is coated with a thin film of grease to prevent epoxy from leaking out of the mold.

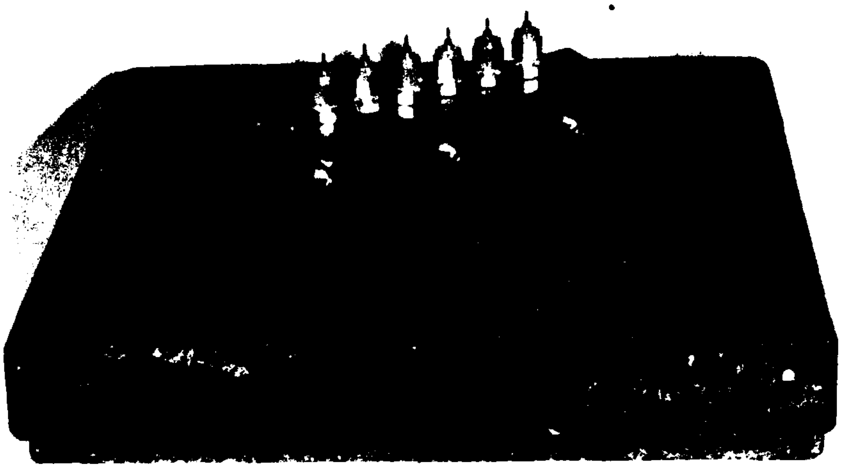


Figure 7. Pinducers in Collets During Cure of First Epoxy Pour

In Figure 8 the lower section of the mold has been split open to show the pinducers and the cured epoxy that forms the tips of the spikeducers. The inserts are still in the mold. (In actual spikeducer fabrication, the lower section of the mold would not be split open until fabrication was complete.)

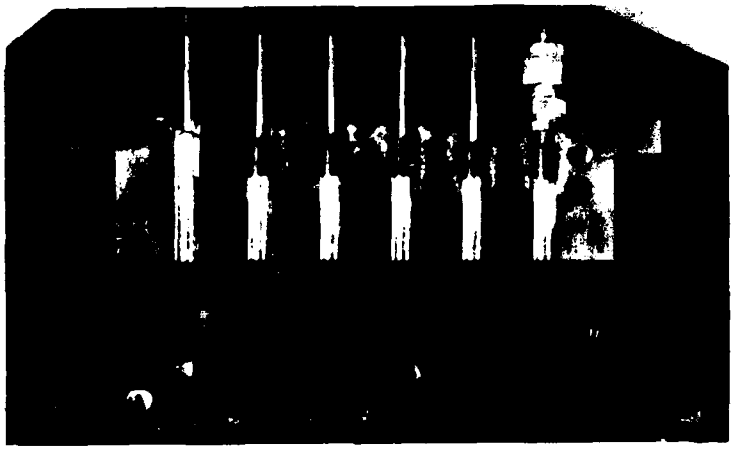


Figure 8. Pinducers in Lower Section of Split Mold After Cure of First Epoxy Pour

The next step in fabrication is illustrated in Figure 9. Nylon centering ferrules are slipped over the cables, and the cables are connected to the pinducers. The ferrules are positioned as shown in the figure. The upper mold sections are then assembled. Toolmaker's clamps hold the upper and lower sections together. The assembled mold is positioned upright and the cables are held vertically with a ringstand and clamp to keep them taut in the mold. Degassed epoxy is then injected around each cable with a hypodermic syringe.

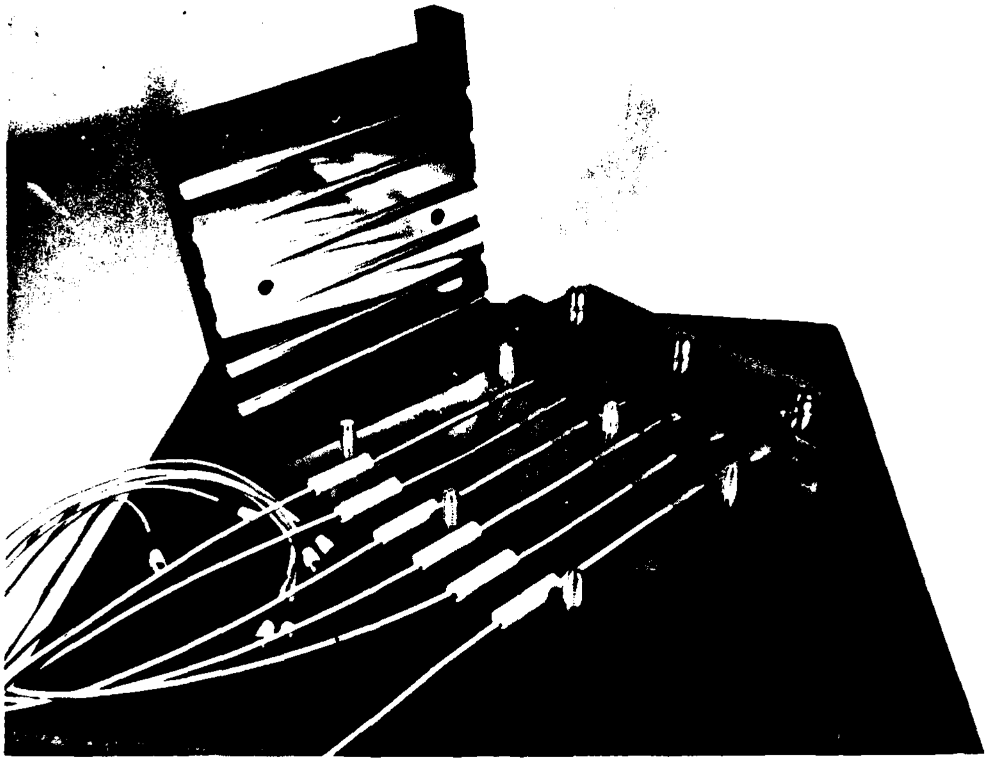


Figure 9. Alignment of Pinducer Cables in Split Mold

Figure 10 shows the mold after the epoxy has cured, before disassembly. Figure 11 shows the screws that are used to separate the mold parts after epoxy cure. The engineering drawings for the spikeducer mold parts are provided in Appendix A.

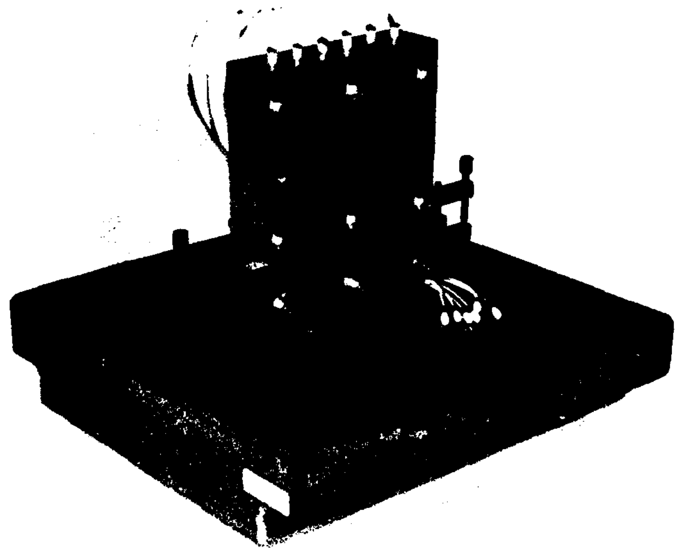
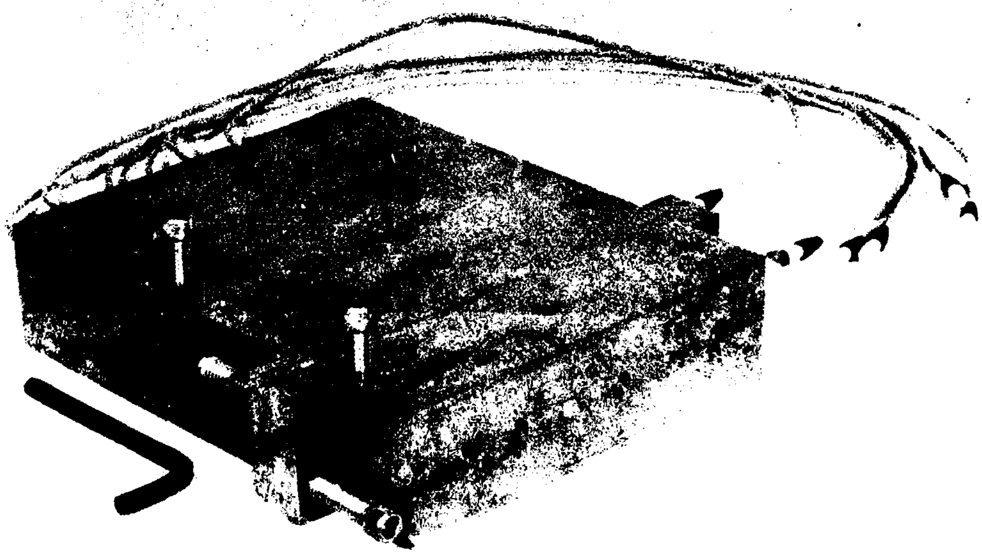


Figure 10. Spikeducer Mold Before Disassembly



Fiqure 11. Spikeducer Mold with Separation Screws

SPIKEDUCER APPLICATION IN SHOCK WAVE EXPERIMENTS

The particular type of experiment used to illustrate the application of spikeducers is the explosive shock loading of epoxy-potted material specimens and/or stress gauges. Figure 12 shows a typical experimental configuration utilizing two spikeducers. Oscilloscopes also monitor the spikeducer output pulses. The Lucite box serves as a positioning reference frame for the items to be shock loaded and as a mold for the epoxy. The base of the frame has been lapped flat. The epoxy will be cast in the frame on a granite gauging surface that has been coated with a thin film of mold release. After the epoxy has cured, the bottom of the configuration will be given a final lapping to form a precision flat surface for contact with an explosive plane wave generator system. Also shown in the figure are aluminum fixtures for positioning the two spikeducers. The spikeducers are held in modified Swagelok reducers, Part No. B-400-R-6. The height of the spikeducer tips from the explosive/epoxy interface is set by placing precision parallels under each spikeducer. The parallels are premeasured with a micrometer. The Swagelok fittings have split nylon ferrules; when the fittings are tightened, the spikeducers are clamped in position. The gauging parallels are then removed. After epoxy potting of the spikeducers and other items in the experimental configuration, the Swagelok collets are loosened and the aluminum fixtures are removed.

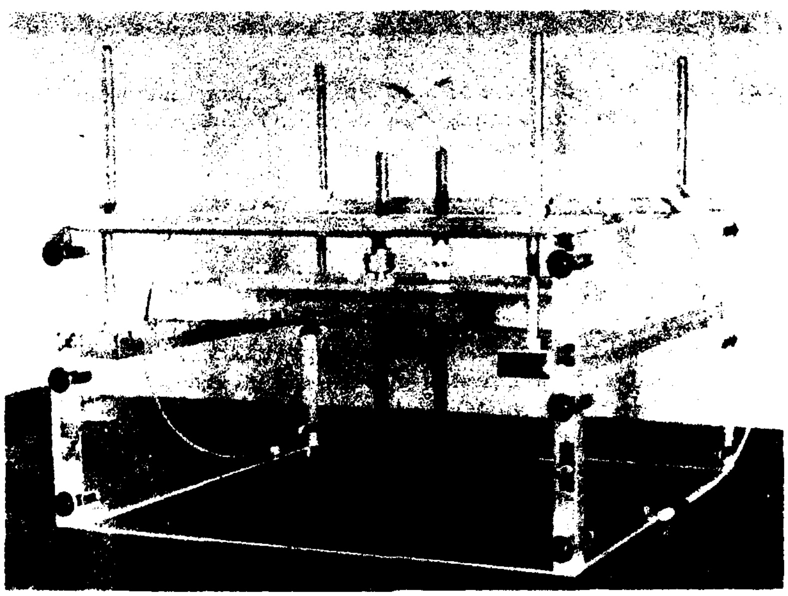


Figure 12. Spikeducer Positioning for an Explosive Experiment

Figure 13 is an oscilloscope record of a spikeducer output pulse (50 .. termination) obtained when an experimental configuration of the type shown in Figure 12 was explosively loaded. The approximately 20 spikeducers that have been used in explosive experiments have performed reliably.

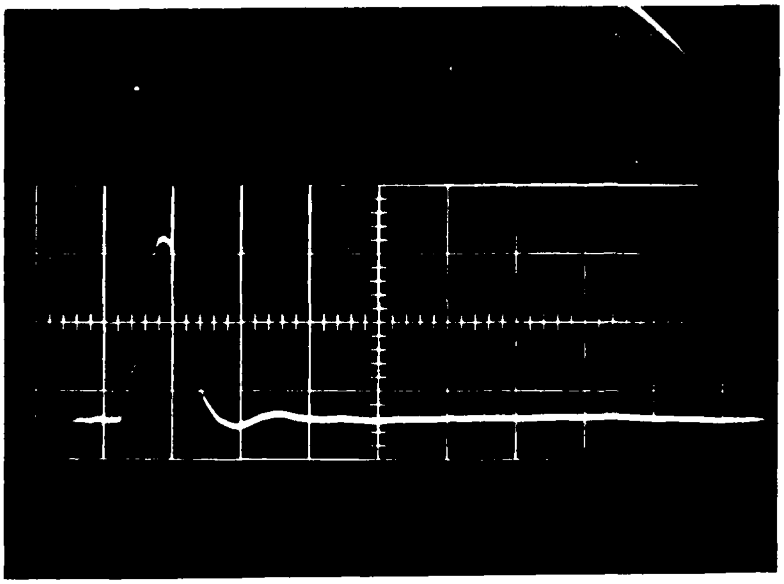


Figure 13. Spikeducer Voltage Pulse (Time Increases from Left to Right, the Vertical Scale is 50V/div and the Horizontal Scale is 100 ns/div)

SUMMARY

An epoxy-encapsulated shock time-of-arrival pin and cable configuration has been described. A precision molding fixture has been designed and fabricated for production of the spikeducers. The spikeducer configuration provides a protective cover for the pin and facilitates its positioning in a shock assembly. This pin configuration has proved to be convenient and reliable in explosive experiments.

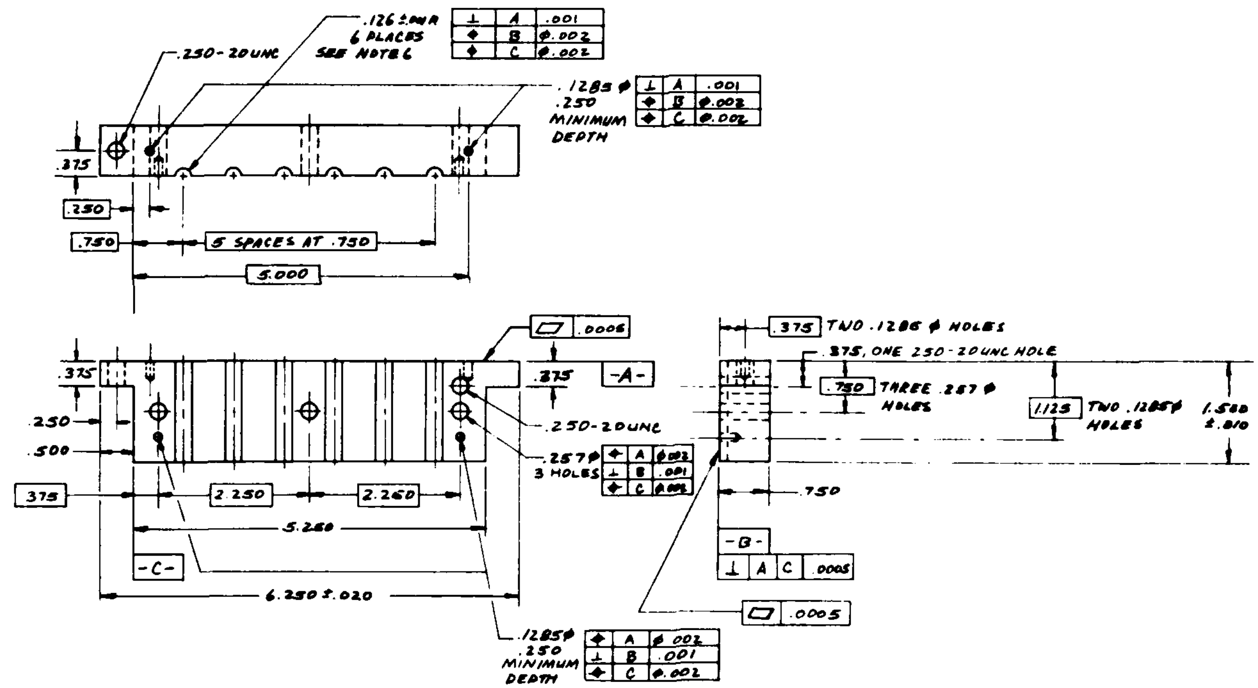
APPENDIX A

SPIKEDUCER MOLD DRAWINGS

(Dimensions are in inches; for conversion to S. I. units, use 1 in. = 25.4 mm.)

NOTES:

1. INTERPRET DRAWING ACCORDING TO ANSI Y14.5-1973.
2. DIMENSIONAL TOLERANCE ±.010 EXCEPT AS NOTED.
3. 32 FINISH.
4. DO NOT BREAK SHARP EDGES.
5. PROVIDE AT LEAST 1/4" PADDING TO PREVENT SURFACE DAMAGE.
6. EACH GROOVE SHALL BE FORMED:
   A. CLAMP TWO PIECES TOGETHER FACE-TO-FACE.
   B. DRILL SIX HOLES, THUS FORMING 12 GROOVES
   C. REAM THE HOLES FOR 32 FINISH
7. QUANTITY. 2



DRAWN J.B.B		
MATERIAL: 410 S STEEL	SCALE 1:1	

LOWER SPLIT MOLD SECTION

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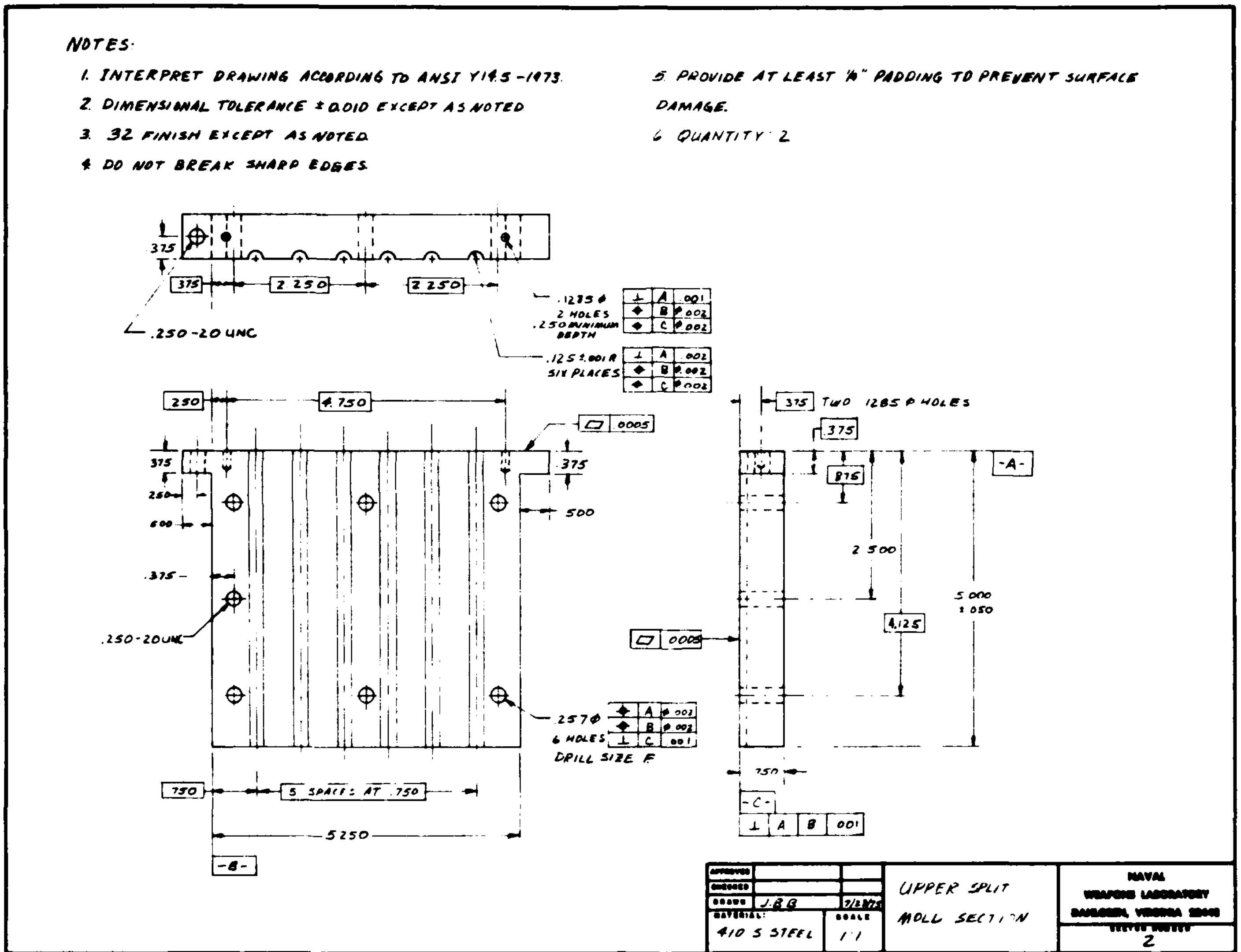
NOTES:
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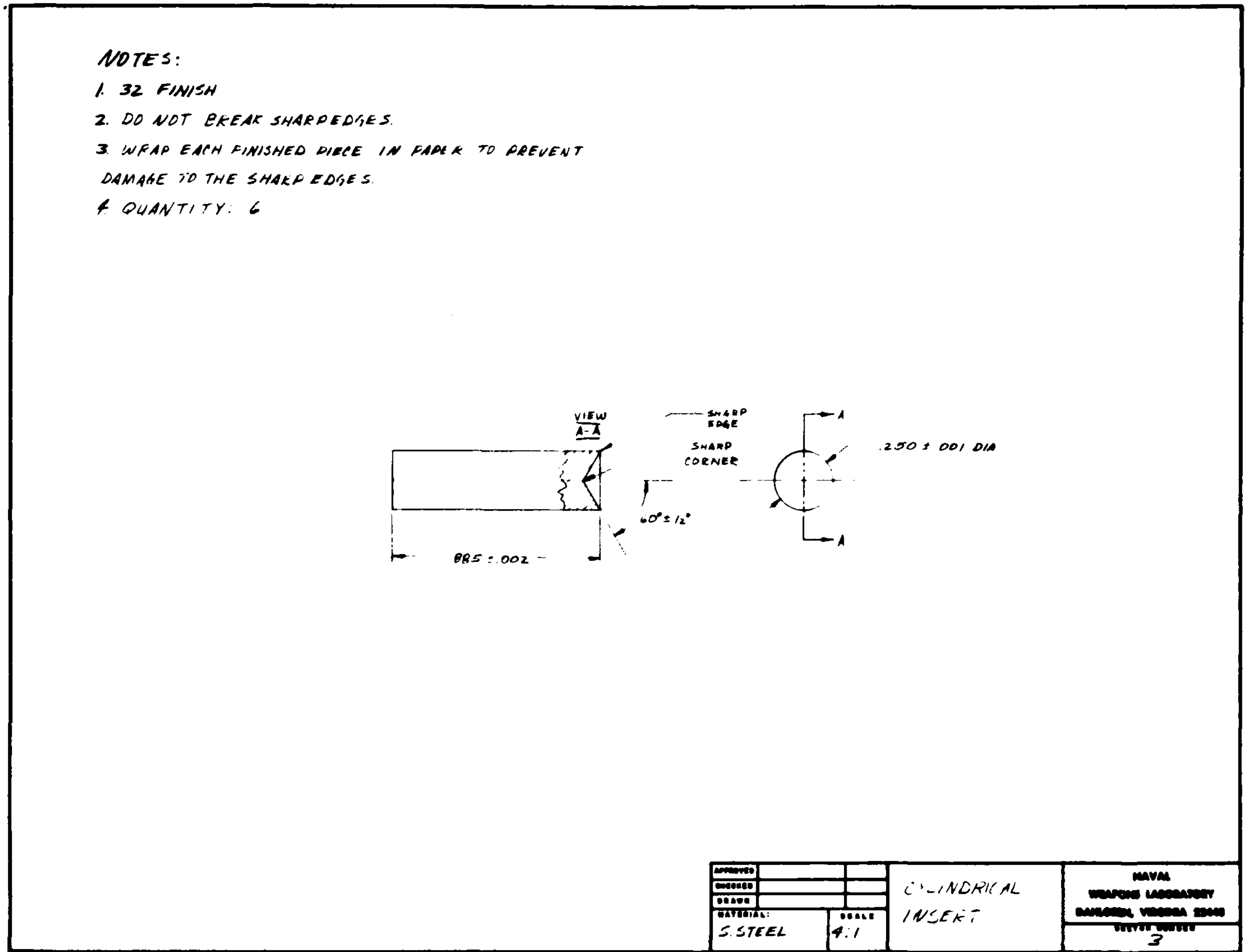
2. DIMENSIONAL TOLERANCE ±0.010 EXCEPT AS NOTED
3. 32 FINISH EXCEPT AS NOTED
4. DO NOT BREAK SHARP EDGES
5. PROVIDE AT LEAST 1/8" PADDING TO PREVENT SURFACE DAMAGE.
6. QUANTITY 2
.250-20 UNC
.1275 Ø 2 HOLES .250 MINIMUM DEPTH
.125 ±.001 R SIX PLACES
TWO .1285 Ø HOLES
.257 Ø 6 HOLES DRILL SIZE F
5 SPACES AT .750
.250-20 UNC
-A-
-B-
-C-
UPPER SPLIT MOLD SECTION
MATERIAL: 410 S STEEL
SCALE 1:1
DRAWN J.B.B.
NAVAL WEAPONS LABORATORY DAHLGREN, VIRGINIA 22448
2


NOTES:
1. 32 FINISH
2. DO NOT BREAK SHARPEDGES.
3. WRAP EACH FINISHED PIECE IN PAPER TO PREVENT
DAMAGE TO THE SHARP EDGES.
4. QUANTITY: 6
VIEW A-A
SHARP EDGE
SHARP CORNER
.250 ± .001 DIA
60° ± 1/2°
.885 ± .002
A
A
APPROVED
CHECKED
DRAWN
MATERIAL:
S. STEEL
SCALE
4:1
CYLINDRICAL INSERT
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