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September 20th, 1943.

R E P O R T

of the

CRE DRAG KING AND METAL SURGICAL LABORATORIES.

Investigation No. 3499.

Examination of Remington Cartridge Cases.

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Bureau of Mines  
Division of Metallic  
Minerals  
Ore Dressing  
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CANADA  
DEPARTMENT  
OF  
MINES AND RESOURCES  
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L A B O R A T O R I E S      O T T A W A      September 20th, 1943.

R E P O R T  
of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1499.

Examination of 2-Pdr. Brass Cartridge Cases.

Origin of Problem:

On August 2nd, 1943, Mr. J. S. Walsh, of the British Admiralty Technical Mission, Ottawa, Ontario, requested verbally an investigation on 2-Pdr. No. 1, Mk. II cartridge cases produced by the Bridgeport Brass Company, Bridgeport, Conn., U.S.A. Trouble had been encountered in proving this type of case, some cases giving trouble in extraction and some other cases, tested under identical conditions, extracting satisfactorily.

Three Bridgeport cases were received, one from Lot No. 171 which had performed satisfactorily and the other two respectively from Lots Nos. 175 and 176 which had given extraction trouble. It was requested that a metallurgical examination of these three cartridge cases

(Origin of Problem, cont'd) -

be carried out to determine the probable cause of the trouble. For comparison, three cartridge cases of British manufacture were also submitted to these Laboratories.

This investigation request was confirmed by a letter (File No. 12-8-1-1) from Captain H. J. B. Hall, R.N., dated August 13th, 1943.

All results obtained and a chart containing 44 photomicrographs were submitted to Mr. J. S. Walsh on August 13th, 1943, but for purposes of confirmation are given herewith.

Description of Samples:

The following brass cartridge cases were received:

<u>Origin</u>	<u>Lot No.</u>	<u>Year of Production</u>
American	171	1943
"	175	1943
"	176	1943
British	407	1940
"	409	1940
"	431	1940

For this investigation the three American cases and one British case (Lot No. 407) were examined.

Mechanical Properties:

TENSILE TESTS -

Each of the four examined cartridge cases was cut transversely into ten consecutive sections. Each of these rings was slit, opened out, and very cautiously straightened. From these straightened sections, tensile test specimens were prepared. For purposes of identification, the samples were numbered from 1 to 10, commencing from the base of cartridge.

Table I gives the results obtained from the tensile tests.

(Continued on next page)

(Mechanical Properties, cont'd) -

TABLE I. - TENSILE TEST RESULTS.

Origin of Case	Speci- men No.	0.2 per cent Proof Strength, p.s.i.	Ultimate Tensile Strength, p.s.i.	Per cent in 2 inches:	ELONGATION in 1 inch
<u>American,</u> <u>Lot No. 171</u>	1	50,000	63,900	12.5	20
	2	56,900	73,800	7.5	14
	3	57,000	73,200	9.5	17
	4	49,100	68,700	9	16
	5	56,200	69,000	8	16
	6	54,800	68,000	11	16
	7	45,800	61,000	23	32
	8	40,200	64,200	36.5	40
	9*	-	-	-	-
	10	41,700	57,500	28.5	39
<u>American,</u> <u>Lot No. 175</u>	1	45,700	61,900	12	22
	2	52,300	72,000	10	18
	3	57,700	76,000	8	16
	4	52,500	69,700	10	17
	5	52,000	69,400	9	18
	6	52,800	69,000	9	18
	7	48,600	64,000	19	28
	8	38,400	59,200	27	36
	9	59,100	60,000	17	38
	10	-	58,800	18	40
<u>American,</u> <u>Lot No. 176</u>	1	47,300	63,200	15	26
	2	54,800	73,700	7	13
	3	56,200	72,100	8	14
	4	49,500	66,800	10	19
	5	55,200	69,200	11	21
	6	50,000	66,600	8	16
	7	49,300	64,000	17.5	30
	8	42,300	60,500	25.5	37
	9	35,000	58,600	30	40
	10	45,600	62,500	28	35
<u>British,</u> <u>Lot No. 407</u>	1	49,000	64,400	15.5	23
	2	45,700	60,700	17	27
	3	49,700	66,700	18	37
	4	42,700	56,600	21	36
	5	44,000	54,800	18.5	22
	6	44,600	59,700	16	30
	7	48,700	59,700	12	23
	8	35,600	56,800	27	37
	9	33,000	52,200	18	40
	10	33,200	48,700	17	25

\* Defective specimen.

(Continued on next page)

(Mechanical Properties, cont'd) -

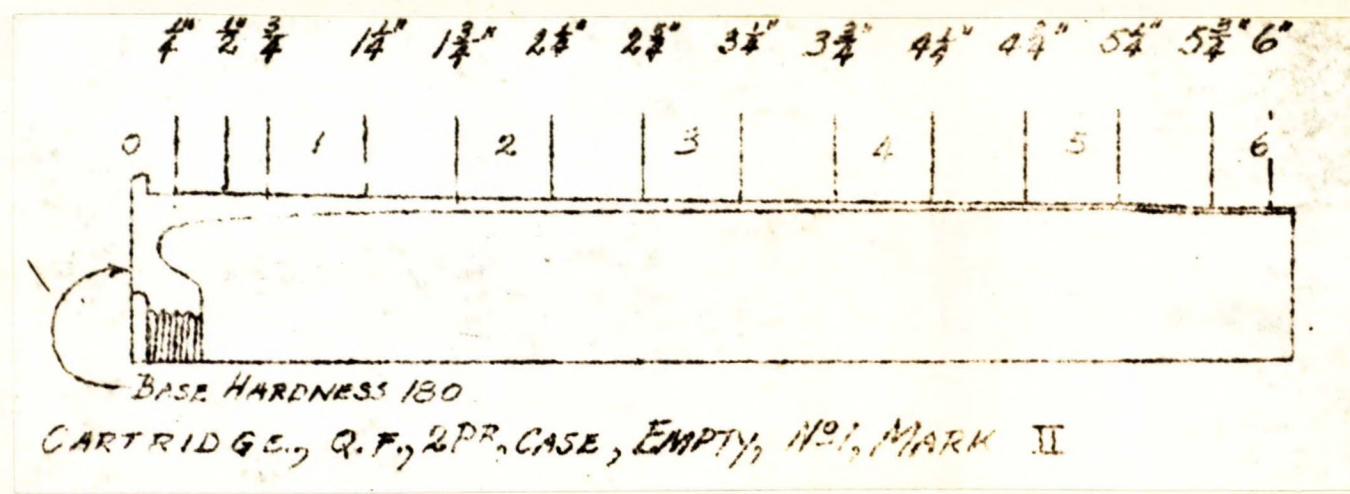
HARDNESS TESTS -

The hardness tests were determined by the Vickers method, using a 10-kilogram load, with the exception of the determinations on the top part of the cartridge cases which, due to the thinness of the material, were made with the 5-kilogram load (these results are marked by "x").

The hardness tests were carried out on the outside wall of the submitted cartridge cases "as received", and on sections cut longitudinally from these cases.

Figure 1 shows the locations of the hardness determinations.

Figure 1.



LOCATIONS OF HARDNESS DETERMINATIONS.

Incidentally, it should be noted that results listed below did not check with values obtained by the Bridgeport Brass Company for the same cases. An appendix to this report (Pages 12 and 13) explains the reason for this divergence.

(Continued on next page)

(Mechanical Properties, cont'd) -  
Hardness Tests, cont'd -

A. Hardness of Unsectioned Cases.

These hardness tests were carried out on the outside walls of the submitted cases. The cases were held in a vise without internal support (without mandrel) and the hardness was determined along the length at specified intervals and then repeated on the opposite side of the case.

Average results were obtained as follows:

TABLE II. - HARDNESS OF UNSECTIONED CASES.

Distance from the base, inches	American Production			British
	Lot No.	Lot No.	Lot No.	Lot No.
- (V.H.N.) -				
1	-	138	175	172
1	-	161	162	173
1	-	166	164	163
1	-	186	177	173
1	-	179	171	174
2	-	173	175	172
2	-	172	170	165
3	-	174	169	164
3	-	153	162	159
4	-	126	136	144
4	-	116	125	127
5	-	115	122	120
5	x	x125	x123	x118
6	-	x125	x117	x118

x = kilogram load used.

B. Hardness of Case Sections.

From each of the examined cartridge cases a longitudinal section, approximately  $\frac{1}{4}$  inch wide, was cut out. The hardness determinations on these sections were carried out on the outside and the inside walls of the cases, and also on the edge of the sections.

(Continued on next page)

(Mechanical Properties, cont'd) -  
Hardness Tests, cont'd -

TABLE III. - HARDNESS ON THE OUTSIDE WALL.

Distance from the base, inches	American Production			British
	Lot No.	Lot No.	Lot No.	Lot No.
	171	175	176	407
$\frac{1}{4}$	141	=	162	178
$\frac{1}{2}$	172	=	=	143
$\frac{3}{4}$	172	=	167	133
$1\frac{1}{2}$	174	166	173	133
$1\frac{3}{4}$	187	166	170	132
$2\frac{1}{2}$	181	166	169	132
$2\frac{3}{4}$	181	164	170	141
$3\frac{1}{2}$	179	171	170	149
$3\frac{3}{4}$	146	167	162	118
$4\frac{1}{2}$	122	149	147	118
$4\frac{3}{4}$	111	131	127	101
$5\frac{1}{2}$	107	121	118	x92
$5\frac{3}{4}$	x122	x123	x131	x88
6	x125	x128	x134	=

TABLE IV. - HARDNESS ON THE INSIDE WALL.

$1\frac{1}{2}$	142	163	160	133
$1\frac{3}{4}$	145	163	152	142
$2\frac{1}{2}$	134	162	151	142
$2\frac{3}{4}$	159	156	148	133
$3\frac{1}{2}$	142	157	148	145
$3\frac{3}{4}$	142	151	146	146
$4\frac{1}{2}$	130	151	140	122
$4\frac{3}{4}$	122	126	131	110
$5\frac{1}{2}$	x125	117	120	88
$5\frac{3}{4}$	x117	120	125	=
6	x118	120	125	=

TABLE V. - HARDNESS ON THE EDGE OF THE LONGITUDINAL SECTION.

$\frac{1}{2}$	164	186	162	180
$\frac{3}{4}$	151	183	143	172
$1\frac{1}{2}$	162	183	142	185
$1\frac{3}{4}$	162	183	168	155
$2\frac{1}{2}$	160	183	166	150
$2\frac{3}{4}$	160	171	162	146
$3\frac{1}{2}$	155	168	159	150
$3\frac{3}{4}$	155	158	164	145
$4\frac{1}{2}$	140	151	160	143
$4\frac{3}{4}$	143	149	145	133
$5\frac{1}{2}$	134	128	118	x111
$5\frac{3}{4}$	x107	x116	x117	x110
$6\frac{1}{2}$	x98	x117	x124	x132
6	x102	x115	x112	=

x 5-kilogram load used.

Microscopic Examination:

Longitudinal sections, approximately  $\frac{1}{4}$  inch wide, were cut out from the examined cartridge cases and prepared for microscopic examination. The samples were etched first in ferric chloride solution (8 g.  $\text{FeCl}_3$  + 25 cc. HCl + 100 cc.  $\text{H}_2\text{O}$ ), and subsequently in a bichromate reagent (2 g.  $\text{K}_2\text{Cr}_2\text{O}_7$  + 4 cc. NaCl + 8 cc.  $\text{H}_2\text{SO}_4$  + 100 cc.  $\text{H}_2\text{O}$ ). A complete set of photomicrographs, 28 at X75 magnification and 16 at X250 magnification, showing the microstructure at seven different locations of the longitudinal sections of the four examined cartridge cases, was submitted to Mr. J. S. Walsh, of the B.A.T.M., on August 13th, 1943.

Figures 2 to 8 show the microstructures of one sample of American production (Lot No. 171), which is typical for all three American cases. For comparison, the microstructures of the British case are shown in Figures 9 to 15.

AMERICAN  
LOT NO. 171



Figure 2.

Distance  
from Base

$\frac{1}{4}$  inch.

BRITISH  
LOT NO. 407

Figure 9.



Figure 3.



$\frac{3}{4}$  inch.

Figure 10.



All above are photomicrographs at X75,  $\text{FeCl}_3$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  etch.

AMERICAN  
LOT NO. 171Distance  
from BaseBRITISH  
LOT NO. 407

Figure 4.

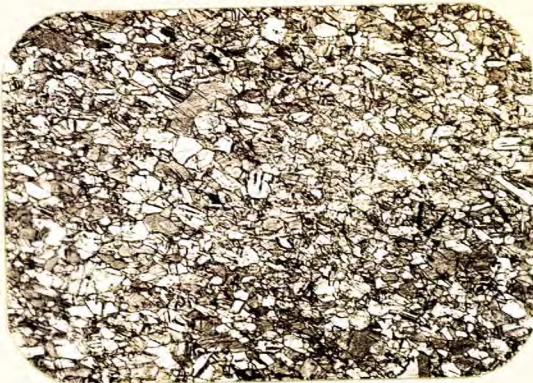
1½ inches.

Figure 11.

Figure 5.

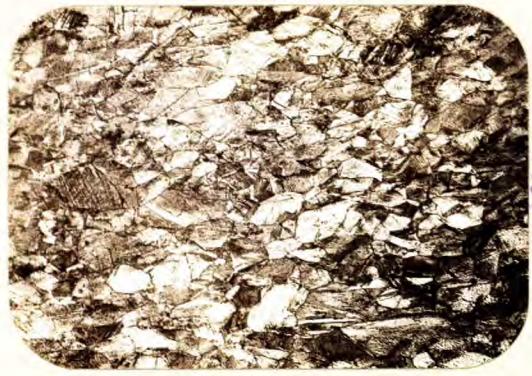
3¼ inches.

Figure 12.

Figure 6.

4½ inches.

Figure 13.

Figure 7.

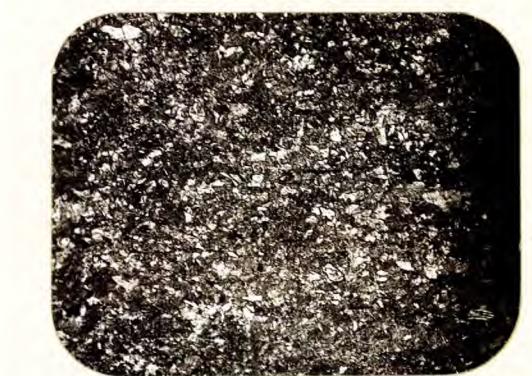
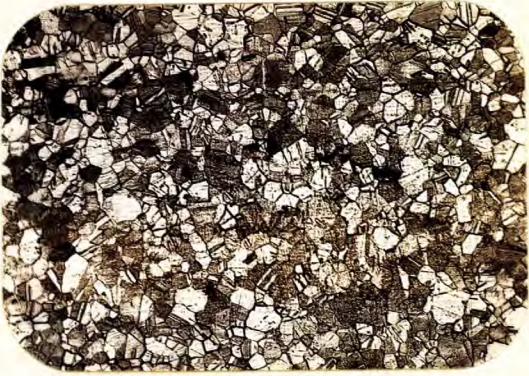
5¾ inches.

Figure 14.

Figure 8.

6 inches.

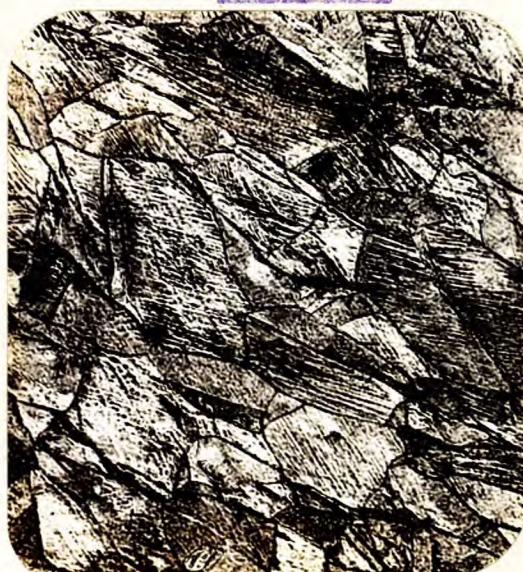
Figure 15.

(Microscopic Examination, cont'd) -

For better comparison of the structures of the top part of the cartridge cases, Figures 16 to 23 show photomicrographs at a higher magnification (X250).

AMERICAN  
LOT NO. 175

Figure 16.



Distance  
from Ease

3 $\frac{1}{4}$  in.

BRITISH  
LOT NO. 407

Figure 20.

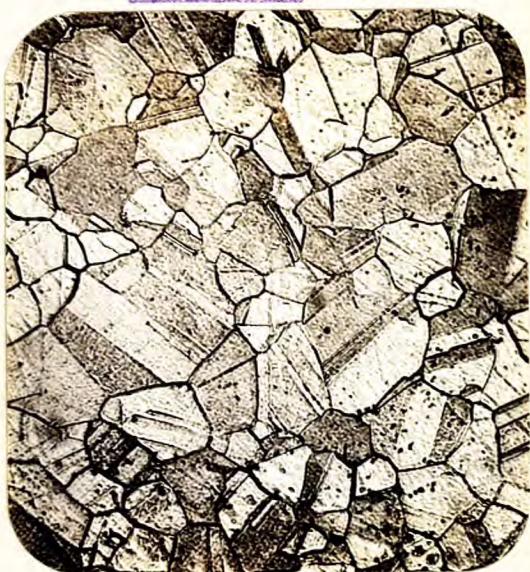


Figure 17.



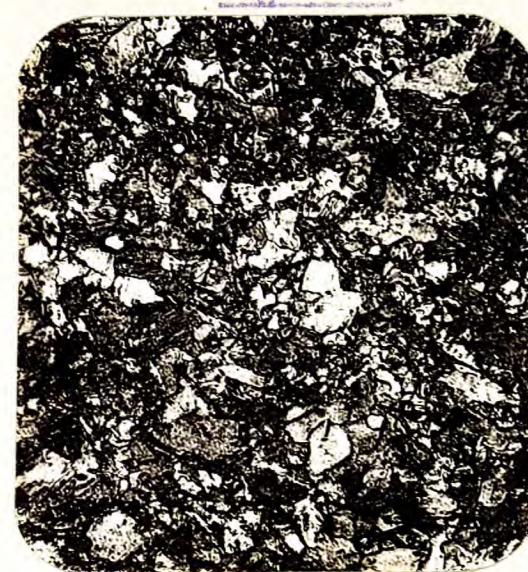
LOT NO. 176

Figure 18.

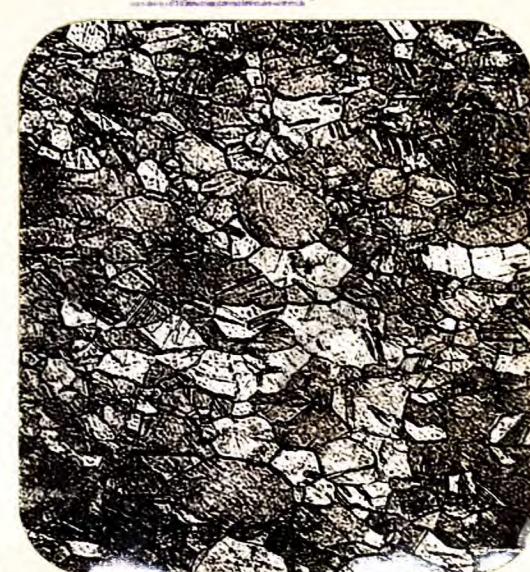
4 $\frac{3}{4}$  in.



Figure 21.

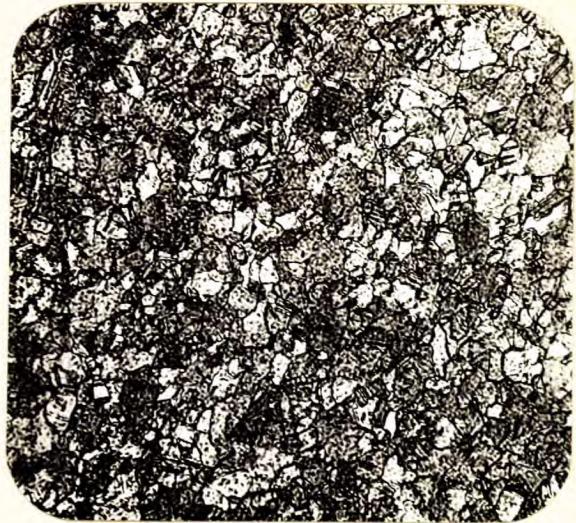


5 $\frac{1}{4}$  in.

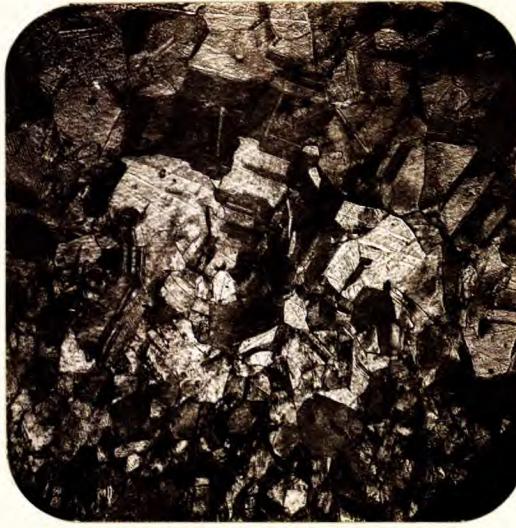


All above at X250, FeCl<sub>3</sub> and K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> etch.

## (Microscopic Examination, cont'd) -

AMERICAN  
LOT NO. 176Figure 19.Distance  
from BaseBRITISH  
LOT NO. 407Figure 23.6 in.Above at X250,  $\text{FeCl}_3$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  etch.

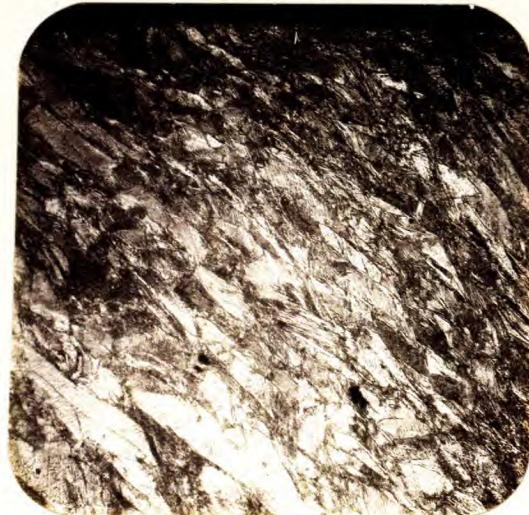
Figures 24 to 27 show the structure at two locations on the outside at the base of the cartridge cases, one at the corner of the rim and case wall and the other slightly up the case wall from the rim.

Figure 24.

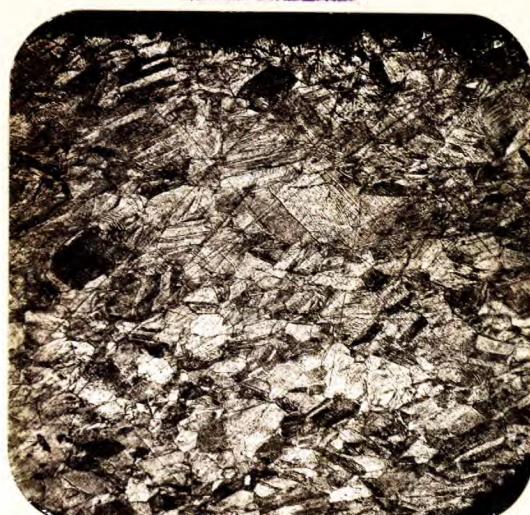
AMERICAN LOT NO. 176.

Figure 26.

BRITISH LOT NO. 407.

Figure 27.

AMERICAN LOT NO. 176.



BRITISH LOT NO. 407.

All above at X75,  $\text{FeCl}_3$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  etch.

Discussion of Results:

Tensile tests and hardness determinations showed no marked differences in the mechanical properties of the three examined cartridge cases from the Bridgeport production. The British case that was tested for comparison showed definitely lower proof stress, tensile strength, and hardness.

Microscopic examination revealed, in the American cases generally, a very ununiform and fibrous structure as compared with the equiaxed and regular structure of the British case. This difference is due to a more advantageous combination of cold work and annealing, or to a greater number of annealing operations, given in the production of the British cartridge cases.

It is obvious that uniformity of structure in the material improves its performance.

Since practically no differences were found in the properties of the three American cartridge cases, it would appear that the different results obtained in proof firing are rather incidental and the material is generally of marginal quality. It is probable that a marked change in physical properties will be needed if sticking troubles are to be avoided. If a harder material is decided upon, care should be taken in making this change, in order that separation trouble, definitely a more serious defect than sticking, shall be avoided.

CONCLUSIONS:

Mechanical tests and microscopic examination revealed no marked differences in the submitted American cartridge cases. No metallurgical reasons for different proof-firing results obtained on these lots were found.

Considerable difference in properties and structure was found in the British cartridge case examined for comparison.

APPENDIX.

Subsequent to the completion of this report, officials of the British Admiralty Technical Mission discovered that the Vickers hardness tester operating at the Bridgeport Brass Company was inaccurate. On correction, this machine was found to give the same results for standard blocks as did the Bureau of Mines equipment.

Comparative tests were also made on two brass cartridge cases. The following table gives the results obtained:

(Table follows on next page)

V.D.H. TEST RESULTS ON 2-FDR, CARTRIDGE CASES

FROM CASES OF CURRENT PRODUCTION, LOT NO. 163.  
(10-Kilogram Load)

Distance From Base, in Inches	CASE NO. 1				CASE NO. 2			
	Position A		Position B		CAN. B. OF MINES		CAN. B. OF MINES	
	Operator X	Operator Y	Operator X	Operator Y	Operator X	Operator Y	Operator X	Operator Y
1 $\frac{1}{4}$	172	181	168	168	172	175	177	172
1 $\frac{1}{2}$	177	168	166	172	171	170	168	164
2	174	170	172	170	172	176	170	170
2 $\frac{1}{2}$	181	161	174	172	177	182	177	170
3	168	174	177	177	172	173	179	170
3 $\frac{1}{2}$	174	176	176	176	170	176	178	172
4	174	177	171	171	176	176	172	164
4 $\frac{1}{2}$	172	164	179	179	174	178	172	166
5	155	148	164	172	174	178	172	162
5 $\frac{1}{2}$	155	146	152	148	152	158	150	155
6	130	134	127	126	130	132	127	133
6 $\frac{1}{2}$	124	127	120	120	123	125	122	123
7 $\frac{1}{2}$	131	131	133	131	131	130	122	124
8 $\frac{1}{2}$	129	128	118	125	122	123	115	125
9 $\frac{1}{2}$	129	128	118	125	122	123	115	125

x 5-kilogram loads.