CC. G. O. Clifford (18)
G. R. McCormick
R. A. A. Hentschel
P. D. Rutherford
M. H. Walker
R. H. Grass
H. C. Moss
C. J. Kirchen
W. Holloway
File (2)
Notebook #299

September 24, 1945

FINAL REPORT

721 & 722 MODEL GUN TEST

REC. R.A.A.H.
SEP 26 1945

Period. Sept. 27, 1944 to Jan. 31, 1945.
Project: L-3121 P.O. 17032
Notebook: #299
Prepared By. H. C. Moss

INTRODUCTION

On October 20, 1944, two model guns were turned over to the Engineering Unit from Design for endurance testing. Both of those were bolt-action, high-powered rifles; the M/721 in caliber .300 H & H Magnum and the M/722 in caliber .300 Savage

The Design Unit had performed sufficient tests on these two models to be reasonably certain that the design was sound. The Engineering Unit, acting as an impartial group, was asked to thoroughly test both guns.

PROGRAM

In order to test these two guns, a test manual was prepared with the following objectives:

1. Define in detail each test.
2. Describe why the test is performed.
3. Evaluate a particular gun.
4. Permit comparison with other guns.
5. Detect flaws in material, workmanship and/or design.
6. Standardize testing procedure.
7. Permit performance of tests by laboratory assistants.

The manual is essentially general in nature and may cover the testing of any rifle. However, it was used here specifically to test the M/721 and 722. Titles of tests covered by this manual are as follows.

Performance Tests -

1. Interchangeability
2. Chamber Dimensions

Performance Tests (Cont'd) -

3. Headspace
4. Stability of Center of Impact
5. Trigger Pull
6. Bolt Lift
7. Firing Pin Protrusion and Indentation
8. Take Down Inspection
9. Accuracy
10. Safety Mechanism

Endurance Tests -

1. Proof Firing
2. Live Firing
3. Dry Fire with Dummies
4. Dry Fire without Dummies
5. No Lubrication Test
6. Cold Test
7. Wet and Dust Test
8. Competitive Ammunition
9. Field Test
10. Defective Ammunition Test

The purpose of the above performance tests is to measure the effect of endurance shooting. In an effort to gain the most information from the least possible testing, the performance tests were liberally distributed throughout the endurance testing.

The pattern of the test was as follows:

1. Accuracy Test - Five 10 shot groups.
2. Trigger Pull - Average of five determinations.
3. Bolt Lift - Average of five determinations.
4. Firing Pin Protrusion and Indentation.
5. Live Fire - 450 rounds.
6. Dry Fire with Dummies - 1,000 rounds.
7. Dry Fire without Dummies - 3,000 rounds.
8. Accuracy Test.
9. Trigger Pull.
10. Bolt Lift.
11. Firing Pin Protrusion and Indentation.
12. Safety Mechanism Test.

This pattern was repeated six times during the testing of each gun. The special tests such as (1) Cold Test, (2) Wet and Dust Test, (3) Field Test, etc. followed.

The total number of endurance rounds on each gun were as follows:

1. 11 Proof Loads
2. 4400 Live Fire
3. 6000 Dry Fire with Dummies
4. 18,000 Dry Fire without Dummies

The most outstanding defect encountered in this testing was Extractor wear and breakage. Consequently, a separate test was performed by Design Section to improve the quality of the Extractors.

OBJECTIVE

To endurance test a M/721 and a M/722 high-power, bolt-action rifle to aid in evaluating their characteristics with regard to:

1. Suitability for Commercial use.
2. Useful life expectancy.
3. Factual information for:
   a. Present and future design.
   b. Material and Heat Treatment.
   c. Processing.
   d. Sales Department Information.
   e. Presentation to Customer.

CONCLUSIONS

1. On the basis of the test program conducted on these two models, the M/721 and 722 appear sound in design and construction.

2. Both guns are simple enough in design to permit takedown by any gunsmith without hesitation.

3. The need for comparative data on other guns such as the Winchester M/70 and the Remington M/720 was quite apparent throughout the test.

4. Percent Malfunctions -

   M/721 - .089%
   M/722 - .12%

5. Gun Performance (or complete failure expected in 10,000 rounds) -

   M/721 - 1.05
   M/722 - 3.51

FUTURE PROGRAM

All parts are ready for processing and tool design preparatory to pilot line manufacture. At least forty guns should be manufactured on the pilot line and certain ones of this lot subjected to a test similar to the one described in this report.

PATENT SITUATION

Not involved.

EXPERIMENTAL DETAILS

Summary of Defects:

M/721 - .300 H & H Magnum - A slight movement of action in stock in the order of magnitude of one sixty-fourth inch (1/64") was detected after firing approximately four hundred rounds. No perceptible movement occurred thereafter.

Failures to feed the last round in the magazine were quite numerous after six hundred rounds. The cause of this failure was found to be burrs on the magazine which were due to faulty manufacturing process. These burrs were removed, after which no further trouble was experienced from this cause.

After 1,400 functional cycles, the bolt began to work very hard. The cause; the primary extraction cam on the bolt was striking the cam surface on the receiver thereby throwing up a burr which bound the bolt. This burr was stoned off and no further trouble was experienced from this cause.

Considerable annoyance occurred from the staking marks failing to hold the extractor in place but this was due to staking after hardening the bolt head. This practice is unsatisfactory.

Broken extractors were not numerous, there being only three installed throughout the test. The first one broke at 4,611 functional cycles. The second broke at 10,621 functional cycles. The third extractor remained in good condition throughout the remainder of the test.

M/722 - .300 Savage - Failures on this gun were considerably more numerous. The reason for this is that the 722 was tested before the 721. The testing disclosed certain defects which were corrected before the 721 was tested. Test results can best be seen in the following table:

Total Fired	Dummy Cycles	Machine Cycles	Cumulative Total	Malfunction	Gun Performance
11	0	0	11		Fire Control Replaced
211	0	0	211	4 Failures to Feed	Broken Extractor
611	1,000	0	1,611	11 Failures to Feed	
1,211	1,000	3,000	5,211	3 Failures to Feed 39 Failures to Eject	
1,211	2,000	3,000	6,211		Broken Extractor
1,711	2,000	6,000	9,711	11 Failures to Eject	
1,711	3,000	6,000	10,711	32 Failures to Eject 20 Failures to Feed	
2,211	3,000	6,000	11,211	21 Failures to Eject	Extractor worn and changed. Receiver slipped so far back in stock, operation became difficult. Design changed.
2,211	4,000	9,000	15,211	77 Failures to Eject	Ejector Failure - Extractor replaced.
3,211	6,000	15,000	24,211	24 Failures to Eject	Extractor Failure
3,211	6,000	16,456	25,667		Bolt Handle broken
4,211	6,000	18,000	28,211		Extractor Failure Ejector Failure Sear Failure
4,411	6,000	18,000	28,411	21 Failures to Eject	Extractor broken

It can be noted from the above that Failures to Feed were quite numerous in the first 10,711 cycles. This was referred to Design Unit and a change was made. The remaining 13,700 cycles showed no such failures, indicating satisfactory correction of the fault.

The above "Ejector Failures" were due to faulty manufacture of this component. The Ejector is made of a low carbon steel which is cyanided for case hardness. Due to an error in the manufacture of the parts, it was necessary to grind after heat treatment. Thru another error they were not re-heat treated. This is, of course, contrary to expected production practice.

The above "Ejection Failures" were due to wear and "set" of the Extractor. This component has been re-designed and re-tested, see Page 12 of this report.

The "Sear Failure" noted at 28,211 cycles was referred to Design. A change was made and tested in the M/721 and no trouble was encountered, indicating satisfactory correction of this difficulty.

Percent Malfunctions:

M/722 - An analysis of the data concerning each case in which any considerable quantity of malfunctions were reported reveals a defect due primarily to design to be the direct cause of the malfunction. The test as conducted did not stop to remedy this malfunction; but as a matter of fact, it could have been and in that event one malfunction only would have been reported.

The percent malfunctions for the M/722 are:

12 malfunctions in 10,160 cycles of operation =

$$\frac{12}{10,160} \times 100 = .12\% \text{ Malfunctions}$$

M/721 - There were 9 malfunctions in 28,411 rounds. This gives 0.039% Malfunctions for the M/721.

Gun Performance.

M/722 - If, in the course of testing the gun fails in such a manner that the factory or the service of a competent gunsmith is required to repair the gun before further operation is feasible, the breakdown is termed a complete failure. In the test, ten (10) complete failures occurred in 28,411 rounds and cycles. Gun Performance has been defined as the quantity of complete failures occurring in 10,000 rounds. Since 10 failures occurred in 28,411 rounds -

$$\frac{10}{28,411} = \frac{x}{10,000} \quad \text{or} \quad x = 3.52$$

M/721 - Three complete gun failures were recorded in 28,411 rounds and cycles. Therefore, the gun failures to be expected in 10,000 rounds is 1.05.

Chamber Dimensions:

M/721 - .300 H & H Magnum - The change in chamber dimensions after firing ten proof rounds was of the order of magnitude of two thousandths inch (.002") increase. However, this increase was recorded after four proof rounds and no further increase was noted thereafter. Actual increase was:

Neck	.0015"
Shoulder	.0001"
Mid Section	.0011"
Head	.0023"
Belt	.0034"

M/722 - .300 Savage - There was a similar change in chamber dimensions. Actual increase was:

Neck	.002"
Shoulder	.0015"
Body	.0005"
Head	.0002"

No attempt was made to measure the change in length of chamber on either the M/721 or 722.

Headspace:

M/721 - .300 H & H Magnum - There was no change in headspace during the test. However, this gun had been previously proof tested.

M/722 - .300 Savage - Gages were not available for measuring the M/722 at the start of the test. The first measurement was obtained after 511 functional cycles. Headspace at that stage was 1.6057". After all testing, headspace was found to be 1.6070", indicating a change of .0013".

Accuracy Test:

The useful life of a gun is largely dependent on the number of rounds which can be fired in it without perceptible impairment of accuracy. Consequently, this test was designed to measure change in accuracy throughout the endurance shooting.

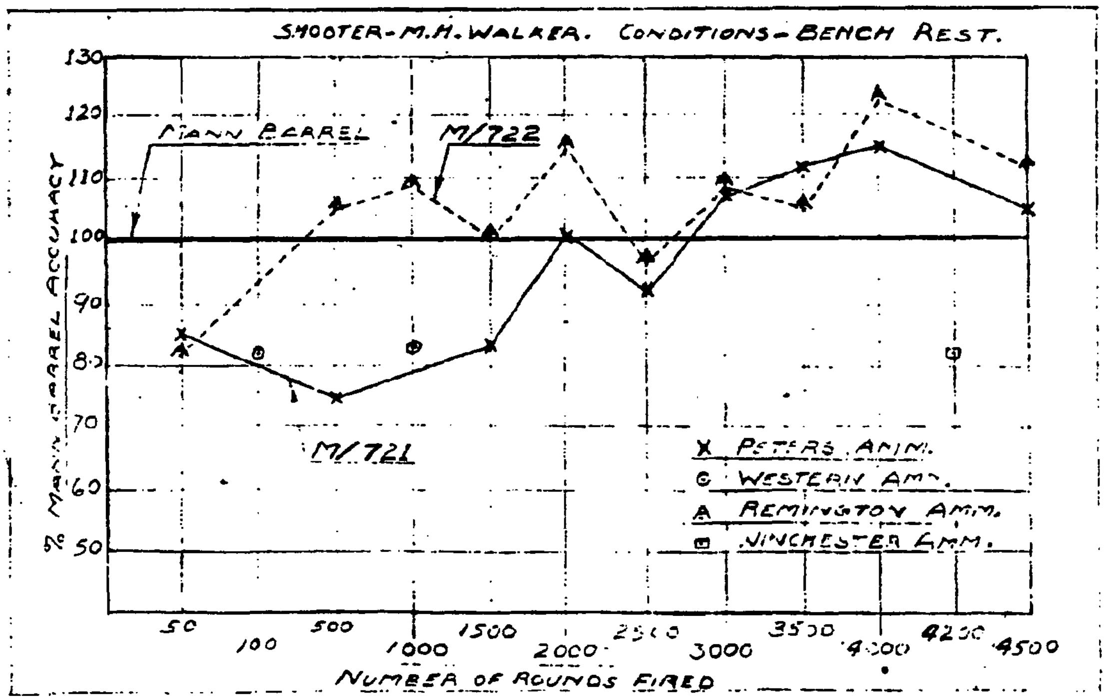
It is interesting to note that both guns improved in accuracy as the test progressed, reaching a maximum at approximately 4,000 rounds. At this stage, the M/721 was 15% better than the Mann barrel with the same ammunition and the M/722 was 22% better.

Mann barrel results were considered as standard and equal to 100% or optimum accuracy of the ammunition. Mean radius was selected as the measure of accuracy. The comparison was made as follows.

$$\frac{\text{Mean Radius (Mann Barrel)}}{\text{Mean Radius (M/721 at a particular stage of testing)}} \times 100 = \text{\% of Mann Barrel Accuracy}$$

$$\frac{1.06}{.92} \text{ (@ 4000 rounds)} \quad \times 100 = 115\%$$

Total Rounds Fired	M/721 Mean Radius	% of Mann Barrel Accuracy	Ammunition	M/722 Mean Radius	% of Mann Barrel Accuracy	Ammunition
Mann	1.06	100.	Peters	.793	100	Remington
Mann	0.49	100	Western	.57	100	Winchester
50	1.24	85.3	Peters	.965	82	Remington
100	0.60	81.6	Western	–	–	–
500	1.42	74.8	Peters	.756	105	Remington
1000	0.59	83.0	Western	.726	109	Remington
1500	1.27	83.5	Peters	[illegible]	100	Remington
2000	1.05	100.1	Peters	.692	114	Remington
2500	1.15	92.2	Peters	.822	96	Remington
3000	0.99	107.	Peters	.732	108	Remington
3500	0.94	112.	Peters	.758	104	Remington
4000	0.92	115	Peters	.648	122	Remington
4200	–	–	–	.696	82	Winchester
4500	1.00	106	Peters	.712	111	Remington



It will be noted from the above that as the mean radius of the test gun decreases below that of the Mann barrel, a better than 100% accuracy is obtained. This indicates the assumption that Mann barrel yields optimum accuracy is in error. It is unimportant, however, since a measure of change in accuracy was desired and such a measure is obtained by this method.

Accuracy was determined as follows:

Ten shots fired from "elbow - forearm" rest at a dngle target under specified conditions constitute one group. Five such groups constitute an accuracy test. All accuracy shooting was done by M. E. Walker of Design.

Mean radius results are shown herewith. Test data on extreme spread, vertical spread and horizontal spread may be obtained from Notebook #299.

Two types of ammunition were used for the accuracy testing as follows:

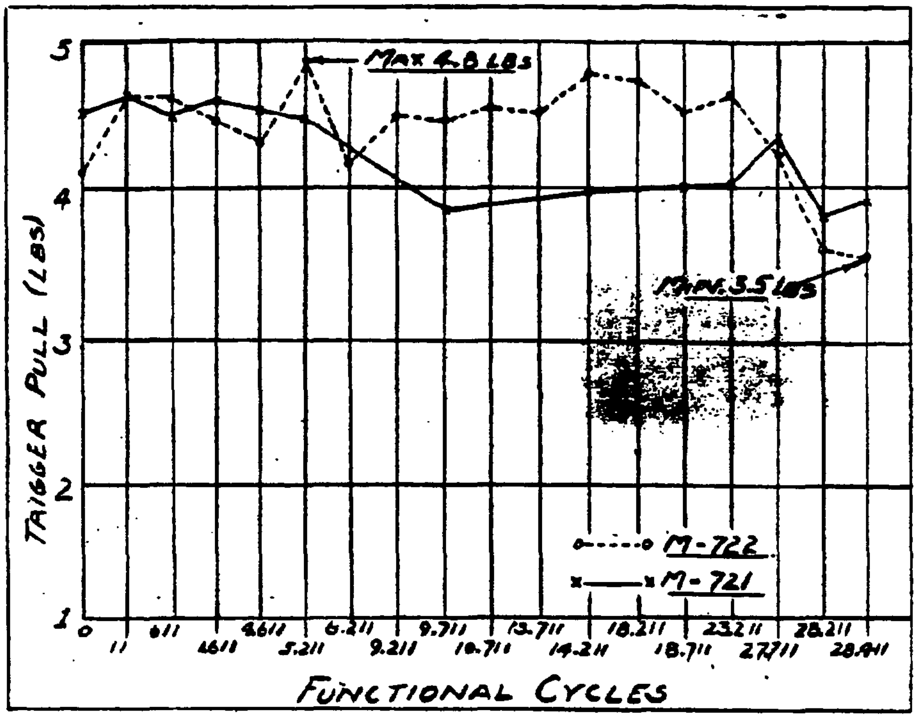
M/721 - 1. .300 H & H Magnum, 220 grain, soft point, Western manufacture.
2. .300 H & H Magnum, 220 grain, soft point, Korelokt, Peters manufacture.

M/722 - 1. .300 Savage, 180 grain, Korelokt, Remington manufacture.
2. .300 Savage, 180 grain, soft point, Winchester manufacture.

Trigger Pull:

Trigger pull was measured by pouring No. 9 shot into a pan supported by the trigger. The weight of shot required to disengage the sear was denoted as the trigger pull. Since some variation was expected, five trials were made by this method at each test interval. Test results are shown in Graph I.

It may be noted that there was no great increase in trigger pull even with dust all over the action (Test #236). There is a slight decrease in trigger pull growing progressively smaller as the test progressed.



Firing Pin Protrusion and Indentation:

A measure of both indentation and protrusion was obtained at nine regular intervals during the test.

The results indicate the main spring and cocking cam, firing pin, and retaining washer to be very satisfactory from a standpoint of material, heat treatment, workmanship and design. The parts involved are identical for both the M/721 and 722.

There was no significant change in either firing pin protrusion or indentation during the test:

	Indentation	Protrusion
M/721 - .300 H & H Magnum		
Initial Test	0.020"	0.053"
Final Test	0.021"	0.055"

	Indentation	Protrusion
M/722 - .300 Savage		
Initial Test	0.021"	0.053"
Final Test	0.021"	0.053"

Bolt Lift:

Bolt Lift is measured to determine:

1. Extraction effort of a particular design.
2. The effect of cocking cam surface and bolt wear.
3. The effect of bolt lug and receiver wear.
4. Location of excessive wear or abrasion.

A determination of "bolt lift" was made with spring balances at nine intervals during the test. It is the average of five determinations each with both dummies and fired cases. The small change in bolt lift from beginning to end of test, except for the substantial increase in the dust and water test seems insignificant. The maximum recorded lift occurred with each gun in the dust test. However, it was no greater than that recorded in the initial test of the particular gun as received.

It is of interest that the force required to open the bolt became progressively less throughout the program, indicating simply a polishing effect from use. The results of measurement were as follows:

M/721 -.300 H & H Magnum	Dummies	Fired Cases
Initial Test	8.5 lbs.	11. lbs
Final Test	6.1 lbs.	6.3 lbs.
Maximum Lift Recorded	10. lbs.	13. lbs.
Minimum Lift Recorded	5. lbs.	6. lbs.
Range of Bolt Lift	5. lbs.	7. lbs

M/722 - .300 Savage	Dummies	Fired Cases
Initial Test	7. lbs.	7.5 lbs
Final Test	6.5 lbs.	6.5 lbs.
Maximum Lift Recorded	7.8 lbs.	9.8 lbs
Minimum Lift Recorded	5.5 lbs.	6.3 lbs
Range of Bolt Lift	2.3 lbs.	3.5 lbs

Safety Mechanism Test:

Quite early in the test program the M/722 showed defects in the safety mechanism. These were noted by Design and a completely new safety mechanism was designed and installed. The M/721 contained the new mechanism from the start of the test.

A further change was made later in the test to reduce the force required to move the safety lever. This change did not constitute a basic design change but, rather, a minor alteration in the length of the lever arm and the angle of the thumb piece.

Both guns conformed to and were safe when tested in this manner. No appreciable wear in the safety mechanism was detected after the entire test.

Interchangeability Test:

This test was designed for Pilot line manufacturing operations. Since only two model guns were submitted, no interchangeability tests were performed on either the Model 721 or 722.

Stability of Center of Impact:

Inadequate supplies of different types of ammunition prevented the performance of this test.

Competitive Ammunition Test:

This test was performed to determine how other makes of ammunition would function in the guns. Insufficient competitive ammunition was available for comprehensive testing. An attempt was made to procure additional supplies but existing conditions prohibited. The following cartridges were fired:

M/721	-	100	Western .300 H & H Magnum, 220 grain, soft point. All were used in accuracy shooting.
M/722	-	500	Winchester .300 Savage, 180 grain, soft point. Fifty of these were used in accuracy testing, balance in endurance testing.

No difficulty was encountered in firing this ammunition.

No Lubrication Test:

No difficulties were encountered in this test with either gun. 450 rounds were fired in each.

Cold Test:

200 cartridges were fired in each gun at -40°. No difficulties were encountered with either gun. However, some of the .300 H & H Magnum ammunition failed to fire. In each case the primer was fired but powder would not burn.

Wet and Dust Test:

M/721 - .300 H & H Magnum -

During the dust test it was discovered that the firing pin would not fall. The gun would fire after pulling the trigger but only when the bolt was given a slight movement. This was caused by grit accumulating between the sear and cocking piece, thereby creating enough friction to keep the sear from falling away from the cocking piece. This condition has been rectified thru a change in design.

M/722 - .300 Savage -

The same condition as noted above existed on the M/722.

Field Test:

No difficulties were encountered in this test with either gun.

SPECIAL EXTRACTOR TESTING - M/722 - .300 Savage
Conducted By: H. W. Young
Notebook #213, PP. 84-89

In view of the high number of Extractor failures (average life 1300 rounds), a separate study was conducted by Design Section to improve Extractor performance. A machine attachment was made for testing Extractors which simulates gun functioning and in which the member representing the cartridge head was made of steel. A series of heat treatments on the redesigned Extractor rings with cold swaged claw were tested. A total of five Extractors were machine tested for 30,000 cycles each with no failures. By another test, it was found that these Extractors would shear off part of the rim of the case (including steel cases) before they would slip off and cause malfunctions. Some measurements of the loads involved were as follows.

1. M/720 Type Extractor - Slips off rim of cartridge between 140 and 165 lbs.

2. M/722 Type Extractor - Shears rim of brass cartridge at 300 lbs.

The Extractors which were tested in the above manner were made of 1095 material. They were heat treated as follows:

Neutral Salt Harden 1450° - Oil Quench
Lindberg Draw 575° - 750°
Rockwell C-56 to 48
Test results were obtained with a draw of 600 ± 25, giving a Rockwell C-54/58 reading.

MC

APPENDIX

MATERIAL AND HEAT TREATMENT INFORMATION

Parts of the mechanism tested were made of materials and given the heat treatment as shown below:

Name	Drwg. No.	Treatment
Barrel	D-101-X	Steel - AISI - 4135 Quench from 1600° into oil Draw - 1100° - 1170°F - 2 hours
Barrel Bracket	A-371-X	AISI C-1118 - no heat treatment
*Bolt Body	B-260-X	Steel - NE-8620 - Normalized & annealed Quench from 1550 in oil from cyanide, 30 min. Draw 325°F - 1.5 hours
*Bolt Head	B-325-X	Steel - NE-8620 Quench from 1550 in oil from cyanide, 30 min. Draw 325°F - 1.5 hours
*Bolt Handle	C-125-X	AISI C-1118 - no heat treatment
*Bolt Handle Ball	C-751-X	AISI C-1118 - no heat treatment
Bolt Plug	C-121-X	AISI C-1118 - Nitre Black
Bolt Stop	B-321-X	NE-8620 Quench in oil from cyanide at 1550°F Draw 300° for 1 hour
Bolt Stop Plunger	AP-B-6	X-1112 C.D. - no heat treatment
Bolt Stop Pin	A-738-X	#3 Pin Wire Quench in oil from 1450°F (Neutral Salt) Draw 900°F nitre for color & water cool
Ejector	A-17017	#3 Pin Wire Quench in oil from 1450°F (Neutral Salt) Draw 900°F in nitre, air cool
Ejector Pin	A-703-X	#3 Pin Wire Quench in oil from 1450° (Neutral Salt) Draw 300 - 350 for 20 min., water cool
Ejector Washer	A-745-X	NE-8620 - Steel Quench from 1550° in oil. No draw.

*Induction braze Bolt Body to Bolt Head and Bolt Handle to Bolt Body and Bolt Handle to Bolt Handle Ball with "EASY FLOW", keeping Bolt Head lugs and cocking cam cool.

APPENDIX

Name	Drwg. No.	Treatment
Extractor	B-323-X	AISI C-1095 Steel Strip

A. Original treatment - Quench in oil from 1425/1450 (neutral salt). Draw 600° in Nitre for 20 min. (water cool). This treatment found unsatisfactory. Therefore, the following treatment was subsequently used.

B. Quench in nitrate-nitrite salt at 600°F from 1450°F. Hold in salt for 30 minutes. Rc hardness 71-74. (R-30N Scale should be used).

Name	Drwg. No.	Treatment
Firing Pin	B-311-X	Steel AISI C-1137 Quench from 1525 into oil Draw 800°F for 30 min.
Firing Pin Head	B-322-X	AISI C-1118 Quench in oil from 1600°F (Cyanide for 15 min.) Draw 350°F for 1 hour in muffle furnace
Front Sight	177	AISI C-1113 - Nitre Black
Front Sight Ramp	A-245-X	AISI C-1113 - no heat treatment
Follower	C-150-X	AISI C-1020 - no heat treatment
Guard Screw, Rear Guard Screw, Front	A-748-X A-749-X	AISI C-1118) AISI C-1118) Quench in water from cyanide at 1600 - 15 min Draw 900 to Nitre Black
Housing	C-144-X	AISI C-1118 C.R. Strip annealed Quench in oil from 1600°F (cyanide for 15 min.) No draw.
Magazine	C-148-X	AISI C-1020 - no heat treatment
Open Sight Base	A-227-X	AISI C-1118 - Brazed on sight leaf with brass
Plug Screw		AISI C-1113 - Nitre Black
Receiver	D-97-X	NE-8620 - Steel C.R. Pentrate for color Quench from 1550 in oil from cyanide - 15 min. Immerse *only* 2" of front end in salt
Safety	C-136-X	AISI C-1020 C.R. Quench in oil from 1550 cyanide 10 min. Pentrate for color

APPENDIX

Name	Drwg. No.	Treatment
Safety Pin Pivot	A-737-X	AISI C-1113 - no heat treatment
Safety Snap Washer	A-736-X	AISI A-1350 Quench in oil for 1500°F (Cyanide for 10 min.) Draw 800°F for 30 min. in nitre
Sear	C-119-X	AISI C-1118 Quench in oil from 1600°F (Cyanide for 15 min.) No draw
Sear Pin	A-728-X	#3 Pin Wire Quench in oil from 1450 (Neutral Salt) Draw 900°F in nitre 10 min., water cool
Sight Leaf (Open)		AISI A-1350 Quench in oil from 1500°F (Neutral Salt) Draw 800°F for 30 min.
Trigger	C-120-X	AISI C-1118 C.R. Strip Annealed Quench in oil from 1600°F (Cyanide for 15 min.) Pentrate for color
Trigger Guide Plate	B-318-X	Nitre Black - AISI C-1020
Trigger Adjust. Screw	A-743-X	AISI C-1113 - no heat treatment
Trigger Spring Screw	A-735-X	AISI C-1113 - no heat treatment
Trigger Stop Screw	A-742-X	AISI C-1113 - no heat treatment
Trigger Guard	C-147-X	AISI C-1020 - 1/4 hard strip - pentrate for color
Trigger Pin	A-729-X	#3 Pin Wire Quench in oil - 1450°F (Neutral Salt) No draw

The above heat treatment is performed after base has been brazed on. Base is brazed on with high melting brass (1700-1750°).

P[illegible] [illegible] MADE [illegible]

Drawing No.	Part Name	No. [illegible]	Type of Operation
D-17001-[illegible]	Barrel	5	Gen. Mac[illegible]
D-17000-[illegible]	"	5	" "
B-17006-[illegible]	Bolt Body	5	" "
C-17007	" Handle	11	Screw [illegible] Mill.
A-17010	" Pin	11	" [illegible]
C-17012	" Plug	11	" "
A-17017	Ejector	11	" "
A-17018	" Pin	11	" "
B-17021-[illegible]	Firing "	11	" "
A-17022	" " [illegible]	11	" "
B-17023	" " [illegible]	11	" "
A-17025	Front [illegible] Screw	11	" "
C-C-68	" Sight	5	Milling
B-17003	" " Ramp	11	Screw [illegible] Mill.
A-17031	Open Sight Base	5	Milling
D-17004-[illegible]	Receiver	5	Gen'l Mac[illegible]
A-17034	Receiver Plug Screw	11	Screw Mac[illegible]
A-170[illegible]	[illegible] Pin	11	" "
A-17043	Safety Pivot Pin	11	" "
A-17049	Trigger Adj. Screw	11	" "
A-17053	" Stop Screw	11	" "