**LIMITATION CHANGES**

**TO:**

Approved for public release; distribution is unlimited.

**FROM:**

Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; 04 MAY 1960. Other requests shall be referred to Naval Ordnance Laboratory, Explosions Research Department, White Oak, MD.

**AUTHORITY**

usnol ltr, 29 aug 1974
NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.
THE ACTUATOR, EXPLOSIVE WOX-23A, AN ACTUATOR TO REPLACE ACTUATOR MK 3 MOD 0 IN THE EXPLOSIVE SWITCH MK 46 MOD 0 (U)

4 MAY 1960
THE ACTUATOR, EXPLOSIVE WOX-23A,
AN ACTUATOR TO REPLACE ACTUATOR MK 3 MOD 0
IN THE EXPLOSIVE SWITCH MK 46 MOD 0

Prepared by:
E. Eugene Kilmer

Approved by:   
Chief, Explosion Dynamics Division

ABSTRACT: In view of Explosive Switch Mk 46 Mod 0 failures, a program was initiated to find a suitable replacement for the Actuator Mk 3 Mod 0. An investigation indicated that the inability of the Olin-Mathieson Ball Powder (W2920.3 Type II class 4) to sustain burning under the leakage condition existing in the Mk 46 Mod 0 Switch to be the cause of the explosive switch failures. Various propellants were investigated both in a variable volume pressure bomb and in the Explosive Switch Mk 46 Mod 0. Of the powders tested, SR4990, a DuPont smokeless powder, gave the desired boundary condition of a fast rise pressure front unaffected by the change of volume in the switch. Consequently, a direct substitution replacing the Olin Mathieson Ball Powder (W2920.3 Type II class 4) by SR4990 (DuPont) will be made in the actuator for the switch Mk 46 Mod 0. The new actuator has been designated Actuator, Explosive, WOX-23A.

PUBLISHED JULY 1960

Explosions Research Department
U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND
This report presents information concerning an investigation to find a suitable replacement for the Actuator Mk 3 Mod 0 as used in the Explosive Switch Mk 46 Mod 0. This work was accomplished by the Explosion Dynamics Division of the Explosions Research Department. It bears on key problem 11, Supporting Research for Antisubmarine Warfare, NavOrd Report 4299. The results of this investigation are intended for the information and use of the Naval Ordnance Laboratory and should be of interest to others working with explosive components and explosive switches.

W. D. COLEMAN

C. J. ARONSON

By direction
CONTENTS

Introduction ........................................... 1
Pressure Bomb Tests .................................... 2
Testing in the Modified Explosive Switch
  Mk 46 Mod 0 ........................................... 4
Actuator Output ........................................ 5
Conclusions ............................................ 6

ILLUSTRATIONS

Table 1. The Mk 46 Mod 0 Explosive Switch
  Functioning Tests ...................................... 7
Table 2. The Mk 46 Mod 0 Explosive Switch
  Functioning Tests Using Lot K, Mk 3 Mod 0
  Actuators Containing Olin-Mathieson Ball
  Powder, W2920.3 ...................................... 8
Table 3. The Modified (Externally Vented) Mk 46
  Mod 0 Explosive Switch Functioning Tests .... 9
Table 4. The Mk 46 Mod 0 Explosive Switch Tested
  for Functioning with Reduced Base Charges .... 10
Table 5. The Mk 46 Mod 0 Explosive Switch
  Functioning Tests Over the Temperature
  Range -65°F to 160°F ................................ 11
Table 6. The Mk 46 Mod 0 Explosive Switch
  Simulator Tests Using the Various Weights
  of Base Charge in the Mk 3 Mod 0 Actuator .... 12
Table 7. The Mk 46 Mod 0 Explosive Switch Function-
  ing Tests with Limited Weights of Base
  Charge .................................................. 13

Figure 1. Explosive Switch Mk 46 Mod 0 ............. 14
Figure 2. Explosive Actuator Mk 3 Mod 0 ............. 15
Figure 3. The Pressure Bomb Arrangement for
  Testing Various Base Charges ....................... 16
Figure 4. The Typical Pressure-Time Curves for
  W2920.3 and SR 4990 Powders ....................... 17
Figure 5. The Typical Pressure-Time Curves for
  SR 4759 and IMR 5010 (Al 40320) Powders .... 18
Figure 6. The Typical Pressure-Time Curves for
  IMR 5010 (Lot OKL 28754) and Unique
  Powders ............................................... 19

(cont'd.)
Figure 7. The Typical Pressure-Time Curves for Hi Vel #2 and FNH 24711 Powders .......... 20
Figure 8. The Typical Pressure-Time Curve for WC 860 Ball Powder ................. 21
Figure 9. The Typical Pressure-Time Curves for FNH 24711 Powder in 0.033, 0.028, and 0.022 Cubic Inches Volume ................. 22
Figures 10 & 11: The Peak Pressures of Various Base Charges as a Function of the Volume of the Pressure and Bomb ................. 23
Figure 12. A Typical Mk 46 Switch Signature and the Schematic Used to Obtain It ............. 25
Figure 13. The Mk 46 Mod 0 Explosive Switch Modified for Functioning with Venting .......... 26
Figure 14. The X-Rays of the Explosive Switch Mk 46 Mod 0 Following Functioning of Actuators with Reduced Base Charge ............. 27
Figure 15. The X-Ray of the Explosive Switch Mk 46 Mod 0 Following Functioning with Lot K Clin Ball Powder .......... 28
Figure 16. The Mk 46 Mod 0 Explosive Switch Simulator (BuOrd L.D. 496529) ............. 29
THE ACTUATOR, EXPLOSIVE WOX-23A,
AN ACTUATOR TO REPLACE ACTUATOR MK 3 MOD 0
IN THE EXPLOSIVE SWITCH MK 46 MOD 0

INTRODUCTION

1. When the first production lot of Explosive Switches Mk 46 Mod 0, Lot K, was tested for switch functioning and delay time, 2/10 switch failures, switch leaks, and variable switch functioning times resulted. The Explosive Switch Mk 46 Mod 0, shown in Figure 1, operates from the gas pressure produced by the Explosive Actuator Mk 3, Figure 2. It was believed that the deficiencies noted were caused by leakage, from the switch, of the gases produced by the actuator. This corroborates information found in other work\(^1\) which indicated poor performance because of extreme leakage.

In view of the switch failures with the Actuator Mk 3 Mod 0, a program was initiated to find a suitable replacement for the W2920.3 base charge in this actuator as used in the Switch Mk 46 Mod 0. This new powder ideally would be one which would reliably function in the switch under adverse conditions such as:

(a) Leakage of gas on actuator functioning
(b) Improperly seated pistons
(c) Variations in tolerances of switch parts.

In addition it was desired that the powder be covered by a military specification.

2. A survey was made of available propellant type powders that might be considered as replacements for the base charge in the Explosive Actuator Mk 3 Mod 0. Samples of several, as given below, were obtained for testing and comparison with Ball Powder W2920.3

\(^1\) NavOrd Report 6131: "Approval of Ball Powder Type WC-860 for Use in the Explosive Actuator Mk 4 Mod 0", by James H. Herd, August, 1958.
NavOrd Report 6761

(a) W2920.3 (Olin Ball Powder)
(b) SR 4990 Smokeless Powder (DuPont)
(c) SR 4759 (DuPont)
(d) IMR 5010, Al 40320 (DuPont)
(e) IMR 5010, OKL 28754 (DuPont)
(f) Unique Powder (Hercules)
(g) Hi-Vel #2 (Hercules)
(h) FNH 24711 (Military 50 caliber powder)
(i) WC 860 (Military 50 caliber powder).

At that time, with the exception of W2920.3 and WC 860, there were no available data on the performance of these propellant type powders in volumes as small as those in the Explosive Switch Mk 46 Mod 0. Therefore, as a first step in the replacement program, tests were conducted on these powders in a pressure bomb containing volumes simulating those in the Explosive Switch Mk 46 Mod 0.

PRESSURE BOMB TESTS

3. A pressure bomb, Figure 3, was designed in which the internal volume could be varied in three discrete steps, 0.033, 0.028, and 0.022 cubic inches. The volume range was approximately that of the expansion chamber in the Explosive Switch Mk 46 Mod 0 before and after firing. This bomb was used to determine the pressure-time-volume relationships for the various powders for comparison with the pressure-time-volume relationship of W2920.3. From the results observed in the pressure bomb, it was hoped that the powders worthy of further consideration could be selected.

4. An engine-pressure transducer (Norwood Controls Model #102) was used to determine the pressure fluctuations in the pressure bomb. This transducer contains two resistive windings as two of the arms of a Wheatstone bridge. Pressure variations cause resistance changes in these two windings. The bridge arrangement was monitored by a Tektronix Oscilloscope, Model 531. The pressure-time curves were recorded.
by a Polaroid-Land camera. The engine-pressure transducer was used because past experience with propellant powders has shown that this transducer would be unaffected by corrosive gases, that it had the desired electrical characteristics, and would facilitate the cleaning of the pressure bomb.

5. Pressure-time curves were obtained for each of the powders tested. Figures 4 through 9 are typical pressure-time curves showing the different burning characteristics for each powder. It was generally observed that

Hi-Vel #2, W2920.3 (Olin Ball Powder); IMR 5010, OKL 28754; WC 860; and IMR 5010, Al 40320 (DuPont) showed an "ignition lag" time.

Unique and SR 4990 powders showed fast pressure rise times. SR 4759, although it did not have appreciable ignition lag, did not have as fast a pressure rise as the Unique and SR 4990 powders.

All the powders except FNH 24711 exhibited a uniform ignition in all volumes tested. FNH 24711 had "ignition lag" in the pressure-time curve when tested in the pressure bomb. As the volume was decreased the ignition lag time decreased as shown in Figure 9. Therefore, this powder would not be suitable for switch application when used as a base charge substitute in the Actuator Mk 3 Mod 0.

6. Peak pressure-volume plots were made from the pressure-time curves for the powders tested. These are shown in Figures 10 and 11. These plots, indicated that several of the powders were more volume sensitive than others. The most volume sensitive powders in the pressure bomb were SR 4759, FNH 24711 (Military 50 caliber powder) and IMR 5010, Al 40320 (DuPont) for which a small incremental change in volume resulted in a marked change in the peak pressure produced.

7. Based on the pressure-volume and pressure-time data, the powders which exhibited sharp pressure-rise time characteristics and relative insensitivity to volume changes, were chosen for testing in the Explosive Switch Mk 46 Mod 0. Two of the powders so chosen were SR 4990 and Unique Powder. A third powder (SR 4759 - DuPont) was chosen for further testing because of its sharp pressure-rise time, even though it was sensitive to volume changes. It was thought that the fast pressure-rise might be of greater importance than the volume sensitivity in effecting proper switch operation.
8. The Explosive Switch Mk 46 Mod 0, as designed, is actuated by the Explosive Actuator, Mk 3 Mod 0. The base charge of the actuator was replaced in the present work by the three powders chosen from the pressure-volume study. These modified actuators containing SR 4990, SR 4759, and Unique Powder, along with the standard Explosive Actuator Mk 3 Mod 0, were then tested in the Explosive Switch Mk 46 Mod 0 Assembly. Table 1 lists the weight of base charge for each powder used and the functioning time of the switch containing actuators having these charge weights. The charge weights were selected from the pressure vs. volume curves shown in Figure 11 in comparison with the results for W2920.3 ball powder. Based on the functioning time of the switch, i.e., the time between the application of the electrical pulse to the actuator and the breaking of the contacts in the switch by the moving piston, the weights of the powders appear to give equivalent performance to the Olin Ball Powder base charge used in the Explosive Actuator Mk 3 Mod 0. The time was measured by a Berkeley Time Interval Meter, Model 5120 C, and was monitored by a Textronix Oscilloscope, Model 531. The test equipment arrangement is shown in Figure 12.

9. A poorly sealed switch which will allow gases to escape is a source of switch functioning failure. This is shown in Table 2 obtained from earlier tests with the Actuator Mk 3 Mod 0 tested in the Switch Mk 46 Mod 0. It was decided to build gas relief holes into a modified switch, as shown in Figure 13 and to ignite and test the selected base charge powders under these conditions. The results of these tests, Table 3, showed that actuators with SR 4759 and Unique Powder base charges were adversely affected by the venting of the gases from the expansion chamber. This was shown by the switch functioning time. To further test this result, actuators with reduced base charges were tested, with the results shown in Table 4. The data definitely show SR 4759 and Unique Powder to be sensitive to leaks while SR 4990 behaves equally well in the vented and unvented systems. Figures 14 and 15 show the radiographs of the modified expended switches. The switches actuated with SR 4990 functioned properly. The reduced movement of the pistons in the switches actuated by the other powders is clearly noticeable.
10. With the completion of this testing for the Explosive Switch Mk 46 Mod 0, it was decided to replace the base charge in the Actuator Mk 3 Mod 0 with SR 4990 smokeless powder. Switches containing modified actuators (25 mg. of SR 4990 base charge) were tested at -65° and 160°F. The results shown in Table 5 indicate a proper switch functioning over this temperature range.

ACTUATOR OUTPUT

11. The output acceptance criterion for the Actuator Mk 3 Mod 0 as used in the Explosive Switch Mk 46 Mod 0 was to test in actual switches for proper switch functioning. This test method was expensive. To reduce the cost of the output testing of the modified Actuator Mk 3 Mod 0, a switch simulator, Figure 16, was designed. The piston and the actuator are replaced in the switch simulator following each test. The fired actuator is pushed from the sleeve and the piston is removed from the switch on disassembly of the simulator. Several weights of SR 4990 base charge were tested in the simulator to determine the functioning times. From the results of these data, Table 6, a base charge weight of 25 to 30 milligrams of SR 4990 powder was indicated for use in the modified Explosive Actuator Mk 3 Mod 0.

12. The weight limit placed on the base charge of the actuator was 0.025 ± .005 grams of SR 4990 powder. Actuators were loaded with the upper and lower charge limits and tested for functioning. The results, given in Table 7, show proper switch functioning at both weight extremes. This weight tolerance was chosen after consideration of the pressures "built up" in the switch, the functioning time, and the fabrication of a reliable actuator. The specification for the manufacture and testing of this actuator will contain these weight limits.

13. The switch signature was a secondary point of interest, but proved valuable as a check on the actuator output. A typical switch signature and the circuit for obtaining it, are shown in Figure 12. The switch contacts were monitored by the Tektronix Oscilloscope, Model 531, which picked up the change in voltage in the switch circuit and displayed it as a vertical deflection on the cathode ray tube. The oscilloscope face was photographed and recorded with a Polaroid-Land Camera. This record was informative in that not only was the switch functioning time obtained, but it served as an indication of the "sharpness" of switching
while the piston was being moved. The sharp clean break shown in Figure 12 is typical for the Explosive Switch Mk 46 Mod 0 with the new actuator.

CONCLUSIONS

14. From the testing and observed data the following conclusions can be drawn:

(a) The method of static testing in a pressure bomb using several volumes is appropriate for gaining insight into the characteristics of actuator base charges.

(b) The smokeless powder, SR 4990, is a suitable base charge for a modified Explosive Actuator Mk 3 Mod 0 of greater reliability in the Explosive Switch Mk 46 Mod 0.

(c) The Explosive Switch Mk 46 Mod 0 will function over the temperature range of -65°F to 160°F, using Mk 3 Mod 0 type actuators with the SR 4990 base charge.

(d) The Explosive Switch Mk 46 Mod 0 simulator is a suitable fixture for use in the quality control testing of Actuators, Mk 3 type.
Table 1

THE MK 46 MOD 0 EXPLOSIVE SWITCH FUNCTIONING TESTS

Mk 46 Mod 0 Explosive Switches
Functioning Time* (microseconds)

<table>
<thead>
<tr>
<th></th>
<th>SR 4759 (30 mg.)**</th>
<th>SR 4990 (25 mg.)**</th>
<th>W2920.3 (40 mg.)**</th>
<th>Unique (25 mg.)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>W2920.3</td>
<td>277</td>
<td>205</td>
<td>242</td>
<td>242</td>
</tr>
<tr>
<td>SR 4759</td>
<td>218</td>
<td>179</td>
<td>263</td>
<td>241</td>
</tr>
<tr>
<td>SR 4990</td>
<td>236</td>
<td>194</td>
<td>251</td>
<td>214</td>
</tr>
<tr>
<td>Unique</td>
<td>236</td>
<td>198</td>
<td>279</td>
<td>255</td>
</tr>
<tr>
<td></td>
<td>265</td>
<td></td>
<td>308</td>
<td>202</td>
</tr>
</tbody>
</table>

\[ \bar{X} = 246 \quad 194 \quad 269 \quad 231 \]

\[ S = 24 \quad 11 \quad 26 \quad 22 \]

* All switches tested at room temperature with a firing pulse from a 6-microfarad capacitor charged to 80 volts.

** Base charge weight of smokeless powder.
### Table 2

THE MK 46 MOD 0 EXPLOSIVE SWITCH FUNCTIONING TESTS USING LOT K, MK 3 MOD 0 ACTUATORS CONTAINING OLIN-MATHIESON BALL POWDER W2920.3

<table>
<thead>
<tr>
<th>Functioning Time* (microseconds)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>372</td>
<td>switch leaked</td>
</tr>
<tr>
<td>switch failed to function</td>
<td></td>
</tr>
<tr>
<td>299</td>
<td>switch leaked</td>
</tr>
<tr>
<td>530</td>
<td>switch leaked</td>
</tr>
<tr>
<td>6,358</td>
<td>switch leaked</td>
</tr>
<tr>
<td>534</td>
<td>switch leaked</td>
</tr>
<tr>
<td>271</td>
<td>switch leaked</td>
</tr>
<tr>
<td>7,518</td>
<td>switch leaked</td>
</tr>
<tr>
<td>410</td>
<td>switch leaked</td>
</tr>
<tr>
<td>switch failed to function</td>
<td>actuator fired, switch leaked</td>
</tr>
</tbody>
</table>

* All switches were fired at room temperature with a pulse from a 6-microfarad capacitor charged to 80 volts.
Table 3

THE MODIFIED (EXTERNALLY VENTED) MK 46 MOD 0
EXPLOSIVE SWITCH FUNCTIONING TESTS

<table>
<thead>
<tr>
<th>Functioning Time* (microseconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR 4759 (30 mg.)**</td>
</tr>
<tr>
<td>304</td>
</tr>
<tr>
<td>1,518</td>
</tr>
<tr>
<td>2,547</td>
</tr>
<tr>
<td>2,323</td>
</tr>
<tr>
<td>304</td>
</tr>
<tr>
<td>282</td>
</tr>
<tr>
<td>( \bar{x} ) 1,213</td>
</tr>
<tr>
<td>S 1,060</td>
</tr>
</tbody>
</table>

* All switches tested at room temperature with a firing pulse from a 6-microfarad capacitor charged to 80 volts.

** Base charge weight of smokeless powder.
Table 4

THE MK 46 MOD 0 EXPLOSIVE SWITCH TESTED FOR FUNCTIONING WITH REDUCED BASE CHARGES

<table>
<thead>
<tr>
<th>Type of Switch</th>
<th>SR 4759 ** (15 mg.)</th>
<th>SR 4990 ** (15 mg.)</th>
<th>Unique ** (15 mg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unmodified</td>
<td>297</td>
<td>222</td>
<td>274</td>
</tr>
<tr>
<td></td>
<td>238</td>
<td>208</td>
<td>282</td>
</tr>
<tr>
<td></td>
<td>292</td>
<td>218</td>
<td>270</td>
</tr>
<tr>
<td></td>
<td>298</td>
<td>224</td>
<td>265</td>
</tr>
<tr>
<td></td>
<td>353</td>
<td>219</td>
<td>245</td>
</tr>
<tr>
<td>Modified</td>
<td>458</td>
<td>262</td>
<td>switch did not function</td>
</tr>
<tr>
<td></td>
<td>switch did not function</td>
<td>278</td>
<td></td>
</tr>
<tr>
<td></td>
<td>277</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>292</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* All switches were tested at room temperature with a firing pulse from a 6-microfarad capacitor charged to 80 volts. All actuators fired in the above tests.

** Base charge weight of powder.
Table 5

THE MK 46 MOD 0 EXPLOSIVE SWITCH FUNCTIONING TESTS
OVER THE TEMPERATURE RANGE -65°F TO 160°F

<table>
<thead>
<tr>
<th>Functioning Time (microseconds)</th>
<th>-65°F</th>
<th>160°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR 4990 (25 mg.)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>251</td>
<td>185</td>
<td></td>
</tr>
<tr>
<td>188</td>
<td>148</td>
<td></td>
</tr>
<tr>
<td>213</td>
<td>172</td>
<td></td>
</tr>
<tr>
<td>197</td>
<td>159</td>
<td></td>
</tr>
<tr>
<td>215</td>
<td>244</td>
<td></td>
</tr>
</tbody>
</table>

\[ \bar{X} = 213 \quad S = 24 \]

* All switches fired with a pulse from a 6-microfarad capacitor charged to 80 volts.

** Base charge weight of powder.
Table 6

THE MK 46 MOD 0 EXPLOSIVE SWITCH SIMULATOR TESTS USING THE VARIOUS WEIGHTS OF BASE CHARGE IN THE MK 3 MOD 0 ACTUATOR

<table>
<thead>
<tr>
<th>POWDER Base Charge Weight</th>
<th>Number Fired</th>
<th>Mean Functioning Time (Microsec.)</th>
<th>Standard Deviation (microsec.)</th>
<th>Coefficient of Variation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR 4990 (30 mg.)</td>
<td>24</td>
<td>179</td>
<td>7.43</td>
<td>4.15</td>
</tr>
<tr>
<td>SR 4990 (25 mg.)</td>
<td>25</td>
<td>182</td>
<td>7.77</td>
<td>4.27</td>
</tr>
<tr>
<td>SR 4990 (15 mg.)</td>
<td>10</td>
<td>199</td>
<td>12.6</td>
<td>6.33</td>
</tr>
</tbody>
</table>

* All switches fired at room temperature with a pulse from a 6-microfarad capacitor charged to 80 volts.
Table 7

THE MK 46 MOD 0 EXPLOSIVE SWITCH FUNCTIONING TESTS
WITH LIMITED WEIGHTS OF BASE CHARGE

Functioning Time *
(microseconds)

<table>
<thead>
<tr>
<th></th>
<th>SR 4990 ** (25 mg.)</th>
<th>SR 4990 ** (30 mg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>161</td>
<td>189</td>
<td></td>
</tr>
<tr>
<td>180</td>
<td>175</td>
<td></td>
</tr>
<tr>
<td>206</td>
<td>168</td>
<td></td>
</tr>
<tr>
<td>167</td>
<td>198</td>
<td></td>
</tr>
<tr>
<td>170</td>
<td>167</td>
<td></td>
</tr>
<tr>
<td>185</td>
<td>169</td>
<td></td>
</tr>
<tr>
<td>186</td>
<td>166</td>
<td></td>
</tr>
<tr>
<td>188</td>
<td>170</td>
<td></td>
</tr>
<tr>
<td>182</td>
<td>185</td>
<td></td>
</tr>
<tr>
<td>169</td>
<td>171</td>
<td></td>
</tr>
<tr>
<td>$\bar{x}$</td>
<td>179</td>
<td>176</td>
</tr>
<tr>
<td>$s$</td>
<td>13</td>
<td>11</td>
</tr>
</tbody>
</table>

* All switches were fired at room temperature with a pulse from a 6-microfarad capacitor charged to 80 volts.

** Base charge weight of powder.
FIG. 1 EXPLOSIVE SWITCH
MK 46 MOD 0
FIG. 2 EXPLOSIVE ACTUATOR MK 3 MOD 0
FIG. 4 THE TYPICAL PRESSURE–TIME CURVES FOR \textit{W2920.3 AND SR 4990 POWDERS}
FIG. 5 THE TYPICAL PRESSURE-TIME CURVES FOR SR 4759 AND IMR 5010 (AL40320) POWDERS
FIG. 6 THE TYPICAL PRESSURE-TIME CURVES FOR IMR 5010 (OKL 28754) AND UNIQUE POWDERS
FIG. 7 THE TYPICAL PRESSURE-TIME CURVES FOR HI-VEL *2 AND FNH 24711 POWDERS
FIG. 8  THE TYPICAL PRESSURE–TIME CURVE
FOR WC 860 BALL POWDER
FIG. 9 THE TYPICAL PRESSURE-TIME CURVES FNH 24711
POWDER IN 0.033, 0.028 AND 0.022 CUBIC INCHES VOLUME
FIG. 10 THE PEAK PRESSURES OF VARIOUS BASE CHARGES AS A FUNCTION OF THE VOLUME OF THE PRESSURE BOMB
FIG. 11 THE PEAK PRESSURES OF VARIOUS BASE CHARGES AS A FUNCTION OF THE VOLUME OF THE PRESSURE BOMB
SWEEP TIME: 50 $\mu$S/CM

FIG. 12 A TYPICAL MK 46 SWITCH SIGNATURE
AND THE SCHEMATIC USED TO OBTAIN IT
FIG. 13. THE MK 46 MOD 0 EXPLOSIVE SWITCH MODIFIED FOR FUNCTIONING WITH VENTING
FIG. 14 THE X-RAYS OF THE EXPLOSIVE SWITCH MK 46 MOD 0 FOLLOWING FUNCTIONING OF ACTUATORS WITH REDUCED BASE CHARGE
FIG.15 THE X-RAY OF THE EXPLOSIVE SWITCH MK 46 MOD 0 FOLLOWING FUNCTIONING WITH LOT K OLIN BALL POWDER
FIG. 16 THE MK 46 MOD 0 EXPLOSIVE SWITCH SIMULATOR (BU ORD L.D. 496529)