

*Rory Shanahan,<sup>1</sup> M.Sc.*

## Corrosion of New, Fired, 0.22-Caliber, Long-Rifle Brass Cartridge Cases Buried in Soil

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An important exhibit at a double murder trial was a 0.22-caliber, long-rifle, rim-fire cartridge case, which was found on microscopic examination to have been fired in the 0.22 pump-action rifle belonging to the accused. It was found at the scene, more than 18 weeks after the murders, buried approximately 50 mm below the surface of a garden.

After its discovery the cartridge case was handled by several policemen before it was forwarded to the laboratory, where it was handled by two scientists during examinations of the firing pin impression, extractor, and other marks. Because at this stage there was no suggestion that the cartridge case had not been exposed for 18 weeks, there was no specific observation of corrosion products and hence they were not recorded.

At the first trial it was not seriously contested whether or not the cartridge case had been buried for 18 weeks. In their preparation for an appeal and a retrial the defense exposed six fired cartridge cases on and in soil adjacent to the property and about 50 m from where the exhibit cartridge case was discovered. They recovered the cases 15 weeks later. After examining those that had been buried they made several claims:

1. The effects of corrosion on their cases did not resemble the effects of corrosion on the exhibit case.
2. The condition of the exhibit case was unusual compared with their cases.
3. They could offer no explanation as to why the exhibit case was relatively uncorroded compared with their cases.

From these experiments the defense alleged that the exhibit cartridge case could not have been exposed for 18 weeks. The history of the cartridge case prior to its discovery then became important.

The defense first closely examined the exhibit cartridge case two years after its discovery and after it had been extensively handled by several persons both in New Zealand and England. They asserted that the case had not been ejected onto the ground at the time of the homicides but had been placed there at a later date. This argument was pursued at the subsequent Court of Appeal hearing and at a second Supreme Court trial.

Questions posed to the prosecution by these defense arguments were these:

- (1) whether or not corrosion products on the outside of the exhibit case were consistent with its being buried for more than 18 weeks;
- (2) whether or not corrosion products on the exhibit cartridge case could be assessed by comparing them with corrosion products on cartridge cases buried 50 m away;

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<sup>1</sup>Scientist, Chemistry Division, Department of Scientific and Industrial Research, Auckland, New Zealand.

- (3) whether or not the corrosion products were permanent and would resist handling; and
- (4) whether or not the characteristic microscopic marks would still be recognizable after this period in the ground.

Published work [1-8] on corrosion of metals buried in the soil was of limited assistance in answering these questions. Samples were usually larger (up to 380 mm long and 20 to 240 mm wide) and buried at greater depths (460 to 1220 mm) for longer periods (2 to 13 yrs). Upon removal from the soil the effects of corrosion were assessed by weight loss of the sample and by measuring the depth of pitting. No information was found on the effects of corrosion on a metal object as small as a 0.22 long-rifle brass cartridge case (15 by 5.5 mm) buried just below the soil surface for the relatively short time of 18 weeks. This paper is concerned with the study undertaken in an attempt to answer the above questions.

### **Experimental Procedure**

Brass 0.22 long-rifle cartridges of ICI brand and of the same batch were fired in a Remington single-shot Model 510 rifle. This weapon imprinted finely detailed characteristic firing pin marks on the cases. The fired cases were numbered on their sides from 1 to 87.

Cases were buried just below (50 mm) the surface of the soil at 21 locations including the crime scene, usually in sets of four. At intervals up to 18 weeks from the commencement of the experiment, cases were recovered, washed with water to remove soil, and dried.

#### *Corrosion Products*

The amount of corrosion products present was estimated as a percentage of the case area, with the side and head of the case recorded separately. The color was assessed by comparison in daylight with color charts according to Kornerup and Wanscher [9].

#### *Permanence of Corrosion Products*

For preliminary tests on the stability of corrosion products, fired 9-mm parabellum cartridge cases, which had been exposed outdoors for unknown times, were picked up at a military firing range. From these cases three were selected of apparently identical dark coloration. One of these was randomly chosen, handled by several persons for a total period of 30 min, and then compared with the two untouched controls.

One of the pair of test-fired 0.22 cases buried at the crime scene was handled by two persons for 15 min and then compared with the untouched control and unexposed control.

#### *Microscopic Markings*

After the corrosion products assessment above, the firing pin marks on exposed cases were examined both under a stereo-binocular microscope and a Leitz comparison microscope.

### **Results**

#### *Corrosion Products*

The amount of corrosion products and corrosion colors observed on the buried cases are presented in Table 1 and summarized in Table 2.



*fired brass cartridge cases.*

14 Weeks Buried				18 Weeks Buried			
Side		Head		Side		Head	
%	Color	%	Color	%	Color	%	Color
55	50% dark brownish gray, B 25% chocolate, D 25% tan, D	55	brownish gray (thin), D	95	40% ink blue, B 30% brown, B 30% brick red, D	95	70% ink blue, B 30% brick red, D
65	90% brown, B 10% Prussian blue, B	100	80% brown, D 20% Prussian blue, D	...	...	...	...
80	50% light brown, D 50% thunder blue (dark bluish gray), B	80	light brown, D	...	...	...	...
20	90% dark brownish gray, D 10% light brown, D	20	50% dark brownish gray, D 50% light brown, D	<i>a</i>	...	...	...
80	dark bluish gray, B	<5	...	<i>a</i>	...	...	...
20	dark grayish brown, B	<5	...	25	50% dark brown, B 50% hair brown, D	5	dark brown, D
...	...	...	...	20	mixture of brown, D and dark grayish brown, B	5	dark grayish brown, D
25	chocolate, D	45	chocolate, D	<i>b</i>	...	...	...
30	indigo blue, B	7	indigo blue, B	45	blackish blue, B	10	blackish blue, D
...	...	...	...	45	60% brown, B 40% blackish blue, B	10	blackish blue, D
90	ink blue, B	5	ink blue, B	90	thunder blue (dark bluish gray), B	90	thunder blue (dark bluish gray), D
...	...	...	...	90	thunder blue (dark bluish gray), B	100	thunder blue (dark bluish gray), D



—Continued.

14 Weeks Buried				18 Weeks Buried			
Side		Head		Side		Head	
%	Color	%	Color	%	Color	%	Color
55	dark brown, D	50	dark brown, D	90	reddish brown, D	95	reddish brown, D
...	...	...	...	100	85% reddish brown, D 15% olive, D	95	reddish brown, D
20	dark grayish brown, D	10	dark grayish brown, D	45	dark grayish brown, D	5	dark grayish brown, D
85	brownish gray, B	55	brownish gray (thin), B	30	dark grayish brown, D	10	dark grayish brown, D
...	...	...	...	100	dark grayish brown, 50% B 50% D	100	dark grayish brown, D
95	50% dark bluish gray, B 50% brown, D	40	50% dark bluish gray, B 50% brown, D	100	dark grayish brown, 50% B 50% D	100	dark grayish brown, D
35	brown, D	<5	...	75 <sup>e</sup>	90% reddish brown, D 10% blackish blue, B	45	reddish brown, D
...	...	...	...	15	hair brown, D	5	hair brown, D
85	sepia (brown), D	100	sepia (brown), (thin), D	25	brown, D	70	brown, D
...	...	...	...	100	teak (brown), D	100	teak (brown), D
30	70% thunder blue (dark bluish gray), B 30% brown, D	10	brown (thin), D	80	50% mustard brown, D 50% thunder blue (dark bluish gray), 50% B, 50% D	50	bluish gray (thin), D
45	85% brown, D 15% thunder blue (dark bluish gray), B	10	brown (thin), D	...	...	...	...



—Continued.

14 Weeks Buried				18 Weeks Buried			
Side		Head		Side		Head	
%	Color	%	Color	%	Color	%	Color
50	75% brown, D 25% blackish blue, B	10	brownish blue (thin), D	...	...	...	...
5	bluish black, D	<5	...	7	mainly mustard brown, D with specks of thunder blue (dark bluish gray), D	0	...
...	...	...	...	15 <sup>c</sup>	raw sienna (brown), B	5	thunder blue (dark bluish gray), D
85	brown, B	0	...	85	brown, 50% B, 50% D	35	brown, 50% B, 50% D
...	...	...	...	75	brown, D	75	brown, D
...	...	...	...	90	brown, 80% B 20% D	45	brown, 80% B 20% D
30	50% blackish blue, B 50% dark grayish brown, B	65	dark grayish brown, D	...	...	...	...
30	80% dark grayish brown, D 20% blackish blue, B	7	dark grayish brown D	...	...	...	...
30	50% blackish blue, B 50% dark grayish brown, B	7	dark grayish brown, D	...	...	...	...
55	90% dark bluish gray, D 10% brick red, D	45	teak (brown), D	75	90% sepia (brown), B 10% deep blue, B	50	marine blue (blackish blue), B
...	...	...	...	70	45% sepia (brown), B 45% dark grayish brown, B 10% deep blue, B	60	90% sepia (brown), D 10% deep blue, B
	grayish						



TABLE 1

Location	4 Weeks Buried				8 Weeks Buried			
	Side		Head		Side		Head	
	%	Color	%	Color	%	Color	%	Color
20 <sup>d</sup>	...	...	...	...	...	...	...	...
20	...	...	...	...	...	...	...	...
21 <sup>d</sup>	...	...	...	...	...	...	...	...
21	...	...	...	...	...	...	...	...

B = bright

D = dull

<sup>a</sup> Two cartridge cases not recovered.

<sup>b</sup> One cartridge case not recovered, another recovered but not examined.

<sup>c</sup> One cartridge case not recovered.

<sup>d</sup> Two cartridge cases were buried.

TABLE 2—Summary of results shown in Table 1.

Time Buried, weeks	Corrosion			
	Side		Head	
	Range, %	Average, %	Range, %	Average, %
8	10- 80	46	0- 95	22
14	5- 95	50	0-100	30
18	7-100	58	0-100	44

#### *Permanence of Corrosion Products*

In preliminary tests, after six persons had handled the 9-mm case for a total time of 30 min, most corrosion products were removed, resulting in a marked change in the coloration from dull olive brown to bright straw yellow (Fig. 1).

The two cases which had been buried for 18 weeks at the crime scene, Location 20,

—Continued.

14 Weeks Buried				18 Weeks Buried			
Side		Head		Side		Head	
%	Color	%	Color	%	Color	%	Color
...	...	...	...	75	60% ink blue, B 40% brown, D	50	ink blue, B
...	...	...	...	75	60% ink blue, B 40% brown, D	45	ink blue, B
...	...	...	...	75	40% fawn, D 40% blackish blue, D 20% reddish brown, D	75	grayish brown, D
...	...	...	...	50	50% dark blue, B 4% fawn, D 5% burnt sienna (brown), D	25	80% burnt sienna (brown), D 20% dark blue, B

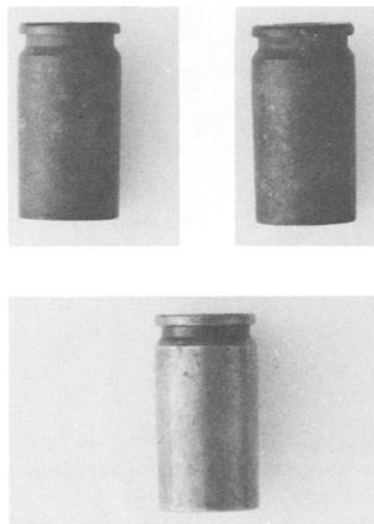


FIG. 1—Permanence of corrosion products: (top) 9-mm parabellum cartridges, not handled, and (bottom) handled 9-mm parabellum cartridge.

were found to be extensively covered with corrosion products (side, 75%; head, 50%; see Table 1 and Fig. 2). Their colors were a combination of ink-blue and brown.

After two persons had handled one case for a total time of 15 min, it was found that most of the corrosion products had been removed (Fig. 3, Rows 4 and 5).

### *Microscopic Markings*

After dirt had been washed from the buried cases, each was examined with a stereobinocular microscope and the characteristic features of the firing pin impression were found to be still recognizable. In addition, the buried cases were readily matched with unexposed reference cases under the comparison microscope.

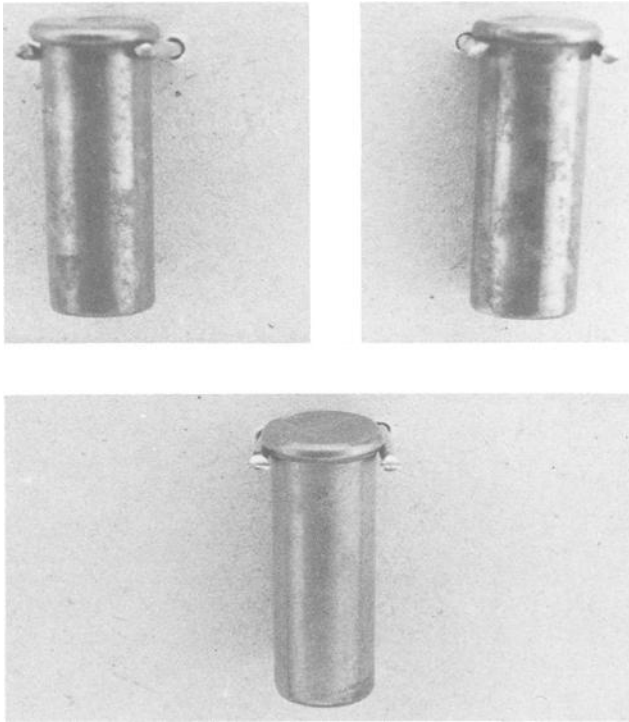


FIG. 2—Corrosion products on cases: (top) cases buried at Location 20 for 18 weeks and (bottom) fired reference case.

## **Discussion**

### *Corrosion Products*

The amount and color of corrosion products on the cartridge cases were extremely variable. The following observations were noted for the sides of the cases. The numbers in parentheses refer to the locations.

Corrosion products could be uniformly distributed or confined to one area. After 18 weeks the proportion corroded varied from 5 to 100%. Although the apparent effects of corrosion might be expected to increase with time, these occurred at only six locations

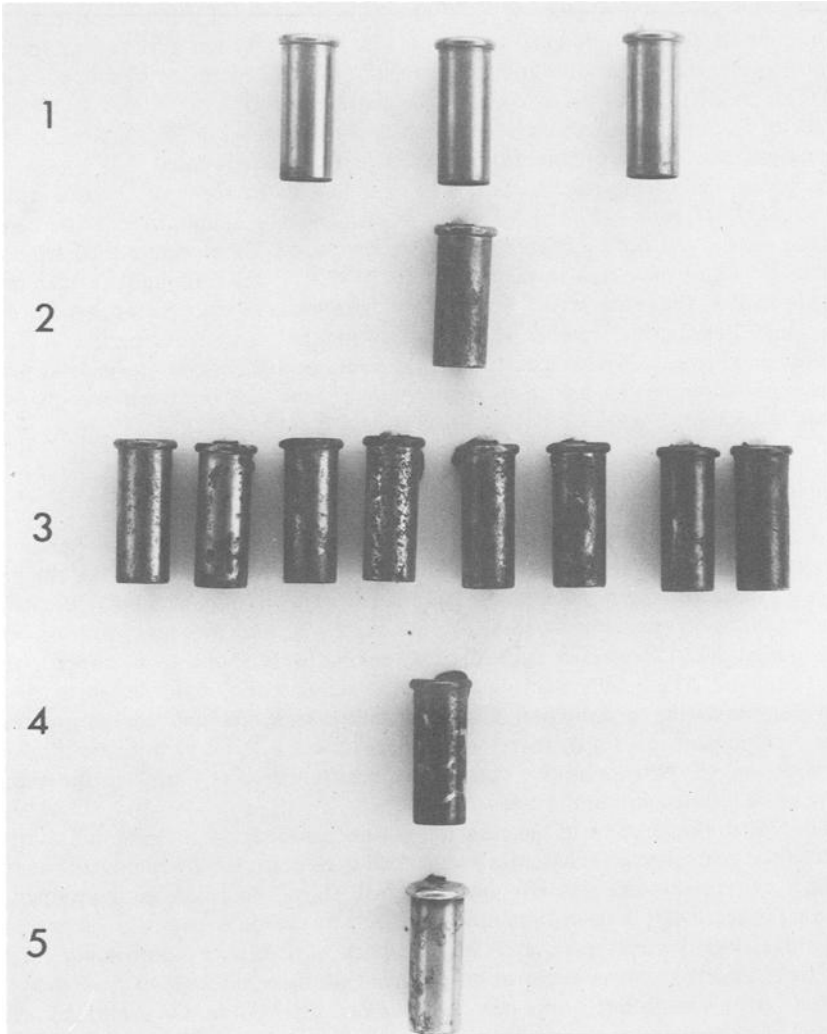


FIG. 3—*Variability and permanence of corrosion products: (Row 1) Fired reference cases. (Row 2) Exhibit case. (Row 3) Corrosion products on cases buried for 18 weeks: (left to right) Location 16, first case; Location 13, first case; Location 5, second case; Location 10, second case; Location 19, second case; Location 12; Location 8, first case; and Location 11, first case. (Row 4) Corrosion products on one of two cases buried at Location 20 for 18 weeks. (Row 5) Corrosion products on the other case buried at Location 20 after handling.*

(2, 4, 7, 11, 14, and 19). At Locations 5, 7, 17, and 18 they were relatively constant after different periods, while at Locations 3 and 6 they were less after the longer period. Corrosion products could decrease and then increase (9), the reverse could happen (12, 13), or they could remain constant for a time and then increase (10). Even cases buried side by side for the same period had different amounts of corrosion products (10, 14, 15, 16, and 21) or different corrosion colors (7, 14, and 15). Although corrosion colors did not change appreciably over the 18 weeks at most locations, they did at 7, 8, 15, 16, 18, and 19. Published work indicated that it was not possible to predict accurately from the

chemical and physical properties of a soil how buried mild steel will corrode [6,8]. There was nothing in the literature cited to suggest that this would not also be true for brass. As this experiment was not an attempt to relate observed corrosion characteristics with soil types, no attempt was made to classify or analyze soils.

Some of the varying corrosion characteristics are illustrated in Fig. 3, Row 3. Similar observations were noted for corrosion products on the heads of cases.

The police alleged that the evidence case was left at the scene of the homicides on approximately 17 June 1970 and found on 28 Oct. 1970. To minimize climatic variables the same season and duration were chosen for this study. Cases were buried from 21 to 25 June 1972 and recovered at periods up to 30 Oct. 1972. Although weather records were not kept at the crime scene, which was a farmhouse in the country, general observations indicated that the weather was normal during the experimental period.

Although when first ejected a cartridge case would probably lie on the ground surface, the cases in this study were buried to minimize the risk of their being removed by curious animals or persons.

#### *Permanence of Corrosion Products*

It is commonly observed that dull (corroded) brass objects brighten as handling removes some corrosion products from the high spots and flats (for example, the handle of a brass tap is usually brighter than the remainder of the tap). Similarly, the handled 9-mm parabellum cartridge case studied brightened, and the corrosion products on one of the buried 0.22 cases taken from the crime scene were found to be superficial and readily removed. The handling was an attempt to simulate the treatment which the cases would receive during examination under the stereo-binocular and comparison microscopes. Throughout this study, therefore, care was taken not to touch the exterior of the cases with fingers. When assessing corrosion products the cases were held for examination by a rod inserted within the cases.

A newly manufactured cartridge case appears uncorroded. After firing and burial for 18 weeks the corrosion products present on such a case are largely removed by normal handling. Microscope examination, however, will show some corrosion products still remaining in scratches, hollows, and other relatively inaccessible parts.

Cartridges kept several years, even in their packets, can have significantly corroded cases. Experiments show these corrosion products are more difficult to remove by handling than corrosion products on a new cartridge case after burial. On each kind of case, however, any remaining corrosion products are brightened by handling.

The scene was unoccupied and under police security for five months after the murders. The garden was undisturbed until a search with a sieve found the exhibit case. When it was found, no notes were made of its appearance. Figure 3, Row 2 shows the appreciable amount of corrosion products still remaining at the time of this study (side, 30%; head, 10%; both mustard-brown colored), even though the case had been extensively handled by several persons both in New Zealand and England. From other evidence, it is believed that before firing the cartridge was at least 7 years old, hence the more tenacious kind of corrosion products could have been on the case when it was ejected onto the soil. This could explain the corrosion products remaining when studied; handling had removed the superficial corrosion products resulting from its burial, leaving the more tenacious kind which had been present before firing. There was nothing inconsistent in the appearance of corrosion products remaining on the cartridge case to suggest it had not been exposed for 18 weeks as alleged.

From this study it was concluded that it was not possible to

- (1) predict the amount or color of corrosion products that would be present on a

new, fired, 0.22, brass cartridge case buried just below the soil surface for 18 weeks;

(2) assess corrosion products on the exhibit cartridge case by comparing with corrosion products on cartridge cases buried at a different location; or

(3) relate corrosion products on the exhibit cartridge case to a time two years earlier, when in the interim period the cartridge case had been extensively handled by several persons.

### Summary

Although new, fired, 0.22, brass cartridge cases buried in soil for more than 18 weeks may be expected to be corroded, the amount and color is extremely variable, even with cases buried side by side. Therefore corrosion products on a cartridge case buried at one location cannot be assessed by comparing with corrosion products on a case buried at a different location.

As corrosion products on the cartridge cases are of a superficial nature they are likely to be removed rapidly by handling. If this occurs, corrosion characteristics cannot be related to an earlier time.

On corroded cases the characteristic fine detail in the firing pin impressions remains recognizable.

### Acknowledgments

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Chemistry Division  
Department of Scientific and Industrial Research  
P. O. Box 2224  
Auckland, New Zealand