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AUTHORITY

FA D/A ltr, 14 Aug 1973

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7.62MM HEAT TREATED STEEL CARTRIDGE CASE

BY

PHILIP B. TAYLOR
SIDNEY WHITE

June 1971

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REPORT #6003

7.62MM HEAT TREATED STEEL CARTRIDGE CASE

BY

PHILIP B. TAYLOR
SIDNEY WHITE

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Ammunition Development and Engineering Laboratories
FRANKFORD ARSENAL
Philadelphia, Pa. 19137

June 1971
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</table>
SUMMARY

Under direction of the Secretary of Defense and in accordance with the Copper Conservation Program, the development of an improved heat treated steel case for 7.62mm ball and tracer cartridges was begun at Frankford Arsenal in 1966.

A previous 7.62mm steel cartridge-case Product Improvement program was conducted at Lake City Army Ammunition Plant and Frankford Arsenal, but was discontinued in 1957 and 1960 respectively, without conclusively establishing a functional cartridge case. A process was established and cartridges were manufactured but were never tested by USATECOM. Past efforts demonstrated though, through manufacture of two million steel-cased cartridges at Lake City, and lesser quantities at Frankford Arsenal, that a heat treated 7.62mm steel cartridge case was feasible. However, improvements were required in material, simplification of process, heat treatment, surface coating, and control of quality, acceptability, and uniformity.

Work under the present program was based largely upon the results obtained from earlier efforts, and resulted in a considerably improved cartridge case, meriting TECOM evaluation for standardization; this case was manufactured utilizing improved material and simplified processing methods. Major changes and deletions to previous processes were made. Induction heat treating with oriented quench and a varnish surface coating were employed; and operations such as mouth and body anneal, retaper and replug, and zinc-plate crown treat were eliminated. In addition, tooling, lubrication, and controls were improved.

The present program was planned and conducted in two phases. Phase I included the evaluation of previously established processes, the examination and testing of the components and ammunition produced, and the acquisition and installation of the necessary process equipment. Temporary manufacturing procedure (TMP) 301 was established, which specified processing methods using Republic C1025 steel, under which developmental quantities of cases were manufactured. Process modifications were made to TMP 301 on a lot-by-lot basis until proof testing indicated that a satisfactory process had been obtained.

Phase II of the program required the production of approximately one million steel-cased cartridges under TMP 305, using Sharon C1025 steel, which was based upon the modifications to TMP 301 found most satisfactory during Phase I of the program.

Cartridge case quantities for ET/ST were shipped to the specified test locations, namely, APG (tests not completed); USA Infantry Board, Fort Benning (tests completed); USA Armor and Engineer Board, Fort Knox (tests suspended pending APG outcome); and USA Arctic Test Center, Fort Greely (tests completed). Official TECOM statement of position is dependent on the outcome of Engineer Tests at APG, which have been delayed due to higher priority work.
Since the start of the steel case program in 1966, supplies of copper in the free world market have become more stable and less costly. The Copper Industry Trade Institute has projected world copper supply over the next few years and has compared this with projected copper demand for the same period. Forecasts indicate that there will be a surplus rather than a shortage of copper in the near future; much of this world copper however, is mined in countries with unstable governments, and labor problems are a continual threat to copper supplies. As a result of this apparently improving condition of copper supplies, present plans call for complete documentation of steel-case manufacturing techniques, as developed to date, in the event that copper again becomes scarce. While determination of the ultimate degree of success or failure of the program rests with ET/ST results, this report relates the present state of the art of heat treated steel case development and manufacture.

**PROCESS METALLURGY**

In addition to routine checks of hardness, microstructure, material quality, etc., conducted throughout processing, two comprehensive process evaluations were made to determine the metallurgical adequacy and suitability of the processes used.

The first of these evaluations was performed during processing under TMP 301 to investigate the effects of different processing methods and to predict the probable outcomes of the various methods. The evaluation is essentially a study of case lot 6, (see Appendix A) with appropriate evaluations of components from other lots, when these components differed metallurgically from those of lot 6. It should be noted that lot 6d was manufactured utilizing the process which was subsequently adopted for processing of TMP 305.

The metallurgical evaluation of processing under TMP 305 shows representative hardnesses and microstructures of sample components taken from each lot, at successive stages of processing. Note that case lot numbers 1 thru 8 listed in the TMP 305 evaluation bear no relationship to case lots 1 thru 9 in TMP 301 processing.

The steels used for manufacture of the heat treated case were both of AISI grade C1025. Manufacturer's ladle analyses and Frankford Arsenal check analyses, given in Table I, show chemical compositions to be within AISI limits for these analyses, respectively. Both steels were fine-grained, aluminum-killed steels having low phosphorus and sulfur content, making them ductile and suitable for deep drawing.
TABLE I

CHEMISTRY of C1025 STEEL STRIP

Manufacturer's Ladle Analysis

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>C</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Si</th>
<th>Al</th>
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Frankford Arsenal Check Analysis

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<td>.006</td>
<td>.018</td>
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</table>

METALURGICAL EVALUATION OF DEVELOPMENTAL CASE LOTS MANUFACTURED FROM REPUBLIC C1025 STEEL UNDER TMP301

1. Strip. The as-received material was relatively fine grained (6 to 7) with most of the carbides in spheroidal form (see Figures 1 and 2). The hardness is between Rb 60-65. Prior to spheroidization, the structure of this strip consisted of areas of pearlite and ferrite. The scattered areas of spheroidization result from transformation of the carbide in the pearlite from lamellar to spheroidal form.

2. Cup.

(a) As-drawn. The sidewalls of these cups were work hardened approximately 30 points to Rb 93. Unrestricted grain flow was evident in all areas. Following is a typical hardness pattern for this piece (all readings are Rb and are taken at 1/8 inch intervals).

```
Rb 93 93 93
93 86 66 72 88
```

(b) Annealed (1320°F). This treatment brought the hardness down to the level of the original strip material.

```
Rb 64 64 64
63 57 60 62 58
```
Longitudinal view of Republic Steel strip, as received. Spheroidal carbides are not discernable at this magnification. It can be seen, however, that these carbides formed only in former pearlite areas. Grain Size: 6 to 7

Same as Figure 1, but spheroids are visible at this magnification.
(a) **As-drawn.** No metallurgical defects were detected at this stage of the process. The sidewall was work hardened to Rb 96.

<p>| | |</p>
<table>
<thead>
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<th></th>
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<td>88</td>
<td>64</td>
</tr>
<tr>
<td>64</td>
<td>85</td>
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(b) **Annealed (1340°F).** This piece was a bit harder than the strip or annealed cup. Nevertheless, it was adequate to permit formation of the second draw piece with little difficulty.

<p>| | |</p>
<table>
<thead>
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<tbody>
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<td>58</td>
<td>60</td>
</tr>
<tr>
<td>62</td>
<td>66</td>
</tr>
</tbody>
</table>

4. **Second draw piece.**

(a) **As-drawn.** The sidewall of this process piece was cold worked to Rb 99. This is only one point below the finished item requirement of Rb 100 (Re 22).

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
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<tr>
<td>86</td>
<td>84</td>
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<td>85</td>
<td>75</td>
</tr>
<tr>
<td>72</td>
<td>79</td>
</tr>
</tbody>
</table>

(b) **Annealed (1320°F).** This piece is a bit harder than the second draw piece after annealing.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
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<td>72</td>
<td>66</td>
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<tr>
<td>68</td>
<td>57</td>
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</tbody>
</table>

5. **Third draw piece.**

(a) **Annealed prior to third draw.** This piece did not get quite as hard as the second draw piece.
(b) Not annealed prior to third draw (lot 9). Some pieces were drawn without an anneal in an attempt to attain the required sidewall properties without a heat treatment. However, it appears that the spheroidized structure had reached its maximum hardness at second draw. An increase in hardness of only one point, from Rb 99 to Rb 100 was achieved.

<table>
<thead>
<tr>
<th>Rb</th>
<th>85</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>93</td>
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<td></td>
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<tr>
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<tr>
<td>92</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>96</td>
<td></td>
</tr>
</tbody>
</table>

| Rb | 86 | 78 | 77 | 84 |

This piece does not meet the sidewall requirements of the item specification.

(c) Hardened and tempered at 1250°F prior to third draw (lot 9).

This treatment was performed in an effort to attain the required properties without necessitating heat treatment of the finished case. With this treatment, cold work is done on a tempered martensite rather than a spheroidized structure. However, the hardness again did not exceed Rb 100.

<table>
<thead>
<tr>
<th>Rb</th>
<th>88</th>
<th>91</th>
</tr>
</thead>
<tbody>
<tr>
<td>99</td>
<td>97</td>
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</tr>
<tr>
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<td>91</td>
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<tr>
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<td></td>
</tr>
<tr>
<td>88</td>
<td>75</td>
<td>78</td>
</tr>
</tbody>
</table>
(c) Annealed after second draw, beaded and body annealed (preparatory to un-cast) after third draw. The body anneal is performed by direct flame impingement. As a result, control of the microstructure is very poor. In most instances, the growth area is heated above the critical temperature producing a ferrite-pearlite structure. The softest point occurs just below the shoulder where the effects of spheroidization are not destroyed (see Figures 3-5).

Rb 74
72
65
59
85
33
96
98
59
99
94 90 89 95

6. Un-beat-treated case (annealed prior to third draw).

(d) Body annealed prior to tapering. The various microstructures present in this piece are shown in Figures 3, 4 and 5. Figure 3 represents the as-drawn sidewall in the area left unaffected by the body anneal. Figure 4 represents the softest area on the case, approximately 1 1/4 inch from the base end. Spheroidization has been retained, the structure has been formed through recrystallization of the cold-worked sidewall. Figure 5 is from the mouth area. The temperature in this area exceeded the lower critical temperature during body anneal resulting in the formation of pearlite during cooling. The existence of the soft area in the sidewall allowed wrinkling to occur during tapering. This condition resulted in sidewall failures during ballistic testing. Following is a hardness pattern for this piece:

<table>
<thead>
<tr>
<th>Distance from Base (in.)</th>
<th>0°</th>
<th>180°</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.875</td>
<td>Rb 89</td>
<td>96</td>
</tr>
<tr>
<td>1.750</td>
<td>79</td>
<td>80</td>
</tr>
<tr>
<td>1.250</td>
<td>65</td>
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<td>92</td>
</tr>
<tr>
<td>.250</td>
<td>91</td>
<td>91</td>
</tr>
</tbody>
</table>
Figure 3  
Neg. #530-1966  Mag: 500X
Mid-Sidewall position, 1-1/8 inch from the head, before heat treatment. The piece has been body annealed and tapered. The structure is essentially ferritic with spheroidal carbides. The effect of cold working is still evident, indicating that body annealing had very little influence in this area.

Figure 4  
Neg. #531-1967  Mag: 500X
Same as Figure 3, but 1-1/2 inch from head. The steel in this area recrystallized during body anneal. This is the softest area of the case at this stage, and as a result wrinkles are produced during tapering.
Figure 5. Neg. #532-1967 Mag: 500X
Same as Figures 3 and 4, but 1-7/8 inch from base (in mouth area). The presence of carbide in other than the spheroidal form shows that this area exceeded the lower critical temperature during body anneal. Ideally, this should be the softest area of the case before tapering.
(b) No body anneal prior to taper. The body anneal was not performed in order to eliminate wrinkling. The wrinkles were successfully eliminated as were the ballistic failures.

7. Heat treated case (lot 4). The following table shows the hardness pattern of several cases hardened by induction, and tempered at various temperatures for 75 minutes. These cases received a body anneal prior to tapering.
Distance from As Tempered
Base (in.) | Quenched | Tempered 75 minutes at
| | 800°F | 850°F | 875°F | 900°F |
| .750 | 50 | 28 | 26 | 25 | 23 |
| .500 | 49 | 28 | 27 | 26 | 22 |
| .250 | 50 | 29 | 26 | 24 |

Base Position
A 50 29 25 22
B 49 29 26 25 22
C 49 29 26 25 24
D 49 29 26 24

All of the tempered pieces fall within the hardness range specified on the drawing as shown on the graph, Figure 5. The induction coil was positioned such that it heated directly only the body and head portions of the case. The natural conductivity of the material was relied upon to heat the mouth and shoulder areas. The cycle was such that the critical temperature was not exceeded in the mouth. As a result, this area did not harden, and a mouth anneal (for crimping) was not necessary. The tempering treatment was sufficient to bring the mouth within the required hardness range.

The microstructure of the as-quenched body is shown in Figure 7. This structure is essentially 100% martensite. The microstructure of various areas of the tempered body are shown in Figures 8-14. These photomicrographs illustrate the differential effect of heat treatment. The area from the upper sidewall to the base is essentially all tempered martensite. The shoulder and lower mouth area is a mixture of martensite and ferrite. The open end is primarily ferrite and spheroidal carbide with some areas of what appears to be pearlite. This is almost identical to the mouth area after body anneal; heat treatment had very little effect on this area other than to relieve the stresses introduced during tapering. Subsequent tempering was sufficient to bring this area within the required hardness range of R(15T) 82-86.

Hardness patterns for two heat-treated cases which received no body anneal prior to taper (Lot 51) are shown below. These pieces were tempered at 800°F for 75 minutes.

| Distance from Base (in.) | No. 1 | | No. 2 |
| | 0° | 180° | 0° | 180° |
| 1.934 | Rb 66 | Rb 65 | Rb 65 | Rb 64 |
| 1.875 | 67 | 73 | 68 | 75 |
| 1.831 | 70 | 77 | 72 | 81 |
| 1.500 | 75 | 89 | 85 | 92 |
| 1.250 | 96 | 96 | 99 | 96 |
| 1.000 | Re 30 | Re 24 | Re 31 | 23 |
| .750 | 31 | 31 | 31 | 29 |
FIGURE 6. DISTANCE FROM HEAD-IN.
Figure 7  

Neg. #279-1967  

Mag: 1,000X

As-quenched sidewall between positions 5 and 6 (See Figure 6). The structure, which has a hardness of HRC50, is primarily untempered martensite.
Mouth area of tempered case, position 1 (See Figure 6). This microstructure consists of ferrite, spheroidal carbide, and probably pearlite. Hardness is $R_b65$, which is sufficiently soft for crimping.

Lower neck, position 2 (See Figure 6). This dual microstructure consists of ferrite (white) and tempered martensite. This structure is typical of a steel held between the lower and upper temperatures prior to quench. (This area probably did rise above the upper critical temperature, but not for long enough to allow complete transformation to austenite).
Figure 10  
Neg. #282-1167  
Mag: 1,000X

Shoulder, position 3. Same as position 2 but showing a higher ratio of martensite to ferrite. This area reached a higher temperature than position 2.

Figure 11  
Neg. #283-1967  
Mag: 1,000X

Upper sidewall, position 4. This area is primarily fine-grained tempered martensite but with small areas of untransformed ferrite.
Middle sidewall, position 5. This structure is almost fully martensite. Some non-metallic inclusions in the form of stringers are visible.

Lower sidewall, position 6. This area is also tempered martensite but the grains are larger than at position 5. It appears that some undissolved carbides remain in the matrix.
Figure 14  
Neg. #286-1967  
Mag. 1,000X  

Head, position 7. This structure, also tempered martensite, exists at the center of the base or head area. This shows that the quench is adequate – all the austenite in the case is transforming to martensite as required.
The mouth area is sufficiently soft to allow crimping. However, the sidewall is significantly harder than that obtained with previous lots. This accounts for the improved ballistic success achieved by this process.

METALLURGICAL EVALUATION OF CASE LOTS MANUFACTURED FROM SHARON C1025 STEEL UNDER TMP 305

Hardnesses and microstructures of TMP 305, lots 1 thru 8, are shown in table II and figures 15 thru 33 respectively; with few exceptions, hardness patterns are included for each process piece in these lots. The microstructures were obtained from lot-4 pieces; photographs from other lots are not included since all lots are essentially identical.

1. Strip (Figures 15 and 16) - The first 20 Sharon steel coils used for this program were, in general, harder than the Republic steel strip used for TMP 301. The ranges obtained for these coils (excluding 4, 5, and 6) are shown below (range of five readings):

<table>
<thead>
<tr>
<th>Coil No.</th>
<th>Hardness (RB)</th>
<th>Coi1 No.</th>
<th>Hardness (RB)</th>
<th>Coil No.</th>
<th>Hardness (RB)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>10</td>
<td>66 - 67</td>
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<td>70 - 71</td>
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<td>64 - 67</td>
<td>15</td>
<td>67 - 69</td>
<td></td>
<td></td>
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</tbody>
</table>

2. Cup (Figures 17 and 18) - The hardness of the sidewalls, as drawn, ranged from the low-to-mid 90's RB. The bases exhibited very little increase over the strip hardness. After annealing, the sidewalls, with the exception of lots 7 and 8, were in the mid-to-upper 60's RB. Lots 7 and 8 were in the low 60's RB. The microstructure of an a-nealed cup shows that a relatively equiaxed ferrite matrix existed in both the sidewall and the base. (Since our primary interest was the condition of the process
Figure 15  Neg. #1694-1967  Mag 1030X
Sharon steel strip. Longitudinal section from coil #3, showing 99% spheroidization.

Figure 16  Neg #1695-1967  Mag 1000X
Sharon steel strip. Transverse section from coil #3, showing grain size of 6 to 8.
Figure 17  
Neg. #2210-1967  
Mag: 500X  
Sidewall of annealed cup showing equiaxed ferrite. Hardness Rb 66-68.

Figure 18  
Neg. #2211-1967  
Mag: 500X  
Base of annealed cup showing equiaxed ferrite. Hardness Rb 62-72.
piece prior to subsequent forming, microstructures for the cups, first-draw pieces, and second-draw pieces were obtained in the annealed condition only).

3. **First Draw Piece** (Figures 19 and 20) - The sidewalls of the first-draw pieces were worked to hardnesses in the mid 90's RB. After annealing, the sidewalls ranged in the mid 60's RB, with the exception of lots 1 and 2. Based on 1-piece samples, lot 2 sidewalls were up over RB 70, and lot 1 exhibited a reading of RB 82; this was probably caused by improper annealing, but produced no excessive difficulties at second draw. The microstructure is essentially equiaxed ferrite and spheroidal carbide. The only evidence of previous working is in the longitudinal pattern of the carbides.

4. **Second Draw Piece** (Figures 21 and 22) - Second-draw piece sidewalls were worked to the hardness range RB 94-101; after annealing, they exhibited hardnesses in the range RB 60-69. The microstructure of the annealed piece is again equiaxed ferrite and spheroidal carbide.

5. **Headed Piece** (Figures 23, 24 and 25) - The hardness table (Table II) shows the condition of the third-draw piece in both the as-drawn and the headed condition. During the drawing operation, the sidewall was worked to a hardness of RB 87-97. (Ignore the 2 1/4 and 2 1/2 inch positions since this material is removed at trimming). During heading, the head is hardened approximately 15 points RB; the sidewall remained unchanged. The photomicrograph shows the sidewall in the cold-worked condition. The photomicrograph of the base was taken from a relatively unworked area. The cold shuts present on the internal radius do not represent a serious condition; cold shuts of this magnitude were present in all eight lots.

6. **Tapered Case** - These pieces were not body annealed prior to tapering; a slight hardness increase was noted in the mouth area.

7. **Hardened Case** (Figures 26 to 29) - All lots exhibited as-quenched hardnesses of RC 50 or greater in the sidewall region. Head hardnesses, in general, ranged from RC 46 to 50, indicating that this area was being quenched out, while the mouth area remained relatively soft. The microstructure of the sidewall and head is essentially untempered martensite, although some high-temperature transformation product, probably pearlite, is visible at the grain boundaries in the head area. The shoulder area contains a mixed structure of martensite and ferrite, indicating that transformation was not completed prior to quench. The mouth area is completely untransformed. The relatively fine-grained structure is the result of annealing the cold-worked structure produced during tapering.

8. **Tempered Case** (Figures 30 to 33) - Except for lots 1 and 6, the sidewall and head hardnesses of all cases are within the desired range (RC 22 to 28). The RC 31 exhibited by cases from lots 1 and 6 was probably the result of a short tempering time or low temperature. The mouth hardnesses of most cases were below the desired range of RB 65 to 78; this did not cause any problem since the mouth is hardened somewhat during crimping. The microstructures of the base and sidewall are essentially tempered martensite. The shoulder area consists of tempered martensite and ferrite. The mouth area is ferrite, along with spheroidal carbides remaining from the original strip material.
Figure 19
Neg. #2242-1967  Mag: 500X
Middle sidewall of annealed first draw piece showing equiaxed ferrite and spheroidal carbide. Hardness Rb 62-68.

Figure 20
Neg. #2243-1967  Mag: 500X
Base of annealed first draw piece showing equiaxed ferrite and spheroidal carbide. Hardness Rb 67-75.
Figure 21  
Neg. #2177-1967  
Mag. 500X  

Figure 22  
Neg. #2178-1967  
Mag. 500X  
Base of annealed second draw piece. Microstructure is similar to that exhibited by the upper sidewall. Hardness $R_p$ 67-71.
Figure 23  
Mag. #3165-1967  
Mag. 500X  
Upper sidewall of headed piece showing cold-worked condition. Hardness 20 90-97.

Figure 24  
Mag. #3176-1967  
Mag. 100X  
Cold shuts in internal radius between sidewall and base of headed component.
Figure 25  
Neg. #3167-1967  Mag: 500X  
Base of headed piece. Photomicrograph shows structure of relatively unworked area. Hardness $R_B$ 87-96.

Figure 26  
Neg. #2984-1967  Mag: 500X  
Neck of hardened case showing completely untransformed fine-grained microstructure resulting from annealing of cold worked structure formed at tapering. Hardness $R_B$ 89-106.
Figure 27  
Neg. #2984-1967  Mag: 500X  
Body-shoulder junction of hardened case showing untempered martensite and ferrite. Hardness R_C 47-54.

Figure 28  
Neg. #2983-1967  Mag: 500X  
Mid-sidewall region of hardened case showing untempered martensite. Hardness R_C 52-54.
Figure 29  
Neg. #2981-1967  
Mag: 500X  
Head of hardened case showing untempered martensite. Hardness Rc 49-50.

Figure 30  
Neg. #2978-1967  
Mag: 500X  
Neck of tempered case. Microstructure contains ferrite along with spheroidal carbides carried over from the original strip material. Hardness Rb 64-65.
Figure 31  
Neg. #2980-1967  
Mag: 500X  
Body–shoulder junction of tempered case showing tempered martensite and ferrite.  
Hardness $R_b$ 83–95.

Figure 32  
Neg. #2979-1967  
Mag: 500X  
Mid-sidewall region of tempered case showing tempered martensite.  
Hardness $R_c$ 26.
Figure 33  
Neg. #2977-1967  
Mag: 500X  
Head of tempered case showing tempered martensite. Hardness $R_C \ 24-26$. 

29
### TABLE II - Hardness of 7.62mm Steel

Case Components for First Eight Lots (TMI 305)
(Number of pieces from which range was obtained is shown at head of column)

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>CONDITION</th>
<th>LOCATION</th>
<th>LOT 1</th>
<th>LOT 2</th>
<th>LOT 3</th>
<th>LOT 4</th>
<th>LOT 5</th>
<th>LOT 6</th>
<th>LOT 7</th>
<th>LOT 8</th>
</tr>
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<tbody>
<tr>
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<td>1 pc.</td>
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<td>3 pcs.</td>
<td>4 pcs.</td>
<td>3 pcs.</td>
<td>3 pcs.</td>
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<td>92-93</td>
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</table>

| Cup Annealed | 1 pc. | 1 pc. | 1 pc. | 3 pcs. | 3 pcs. | 3 pcs. | 3 pcs. | 3 pcs. | 3 pcs. |
| 2 | 66 | 66 | 67 | 64-67 | 64 | 64-65 | 59-62 | 59-62 | 59-62 |
| 3 | 60 | 66 | 68 | 67-72 | 60-68 | 60-70 | 60-62 | 51-52 | 51-52 |
| 4 | 64 | 64 | 68 | 62-68 | 62-68 | 64 | 59-61 | 58-62 | 58-62 |
| 5 | 70 | 68 | 72 | 69-71 | 61-71 | 65-69 | 58-64 | 52-53 | 52-53 |
| 6 | 68 | 66 | 63 | 64-66 | 62-66 | 62-67 | 60-63 | 59 | 59 |
| 7 | 68 | 68 | 68 | 64-69 | 64-69 | 65-66 | 61-63 | 62-64 | 62-64 |

| 1st Draw As Drawn | 1 pc. | 1 pc. | 1 pc. | 3 pcs. | 3 pcs. | 3 pcs. | 3 pcs. | 3 pcs. | 3 pcs. |
| 1 | 97 | 93 | 93 | 94-96 | 94-96 | 94-97 | 96-98 | 92-95 |
| 2 | 95 | 93 | 94 | 93-95 | 92-95 | 93-96 | 95-98 | 93-94 |
| 3 | 95 | 92 | 91 | 93-93 | 92-96 | 92-93 | 94-96 | 90-92 |
| 4 | 70 | 66 | 75 | 69-75 | 65-71 | 69-75 | 65-71 | 67-71 | 67-71 |
| 5 | 73 | 65 | 65 | 67-72 | 65-69 | 65-67 | 71-73 | 65-70 | 65-70 |
### TABLE II (cont'd)

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<th>LOT 7</th>
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B II

Table

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A

Table

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PROCESSING

This section summarizes, with a brief description, each operation performed to produce heat treated steel cases according to TMP-305, at the conclusion of pilot production.

Procedures and equipment specified are current as of this writing. However, equipment and process improvement studies are continuing, particularly in the areas of extrusion, induction heat-treating, iron phosphating, and surface finishing. Efforts are being made to improve both the quality and efficiency of these operations, which at present have not been developed to the state necessary for continuous high-volume production.

Table III presents, in columnar form, a process comparison between the Frankford Arsenal heat treated steel-case process, the former Frankford Arsenal and LCAAP steel case process, used from 1954 to 1960, and the present brass-case process used by the GOCO plants. Identical operations, e.g., first draw, second draw, head, etc., are aligned horizontally.
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<tr>
<th>Present Steel (FA Heat Treat)</th>
<th>Former Steel (FA and LCAAP)</th>
<th>Present Brass</th>
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<tbody>
<tr>
<td>1. Blank and Cup</td>
<td>1. Blank and Cup</td>
<td>1. Blank and Cup</td>
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<tr>
<td>2. Wash, Rust Preventive Rinse, and Dry</td>
<td>2. Wash, Rust Preventive Rinse, and Dry</td>
<td>2. Wash, Rinse, and Dry</td>
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<td>5. First Draw</td>
<td>5. First Draw</td>
<td>5. First Draw</td>
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<td>10. Wash, Rust Preventive Rinse, and Dry</td>
<td>10. Wash, Rust Preventive Rinse, and Dry</td>
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<td>15. Trim</td>
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<td>15. Third Draw</td>
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<td>17. Head</td>
<td>17. Head</td>
<td>17. Trim</td>
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<td>18. Wash, Rust Preventive Rinse, and Dry</td>
<td>18. Wash, Rust Preventive Rinse, and Dry</td>
<td>18. Sort</td>
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<td>19. Pocket</td>
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<td>20. Head</td>
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<td>21. Wash, Rinse, and Dry</td>
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<td>Former Steel (FA and LGAAP)</td>
<td>Present Brass</td>
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<tr>
<td>32. Visual Inspect</td>
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Figure 34. 7.62MM Steel Ctg. Case Heat Treat Process (TMP 301)
Blank and Cup - Blanking and cupping were performed at Frankford Arsenal for the production of approximately 1,200,000 7.62MM steel cases processed under TMP 301 and TMP 305. An additional 40,000 cups were produced for fabrication into cold-worked 7.62MM steel cases. The cups used in both processes are identical.

The press used for blanking and cupping was a Bliss #6 double acting press, equipped with twin flywheels, operating at approximately 90 strokes/min. The die set used with this press contained five stations, allowing up to 5 cups to be formed by each press stroke. A single blank and cup die was used at each station for completely forming the cup; no sizing die was employed.

Blanking and cupping were accomplished using oiled steel strip as received from the steel supplier, without the benefit of a zinc phosphate coating. A trial run was performed by wiping DuPont "Vydax" on the strip before blanking, which appeared to lessen the force required for cupping, this approach was never fully exploited due to the volatility of the Vydax solvent. It was felt that installation of the required ventilation equipment would be too costly for the advantages gained.

Lubrication of the unphosphated strip proved to be a continuing problem to which a completely satisfactory solution was never found. Lubro 44, manufactured by G. Whitfield Richards Company, proved to be the most effective coolant solution tried, particularly when mixed with Lubri-Cool, manufactured by Lord Laboratories, Detroit, Mich., in the amount of 1 pound of Lubri-Cool to 55 gallons of Lubro 44 solution. In production, a coolant concentration of 1 part Lubro 44 to 1-1/2 parts water was found to be most satisfactory.

Coolant solution was applied to the tools using a pump-fed circulating system installed on the press. Streams of lubricant were directed onto the top of the stripper plate to achieve a puddling effect on the upper surface of the strip. In addition, streams of lubricant were also directed onto the underside of the strip, between the strip and the die block. With both of these methods however, coolant-flow into the dies ceases as the blanking punch brings the bottom surface of the strip into contact with the top surface of the die.

Due to the lack of a sizing die, injection of coolant thru a lube ring located below the blank and cup die was precluded. Consideration was given to the use of jets to direct lubricant upward into the die under pressure, but this was never attempted, due to the high viscosity of the coolant solution which requires the use of relatively large-diameter tubing to deliver a sufficient quantity of lubricant to the dies.

Various coatings were applied to the dies to reduce die pickup. Uncoated chrome-plated dies were able to be run for approximately 1,000 pieces before pickup reached an intolerable level. Rate of pickup was reduced with the use of manganese phosphated dies coated with Surf-Cote M1284, a matrix-bonded solid film lubricant manufactured by Kohman Plating and Manufacturing Company, Dayton, Ohio, use of this lubricant, qualified under MIL-L-8937, extended the interval between polishings of dies to approximately 8,000 pieces.
Die life, using a mixture of Lubro 44 and Lubri-Cool, with uncoated dies manufactured from FS-WI-10 or FS-WI-12 steel, is estimated to be approximately 25,000 pieces.

In an effort to determine the effects of zinc phosphate coating of the strip on blanking and cupping, 32 strips, each seven feet in length, were cut from a coil of steel and phosphate coated; these strips, containing approximately 4,000 pieces, were processed with comparative ease - most problems were eliminated, and tool life and production rate were increased. A process was also tried wherein partially-formed cups were made from unphosphated strips. The partial forming was performed with a blank and cup press without ironing, minimizing the friction between the cup and cupping die. The partially-formed cups were to be phosphated and lubed, and final-formed on a modified first-draw press. The process was never carried to completion due to tight pilot production scheduling, but results appeared promising for further development.

Wash and Rust Prevent - Following the blank and cup operation, the cups were washed to remove all traces of dirt and lubricant and thereby prevent the formation of any residue on the pieces during annealing. The rust prevent: e. consisting of a final rinse in potassium dichromate solution, retards rust formation during short periods of storage, and does not require removal prior to annealing.

Two methods were used to perform this operation, the first method, which is preferred, utilizes a Baird meltable-barrel rotary washer. The pieces are introduced into the rotary barrel and tumbled without water (or with a slight amount, if cups contain dried lubricant) to remove any burrs produced at the blank and cup operation. The tumbling action produced by the baffles within the barrel removes the sharp edges from the cups and facilitates feeding to the first-draw press. The baffles in the rotary barrel of the washer are positioned such that rotation of the barrel in a clockwise direction permits drainage of the solution, rotation in a counterclockwise direction retains the solution, both cleaning and rust preventive solutions are added manually.

The second method of performing the wash-and-rust prevent operation utilizes a Niagara washer, this method lacks the rumbling action of the Baird washer. Several lots of cups were processed in this manner when the Baird washer was unavailable, but only as an emergency measure to maintain production schedules. No serious difficulties were encountered at first draw due to the presence of burrs on the cups. Two advantages of the Niagara washer are its drying section, which aids in rust prevention, and its relatively high speed.

The Niagara washer uses a rotating barrel with an augur to transfer the pieces from one solution to the next. The work is carried in the barrel above the solution surface, scoops built into the external surface of the barrel raise the solution into the barrel, immersing the pieces, the solution drains back into the holding reservoir thru holes in the barrel.
Anneal for First Draw - In all lots of heat treated cases, the cups were annealed in a Lindberg furnace prior to first draw. The purpose of this anneal is to reform the relatively- equaxed grain structure present in the original steel strip, thereby increasing the ductility of the material and rendering it more suitable for additional forming.

TMP 301 required a hardness of RB 46-55 on the outer sidewall 1/16" above the junction of base and sidewall (not 1/16" from inside base, as stated in the TMP), during processing, it was discovered that the Lindberg furnace, using the maximum heating and cooling times available, would not deliver this hardness - the minimum hardness obtainable was approximately RB 59-62 at the specified position. Actually, this material was probably incapable of being annealed to RB 46-55 by any conventional annealing cycle. Processing was satisfactory at this hardness, and TMP 305 subsequently specified a slightly higher hardness of RB 65 max.

The furnace used for annealing was a 3-zone rotary retort-type furnace utilizing a carbon monoxide atmosphere to prevent oxidation of the components during heating and cooling. The temperature within the retort is controlled by zones: entrance, center, and discharge. During the annealing cycle, all zones were maintained at 1520°F. Due to heat loss thru the wall of the retort, the temperature of the pieces is maintained at 1290°F.

Phosphate Coat and Lubricate - Following annealing, the pieces were cleaned, pickled, zinc phosphated, and lubricated.

The machine used to perform this operation was a 2-section, rotary-cylinder type machine manufactured by N. Fansohoff, Inc. The various cleaning and coating solutions are maintained at the proper temperatures until ready for use, when they are pumped into the first section of the rotary cylinder containing the work. Upon completion of the cleaning and zinc phosphating stages, the work is transferred to the second section of the rotary cylinder, containing the lubricant solution, by reversal of the direction of rotation of the drum.

The first stage of the phosphate coat and lubricate operation consists of a cleaning treatment in alkaline solution to remove grease, oil and similar foreign matter, this is followed by a hot water rinse.

A pickle stage follows, using hot sulfuric acid solution to remove any oxidation and scale formed during annealing, and to etch the surface slightly to provide a surface to which the zinc phosphate will adhere. Pickling is followed by a cold-water rinse.

The zinc-phosphate coating is the last operation performed in the first section of the rotary drum. The coating used was Bonderite 160X, which is an adherent coating used to retain the lubricant film during subsequent forming operations. A cold-water rinse follows the zinc phosphate application.

Following phosphating, the pieces are transferred to the second section of the rotary drum where the lubricant coating is applied, the lubricating compound used was Bonderlube 235. The lubricant and the zinc phosphate must be purchased from the same manufacturer to assure compatibility between the two coatings.

First Draw - The first-draw operation was performed on the annealed cups using a Bliss #62 duplex press with a 5-inch stroke, producing four pieces per stroke (2 pieces each side). As with all drawing operations, two dies, top and bottom, were used to form the metal, these were used in conjunction with a guide ring and a stripper, but no lube ring was used.
Lubrication and tool cooling were accomplished using a single stream of lubricant per station, supplied by a circulating system and directed onto the punch and downward into the dies. No problems were encountered relative to lubrication and cooling, provided the zinc phosphate and lubricant films applied during the previous operation were satisfactory.

The wall thickness of 0.051 - 0.107" measured to 0.030" from inside base was changed during hot processing to 0.055 - 0.044" measured at 0.127" from inside base; this was done when it was found that accurate readings could not be obtained close to the mouth.

Wash, Blast, Preventive Finish, and Dry — The purpose of this operation is identical to that of the cleaning operation following blank and cup; however, the washing action produced by the Blast washer is neither necessary nor desired at this stage of manufacture. For this reason, the Neopren washer, used as the alternate following blank and cup, was used for this and all succeeding washing operations.

Anneal for Second Draw — The procedure and equipment used to perform this operation was identical to that used as anneal for first draw.

TMP 301 required a hardness of Hg 45–55 on the outer sidewall of the component, 1/16" above the junction of base and sidewall, however, as with the anneal for first draw, it was discovered that one annealing cycle in the Lindberg furnace, using the lowest speed available, would not yield the required degree of annealing. Thus, the maximum heating and cooling cycles (50 minutes each) were again used, yielding a hardness of Hg 55–58. A minimum hardness of Hg 60 maximum was subsequently adopted for processing under TMP 301.

Phosphate Coat and Lubricate — This operation is identical to the phosphate coat and lubricate operation preceding first draw.

Second Draw — The second-draw operation was performed on a Bliss model 304 press with an 8-inch stroke utilizing a maximum of four strokes to produce up to 4 pieces per stroke. In pilot production, however, only a single punch was used. The die set incorporated a guide ring, top die, lube ring, bottom die, and stripper.

Coolant solution was introduced at two locations: from a stream directed downward onto the punch and into the die set, and from the lube ring located between the top- and-bottom dies; it was found particularly important to maintain an unobstructed flow of coolant to the lube ring to prevent heating of the dies, and subsequent pickup and scratching of work.

The components were fed to the draw press by means of a rotary pan hopper, followed by an air-operated turnover to properly orient any piece fed upside down from the hopper. Flexible tubes were used to convey the pieces from the turnover to feed tracks located on the press; the pieces are pushed along the feed tracks by means of mechanically-operated fingers which cause each piece to drop by gravity into the guide ring prior to the downward stroke of the draw punch.
Wash, Rust Preventive Rinse, and Dry — This operation is identical to the wash, rust preventive rinse, and dry operation following first draw.

Anneal for Third Draw — This operation is identical to the anneal for second draw. As with the anneals preceding first- and second draws, the hardness requirement of HRC 48-55 imposed by TRP 291 could not be met using the Lindberg furnace; consequently, a maximum hardness of HRC 45 was specified in TRP 295.

Phosphating, Coating, and Lubricate — This operation is identical to the phosphating, coat and lubricate operation preceding first draw.

Third Draw — The equipment used to perform the third (final) draw was essentially identical to that used for the second draw. The press used was again a Bliss model 246, but having an increased stroke of nine inches; the longer stroke was required so that the draw punch would clear the top of the second-draw component upon feeding, and so that the final-draw component would be pushed completely into the stripper on completion of the downward press stroke. The press used could accommodate a maximum of three punchers, although a single punch was used for pilot production.

The draw punch used on final draw incorporated four tapers, which determined the inner diametral shape of the finished cartridge case. Failure to blend two adjacent tapers properly was found to be the cause of circumferential ruptures encountered in proof testing; these ruptures were located at a distance of 1.05" from the inside base of the case — this corresponds to the junction point of two tapers on the first-draw punch.

Wash, Rust Preventive Rinse, and Dry — This operation is identical to the wash, rust preventive rinse, and dry operation following first draw.

Trim — The machine used to perform this operation was a single-spindle horizontal trim machine, manufactured by Peters Engineering Company, employing both rotary and boring cutters; spindle speed used was 1740 rpm — cutter speed was 430 rpm. No lubricant was used at the trim operation; however, it was found in production that cutting-tool life was extended by incorporation of the wash, rust preventive rinse, and dry operation immediately preceding.

Sort — The purpose of the sort operation is to remove any scrap or mutilated pieces prior to the heading operation. The trimmed pieces are fed from a hopper onto a moving conveyor belt where the operator performs a 100% visual inspection, manually picking out defectives.

Head and Identify — At this operation the head, headstamp, and case-base configuration are formed. All processing of heat treated cases utilized this "one shot" heading technique, eliminating the necessity of performing separate hemi and/or pocket operations.
The machine used for heading was a 65-ton horizontal crank-and-toggle press manufactured by Jarecki Machine Company, having a crank stroke of 8 1/2" (pocket punch), and a toggle stroke of 7 7/8" (eject stem). Feed was by means of a pin hopper; an automatic knockoff device, actuated by a limit switch on the feed mechanism, stopped the press in the event of a feed stoppage — this was necessary to prevent contact between the heading punch and eject stem when no work was present in the die.

A 2-piece heading punch was used throughout the program because of difficulties encountered in obtaining 1-piece punches, this method was found satisfactory, although it produced a slight burr at the junction of primer pocket and head surface. This burr was subsequently removed by the addition of a deburring station at the testing operation. For future production, it is recommended that 1-piece heading punch PT 1055 be utilized, with the pilot size modified to that shown on drawing SKFSA 11277 (0.2051” – 0.2061” diameter).

Wash, Rust Preventive Rinse, and Dry — This operation is identical to the wash, rust preventive rinse, and dry operation following first draw.

Feast Turn — The machine used to perform this operation was a single-spindle horizontal head-turning machine manufactured by Standard Kapp, spindle speed of 2200 rpm, and machine speed of 40 rpm (40 pieces per minute) were found to be most satisfactory in production.

Tool life and breakage continued to be a problem, although improvements resulted from adoption of the 40 rpm machine speed and a change to carbide tooling. Tool coating and lubrication were accomplished by means of an atomizer dispensing a mist of lubricant directly onto the cutting tool. Lubricant cannot be applied prior to the head-turn operation as this causes slippage between the component and the collet used to grip the piece.

Due to the difficulties encountered at the head-turn operation, it is recommend that any future developmental work on head turning of steel cases be performed on a Blackstock Universal type machine, this machine, having variable-speed motors and adjustable feed is more versatile where developmental work is required to determine optimum speeds and feeds.

Vent and Deburr — The vent-and-deburr operation for the steel case was separated from the prime operation in order that the varnish applied to the finished case would completely cover the case, including the vent hole. Venting at this stage also results in more satisfactory operation at the carding operation.

The machine used was a crank-and-rocker, vertical, straight-line, underdrive primer-insert machine manufactured by Waterbury Farrel Foundry and Machine Company, the machine was altered by removal of features in order that only the burr, vent and re-vent detect functions would be performed.

Various automatic knockout devices were incorporated into the machine setup, these were as follows:
a. At the burr station a knockoff device was actuated in the event that a case failed to feed into the machine.

b. At both the first- and-second no-vent detect stations, a knockoff device was actuated in the event that a case was produced with no vent hole, an eccentric vent hole, or with foreign matter in the pocket.

As stated in the description of the head operation, the burr station incorporated in the vent and deburr operation may be eliminated when a 1-piece heading punch is used. In the event that a 1-piece heading punch is used in future production, it is recommended that a horizontal crank, single-punch press manufactured by Derbyshire Machine Company, be utilized to perform the vent operation. The Derbyshire machine operates faster but is unable to accommodate both the venting punch and the deburring punch.

Taper and Plug - The taper-and-plug operation was performed on a vertical double-action crank press, Bliss model 162. The press utilizes a rotary indexing table to feed the pieces to each successive stage of the operation.

TMP 301 and TMP 305 specified a "one shot" taper in which only one tapering station was used — thus, the stages in the operation consisted of no cut area, taper, and plug. The work produced by this method was satisfactory, although constant surveillance and frequent machine adjustment were required to maintain dimensional quality and freedom from physical defects.

During processing of TMP 305, a first-taper station was added which eased the mouth of the untempered case prior to final tapering, thus change improved the quality of work and reduced press downtime.

The mouth-ironing operation was not used for a portion of the production, particularly when the work coming to the taper-and-plug operation contained no defects in the mouth area, however, it is recommended, due to the seriousness of neck-and-shoulder area defects and folds, that the mouth-ironing operation be utilized.

With the processing of lot 6d under TMP 301, the body anneal, and phosphate coat and lubricate operations preceding taper and plug had been eliminated. Processing of lots 6a thru 6d constituted efforts to eliminate the annealing which was occurring at the taper-and-plug operation. Proof testing of lot 6d, indicating success, showed that the body anneal had produced a soild area below the shoulder in the upper sidewall which did not possess sufficient strength to resist the tapering forces being applied to the shoulder and neck, and was subsequently annealing; this was observed by removing the varnish coat from the upper sidewall of a split case after firing — the wrinkles then became readily visible. This same method was used as a check on processing at the taper-and-plug operation to assure freedom from folds and wrinkles in the neck, shoulder, and upper-body areas. The case to be examined was rotated in a lapping head while fine emery cloth was held against the areas to be examined — in this manner, indentations were incurred by unburnished areas.
It was discovered that the cleanest possible outside surface prior to tapering produced the most satisfactory tapered case; it was for this reason that the phosphate coat and lubricate operation was eliminated. The only lubricant used was a light film of mineral cutting oil applied at a lubrication station on the press preceding the first taper station. A drop of cutting oil entrapped between the tapering dies and case will produce a dent, as will a buildup of dirt or solid-film lubricant -- therefore, the amount of oil applied at the lubrication station should be limited to the minimum necessary to prevent the heating, and subsequent pickup and scratching of work.

**Wash, Rust Preventive Rinse, and Dry** - This operation is identical to the wash, rust preventive rinse, and dry operation following first draw.

**Finish Trim** - The finish-trim operation was the last forming operation performed in the case manufacturing process. The machine used was a single-spindle vertical trim machine manufactured by Fidelity Machine Company, having an operating speed of 107 rpm, and a cutter spindle speed of 185 rpm.

Carbide cutters, identical to those used for 7.62MM brass case processing, were used throughout -- tool life was satisfactory for the quantities of cases produced, although cutter-design changes are recommended for processing of production quantities of steel cases. A smaller amount of metal is removed from the steel case than is removed from the brass case, thus extending tool life slightly.

In using the Fidelity machine to perform the finish-trim operation, it was found particularly important to prevent feed stoppages which would allow the flexible feed tube to become empty. When the tube became empty, the last piece fed to the machine, including the downward force produced by the weight of the pieces in the tube, tended to bounce and be held by the case support at a position abnormally close to the head of the case, causing a short-trim length.

**Wash, Rust Preventive Rinse, and Dry** - This operation is identical to the wash, rust preventive rinse, and dry operation following first draw.

**Visual Inspect** - 100%. Upon completion of forming and heat-treating operations, all cases were visually inspected 100% for the defects listed in the Procedure for Control of Quality (see appendix).

This inspection is virtually identical to the visual-inspect operation following varnish cure.

It was found that a single finished-case inspection was not sufficient to call out all defectives, particularly those having folds and wrinkles occurring in the neck and shoulder. Many of these defects are obscured by the varnish coating.

TMP 205 lists this operation following tempering. However, the color of the cases following tempering obscured the defects due to loss of surface reflectivity. Consequently, visual inspection was later performed prior to tempering.
Quench Harden - Hardness of the finished case is achieved by means of an induction-heating cycle followed by a mouth-down oriented quench in caustic soda solution. High-frequency alternating current is supplied to the induction coil by means of a 10,000 Hz motor-generator set.

Cases to be hardened are fed from four hoppers thru flexible tubes to an inverting mechanism. An ejection device causes any cases fed to the inverter upside down to be rejected. The inverter, by means of a "ferris wheel", inverts the cases before transferring them mouth-down to an indexing table. The cases are held vertically in transite case carriers attached to the indexing table as they are passed transversely between the coils of the heating fixture by the rotation of the table.

The magnetic field produced by the induction coil lifts the cases slightly in the transite holders until they are stopped by a permanently-located strip of nonmagnetic material - thus positioned, the head and sidewall of the case are located within the alternating field, which raises the temperature to approximately 1700°F, for 11 seconds. The neck and shoulder of the case protrude below the coil and are heated only by the weaker field existing below the coil and by conduction from the hotter portion of the case — thus positioned, the head and sidewall of the case are located within the alternating formation to martensite, resulting in lower hardnesses in these areas (see "Metallurgy" section of this report).

Following the heating cycle, a retainer plate under the transite carriers is retracted and the cases, assisted by an airblast, fall mouth-downward into four tubes leading to the caustic quench solution, a wire-mesh conveyor then transfers the quenched cases from the quench solution into a truck for further processing.

Two separate indexing-table drives, both air-operated, were tried during pilot production of steel cases — both were operated by a pneumatic cylinder operating thru a General-type linkage located beneath the indexing table, problems were encountered with both of these drives. Heat from the cartridge cases and the effect of chemicals in the quench solution caused lubricants to become ineffective, materials to corrode, and friction to increase, resulting in erratic operation and inaccurate positioning of the indexing table.

At the present time, an electric drive is being installed but has not as yet been tested. Drive is by means of an electric motor and a positive-stop transmission located above the indexing table, away from heat and chemicals. Motor speed is continuously variable by means of an SCR circuit. A magnetic clutch connects the electric motor to the transmission, providing instant start-end-stop capability.

A simulated firing test was performed in which 50 steel cases improperly heat treated mouth down, rather than mouth up, were assembled into cartridges and fired in an M73 machinegun. Despite efforts and controls to assure proper positioning, it was recognized that improper heat treatment such as this was a possibility. Case casualties included two stoppages, 10 blown primers, 10 large primer leaks, and two small 1-splits, all of which were attributed to the soft heads and excessively hard mouths and necks which resulted.
Due to the extreme hardness produced by the quench-harden operation, it is inadvisable to store the cases longer than necessary following this operation. Recommended time period for storage prior to the temper operation is two hours maximum. During a single-shift production schedule, as followed in pilot production, it was found difficult to perform the quench harden; wash, rust preventive rinse, and dry; and temper operations within one 8-hour shift. Thus, the following time schedule was substituted: all cases quench hardened before noon were tempered the same day; all cases quench hardened in the afternoon were tempered before noon the following day.

Wash, Rust Preventive Rinse, and Dry - This operation is identical to the wash, rust preventive rinse, and dry operation following first draw.

Temper - The tempering operation is performed on a batch basis in an electric furnace having a recirculating air atmosphere. The interior of the furnace is raised to 800°F, and the work is maintained at that temperature for 75 minutes.

During development, several different tempering times and temperatures were tried before the above was adopted. TMP 305 lot 66 was tempered at 800°F for 75 minutes. TMP 305 lots 2-3 and 7-8 were tempered at 850°F for 75 minutes in order that the sidewall hardness could be reduced to coincide with the desired gradient. With processing of TMP 305 lot 9, tempering was again performed at 800°F for 75 minutes, since the case mouth was becoming excessively soft. Final case hardness is determined both by the quench-harden operation, and by the temper operation. Thus, adjustments in tempering time and/or temperature may be required to meet the recommended finished-case hardness gradient, depending on lot-to-lot variations in hardened-and-quenched case hardness.

Iron Phosphate - The iron phosphate operation, consisting of several separate operations utilizing a series of tanks, was performed to clean and etch the cases and provide a base upon which to apply the varnish coating.

The pieces were placed in a rotating perforated nylon barrel suspended from a hoist, such that the barrel could be immersed in each solution tank for the required time interval and then withdrawn.

It is particularly important that utmost care be taken to assure satisfactory results at this stage of processing due to the need for adequate corrosion protection of the finished case. Poor iron phosphate application precludes proper varnishing. Specification TT-C-00490a (Army MIt) should be consulted for test procedures.

The appearance of the iron phosphate coating deposits must be continuous, and the coating must be uniform in texture and evenly deposited. The coating must be golden yellow to purple in color. There shall be no smut, powder, corrosion products, or white stains due to dried phosphating solutions.
Varnish - Varnishing was performed using a centrifuge-type varnishing machine, manufactured by Ronco. In operation, the iron-phosphated cases are placed in varnishing ranks which are inserted one at a time into the varnish machine. The cases are first immersed in varnish for approximately one minute, and are then spun for approximately one minute to remove excess varnish. The varnish removed drains back to the varnish reservoir in the machine.

The phenolic varnish used is purchased in accordance with MIL-V-12276, Type III, Class B. Varnish viscosity at room temperature must be 26 to 50 seconds, Zahn #2 cup, for proper application.

Because of the amount of time and labor involved in applying the varnish using the Ronco machine, a large-capacity production type machine was designed and procured in 1960 to perform the varnishing and curing operations on a continuous basis. The machine utilized a series of pins which were loaded manually and conveyed the cases through varnish, drain, cure, and eject stations. Provisions were also made for stripping the excess varnish from the conveyor pins prior to reloading.

The machine was tested using sample cases. Varnish application was satisfactory, although stripping of cured varnish from the conveyor pins could not be accomplished satisfactorily. Use of the machine was consequently discontinued.

Varnish Cure - The varnished cases are allowed to dry following varnishing until the varnish has air dried to some degree. The racked cases are then wheeled into a Genrich oven where they are cured at 375°F to 400°F (metal temperature) for a minimum of 20 minutes. Total time in the oven is 30 to 45 minutes, including the time required for the oven to reach operating temperature.

The color of the cured cases was used as a general check on the varnish curing operation. Properly-cured cases were uniformly dark green in appearance, a gray appearance indicated incomplete curing, dark brown indicated excessively high-curing temperature -- both of these latter conditions should be avoided.

The following test was devised to check for complete curing. Three cases from the batch to be tested were immersed in acetone purchased in accordance with Federal Specification O-A-51, for a period of five minutes. On removal from the acetone, the sample cases were rubbed vigorously with the thumb, hand, or suitable wiping material, and visually inspected for evidence of lifting, blistering, or softening of the varnish. In the event that the sample cases failed to pass the acetone immersion test, the group of cases was returned to the oven for additional curing.

Varnish thickness, as specified by drawing IX 10532452, is 0.0002 to 0.0010". Varnish thickness is measured in accordance with Specification TT-C-04299 (Army MR). Salt spray tests were performed on all lots of heat treated cases. The test method was as prescribed by Federal Test Method Standard 141a, Method 6061. However, reported results of salt spray testing conveyed little useful data, primarily due to lack of adequate direction needed for meaningful evaluation of results. To evaluate test results
properly and to assure reproducibility in the future, the following guidance is offered:

a. Twenty cartridges are exposed to 20% salt spray for 24 hours.

b. The specimens shall be positioned in the chamber at an angle of 150° from the vertical with the bullet uppermost.

c. The significant surface shall be that surface lying 60° to either side of the vertical, i.e., the upper 1/3 of the circumference.

d. The specimens shall not be scored as stated in para 3.4.2 of method 6061 of Federal Test Method Standard No. 141.

e. The specimens shall be rinsed and dried to remove corrosion products and salt, as stated in para 4.1 of method 6061, before examination.

f. After preparation for examination, significant surfaces of the cartridge shall show no signs of corrosion, pitting, or rusting. However, rust within 1/32" of any edges, or on any surface not requiring coating shall be permitted.

Visual Inspect - 1 1/2" This inspection is similar to the 10 1/4 visual-inspect operation preceding quench hardening. At this inspection, both forming and coating defects are called out. Some types of defects become more readily visible at this operation, due to the increased reflectivity of the case surface.

It was found difficult to detect folds, draw scratches, dents, and wrinkles with simply a visual inspection as used with small caliber brass cases. The seriousness of these defects is increased with the use of steel -- it thus becomes particularly important that all of these defects be removed. It is important that inspectors be trained in advance to recognize and separate cases containing even the slightest defects, that lighting be sufficient and that magnifiers be of adequate size and power. Paddle hoppers of inspection machines and all other machines through which varnished cases pass should be kept as clean as possible. It was noted that inspection-machine paddle hoppers which contained a build up of dust and non-adherent zinc phosphate from the inspection operation preceding quench harden, severely scratched the varnish coating on the cases.

Prime - Primer insertion was performed using a Waterbury Farrel primer insert machine identical to that used for the vent and deburr operation, with the vent and deburr stations removed. The two no-vent detect stations were used at both the vent and deburr, and prime operations, while these stations were not entirely necessary at this stage of processing, they were included to eliminate the possibility of occurrence of this serious defect. In the event that the Derbyshire venting machine, not having no-vent detect stations is used, these stations must be operational at priming.
At the priming operation, (using the Waterbury Farrel vent-and-deburr press), the following functions are performed:

a. No-case detect - an automatic knock-off device is actuated when a case is omitted, stopping the machine.

b. Spread mouth - the mouth and neck of the case are straightened to facilitate bullet insertion.

c. No-vent detect No. 1 and 2 - an automatic knock-off device is actuated when a missing vent hole or foreign matter is detected in the pocket at either of these two stations.

d. Insert and seat primer - the primer, fed in by a conveyor, is inserted into the case to the proper depth.

e. Inverted and no-primer detect - in case of an inverted or missing primer, an escapement is automatically opened to allow the case to drop into a reject container.

f. Crimp - the metal immediately surrounding the primer is circularly crimped to retain the primer in the pocket.

g. Waterproof mouth and primer - waterproofing compound is applied to the case mouth by means of a plunger, and to the space between the primer and the pocket. Before cartridge assembly, the mouth waterproofing should be allowed to dry for a period of not less than two hours, nor greater than two days. This time limit was imposed as a result of vacuum tests which indicated a high incidence of waterproofing failures caused by insufficient or excessive drying periods.

**PROOF TESTING**

Simulated acceptance testing was performed on all lots of cartridges produced under TMP 305. Selected tests were performed on TMP 301 lots 4, 5, and 6D. Testing was performed according to AMCR 715-505 "Ammunition Ballistic Acceptance Test Methods, Vol 3: Test Procedures for 7.62MM Cartridges" dated Feb 64. Specifications MIL-C-16281C (MU), dated 1 May 65, and MIL-C-46931B (MU), dated 1 May 65 were used for evaluation of tracer and ball ammunition, respectively.

Briefly, the acceptance tests fired and the requirements of the tests are as follows:

**Accuracy** - mean radii of 90 cartridges fired at ambient temperature and at 600-yard range shall not exceed 5.0 inches for ball ammunition packed in cartons or clips, 7.5 inches for ball ammunition packed in links, or 15.0 inches for tracer ammunition.
Velocity - average velocity of 20 cartridges conditioned at 68° - 72° F, shall be 2750 ± 30 fps. Average velocity of 20 cartridges subjected to high or low temperatures shall not vary from the average velocity of the same lot conditioned at 68° - 72° F, by more than ±250 fps, nor more than ±150 fps.

Chamber Pressure - average chamber pressure of 20 cartridges conditioned at 68° - 72° F, shall not exceed 50,000 psi. Average chamber pressure of 20 cartridges subjected to high or low temperatures shall not exceed 55,000 psi, nor exceed the average chamber pressure of the same lot conditioned at 68° - 72° F, by more than ±7,500 psi, nor more than ±15,000 psi.

Port Pressure - average port pressure of 20 cartridges conditioned at 68° - 72° F, shall be 12,500 ± 2,000 psi.

Action Time - average action time of 50 cartridges fired at 70° - 20° F, shall not exceed 4 milliseconds.

Trace - 30% of a sample of 200 tracer cartridges fired at ambient temperature must function according to specification.

Vacuum - 50 cartridges are immersed in water in a container which is evacuated to 7-1/2 psi below atmospheric pressure. Data given in table V lists the number of leaking cartridges of a sample of 50, in the event that a re-test was performed, the table lists the number of leaking cartridges of a sample of 100.

Bullet Pull - the force required to extract the bullet from the case shall not be less than 60 pounds. Averages listed are for 10 cartridges.

Function and Casualty - quantities of cartridges fired in each weapon, at each temperature, are listed below:

<table>
<thead>
<tr>
<th>Weapon</th>
<th>+70</th>
<th>+125</th>
<th>+160</th>
<th>-65</th>
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</thead>
<tbody>
<tr>
<td>M50</td>
<td>300</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>M52</td>
<td>300</td>
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</tr>
<tr>
<td>M14</td>
<td>120</td>
<td>40</td>
<td>40</td>
<td>80</td>
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<td>G3</td>
<td>120</td>
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<td>40</td>
<td>80</td>
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<td>LAR</td>
<td>120</td>
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<td>40</td>
<td>80</td>
</tr>
<tr>
<td>LIA1</td>
<td>120</td>
<td>40</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td>M73</td>
<td>1000</td>
<td>50</td>
<td>50</td>
<td>300</td>
</tr>
</tbody>
</table>

Firing in the M73 machine gun is not required by specification and was performed for information only.

Permissible quantities of the defects shown in the tables are as follows.
Large primer leak (LPL)  - 2% (12) *
Small primer leak (SPL)  - 15% (26) *

Splits

- Neck and shoulder (1 and 2)  - 19% (22) *
- Body (3)  - 3% (3) *
- Back (4)  - 1%

Primer rejected - no defect if not loose.

Failure to extract (FX)  - 9

Weapon stoppage  - 8

* Numbers in parentheses refer to reduced-sample testing, when performed only on 3314 and 3364 weapons, such as that performed on TNP 33, Lot 44.

The above summary should be used only for interpretation of the proof test results presented in this section. Full details are available in the referenced specifications and regulations.

Three thousand rounds of steel-cased hull ammunition from Cartridge Lot FAX-3314 were fired on an M1A1 M203 for informational purposes. One-half the cartridges were fired using short bursts, the other half were fired "rapid fire". No functioning problems or case casualties were noted.
<table>
<thead>
<tr>
<th>TABLE IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROOF TEST RESULTS</td>
</tr>
<tr>
<td>TMP 294</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Numbers</th>
<th>Lot 4</th>
<th>Lot 4A</th>
<th>Lot 6D</th>
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</thead>
<tbody>
<tr>
<td>Small leaks</td>
<td>0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Large leaks</td>
<td>0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Velocity (fps)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+72°F</td>
<td>2721</td>
<td>2771</td>
<td>2771</td>
</tr>
<tr>
<td>+125°F</td>
<td>—</td>
<td>2799</td>
<td>2777</td>
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<tr>
<td>+65°F</td>
<td>—</td>
<td>2959</td>
<td>2614</td>
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<tr>
<td>Corrected Pressure (psig)</td>
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<td></td>
<td></td>
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<tr>
<td>+72°F</td>
<td>42.160</td>
<td>44.160</td>
<td>44.260</td>
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<tr>
<td>+125°F</td>
<td>44.160</td>
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<tr>
<td>-65°F</td>
<td>39.260</td>
<td>42.560</td>
<td>41.960</td>
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<tr>
<td>Pull tests (atm)</td>
<td>215</td>
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**Function and Casualty**

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<tr>
<th></th>
<th>+70</th>
<th>+125</th>
<th>-65</th>
<th>+10</th>
<th>+125</th>
<th>-65</th>
<th>+10</th>
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<th>-65</th>
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<tr>
<td>K60</td>
<td>ISPL</td>
<td>—</td>
<td>25J</td>
<td>1SP</td>
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<td>5SP</td>
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<td>M62</td>
<td>—</td>
<td>4SP</td>
<td>7J</td>
<td>1J</td>
<td>9S</td>
<td>2SP</td>
<td>1SP</td>
<td>2SP</td>
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</tr>
<tr>
<td>M14</td>
<td>2J</td>
<td>4SP</td>
<td>1J</td>
<td>1SP</td>
<td>2SP</td>
<td>4SP</td>
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</tr>
<tr>
<td>1K</td>
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<td>—</td>
<td>—</td>
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<td>—</td>
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</tr>
<tr>
<td>G3</td>
<td>—</td>
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<td>—</td>
<td>—</td>
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<td>0</td>
<td>3SP</td>
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<tr>
<td>LAR</td>
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<tr>
<td>LAR</td>
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<td>—</td>
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<td>—</td>
<td>—</td>
<td>1SP</td>
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Double sample in F and C testing

— Test not performed
<table>
<thead>
<tr>
<th>CARTRIDGES</th>
<th>LOTS FAR-8</th>
<th>TRAC 105</th>
<th>TRAC 118</th>
<th>TRAC 125</th>
<th>J103</th>
<th>J104</th>
<th>J105</th>
<th>J114</th>
<th>J116</th>
<th>J118</th>
<th>J118</th>
<th>J110</th>
<th>J111</th>
<th>J118</th>
<th>J118</th>
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<tr>
<td>Accuracy N.R. 400 Tds</td>
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<td>4.35</td>
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<td>Velocity (fps)</td>
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<tr>
<td>Chamber Pressure (psig)</td>
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<td>14,000</td>
<td>14,000</td>
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<td>_______</td>
</tr>
</tbody>
</table>

**Function and Casualty**

- M40: Blank space indicates satisfactory function and no casualties.
- H32: Blank space indicates satisfactory function and no casualties.
- N1: Blank space indicates satisfactory function and no casualties.

**Lots Far-125 and Far-173**

- LAR: Not recommended for N1.
- LIA: Not recommended for N2.
- L3: Not recommended for N2.
CONCLUSIONS

As a result of the 7.62MM steel-case product improvement program, a process has been established and one million steel cases have been manufactured and submitted for ET ST.

Ultimate determination of the success or failure of the program depends upon ET ST results and TECOM recommendation regarding standardization.

The equipment used for steel case production is, in some instances such as heat treating and varnish application, not satisfactory for mass production. In the event that a change-over becomes necessary from brass to steel-case production, these areas will require further development.

New methods and concepts for manufacture of a better-quality, lower-cost steel case are being investigated. Presently under way are studies of extrusion from bar stock, cold working in lieu of heat treating, and automated non-destructive testing to eliminate human error during final inspection. In addition, studies in steel-case development for other calibers are continuing.

RECOMMENDATIONS

Recommendations regarding the future of 7.62MM heat-treated steel case development depend upon ET/ST results. In the event that type classification as STD A is recommended, the process will be shelved following standardization, for possible future use in the event that copper becomes unavailable.

If standardization is not recommended, TECOM test results will be reviewed to determine problem areas and their possible causes. If it is determined that satisfactory performance can be obtained with little additional effort, it is recommended that appropriate measures be taken to correct the deficiencies. If it is determined that correction of deficiencies would require much additional development, it is recommended that the process be shelved along with documentation indicating the level of performance obtained and suggestions for necessary modifications to the process in the event that change-over to steel case production becomes necessary and/or economically feasible.
### APPENDIX A

#### TMP 301

**Summary of Case Lots**

<table>
<thead>
<tr>
<th>Lot</th>
<th>Qty</th>
<th>Process Used</th>
</tr>
</thead>
</table>
| 1   | 4,000 | Cupped from LC strip  
1.25 wash, rust preventive rinse, and dry eliminated.  
1.50 temper to take place within two hours after 1.25 harden;  
quantity remaining too small to proof test. |
| 2   |     | Cupped from LC strip - discontinued due to problems at blank and cap. |
| 3   |     | Cupped from LC strip - discontinued due to problems at blank and cap. |
| 4   | 25,000 | Cupped from 1st coil of Republic steel  
Hardness after 1.5 anneal 59-62 Rb  
Hardness after 1.7 anneal 55-55 Rb  
Wall thickness at 1.5 first draw measured at 0.25"  
Deburring punch FB 56637 used at 1.21 vent and deburr.  
Phosphate coat only at 1.25 phosphate coat and lubricate.  
Mineral oil used at 1.24 taper and plug, and 1.35 re-taper and re-plug.  
1.17 phosphate coat and lubricate, and 1.33 month and neck anneal eliminated.  
Alternate tooling used at 1.15 trim. 1.24 taper and plug, and 1.35 re-taper and re-plug.  
1.27 wash, rust preventive rinse, and dry eliminated.  
1.39 varnish performed on Rosei machine. Immersion time 2 min.  
centrifuge time 2 1/2 min. varnish viscosity 28 sec  
- Zahn No. 2 cup. Cured 400°F for 30 min. |
| 4a  | 2,500 | Taken from 25,000-piece, lot 4  
1.30 temper at 875°F  
Case casualties in function and casualty testing. |
| 5   | 20,000 | Cupped from 2d coil of Republic steel  
Suspected during processing of lot 6a - d. |
| 6   | 19,000 | Divided into lots 6a to 6d.  
Cupped from 3d coil of Republic steel |
| 6a  | 2,000 | Taken from 19,000-piece, lot 6.  
Intended for processing same as lot 4a, until poor results were encountered in proof testing. Not processed. |
| 6b  | 2,000 | Entire head turned piece annealed at 1340°F, in lieu of body anneal.  
Suspended in favor of lot-6d process. |

* Numbers refer to operations in TMP 301, Appendix D*
**APPENDIX A (cont) "TMP 301" Summary of Case Lots**

<table>
<thead>
<tr>
<th>LN</th>
<th>Qty</th>
<th>Process Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>6c</td>
<td>2.000</td>
<td>Processed as lot 4, but utilizing .415&quot; body tapering the instead of .438&quot;. Suspected in favor of lot 6d process</td>
</tr>
<tr>
<td>6d</td>
<td>2.000</td>
<td>Processed as lot 4, but without 1.22 body anneal and 1.22 phosphate coat. Gave satisfactory results in proof testing.</td>
</tr>
<tr>
<td>7</td>
<td>25.000</td>
<td>Cupped from 4th coil of Republic steel. Suspected after lot 5d indicated success.</td>
</tr>
<tr>
<td>8</td>
<td>25.000</td>
<td>Cupped from 5th coil of Republic steel. Suspected after lot 6d indicated success.</td>
</tr>
<tr>
<td>9</td>
<td>25.000</td>
<td>Cupped from 6th coil of Republic steel. Hardened and tempered prior to third draw. Suspected after lot 6d indicated success.</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Composed of caps from lots 4 - 9, having excessive wall variation. Suspected after lot 6d indicated success.</td>
</tr>
</tbody>
</table>
### APPENDIX B

**TMP 305**

#### Summary of Cartridge Lots

<table>
<thead>
<tr>
<th>Lot</th>
<th>Qty</th>
<th>Type</th>
<th>Date Accepted</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAX-S3104</td>
<td>77,720</td>
<td>Tracer</td>
<td>31 Oct 67</td>
</tr>
<tr>
<td>FAX-S3105</td>
<td>58,850</td>
<td>Ball</td>
<td>7 Nov 67</td>
</tr>
<tr>
<td>FAX-S3106</td>
<td>57,040</td>
<td>Ball</td>
<td>15 Nov 67</td>
</tr>
<tr>
<td>FAX-S3107</td>
<td>92,400</td>
<td>Ball</td>
<td>17 Nov 67</td>
</tr>
<tr>
<td>FAX-S3111</td>
<td>64,160</td>
<td>Ball</td>
<td>5 Dec 67</td>
</tr>
<tr>
<td>FAX-S3113</td>
<td>53,000</td>
<td>Ball</td>
<td>22 Jan 68</td>
</tr>
<tr>
<td>FAX-S3114</td>
<td>97,260</td>
<td>Ball</td>
<td>31 Jan 68</td>
</tr>
<tr>
<td>FAX-S3115</td>
<td>125,440</td>
<td>Ball</td>
<td>5 Feb 68</td>
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<td>FAX-S3116</td>
<td>85,460</td>
<td>Tracer</td>
<td>8 Feb 68</td>
</tr>
<tr>
<td>FAX-S3127</td>
<td>101,200</td>
<td>Tracer</td>
<td>25 Apr 68</td>
</tr>
<tr>
<td>FAX-S3128</td>
<td>113,160</td>
<td>Ball</td>
<td>16 May 68</td>
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</table>

#### Functional Cartridge Lots

<table>
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<tr>
<th>Lot</th>
<th>Qty</th>
<th>Composed of</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAXL-S-3105</td>
<td>81,600</td>
<td>3105 Ball 65,260</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3104 Tracer 16,320</td>
</tr>
<tr>
<td>FAXL-S-3109</td>
<td>108,800</td>
<td>3106 Ball 87,040</td>
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<tr>
<td></td>
<td></td>
<td>3104 Tracer 21,760</td>
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<tr>
<td>FAXL-S-3110</td>
<td>99,200</td>
<td>3107 Ball 79,360</td>
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<tr>
<td></td>
<td></td>
<td>3104 Tracer 19,840</td>
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<tr>
<td>FAXL-S-3112</td>
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<td>3111 Ball 32,640</td>
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<tr>
<td></td>
<td></td>
<td>3104 Tracer 8,160</td>
</tr>
<tr>
<td>FAXL-S-3117</td>
<td>18,400</td>
<td>3113 Ball 14,720</td>
</tr>
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<td>3104 Tracer 3,680</td>
</tr>
<tr>
<td>FAXL-S-3118</td>
<td>121,600</td>
<td>3114 Ball 97,280</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3116 Tracer 24,320</td>
</tr>
</tbody>
</table>
NOTES:
1- WALL THICKNESS VAR. .500 FLAT INSIDE BASE .004 MAX.
2- HARDNESS 1/4" MAX. ABOVE JUNCTION OF BASE & SIDEWALL ON O.D. R/B 65 MAX. (ANNEALED)
NOTES:
1. ALL THICKNESSES ARE .250 MAX.
   M-5-60 FORM 015 MAX.
2. ALL THICKNESSES ARE .250 MAX.
   M-5-60 FORM XXX MAX.

DIA. CONCENTRIC WITH AXIS
ENDS PARALLEL & SQUARE WITH AXIS

DATE: JUNE 3, 1966
5-86-4

FA-33914

FARE+ 2ND DRAW

762MM (STEEL)
APPENDIX D

FRANKFORD ARSENAL
SMALL CALIBER ENGINEERING DIRECTORATE
ENGINEERING DIVISION TMP 301-7.62mm

Project Engineer: Walter Weis, U2200, Ext. 4233
Project Coordinators: P. Bertino, U4100, Ext. 22251
S. White, U4100, Ext. 22251

Subject: Case, Cartridge, Steel, 7.62mm FATIE4, Establish Manufacturing Process

Requirements and Instructions:

Industrial Services Directorate, X1000

1. Purchase sufficient steel strip (phosphate coated and lubricated preferred) in accordance with Specification MIL-S-645 having a carbon content of 0.22 to 0.28 percent and a thickness of 0.150" / 0.006" to produce 150,000 cups. Process the cups in 25,000 lot samples when requested by Project Coordinators through the following sequence of operations, using the tools, inspection limits, hardness controls and solutions listed. Identify each sample lot in sequence beginning with TMP No. 301-7.62mm, Lot 1. Strip width 5.125 ± 0.010.

1.1 Blank & Cup

Press: crank, vertical, double action - Bliss No. 6
Tools: Blanking punch SKFSA 11205 Rev. A
Cupping punch SKFSA 11206
Blank & cup die SKFSA 11207 Rev. B
Stripper SKFSA 11208
Stripper spring PT-1006

Cages & limits: SKFSA 9863 - outside diam. - 0.694-0.700
SKFSA 9864 - base thick. - 0.150-0.156
SKFSA 9865 - wall thick. 0.180 from inside base -0.107-0.117
wall thick. var. 0.180 from inside base-0.004 max.
wall height var.-0.035 max.
weight-194 grs. (approx.)

Solution: 1 1/2 parts water to 1 part Lubro #44 or
4 parts water to 1 part Warco #1673

Hardness: 1/16" from inside base-R_B 80 to 86
1.2 Wash

Barrel: metal, rotary, inclinable, Baird.
Solution: Hot water, 4 cups tri-sodium phosphate; wash for 1/2 hour; Rust preventive: potassium dichromate added to final rinse.

1.3 Anneal

Furnace: Lindberg, atmosphere controlled
Hardness: 1/16" from inside base - $R_B$ 48-55

1.4 Phosphate coat & lubricate

Machine: Ransomatic unit

1.5 First Draw

Press: crank, vertical, duplex - Bliss No. 62
Tools: Punch PT 1291
Guide ring FB 52210
Top die PTC 1982
Bottom die PTC 1983
Stripper PT 1296A
Stripper holder PT 1605
Stripper spring PT 1006

Gages & Limits: SKFSA 9866 - outside dia., 0.595-0.600
FB 36261 - base thick. 0.156-0.158
SKFSA 9867 - wall thick.
0.500 from inside base 0.058-0.062
wall thick, var.
0.500 from inside base 0.004 max.

Solution: 4 parts water to 1 part Warco #1673
Hardness: 1/16" from inside base - $R_B$ 80 to 86

1.6 Wash, Rust Preventive Rinse & Dry

Washer: Niagara
Solution: 9.5 lbs. of Pennsalt to 200 gals. of water
Rust Preventive: 3 oz. of potassium dichromate added to rinse water
1.7 Anneal:

Furnace: Lindberg, atmosphere controlled
Hardness: 1/16" from inside base R_b 48 to 55

1.8 Phosphate Coat & Lubricate

Machine: Ransomatic Unit

1.9 Second Draw

Press: crank, vertical, single action - Bliss No. 304
Tools: Punch PT 1901
Guide ring FB 52211
Top die PTC 1902
Lub. ring SKFSA 10768
Bottom die PTC 121A
Stripper PT 1003D
Stripper holder PT 1005B
Stripper spring PT 1006

Gages & Limits:
FB 36052 - outside diam. 0.516-0.519
SKFSA 9873 - base thick. 0.155-0.165
SKFSA 9874 - wall thick.
1/4" from inside base 0.039-0.045
wall thick. var.
1/4" from inside base 0.005 max.
wall thick.
1 1/8" from inside base 0.020-0.025
wall thick. var.
1 1/8 from inside base 0.003 max.

Solution: 4 parts water to 1 part Warco #1673
Hardness: 1/16" from inside base R_b 81 to 86

1.10 Wash, Rust Preventive Rinse & Dry

Washer: Niagara
Solution: 9.5 lbs. of Pennsalt #30 to 200 gals. of water
Rust Preventive: 3 oz. of potassium dichromate added to rinse water

1.11 Anneal

Furnace: Lindberg, atmosphere controlled
Hardness: 1/16" from inside base R_b 48 to 55
1.12 Phosphate Coat & Lubricate

Machine: Ransomatic unit

1.13 Third Draw

Press: crank, vertical, single action - Bliss No. 304
Tools: Punch FB 52212
      Guide ring SKFSA 10770
      Top die PTC 131A
      Bottom die PTC 132B
      Stripper PT 1004E
      Stripper holder PT 1005B
      Stripper spring PT 1006
Gages & Limits:
      FB 17480 - outside diam. 0.4635-0.4642
      FB 22303 - base thick.
      FB 23471 - wall thick.
          1/4" from inside base 0.035-0.042
          wall thick. var.
          1/4" from inside base 0.006 max.
      FB 23471 - wall thick.
          1.70 from inside base 0.0095-0.0125
          wall thick. var.
          1.70 from inside base 0.002 max.
Solution: 4 parts water to 1 part Warco #1673
Hardness: 1/16" from inside base RB 73 to 79

1.14 Wash, Rust Preventive Rinse & Dry

Washer: Niagara
Solution: 9.5 lbs. of Pennsalt #30 to 200 gals. of water
Rust Preventive: 3 oz. potassium dichromate added to rinse water

1.15 Trim:

Machine: horizontal, single spindle
Tools: Cutter PT 126A
       Spindle PT 1904
       Sleeve PT 1907
       Stripper ring PT 138
       Nut PT 1906
       Burring cutter PT 1905
       Spring PT 1971
Gages & Limits:
      SKFSA 9871 - inside length 1.840-1.860
1.16 Sort

Inspection Belt

1.17 Phosphate Coat & Lubricate

Machine - Ransomatic unit

1.18 Head

Press: horizontal toggle & crank
Tools: Die PT 146E
Eject stem PT 142C
Punch (1 pc.) PT 1038J (Modify pilot to size shown on SKFSA 11277)
Punch (2 pc.) SKFSA 11277
Punch holder SKFSA 11276
Gages & Limits:
   FB 22321 - outside diam. 0.4645-0.4670
   SKFSA 9869 - pocket diam. 0.2077-0.2082
   FB 22323 - pocket depth 0.1265-0.1305
   FB 22303 - web thickness 0.052-0.062
   FB 23482 - pocket concentricity 0.003 max.
   FB 23380 - head crookedness 0.004 max.

1.19 Wash, Rust Preventive Rinse & Dry

Washer: Niagara
Solution: 9.5 lbs. of Pennsait #30 to 200 gals. of water
Rust Preventive: 3 oz. potassium dichromate added to rinse water

1.20 Head Turn

Machine: horizontal single spindle
Tools: Collet PT 1008B
Spring PT 1009
Form tool FB 52213
Gages & Limits:
   FC 2884 - head diam. 0.467-0.471
   FC 2927 - head thick. 0.048-0.053
   FC 2884 - ext. groove diam. 0.403-0.407
1.21 Vent & Deburr

**Machine:** W.F.F. Primer Insert

**Tools:**
- **Punch:** PT 1025
- **Stem:** FB 152563

**Vent**
- **Punch Holder:** PT 1763
- **Punch:** FB 36474
- **Die:** PT 36475
- **Stem:** FB 36476

**1st No. Vent Detect**
- **Holder:** PT 176A
- **Clamp:** PT 175A
- **Stem:** PT 177B
- **Detect Pin:** PT 178

**2nd No. Vent Detect - same as 1st No. Vent Detect**

**Cages & Limits:**
- **SKFSA 9555 - diam. of vent hole 0.675-0.682**

**Note:** Operation and tools mentioned above are to be used when two piece heading punch is used at heading operation. If one piece heading punch is utilized, the Derbyshire venting machine shall be used. Tools for this operation to be established.

1.22 Body Annex

**Machine:** gas (induction preferred - required development for application in Phase II)

**Hardness:** Rockwell 15T (sectioned case)

<table>
<thead>
<tr>
<th>distance from mouth</th>
<th>hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8&quot;</td>
<td>79-83</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>79-83</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>79-83</td>
</tr>
<tr>
<td>7/8&quot;</td>
<td>69 min</td>
</tr>
</tbody>
</table>

1.23 Phosphate Coat & Lubricate

**Machine:** Ransomatic Unit
1.24 Tape & Plug

Press: vertical, double action, crank - Bliss No. 162
Tools: 
- Mouth ironing punch: T 7342
- Mouth ironing die: PT 1000
- Mouth ironing spring: PT 1012
- Shoulder die: PTC 1921A
- Body die: PTC 1989
- Eject stem: PT 1918
- Plug punch: PT 159A

Gages & Limits:
- FB 23520: profile of body
- SKFSA 9870: mouth diam. 0.3078-0.3085
- FB 23522: length, head to shoulder 1.6295-1.6325
- FB 23460: neck diam. 0.3413-0.3433

Lubricant: lard oil (if necessary)

1.25 Wash, Rust Preventive Wash & Dry

Washer: Niagara
Solution: 9.5 lbs. of Pennsalt #30 to 200 gals. of water
Rust Preventive: 3 oz. of potassium dichromate added to rinse water

1.26 Finish Trim

Machine: vertical, single spindle
Tools: 
- Cutter: PTC 1010B
- Cutter holder: PT 1011B
- Support Cover: PT 1011B
- Retainer Seat: PT 1923
- Case Support: T 7242
- Cutter Clamp: PT 1015A

Gages & Limits:
- FB 23526: total length 2.0003-2.0093

1.27 Wash, Rust Preventive Rinse & Dry

Washer: Niagara
Solution: 9.5 lbs. of Pennsalt #30 to 200 gals. of water
Rust Preventive: 3 oz. of potassium dichromate added to rinse water
1.28 Harden
Machine: Westinghouse induction unit
Hardness: 1/16 above extractor groove - HRC 42-50
Temperature: 1650°F ± 10°F
Quench Solution: Caustic Soda 6% ± 0.5%
Quench Solution Temp: 60°F ± 5°F

1.29 Same as Operation #1.27

1.30 Temper
Furnace: Lindberg electric recirculating air
Temperature: 800°F ± 10°F for 75 minutes
Hardness: 1/16 above extractor groove - HRC 22 to 28

1.31 Pickle & Rinse
Machine: Blakeslee pickling unit

1.32 Wash, Rush Preventive Rinse & Dry
Washer: Niagara
Solution: 9.5 lbs. of Pennsalt #30 to 200 gals. of water
Rust Preventive: 3 oz. of potassium dichromate added to rinse water

1.33 Mouth & Neck Anneal
Machine: horizontal straight-line twin screw conveyor, gas
Hardness: Rockwell 15T

<table>
<thead>
<tr>
<th>Distance from Mouth</th>
<th>Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8&quot;</td>
<td>82-86</td>
</tr>
<tr>
<td>1/4&quot;</td>
<td>88 min</td>
</tr>
</tbody>
</table>

1.34 Wash, Rust Preventive & Dry (if necessary)
1.35 Retaper & Replug

Press: vertical, double action, crank - Bliss No. 162
Tools: Plugging punch PT 159A
        Shoulder die  PTC 1990
        Body die      PTC 1989
Gages & Limits:
        SKFSA 9870 - mouth diam. 0.3078-0.3085
        FB 23520 - profile of body
        FB 25522 - length, head to shoulder 1.6295-1.6325
        FB 23660 - neck diam. 0.3413-0.3433
Lubricant: lard oil

1.36 Wash, Rust Preventive Rinse & Dry - Same as #1.32

1.37 Visual Inspect

1.38 Iron Phosphate - to be established and verified

1.39 Varnish - to be established and verified

1.40 Visual inspect

1.41 Prime, Load, Insert Bullet, Gage & Weigh & Inspect -

        Same machines as shown in the Operations Control Section per-
        taining to Cartridge, Ball, NATO, 7.62mm, M80

2. Furnish gages required to accomplish this project

3. Record the following information:

   3.1 number of pieces processed through each operation
   3.2 amount of scrap obtained at each operation
   3.3 number of pieces processed by each tool
   3.4 reason each tool is discarded
3.5 amount and cause of downtime

3.6 annealing and heat treating data (time in each zone, time in cooling chamber, temperature in each zone, temperature and strength of quench solution)

3.7 machine speeds

4. Record and submit a record of BPC bullet pull, velocity, pressure and waterproof tests taken at loading operation.

5. Perform a hardness test on five pieces taken hourly from each of the interdraw anneals, the body and mouth and neck anneals, the temper anneal and quench harden operations. Submit results to project coordinators.

6. Measure five pieces from each cup and draw punch every hour. Record and submit results to project coordinators.

7. Measure five pieces every 30 minutes from the trim operation through all subsequent operations with the exception of the taper and plug and retaper and replug operations, which shall be measured every 15 minutes. Record and submit measurements to project coordinators.

8. Submit a copy of the cartridge case 100% visual inspection before and after varnishing operation, the gage and weigh operation and the 100% cartridge visual inspections to the project coordinators. (Note: It may be necessary to reduce the speed of the inspection operations to obtain proper inspection.)

9. Perform a measurement survey (periodic check) on a sample of ten cartridge cases each taken at the beginning and end of each day.

10. Perform a weight check on samples of ten cartridge cases each, taken from the 2nd 100% visual inspection. The samples shall be taken at the beginning and end of each day.

11. Perform a hardness check on samples of ten cartridge cases each, taken from the 1st 100% visual inspection. The samples shall be taken at the beginning and end of each day. Take readings at positions shown on drawings #10521597. Readings on the head and on the sidewall from the head up to and including the 1.5 inch position shall be read on the Rockwell 15R scale. Position 1.75 shall be read on the Rockwell 15T scale.

12. Perform a hardness test on the strip at the beginning and end of each coil.
13. Supply a sufficient quantity of Bullets, Ball, NATO, 7.62mm, M89 to accomplish tests.
14. Supply a sufficient quantity of primers No. 34 to accomplish tests.
15. Supply a sufficient quantity of Western Ball propellant to accomplish tests.
16. Maintain identity of work through all operations.
17. Furnish a complete cost breakdown of expenditures to Project Engineer.
18. Forward quantities of cartridges specified by Project Coordinators to the Engineering Proof Testing Laboratories, UA200, when requested.
19. Pack cartridges when requested by Project Coordinators.
20. Section cartridge cases as requested by Project Coordinators.
21. Remove tools from machine as each operation is completed and store properly identified.
22. Manufacture additional tools as requested.

Pittman-Dani Research Laboratories, L1000
Mechanical Metallurgy Branch, L7200

23. Furnish photomicrographs of the steel strip microstructure - 750 magnification.
24. Furnish photomicrographs of samples of three components each taken from the interdraw anneals and hardening and tempering operations. Photomicrographs shall be taken of the middle wall area using 750 magnifications.
25. Examine a sample of five cartridge cases each for cold shut determination. Take photomicrographs of them (100 magnification).

Test and Evaluation Division, Q6000
Basic Materials Evaluation Branch, Q6100

26. Perform a wet chemical analysis on a sample of steel cartridge case strip from each coil.
27. Perform hardness determinations as requested by Project Coordinators.
28. Perform a salt spray test utilizing a 5% solution on a sample of five cartridge cases. Method of test shall be in conformance with Federal Test Method Standard No. 151.

29. Perform a salt spray test utilizing a 5% solution on a sample of five cartridges. Method of test shall be in conformance with Federal Test Method Standard No. 151.

30. Forward samples of steel cartridge case strip to Basic Materials Evaluation Branch, Q6100 for a wet chemical analysis.

31. Forward samples of the steel cartridge case strip to Mechanical Metallurgy Branch, L7200, for photomicrographs of grain structure.

32. Forward three components from each interdraw anneal and hardening operation to Mechanical Metallurgy Branch, L7200 for photomicrographs of grain structure.

33. Forward five finished cases to Mechanical Metallurgy Branch, L7200, for cold shut determinations and photomicrographs. Take from Head Operation.

34. Forward samples of finished cases to the Basic Materials Evaluation Branch, Q6100, for hardness determinations.

35. Forward samples of varnished cartridge cases and cartridges assembled with varnished cases to Environmental Branch, Q6200, for salt spray testing.

36. Properly identify all samples as to program number, operation and type of test to be performed.
APPENDIX E

FRANKFORD ARSENAL
AMMUNITION DEVELOPMENT & ENGINEERING LABORATORIES
ENGINEERING DIVISION TMP-305-7.62MM, STEEL

Project Engineer: Walter Weis, J7200, Ext 4233
Tool & Component Design Engineer: Rudolph Groskurth, J7200, Ext 4194
IED Technical Administrator: Joseph Charno, J9100, Ext 3241
Process Engineers: Peter Bertino, J9100, Ext 22251
S. White, J9100, Ext 22251
Support Engineering:
Metallurgy: E. Dougherty, J4500, Ext 24195
Chemistry: W. Svekla, J4400, Ext 24285
Subject: Manufacturing of 1 Million Case, Cartridge, Steel, 7.62mm, M80 & M62 for Engineering and Service Tests

Instructions and Requirements:

1. Sufficient steel (40 tons) to produce 1 million 7.62mm steel cartridge cases, drawing No. FB 30544, was ordered from Sharon Steel Co. in two heats. The first heat (approximately 45,000 lbs) heat No. 529328 will be delivered to Frankford Arsenal on or about 17 April 1967. This steel has a carbon content of .26%. The second heat will be poured to supply the remainder of the order by 15 May 1967. The steel will not be phosphate coated. ISD shall process this strip in the following manner using the sequence of operations, tools, inspection limits, hardness controls, and solutions listed below.

NOTE: It is imperative that the information requested throughout this TMP be gathered as required. This information is required to prepare specifications, Technical Data Packages, manufacturing procedures, and a final report at the completion of the program. Therefore, each area responsible for portions of this TMP shall acknowledge by submitting the information monthly starting May 1967, to the Project Engineer, Mr. Walter Weis, Bldg. 219-2.
Any discrepancies or changes to this TAP shall be brought to the attention of the Project Engineer as soon as noted.

1.1 Blank & Cup

Press: crank, vertical, double action - Bliss No. 6

Tools: Blanking Punch, SKFSA 11205, Rev C
      Cupping Punch, SKFSA 11206, Rev C
      Blank & Cup Die, SKFSA 11207, Rev E
      Stripper, SKFSA 11208
      Stripper Spring, PT-1006
      Stripper Holder, SKFSA 3682

Gage Limits:  SKFSA 9863 - 0.0, 0.594-0.700
             SKFSA 9864 - Base thick. 0.150-0.156
             SKFSA 9865 - Wall thick. 0.160 inside
               Base - 0.107-0.117
               Wall thick. variation - 0.180 from inside
               Base - 0.605 max
               Wall height variation - 0.035 max
               Weight - 194 gms (approx)

Solution: 1-1/2 parts water to 1 part Lubro No. 44

Hardness: 1/16" from junction of base and sidewall
          Rb 80 to 86

1.2 Wash, Rust Prevent

Barrel: metal, rotary, inclinable, Baird

Solution: Hot water, 4 cups tri-sodium phosphate; wash for 1/2 hour; Rust Preventive: potassium dichromate added to final rinse.

1.3 Anneal

Furnace: Lindberg, atmosphere controlled

Temperature: 1320°F

Time in furnace: longest time possible (approx 162 min)

Hardness: 1/16" from junction of base and sidewall
          Rb 65 max
1.4 Phosphate Coat & Lubricate

Machine: Ransomeatic unit or other appropriate equipment

1.5 First Draw

Press: crank vertical duplex Bliss No. 62
Tools: Punch PT-1291
    Guide Ring PT-1966A
    Top Die PT-1982
    Bottom Die PT-1983
    Stripper PT-1296A
    Stripper Holder PT-1005
    Stripper Spring PT-1006

Cage Limits: SKFSA 9866 - O.D. 0.505-0.600
    FS 36261 - base thick. 0.150-0.156
    SKFSA 9867 - wall thick. 0.437 from inside base
                  0.058-0.062
    wall thick, var. 0.437 from inside base - 0.004 max

Solution: 6 lbs industrial soap chips to 50 gals water. If difficulties are encountered, revert to 4 parts water to 1 part Warco No. 1673
Hardness: 1/16" from inside base Rb 80 to 86

1.6 Wash, Rust Preventive Rinse & Dry

Washer: Niagara
Solution: 7.5 lbs of Pensalt to 200 gals of H2O
Rust Preventive: 3 oz of potassium dichromate added to rinse water

1.7 Anneal

Furnace: Lindberg, atmosphere controlled
Temperature: 1320°F
Time in Furnace: longest time possible (approx 102 min)
Hardness: 1/16" above junction of base and sidewall Rb 66 max
1.8 Phosphate Coat & Lubricate

Machine: Ransomatic unit or other appropriate equipment

1.9 Second Draw:

Press: crank, vertical, single action, Bliss No. 304

Tools:
- Punch: PT-1901
- Guide Ring: FB 52211
- Top Die: PTC-1902
- Lub Ring: SKFSA 10768
- Bottom Die: PTC-121A
- Stripper: PT-1003D
- Stripper Holder: PT-1005B
- Stripper Spring: PT-1006

Gages & Limits:
- FB 36052 - 0.0, 0.516-0.519
- SKFSA 9873 - base thick. 0.155-0.165
- SKFSA 9874 - wall thick. 1/4" from inside base 0.039-0.045
- wall thick var. - 1/4" from inside base 0.005 max
- SKFSA 9875-1 1/8" from inside base
  wall thick - 0.020-0.025
  wall thick var - 1 1/8" from inside base 0.003 max

Solution: 6 lbs industrial soap chips to 50 gals water. If difficulties are encountered, revert to 4 parts water to 1 part Warco No. 1673.

Hardness: 1/16" above junction of base and sidewall
- RB 81 to 86

1.10 Wash, Rush Preventive Rinse & Dry

Washer: Niagara - See 1.6

1.11 Anneal

Furnace: Lindberg, atmosphere controlled
Temperature: 1320°F
Time in furnace: longest time possible (approx 102 min)
Hardness: 1/16" above junction of base and sidewall
- RB 69 max
1.12 Phosphate Coat & Lubricate

Machine: Ransome's unit or other appropriate equipment

1.13 Third Draw

Press: crank, vertical, single action, Bliss No. 304
Tools: Punch PT 1903A
Guide Ring SKFSA 10770
Top Die PTC 131A
Bottom Die PTC 132A
Stripper PT1004E
Stripper Holder PT1005E
Stripper Spring PT1006

Gages & Limits: FB 17480 outside dia. 0.4636-0.4642
FB 22303 base thick. 0.165-0.174
FB 23471 wall thick. 1/4" from inside base 0.035-0.042
wall thick, var. 1/4" from inside base 0.006 max
FB 23471 wall thick 1.70 from inside base 0.0095-0.0125
wall thick, var. 1.70 from inside base 0.002 max

Solution: 6lbs commercial soap chips to 50 gallons water.
If difficulties are encountered, revert to 4 parts water to 1 part Warco No. 1673

Hardness: 1/16" above junction of base and sidewall
R 73 to 79
B

1.14 Wash, Rust Preventive Rinse & Dry

Washer: Niagara - See 1.6
3.15 Trim

**Machine:** horizontal, single spindle

**Tools:**
- Cutter: SKFSA 10268
- Spindle: F1 30254
- Sleeve: SKFSA 6118
- Stripper Ring: SKFSA 6122
- Nut: F1 30255
- Burring Cutter: SKFSA 6119
- Spring: SKFSA 6123

**Cage & Limits:** SKFSA 9371 - inside length 1.840-1.860

3.16 Sort

Inspection Belt

3.17 Bend

**Press:** horizontal toggle & crank

**Tools:**
- Die: PT-1462
- Eject Stem: PT-1426
- Punch (1 pc): SKFSA-11277
- Punch (2 pc): SKFSA-11276

**Cage & Limits:**
- F1 22321 - outside dia. 0.6545-0.6670
- SKFSA 5869 - pocket dia. 0.2277-0.2382
- F1 22323 - pocket depth 0.1265-0.1365
- F1 22303 - web thick. 0.052-0.062
- F1 23482 - pocket concentricity 0.003 max
- F1 23380 - bend crookedness 0.004 max

3.18 Wash, Rest Preventive Rinse & Dry

**Washer:** Niagara - See 1.6
1.19 Head Turn

Machine: horizontal single spindle  
Tools: Collet PT-1008B  
Spring PT-1009  
Form Tool FB 52213 (carbide type C6)  
Gages & Limits:  
FC 2884 - head dia. 0.467-0.471  
FC 2927 - head thick. 0.048-0.053  
FC 2884 - ext groove dia. 0.403-0.407

1.20 Vent & Deburr

Machine: WFF Primer Insert  
Tools: Burr  
Punch FB 56637  
Stem FB 18636B  
Vent  
Punch Holder PT-170B  
Punch FB 36474  
Die FB 36475  
Stem FB 36476  
1st No Vent Detect  
Holder PT-176A  
Clamp PT-179A  
Stem PT-177B  
Detect Pin PT-178  
2nd No Vent Detect - Same as 1st No Vent Detect  
Gages & Limits: SKFSA 9868 - dia. of vent hole 0.078-0.082

Note: Operation and tools mentioned above are to be used when two piece heading punch is used at heading operation.

1.21 Taper & Plug

Press: vertical, double action, crank - Bliss No. 162  
Tools: Mouth ironing punch FA 33875  
Mouth ironing die PT-1000  
Mouth ironing spring PT-1012  
Shoulder Die SKFSA 6143  
Body Die PTC-1989  
Eject Stem PT1918 or SKFSA 6142  
Plug Punch PT-159A
1.21 Taper & Plug (cont'd)

Gages & Limits:
- FB 23520 - profile of body
- SKFSA 9870 - mouth dia. 0.3078-0.3085
- FB 23522 - length, head to shoulder 1.6295-1.6325
- FB 23460 - neck dia. 0.3413-0.3433

Lubricant: machine oil

1.22 Wash, Rust Preventive Rinse & Dry

Washer: Niagara (see 1.6)

1.23 Finish Trim

Machine: vertical, single spindle
Tools:
- Cutter: PTC 1010B or SKFSA 6148
- Cutter Holder: PT-1011B or SKFSA 6147
- Support Cover: PT-1014 or SKFSA 6149
- Retainer Seat: PT-1923 or SKFSA 6150
- Case Support: FA 33876 or SKFSA 6149
- Cutter Clamp: PT-1015A or SKFSA 6149

Gages & Limits: FB 23526 - total length 2.903-2.0093

1.24 Wash, Rust Preventive Rinse & Dry

Washer: Niagara (see 1.6)

1.25 Harden (Temper within two hours)

Machine: Westinghouse induction unit
Hardness: 1/16" above extractor groove -Rc 42-50
Voltage Setting: To be established
Quench Solution: Caustic Soda 6% ± 0.5%
Quench Solution Temp: 60°F ± 5°F

1.26 Wash, Rust Preventive Rinse & Dry

Washer: Niagara (see 1.6)
1.27 Temper (within two hours of Harden 1.25)

Furnace: Lindberg, electric, recirculating air
Temperature: 800°F ± 10°F for 75 minutes
Hardness: 1/16" above extractor groove A = 22 to 28.

1.28 Clean & Rinse

Machine: Blakeslee pickling unit
Cleaning agent to be established.

1.29 Wash, Rust Preventive Rinse & Dry

Washer: Niagara (see 1.6)

1.30 Retaper & Replug (if necessary)

Press: vertical, double action, crank – Bliss No. 62
Tools: Plugging Punch PT-159A
Shoulder Die SKFSA 6143
Body Die PTC-1989
Gages & Limits: SKFSA 9870 – mouth dia 0.3078-0.3085
FB 23520 – profile of body
FB 25522 – length, head to shoulder 1.6295-1.6325
FB 23460 – neck dia 0.3413-0.3433

1.31 Wash, Rinse & Dry (if retaper is necessary)

Washer: Niagara (see 1.6)

1.32 Visual Inspect

1.33 Iron Phosphate – to be established
Process will be provided at a later date.
Alternate method – Plating Shop Bldg 46-1

1.34 Varnish – to be established
Process will be provided at a later date.
Alternate method – Ronci varnishing machine and curing oven located in Bldg 39.
1.35 Visual Inspect

1.36 Prime, Load, Gage & Weigh & Inspect

Same machines as shown in the Operations Control Section pertaining to Cartridge, Ball & Tracer, .50, .50mm, .300 and .502.

2. Furnish gages required to accomplish this project.

3. Record the following information:

3.1 Number of pieces processed through each operation.

3.2 Amount of scrap obtained at each operation.

3.3 Number of pieces processed by each tool.

3.4 Reason each tool is discarded.

3.5 Amount and cause of downtime.

3.6 Machine speeds.

4. Perform a hardness test on five pieces, taken hourly, from each of the interdraw anneals, the quench harden and temper anneal operations. Submit results to Project Engineer, Mr. W. Weis.

5. Measure five pieces from each cup and draw punch every hour. Record and submit to Project Engineer.

6. Measure five pieces every 30 minutes from the trim operation through all subsequent operations with the exception of taper and plug and retaper and replug (if needed), which shall be measured every 15 minutes. Record and submit measurements to Project Engineer.

7. Submit a copy of the cartridge case 100% visual inspection before and after varnishing operation, the gage and weigh operation, and the 100% cartridge visual inspections to the Project Engineer.
8. Perform a measurement survey (periodic check) on a sample of ten cartridge cases each, taken at the end of each day.

9. Perform a weight check on samples of ten cartridge cases each, taken from the second 100% visual inspection. The samples shall be taken at the end of each day.

10. Perform a hardness check on samples of ten cartridge cases each taken from the first 100% visual inspection. The samples shall be taken at the end of each day. Take readings at positions shown on drawing No. D10021997. Readings shall be taken similar to brass case using Vickers BPS and 2-1/2 K load. Once each week ten cases shall be sectioned, one-half section mounted and hardness tests taken at the same positions on the sectioned sidewall using Vickers or Tukon BPS with a 2-1/2 K load.

11. Perform a hardness test on the strip at the beginning and end of each coil. Use Rockwell "B" scale.

12. Supply a sufficient quantity of Bullets, Ball, NATO, 7.62mm, M52 for loading and assembling 650,000 Ball, M52, Cartridges.

13. Supply a sufficient quantity of Bullets, Tracer, NATO, 7.62mm, M52 for loading and assembling into 250,000 Tracer, M52 Cartridges.

14. Supply a sufficient quantity of No. 34 primers for tests and one million production quantity.

15. Supply a sufficient quantity of Western Ball, MG46 propellant to accomplish testing and the one million production quantity.

16. Maintain identity of work through all operations.

17. Furnish a complete cost breakdown of expenditures to Project Engineer, Mr. W. Weis.
18. Forward quantities of cartridges specified by Project Engineer to Engineering Proof Testing Laboratories, J9200, when requested.

19. Pack cartridges when requested.

20. Remove tools from machine as each operation is completed and store properly identified, unless otherwise specified.

21. Manufacture additional tools, if required.

   Pitman Dunn Research Lab, L1000
   Mechanical Metallurgy Branch, L7200

22. Furnish photomicrographs of the steel strip microstructure - 750 magnification.

23. Furnish photomicrographs of samples of three components each, taken from the interdraw anneals, hardening and tempering operations. Photomicrographs shall be taken of the middle wall area using 750 magnification.

24. Examine a sample of five cartridge cases each for cold shut determinations. Take photomicrographs (100 magnification).

   Test & Evaluation Division, Q6000
   Basic Materials Evaluation Branch, Q6100

25. Perform a wet chemical analysis on a sample of steel cartridge case strip from each heat of Sharon Steel.

26. Perform hardness determinations as requested by Project Engineers.

   Environmental Branch, Q6200

27. Perform salt spray test using 5% and 20% solutions on a sample of five cartridge cases. Method of test shall be in conformance with Federal Test Method Standard No. 141.
28. Perform salt spray tests utilizing 5% and 20% solutions on samples of five cartridges. Method of test shall be in conformance with Federal Test Method Standard No. 141.

Ammunition Development & Engr Lab, J4000
Metallurgical Engr Branch, J4400

29. Forward samples of cartridge case steel strip (Sharon Steel Co) from both heats of steel to Basic Materials Evaluation Branch, Q6100, for wet chemical analysis.

30. Forward samples of the cartridge case steel strip (Sharon Steel Co) from both heats of steel to Mechanical Metallurgical Branch, L7200, for photomicrographs of grain structure.

31. Forward three components from each interdraw anneal, hardening and tempering operation to Mechanical Metallurgical Branch, L7200, for photomicrographs of grain structure.

32. Forward five headed components to Mechanical Met Branch, L7200, for cold shut determinations and photomicrographs.

33. Provide metallurgical technical assistance where and when required.

Chemical Engr Branch, J4300

34. Forward samples of varnished cartridge cases and cartridges assembled with varnished cases to Environmental Branch, Q6200, for salt spray testing.

35. Provide chemical technical assistance where and when required.

Small Caliber P&M Engr Lab, J9000
Ammunition Engr Branch, J9100

36. Forward samples of finished cases to Basic Materials Evaluation Branch, Q6100, for hardness determinations.

37. Provide technical assistance relative to tooling and process where and when required.
Under the Copper Conservation Program, a process was established and pilot facilities set up at Frankford Arsenal for the production of a heat treated steel case for 7.62mm cartridges.

Work was based upon a previous attempt to develop a 7.62mm steel case which was partially successful. Small lots of cases were manufactured until a satisfactory process was obtained. The process thus developed was used for production of one million ball and tracer cartridges which were submitted for ET/ST.

The report covers process development, process metallurgy, processing methods, test results, and quality assurance.
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