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CASE REPORT

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Trace Element Analysis of Steel Sections on Either Side of an Oxygen Cut in a Vehicle Suspected of Being Stolen

There is an increasing number of criminal offenses that involve the cutting up or destruction of steel components. The most common of these is the oxygen cutting of steel safes. Also on the increase is the theft of late model cars and trucks. These vehicles are taken to isolated sites and dismantled for the resale of expensive parts. With car and truck parts becoming increasingly more expensive this form of theft is likely to continue.

In order to successfully prosecute this form of crime in the law courts, it is necessary to prove an original relationship between the metal pieces. Sometimes this connection can be made through the similarity of steel microstructure or paint composition. However, not infrequently, the discarded portion of a vehicle is doused with gasoline and burned to give the appearance of an older, weathered, discarded wreck. In this event the paint work is destroyed, and even the microstructure may be altered by heating; all that is left is the heavily scaled steel component.

In a case of this type which arose in South Australia, a burnt portion of the front end of a vehicle, recognized as being from a late model, was recovered from a large public rubbish dump. Guided by information received, police found the front subframe of a similar late model vehicle in a suburban backyard. It then became necessary to check for common origin (Fig. 1).

The subframe had been cut with oxygen from the suspension-tower mounting (Fig. 2). The matching of the oxygen-cut surfaces is shown in Fig. 3. In oxygen cutting, the heat for melting is derived from the oxidation of the steel. With thick steel parts, the pattern of drag lines enables an unequivocal conclusion regarding common origin to be drawn. However, with thin sections control of oxygen cutting is more difficult and a less well-developed drag line pattern is made.

On the charred body of the subject vehicle no paint remained, and even the microstructure had been altered because the upper critical temperature of the steel had been exceeded. Thus trace analysis of the steel sections was the only remaining technique. Fortunately, at the point of the cutting, the engine-supporting subframe of this particular

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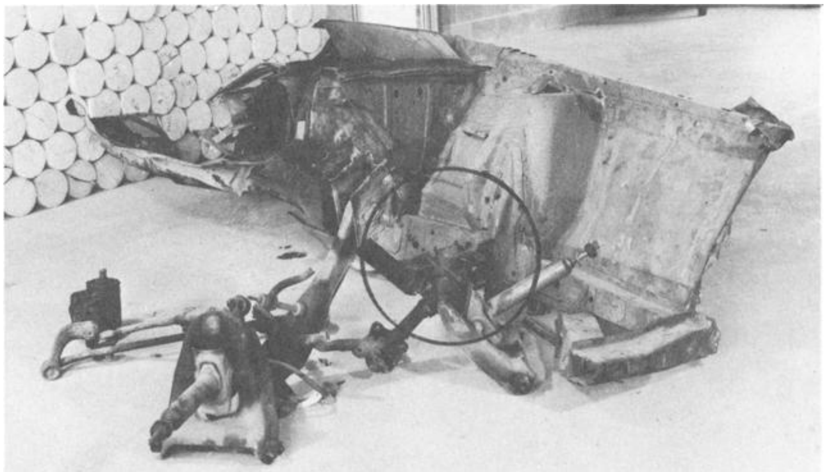

FIG. 1 —*Photograph of part of a vehicle with unburnt subframe in left-hand bottom region and burnt body section in right top region. The circle shows the position of the oxygen cut.*

sedan consisted of seven separate steel sections welded together to form the supporting structure. All seven sections were represented both in the suspension-tower mount and on the engine-supporting subframe. All seven corresponding sections were compared by emission spectroscopy.

Experimental Procedure

The emission spectrography was carried out on a Baird Atomic 3-m Eagle-mounted concave diffraction grating spectrograph. Although a direct-reading spectrometer was available it could not be used because some of the samples were too small for the spark chamber. Furthermore, although the additional elements carbon, sulfur, and phosphorus would have been obtained, the levels may have been altered by the intense heating of the samples. Also, in our experience, minor trace element variations become more apparent through spectrographic comparison.

The spectrographic analysis consisted of burning chemically cleaned 10-mg samples to completion in high purity anode cups, together with graphite cathodes. The excitation consisted of a 30-A d-c discharge for 90 s with a Stallwood air jet. The second-order spectral range 280 to 340 nm (2800 to 3400 Å) was used. With a dispersion of 0.28 nm/mm and a resolution of 0.007 nm this range contains strong interference-free lines of most elements of interest, in spite of the overall complexity of the iron spectra. Each sample was spectrographed in triplicate to eliminate any possibility of error resulting from contamination. The triplicate results did not show any significant variations as the acid cleaning of the 10-mg samples prior to burning eliminated the possibility of stray contamination.

Semiquantitative values were obtained by visual comparison through a Judd-Lewis comparator against standard steel samples, although densitometry could have been used if required. Although approximate parts-per-million levels of trace elements can be recorded for ease of comparison, it is the overall spectral comparison, not the absoluteness of the values given, that is most important.

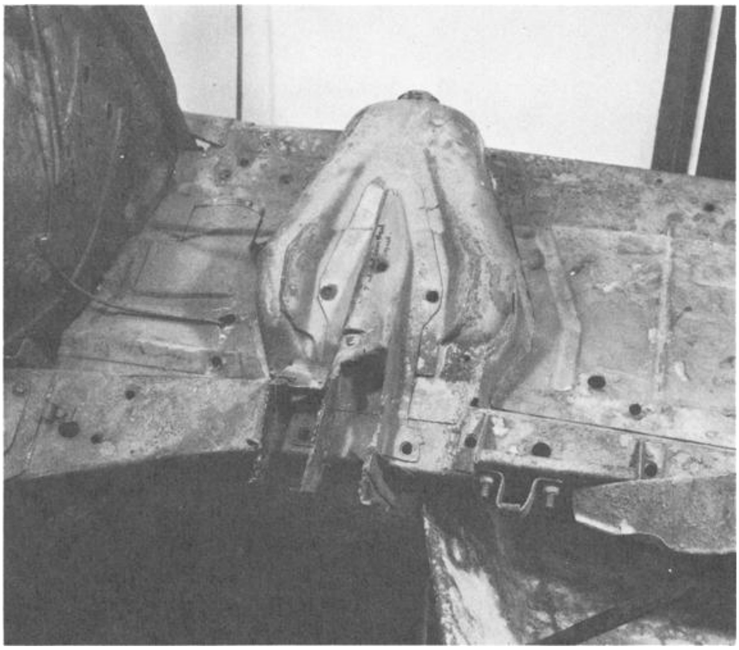

FIG. 2—*Close-up photograph of burnt body section in the region of the suspension-tower mounting. The oxygen-cut surfaces are in the center of the photograph.*

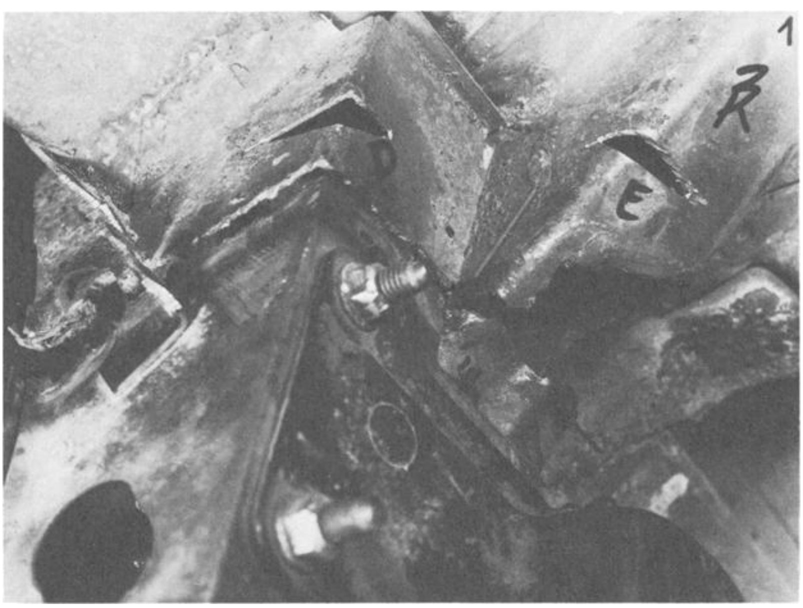

FIG. 3—*Close-up photograph of the oxygen-cut section within the circled area of Fig. 1. The subframe is in the foreground.*

Results and Discussion

The spectrographic analyses are shown in Table 1. On comparison, it was found that all seven pairs of steel sections matched spectrographically and five of the pairs contained levels of at least one trace element that distinguished one pair from the other pairs. Two sections (2 and 6) contained trace element levels so similar as to be classified as indistinguishable.

If a component should consist of only one or two sections of steel of the type (plain carbon) on this vehicle, a spectrographic cross-match may not be very helpful unless some unusual variant exists in the trace elements present. In this case, however, there were no less than seven cross matches, with the steels falling into six distinct classifications as to trace element composition. Section 5 with 1000 ppm of aluminum was an aluminum-killed, stabilized grade of steel. Section 5 was examined metallographically and was found to have the characteristic "pancake" ferrite grain stage, thus confirming the spectrographic result.

Aluminum is intentionally added to steel to produce a strip that is very ductile and nonaging and as such is used for exposed vehicle parts [*1*]. The use of such a steel for a concealed vehicle component, in this instance a component joining a subframe to a suspension-tower mounting, is unusual and most probably represents a mix at the steel plant or the press shop.

Only one pair of sections contained a high tin trace element content. The steel plant in Australia producing low-carbon steel strip for vehicle components also produces low-carbon steel sheet for tinplate. The steel-making plant takes scrap from various parts of the plant for remelting. The melt from which the steel of Section 1 was rolled was thus one to which scrap containing tin had been added. The likely source of the tin-containing scrap was the tinplate plant, and thus Section 1 had a high tin trace element content.

How was the complex cross matching to be interpreted? Certainly, taken in isolation, it did not prove common origin. However, it reduced both matching parts to the membership of a small set of such components. It was even possible that the composite steel member represented a unique mix of steel, but there was insufficient information available for reliable permutation statistics.

In any event the composition of the steel was physical evidence that had to be available to the court. The comparison supported the prosecution's case, but if the pairs had not matched the case would have collapsed. For this reason the defense could also have demanded the comparison be done to support the defense. If we are to obtain objective knowledge of the relationships between crime scene and suspect then, in the words of Popper [*2*], "The theory must be falsifiable." By checking the steel trace levels we selected

TABLE 1—*Trace element levels in parts per million.*

Element Wavelength, nm	Steel Section 1	Steel Section 2	Steel Section 3	Steel Section 4	Steel Section 5	Steel Section 6	Steel Section 7
Aluminum, 308.2	50	50	50	20	1000	30	50
Chromium, 301.5	300	150	300	300	150	150	<100
Tin, 317.5	100	<50	<50	<50	<50	<50	<50
Manganese, 393.3	≃7000	≃7000	≃7000	≃7000	≃7000	≃7000	≃7000
Silicon, 288.1	≃50	≃50	≃50	≃50	≃50	≃50	≃50
Nickel, 305.1	≃250	≃250	≃250	≃250	≃250	≃250	≃250
Copper, 327.4	≃50	≃50	≃50	≃50	≃50	≃50	≃50
Vanadium, 318.4	≃50	≃50	≃50	≃50	≃50	≃50	≃50
Molybdenum, 319.4	<50	<50	<50	<50	<50	<50	<50

a test that could have either supported the prosecution to a degree or negated the case completely, an unbiased position.

As it turned out the complex cross matching, when taken with the congruence of the oxygen-cut section and other corroborative evidence, proved overwhelmingly persuasive. Consequently the defendants changed their joint plea to guilty during the lower court hearings.

Summary

A vehicle suspected of being stolen was dismantled by oxygen cutting. Two parts of an engine-supporting subframe consisting of seven individual steel sections were subsequently located and when placed together at their oxygen-cut surfaces a good physical match was obtained. Since the steel sections were thin, the pattern of drag lines on the oxygen-cut surfaces was not sufficiently distinctive to enable an unequivocal conclusion to be drawn. All seven sections from both parts were compared spectrally. The sections matched with respect to trace elements, but they differed and could be distinguished from each other in six of the seven sections.

Acknowledgment

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[*2*] Popper, K. R., *Conjectures and Refutations,* 5th ed., Routledge & Kegan Paul, London, 1974, p. 256.

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