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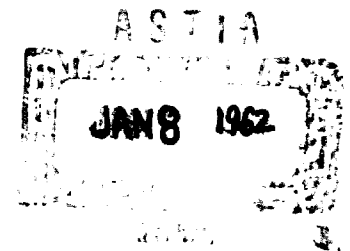
INDUSTRIAL ENGINEERING DIVISION

Lake City Arsenal

Independence, Missouri

**ENGINEERING FOR PRODUCTION OF CARTRIDGE,
20MM, HPT, M54E2**

I. E. D. REPORT NR. 61-15



PROJECT:

OAC 5749

OCTOBER 1961

BEST AVAILABLE COPY

INDUSTRIAL ENGINEERING DIVISION
LAKE CITY ARSENAL
Independence, Missouri

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OF CARTRIDGE, 20MM, HPT, M54E2

Industrial Engineering Division
Report No. 61-15

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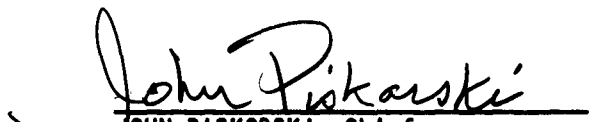
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Production Engineering Branch, IED

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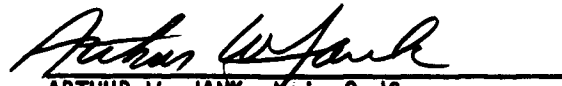

ARTHUR W. JANK, Maj, OrdC
Commanding

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I. ABSTRACT

Feeding and ramming difficulties during short burst automatic fire with the Cartridge, 20MM, HPT, M54 were traced to the external configuration of the projectile nose; a redesign being indicated. Frankford Arsenal developed the T46 and T51 Projectiles which proved satisfactory in limited tests. The T46 closely followed standard (M55) Projectile design, but the T51 was completely unconventional, being of one-piece construction. The central portion of the body O.D. was reduced for weight control, giving it a distinctive "dumbbell" shape (See drawing in Appendix A). A cost study by IED indicated the T51 design to be the more economical to manufacture and its unusual shape made it inherently identifiable. The one-piece construction also eliminated nose assembly difficulties and security problems during feeding and ramming. Minor design and dimensional changes were made to the T51 projectile to promote volume production and it was designated the M54E2. Engineering for production was completed with the satisfactory production and acceptance of a production quantity of 121,000 Cartridge, 20MM, HPT, M54E2 at LCA.

It is recommended that the Cartridge, 20MM, HPT, M54E2 be standardized as the Cartridge, 20MM, HPT, M54A1 for procurement where high pressure test ammunition is required for use in 20mm aircraft weapons of the M39 or M61 type.

11. INTRODUCTION:

The Cartridge, 20MM, HPT, M54 was developed by Frankford Arsenal to meet the requirement for ammunition loaded to 120% service pressure for weapon and barrel acceptance purposes. In the course of development of this cartridge, it was found expedient to obtain the required excess pressure by utilizing a projectile weighing 1965 grains instead of the normal 1521 grains weight of service projectiles. The heavier (2,000 grains) M99 Projectile modified by cutting off the tip of the nose to achieve correct length was found to meet these requirements and was subsequently utilized in the Cartridge, 20MM, HPT, M54. After standardization of the M54 Cartridge, difficulties were attributed to interference of the square or flat meplat on the nose of the modified M99 Projectile with the gun feed chuting and feeder which were designed to accommodate the rounded nose of the standard service ammunition.

Frankford Arsenal accordingly initiated development of a new item and generated two designs. One of the designs, T46, is a modification of the current M55 Projectile design (smaller cavity), but the other, T51, has an unusual external configuration, the body being solid and having metal removed from the O. D. for weight control. This results in a "dumbbell" shape. Limited tests of these two designs conducted by Frankford Arsenal were satisfactory.

As a result of the continuing technical liaison maintained with Frankford Arsenal, initial engineering for production of the M54E2 Cartridge was initiated by the IED, LCA, to coincide with completion of development by Frankford Arsenal.

During the latter part of 1956, Lake City Arsenal was assigned a production order for a quantity of approximately 120,000 Cartridges, 20MM, HPT, M54. Because of difficulties encountered in meeting ballistic acceptance requirements (pressure) in the production of these cartridges, completion of the engineering for production of the Cartridge, 20MM, HPT, M54E2 was expedited by the IED, LCA.

Since M99 Projectiles were unavailable, it was a propitious time to make a design change.

III. PROCEDURE:

The T46 and T51 sketches forwarded from Frankford Arsenal were studied, indicated changes made, and were placed on Ordnance format drawings.

A cost and feasibility study was made by IED to determine which of the two FA designs was the more economical to manufacture, and which would result in the more satisfactory over-all item. Drawings were forwarded to prospective vendors for comment as to producibility and cost. Suggestions resulting from this survey were evaluated and those found valid were incorporated into the item selected.

Test quantities of the selected item were manufactured by the Contractor-Operator, LCA. Minor dimensional difficulties in the nose area were encountered and drawing changes were made as required. Firing tests were conducted to determine if interference problems had been corrected.

The latest rotating band seat configuration was applied to the LCA sketches of this projectile for uniformity of tooling and economical purchase of band blanks.

Projectile weight was specified at 1965 $\pm$ 10 grains per ballistic studies made by the Ballistic Engineering Branch, Industrial Engineering Division. (See IED Report No. 58-4).

Action toward a new purchase description for the projectile described herein was initiated by Lake City Arsenal.

IV. RESULTS:

The cost and feasibility study indicated the T51 design projectile to be cheaper than the T46 to manufacture even by commercial vendors who were currently producing the M55A1 and A2 Projectile which is very similar to the T46 design. In addition, its one-piece construction eliminated nose assembly costs and security problems, and provided positive identification with its unconventional "dumbbell" shape.

Vendors reported that the T51 design would present no major manufacturing problem, except that at least one-quarter inch (1/4") length was required forward of the rotating band for the rechucking operation (trim band, reduce heel diameter, cut crimp groove, and cut radii on heel).

Initial test quantities manufactured at Lake City Arsenal by the Contractor-Operator indicated that minor dimensional changes were necessary. These were the dimensions which control forming of the nose portion of the projectile. The 1.086" - .020" nose length dimension was too restrictive when using the 30° basic angle specified. Also, it was

found that the front bourrelet would be as short as .114" under certain conditions. The nose angle was changed to $32^{\circ} 30' \pm 0^{\circ} 30'$, the nose radius to .130" + .005 , and the nose length to 1.020" max. A bourrelet length of .180" approximate was assured by the above dimensional changes.

A study of ballistic problems associated with this projectile has been prepared and published as Industrial Engineering Division Report No. 58-4, entitled "Ballistic Study of Projectile, HPT, 20MM, M54E2".

Purchase Description LCA-PD-3 covers specifications for and inspection of Projectile, 20MM, HPT, M54E2.

Approximately 11% of the first 92,000 items produced were outside the specified weight limits. Examination of the production records indicated that 99.2% of the last production lot met the specified weight tolerance of 1965 ± 10 grains. This percentage figure closely approaches the AQL (Acceptance Quality Limit) recommended for the weight characteristic in the specification (LCA-PD-3) prepared for this projectile.

Physical constants were measured and are contained in Appendix D of this report.

V. CONCLUSIONS:

Results of the initial production engineering study indicated the FA T51 projectile design to be preferable to the FA T46 design on the basis of:

- a. Cost
- b. Elimination of nose assembly costs and nose security.
- c. Easy and positive identification. Eliminates need for stannic stained cartridge case.

The Projectile, 20MM, HPT, M54E2 as production engineered by the Industrial Engineering Division, LCA, satisfactorily meets all ballistic and functioning requirements.

V. RECOMMENDATIONS:

It is recommended that the Cartridge, 20MM, HPT, M54E2 be standardized as the Cartridge, 20MM, HPT, M54A1 and that any future requirements for the ammunition be fabricated as this cartridge.

VII. APPENDICES.

APPENDIX A.

Design T46, Drawing FC 5950
Design T51, Drawing FD 18218

APPENDIX B.

Projectile, 20mm, HPT, M54
Drawings D7553822
D7553823
C7553824

APPENDIX C.

Projectile, 20mm, HPT, M54E2
Drawings D7258859
D7258860

APPENDIX D.

Physical Constants.

APPENDIX E.

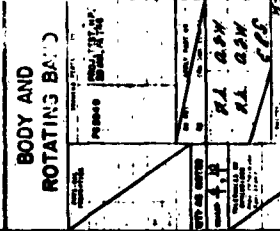
Distribution List

APPENDIX A

Projectile, 20MM, HPT:

Design T46, Dwg. FC 5950

Design T51, Dwg. FD 18218



VIEW OF ROTATING BAND
AND CRIMPING GROOVE

SURFACE-
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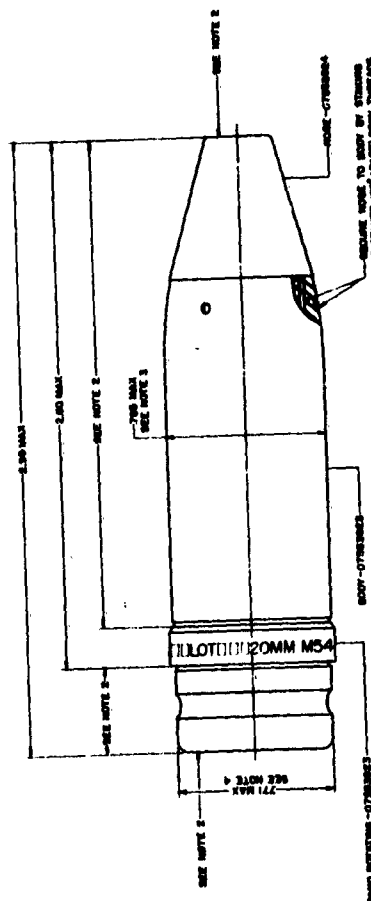
APPENDIX B

Projectile, 20MM, HPT, M54:

Drawing D7553822

Drawing D7553823

Drawing C7553824



WOMEN HAVE TO STOP BY STRESS
TO SLOWER AND AVOID THE
TO MORE FREQUENT WITH OVER THE
PLAT MORE PUNCH AS TO AS WITHIN
NAME SMALL WITHIN THE AS TO AS
(COURT-CLOTHES) WITHOUT LONGER

SET OF SPECIFICATIONS AND STANDARDS

LINE	CHARGE	PART	NAME	UNIT	QTY	UNIT PRICE	TOTAL
1	0 794 3411		PROBABLE TEST, HP 200000000	1000 SET			
2	0 795 3420		PROBABLE TEST, HP 200000000	78 APPROX			
3	0 794 3413		PROBABLE TEST, HP 200000000	1897 APPROX			
4	0 795 3421		PROBABLE TEST, HP 200000000	500.57			
5	0 795 3422		PROBABLE TEST, HP 200000000	500.57			

NO.	DATE	TITLE	NO. OF PAGES	DATE
1		RETN. MATH. ANALYSIS FOR PROBABILTY, TEST. OF HYP. AND	ML-8-43	
2		RETN. MATH. FOR PROB. AND STATS. EDUC.	54-1-130	
3		STAT. THEORY AND METHODS	ML-3-130	
4		STAT. THEORY AND METHODS	ML-3-130	
5		STAT. THEORY AND METHODS	ML-3-130	
6		STAT. THEORY AND METHODS	ML-3-130	
7		STAT. THEORY AND METHODS	ML-3-130	
8		STAT. THEORY AND METHODS	ML-3-130	
9		STAT. THEORY AND METHODS	ML-3-130	
10		STAT. THEORY AND METHODS	ML-3-130	

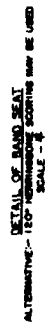
1. CLEAN AND PREPARE ALL METAL SURFACES IN ACCORDANCE WITH GRADE-1, SPEC 100-1-1000, AND GRADE 2 PAINTING.
2. COAT ENTIRE EXTERIOR SURFACE OF ASSEMBLY, EXCEPT JOINTS, WITH EPOXY, UNLIMITED, 200, SPEC 100-1-1000, SPEC 100-1-1000 (BLACK, NO. 3725 SPEC 11-C-1000).
3. DOWNGRADE TWO MAX ON THE DOWNWELET APPLIES AFTER PAINTING, INCLUDING TOUCH-UP.
4. DOWNGRADE 771 MAX AT REAR OF NOTWING APPLIES AFTER PAINTING.

*NOTE-
WENT OF BODY AND
ROTATING BAND ASSEMBLY
LOOKS TO BE SEARS.

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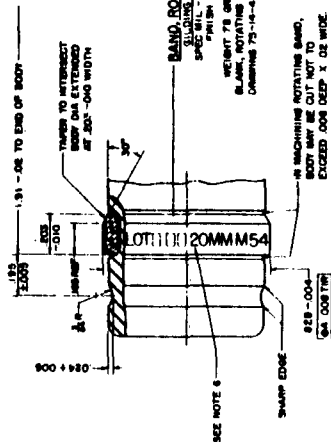
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DATE 08-11-2010 BY 60322 UCBAW

017553823



BODY
* STEEL - 301-5-43
C11137
C11141
SPEC. 00-2-433
A181 C1132 @
A181 C1144 @
FINISH 123 / EXCEPT AS NOTED
WEIGHT 1597 GRAMS APPROX

BAND, ROTATING
GLIDING METAL
SPEC MIL - 8 - 2029C
PARTIAL 123



**VIEW OF ROTATING BAND
AND CRIMPING GROOVE**

FOR THE 1. NAME OF THE 2. ADDRESS 3. CITY 4. STATE 5. ZIP CODE		FOR THE 6. NAME OF THE 7. ADDRESS 8. CITY 9. STATE 10. ZIP CODE		FOR THE 11. NAME OF THE 12. ADDRESS 13. CITY 14. STATE 15. ZIP CODE		FOR THE 16. NAME OF THE 17. ADDRESS 18. CITY 19. STATE 20. ZIP CODE		FOR THE 21. NAME OF THE 22. ADDRESS 23. CITY 24. STATE 25. ZIP CODE		FOR THE 26. NAME OF THE 27. ADDRESS 28. CITY 29. STATE 30. ZIP CODE		FOR THE 31. NAME OF THE 32. ADDRESS 33. CITY 34. STATE 35. ZIP CODE		FOR THE 36. NAME OF THE 37. ADDRESS 38. CITY 39. STATE 40. ZIP CODE		FOR THE 41. NAME OF THE 42. ADDRESS 43. CITY 44. STATE 45. ZIP CODE		FOR THE 46. NAME OF THE 47. ADDRESS 48. CITY 49. STATE 50. ZIP CODE		FOR THE 51. NAME OF THE 52. ADDRESS 53. CITY 54. STATE 55. ZIP CODE		FOR THE 56. NAME OF THE 57. ADDRESS 58. CITY 59. STATE 60. ZIP CODE		FOR THE 61. NAME OF THE 62. ADDRESS 63. CITY 64. STATE 65. ZIP CODE		FOR THE 66. NAME OF THE 67. ADDRESS 68. CITY 69. STATE 70. ZIP CODE		FOR THE 71. NAME OF THE 72. ADDRESS 73. CITY 74. STATE 75. ZIP CODE		FOR THE 76. NAME OF THE 77. ADDRESS 78. CITY 79. STATE 80. ZIP CODE		FOR THE 81. NAME OF THE 82. ADDRESS 83. CITY 84. STATE 85. ZIP CODE		FOR THE 86. NAME OF THE 87. ADDRESS 88. CITY 89. STATE 90. ZIP CODE		FOR THE 91. NAME OF THE 92. ADDRESS 93. CITY 94. STATE 95. ZIP CODE		FOR THE 96. NAME OF THE 97. ADDRESS 98. CITY 99. STATE 100. ZIP CODE	
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4. MAY BE VARIED TO OBTAIN REQUIRED WEIGHT.

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APPENDIX C.

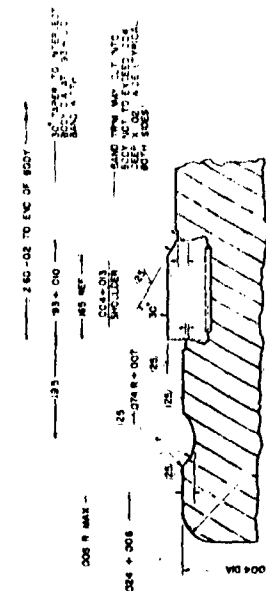
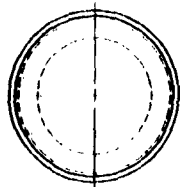
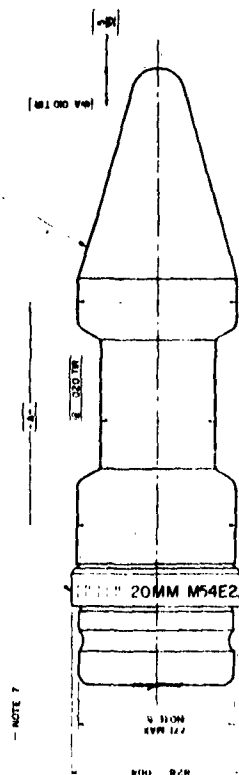
Projectile, 20MM, HPT, M54E2:

Drawing D7258859

Drawing D7258860

D 7258859

—BLANK, ROTATING BAND—7258859 —BODY—7258860



ENLARGED VIEW OF ROTATING BAND AND CRAMP GROOVE

PROPOSED MARKED BAND HEIGHT .0015
CRAMP GROOVE REMOVES APPROX .0015
BODY.

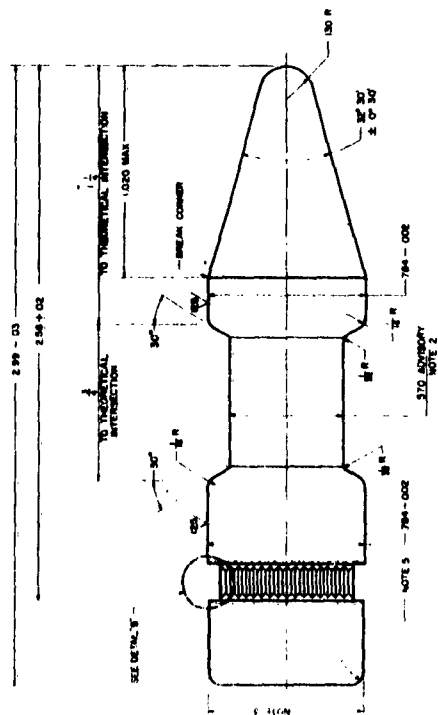
FOR LIST OF PARTS SEE
ENGINEERING PART LIST 7258859

ENGINEERING PART LIST 7258859

ITEM	DESCRIPTION	QTY	UNIT	REMARKS
1	PROJECTILE, HIGH PRESSURE TEST	1	PC	
2	20MM M54E2	1	PC	
3	ASSEMBLY	1	PC	

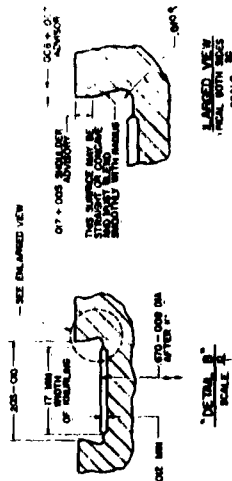
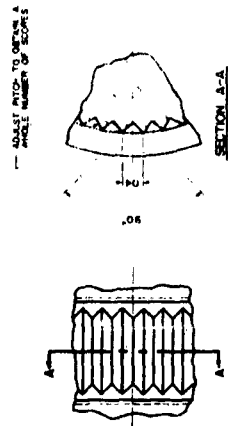
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220. ALL OVER EXCEPT AS NOTED

- NOTES: -
- 1 SPECIFICATIONS WL-6-2300, WL-STD-8, WL-STD-10 AND LCA-PO-8 APPLY
 - 2 THIS SWITCHING MAY BE VAIRED TO CONTROL WEIGHT
 - 3 CUMULATIVE BASE TO BE 780-004 ON PRESSED BODY AND NOTATIME BAND ASSEMBLY BEFORE PARTING.
 - 4 BODY WEIGHT SET ON APPROX. TO BE CONTROLLED TO MEET WEIGHT 780-003 ON RECALCULATED WEIGHT OF 780-003
 - 5 PEOPLE ON PRESSED BODY & NOTATIME BAND ASSEMBLY TO BE 780-003 ON RECALCULATED WEIGHT



CALL TOLL FREE 800 725 8860

BODY

ORDNANCE CORPS
CAPT OF THE ARMY
JAME CITY ARMY
HEADQUARTERS, ARMY
7258860

7258860

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APPENDIX D

Physical Constants of M54E2 Projectile

Lot Nr. - LC-3-4-57
Axial Moment, A - 8.1306 gm - in²
Trans Moment, B - 80.7287 gm - in²
Center of Gravity - 1.52 cal from base
 $A^2/B = .8189$
 $\frac{2B}{A} - 1 = 19.858$

APPENDIX E
DISTRIBUTION LIST

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