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O T T A W A May 13th, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1646.

Examination of 6-pdr., 7-cwt. Brass Cartridge Cases.

(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals
-
Physical Metallurgy
Research Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch
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Origin of Material and Object of Investigation:

On April 10th, 1944, ten (10) 6-pdr., 7-cwt. brass cartridge cases were received, for examination, from the Inspector General, Inspection Board of United Kingdom and Canada, Ottawa, Ontario. The work on these cases was covered by Analysis Requisition No. O.T. 4165.

In an accompanying letter (File No. 4/2/13/U.K.), dated April 7th, from Mr. D. R. W. Gedge, Inspector of Propellants and Cartridges, it was reported that the cases had been manufactured by the Canadian Motor Lamp Company Limited, Windsor, Ontario, and that two of the cases had good hardness, two were soft along their whole length, and the remaining six had a ring of soft material in the case wall about one inch from the base. A metallurgical examination of the cases was requested.

On April 26th, 1944, five more cases, reported to be of normal hardness, were received and given various heat treatments. The results of these heat treatments and of the examination of the cases previously received were reported verbally to the I.B.U.K. & C. on May 3rd, 1944.

Macro-Examination:

Examination of the markings on the base of the cases showed that they had been manufactured in 1943 and that they were of Lot No. 68. Numbers had been painted on the base of each case. These numbers a r e used to refer to the individual cases in this report.

Hardness Tests:

Hardness tests were taken along the length of the cases, using the Vickers hardness tester with the 10-kilogram load. The case was clamped in the vise and was without internal support. A strip was cut from each case and hardness determinations were made along the cross-section of the wall, the strip being clamped in a vise. Tables I and II show the results of the hardness tests on the surface and cross-section of the wall, respectively. Figure 1 shows graphically these results for the first four inches of the wall nearest the base.

TABLE I.

HARDNESS ALONG SURFACE OF 6-PDR. CASES.

Distance from base, inches	Number of Case						
	11	60	14	57	8	73	69
	Vickers Hardness Number - 10-kg. load						
¼	102	97.6	179	181	123	124	155
½	102	101.0	182	180	128	129	157
¾	106	95.3	186	181	127	124	165
1	104	102.0	185	192	122	128	157
1¼	104	94.5	187	193	124	124	163
1½	118	94.1	178	194	136	156	167
2	123	94.1	175	181	146	149	162
3	124	92.8	165	177	142	159	175
4	109	90.0	164	155	147	151	161
Neck	106	114.0	120	103	116	107	113
Mouth	66	90.0	67.3	79	78.8	70.7	105

(Continued on next page)

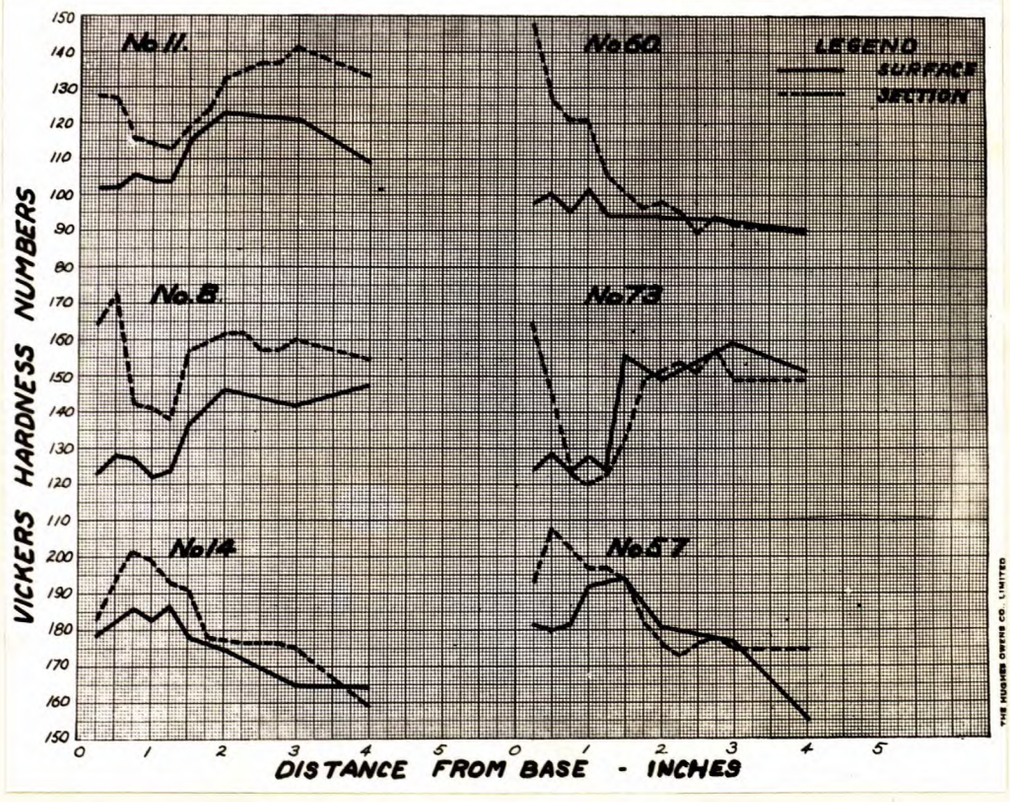
(Hardness Tests, cont'd) -

TABLE II.

HARDNESS ALONG CROSS-SECTION OF WALL OF 6-PDR. CASES.

Distance from base, inches	Number of Case: 11	60	14	57	8	73
	Vickers Hardness Numbers - 10-kg. load					
¼	128	148	183	193	164	165
½	127	127	195	208	173	146
¾	116	121	201	203	142	124
1	114	121	199	197	141	120
1¼	113	106	193	197	138	123
1½	119	101	191	194	157	132
1¾	124	96.7	178	183	159	149
2	133	98.0	175	176	162	151
2¼	135	95.8	177	173	162	154
2½	137	89.6	177	176	157	151
2¾	137	94.1	177	178	157	157
3	141	91.6	170	175	160	149
4	133	89.2	159	175	155	149

Figure 1.



HARDNESS SURVEY ON SURFACE AND CROSS-SECTION OF WALL OF 6-PDR. CARTRIDGE CASES - AS RECEIVED.

Microscopic Examination:

A strip about ¼ inch wide was cut from each case and prepared for metallographic examination. Photomicrographs were taken to illustrate the structure at various points along the wall and are shown herein. Figures 3 to 8 were taken from Case No. 60, which was soft along its whole length. All these photomicrographs show recrystallization of the material, with variable grain size. Figures 9 to 14 were taken on Case No. 73, which was soft near the base. The material near the base (Figures 9 to 12) shows evidence of recrystallization. Figures 15 to 20 were taken on Case No. 14, which had a normal hardness. Heavily cold-worked material is seen.

All photomicrographs are at X75 magnification. The etch used was chromium trioxide solution (2 grams CrO_3 + 2 cc. HCl + 20 cc. H_2O) followed by ferric chloride solution (8 grams $FeCl_2$ + 25 cc. HCl + 100 cc. H_2O).

Annealing Experiments:

The cases received on April 26th were numbered 9, 25, 53, 61, and 67. In order to attempt to duplicate the defects occurring in the cases previously received, Cases Nos. 25, 53 and 67 were cut in half longitudinally and the halves were annealed at various temperatures and times. The annealing was carried out in a Homocarb furnace, the temperature of which is accurately regulated and recorded by automatic means. The hardness was measured along the wall with the half-section clamped in a vise and not supported internally. The Vickers hardness tester was used with the 10-kilogram load and the hardness was determined both before annealing and after 1, 2 and 18 hours at temperature. The results are shown graphically in Figure 2.

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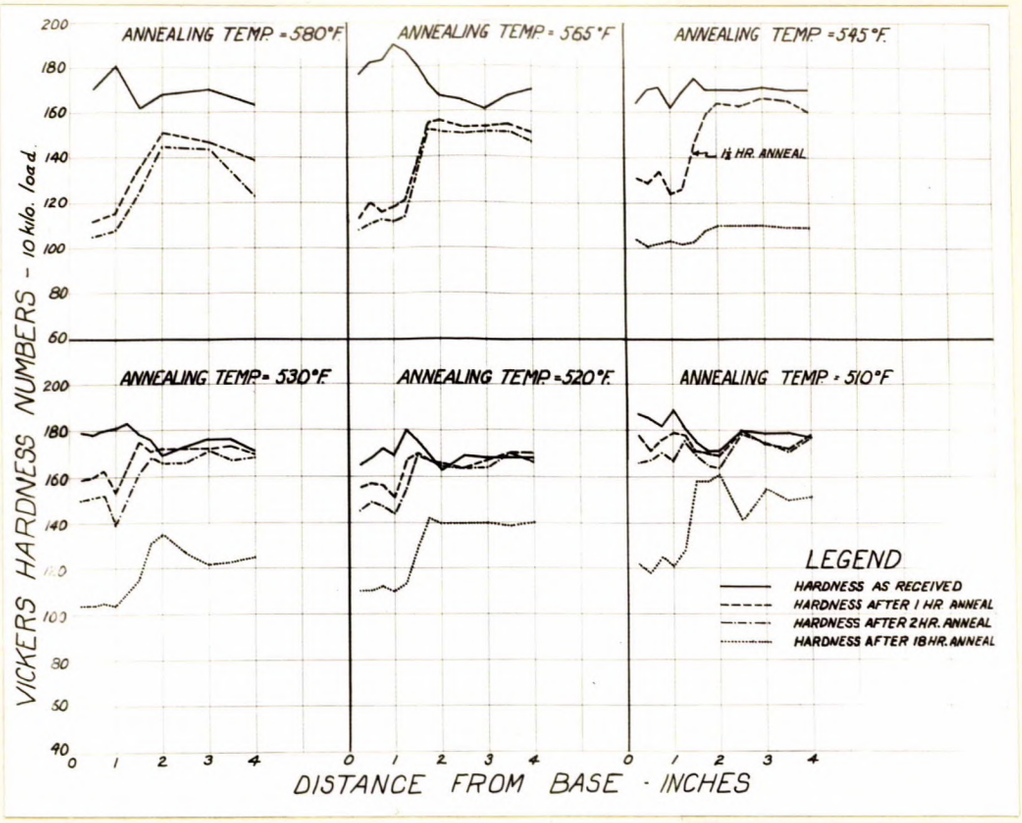
(Annealing Experiments, cont'd) -

Figure 2.



VARIATION IN HARDNESS OF 6-PDR. CARTRIDGE CASES AFTER ANNEALING AT DIFFERENT TEMPERATURES AND TIMES.

Discussion:

Examination of six of the first lot of cases received indicated that two types of defect existed. The hardness tests along the length of the cases showed that Cases Nos. 11 and 60 were soft along their whole length and that Cases Nos. 8 and 73 were soft near the base but reached a normal hardness about 1½ inches from the base. Cases Nos. 14 and 57, however, were of normal hardness along the whole length (see Figure 1).

Microscopic examination of longitudinal strips from Cases Nos. 11 and 60 showed that the material had recrystallized (see Figures 3 to 8).

Microscopic examination of Cases Nos. 8 and 73, which

(Discussion, cont'd) -

were soft near the base, and of Cases Nos. 14 and 57, which were of normal hardness, indicated, by comparison of the structures of the materials, that there is some evidence of recrystallization in the material near the base in Cases Nos. 8 and 73 (compare Figures 9 to 14 with Figures 15 to 20).

The annealing experiments, the results of which are shown in Figure 2, showed that there was a slight lowering of hardness due to recrystallization even after annealing for 1 hour at 510° F. (265° C.), and that after annealing for 2 hours a further lowering of hardness occurred. On examination of Figure 2 it will be seen that, in all instances, the most marked lowering of hardness occurred at a point about one to one-and-a-half inches from the base. This indicates that the material at this point has a greater tendency to recrystallize than the rest of the material because it has received a greater amount of cold work during the manufacturing process.

The material in this region is cold-worked by two processes: the heading of the case, and the drawing of the case wall. If the effects of these two processes overlap, the material near the base will receive a maximum amount of cold work and will therefore have a greater tendency to recrystallize than material farther away from the base which has not received as much cold work. As has been shown by the annealing experiments, the stress-relief anneal is sufficient to cause recrystallization in this region.

If the case is allowed to remain at the stress-relief annealing temperature for a sufficient length of time (18 hours), a lowering of the hardness along the whole length of the case occurs resulting in a "dead soft" case. This is seen in Figure 2 at an annealing temperature of 545° F. (285° C.), and, less markedly,

(Discussion, cont'd) -

at 530° F. (275° C.).

It is the practice, during the manufacture of these cartridge cases, to stress-relief anneal them at 540° F. (282° C.) for 1 hour. It has been shown, by the experiments described in this report, that at this temperature, and even at lower temperatures, a marked lowering of hardness near the base may occur after a one-hour anneal, and it has been further shown that if the case is allowed to remain in the furnace long enough--overnight, for example--the hardness along the whole length of the case will be lowered, resulting in a "dead soft" case.

CONCLUSIONS:

The soft ring of material near the base of the cases is caused by recrystallization during the stress-relief anneal. The tendency to recrystallize is increased if the material in this region receives an excessive amount of cold work.

The "dead soft" cases are caused by allowing the cases to remain in the stress-relief annealing furnace for an excessive length of time.

In order to avoid these defects it would be advisable to lower the temperature of the stress-relief anneal to 500 to 510° F. (260-265° C.) and to take precautions to ensure that no case remains in the annealing furnace for more than one hour.

It is most important that the temperature of the furnace and of the cases in the furnace be closely regulated and controlled.

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Figure 3.

Location, ¼ inch
from base.

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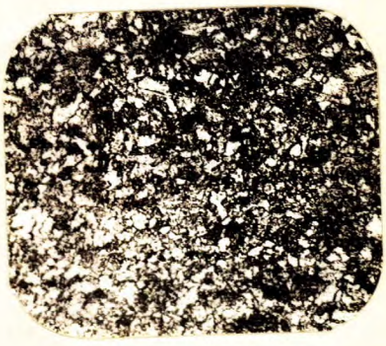
Figure 6.



Location, 2½ inches
from base.

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Figure 4.

Location, 1 inch
from base.

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Figure 7.

Location, 3 inches
from base.

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Figure 5.

Location, 1¾ inches
from base.

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Figure 8.

Location, 4 inches
from base.

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PHOTOMICROGRAPHS FROM CASE NO. 60.

Magnification, X75.
Etch: chromium trioxide and ferric chloride.

Figure 9.

Location, $\frac{1}{4}$ inch
from base.

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Figure 10.

Location, $\frac{1}{2}$ inch
from base.

—

Figure 11.

Location, 1 inch
from base.

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Figure 12.

Location, $1\frac{1}{2}$ inches
from base.

—

Figure 13.

Location, 2 inches
from base.

—

Figure 14.

Location, 3 inches
from base.

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PHOTOMICROGRAPHS FROM CASE NO. 73.

Magnification, X75.
Etch: chromium trioxide and ferric chloride.

Figure 15.

Location, $\frac{1}{4}$ inch from base.

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Figure 16.

Location, $\frac{1}{2}$ inch from base.

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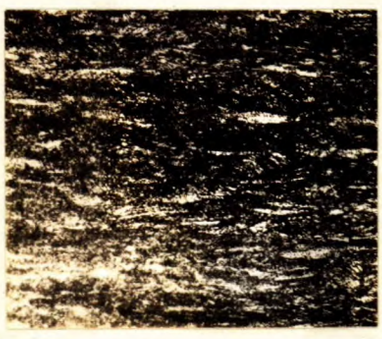
Figure 17.



Location, 1 inch from base.

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Figure 18

Location, $1\frac{1}{2}$ inches from base.

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Figure 19.

Location, 2 inches from base.

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Figure 20.

Location, 3 inches from base.

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PHOTOMICROGRAPHS FROM CASE NO. 14.

Magnification, X75.
Etch: chromium trioxide and ferric chloride.

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