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EXAMINATION OF METAL COMPOSITE USED IN THE MANUFACTURE OF SAFES

by

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PHYSICAL METALLURGY DIVISION

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SUMMARY OF RESULTS

As a result of discussions on improved materials for the construction of safes, an examination was made of a sample of drill resistant material to determine its method of fabrication.

It was surmised that the component had been made by packing a mixture of tungsten carbide chips (broken drill bits, etc., not pure tungsten carbide) and a powdered copper brazing alloy into a welded steel sheath. The assembly had then been furnace brazed to consolidate the whole.

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INTRODUCTION

In the course of discussions on the various components and construction methods used in modern safes, it was noted that the locks, and other points are protected by plates designed to offer maximum resistance to attack by rotary cutters. A sample of such a drill resistant material was submitted to this Division in order to determine the materials used and the method of manufacture. (Chubb-Mosler and Taylor Safes Limited, Brampton, Ontario, October, 1965).

VISUAL EXAMINATION

The sample, illustrated in Figure 1, comprised a steel-jacketed assembly of irregularly-shaped particles embedded in a yellow, copper-base matrix. The steel jacket, 0.04 in. thick, covered all surfaces and edges, (including a 3/4 in. diameter hole), except for the sawn edge shown in Figure 1. The sample measured 3.5 in. in width, 5.5 in. long and had an overall thickness of 3/16 in. It was noted that the closed end of the sample was convex and that all edges appeared to be slightly barrelled, as if the material had been flattened by rolling, or in a press. The sections cut for chemical and metallographic analysis are shown in Figure 2.

METALLOGRAPHIC EXAMINATION

Because of the non-uniform nature of the material and the marked differences in the hardness, and chemical characteristics of the components, the samples proved difficult to polish.

A section through the plate showed a general absence of voids and a good bond between the copper-base matrix and both the hard particles and sheath material. The matrix had a microstructure suggestive of a copper-zinc brazing alloy. The steel microstructure was shown to be deeply decarburized from the outside, and composed of equiaxed ferrite grains, as shown in Figure 3. It was noted that in the closed end corners of the assembly, the slag stringers running longitudinally in the sheet were aligned tangential to the inner bend. As illustrated in Figure 4, all edge sections showed a V-shaped undercut on the centre of the inside steel face. A detail of these notched areas (Figure 5) shows them to have a finer grain size than adjacent parts of the steel jacket. The position of these notches and the grain size of the steel around them, would suggest that the jacket has been made by butt welding the bent edges of two identical dished steel sheets.

A smooth convex outside surface could be obtained by grinding.

The manner in which the hole in the plate has been contrived substantiates the above deduction, since it is seen in Figure 6, that a steel cylinder has been inserted between the top and bottom surfaces to form the wall of the hole. In addition, it may be noted that the steel insert has been brazed into position by brazing alloy from the inside seeping into the joint.

The "cast" structure in the brazing alloy, and the marked attack of this alloy on the steel jacket in some areas confirm that the material had been melted rather than sintered.

QUANTITATIVE ANALYSIS

(a) Steel

A quantitative spectrographic analysis of the steel face gave negative results for chromium, molybdenum, nickel, titanium, tungsten and vanadium, whereas copper and manganese were found in minor amounts. It is impossible to evaluate the original carbon content since the steel is highly decarburized, as can be seen in Figure 3 and 5. These results indicate that a mild carbon steel has been used as a sheath material.

(b) Matrix

To obtain a sample for chemical analysis, the two steel faces of a section of the assembly were ground off and the remaining composite of brazing alloy and carbides was exposed to cold dilute nitric acid. The acid dissolved the brazing alloy rapidly and the unattacked carbide particles were filtered from the solution.

The chemical analysis of the acid solution indicated that the matrix of the composite was a high strength brazing alloy, corresponding to ASTM Specification B260-62T, Alloy Classification RBCuZn-D (approximately 50% Cu, 10% Ni, 40% Zn). The nominal solidus and liquidus of this brazing alloy are respectively 921°C (1690°F) and 934.5°C (1715°F) with a brazing range from 938°C (1720°F) to 982°C (1800°F). This material is commonly used in furnace brazing steel components.

(c) Carbide Particles

The hard particles were found to be tungsten carbide of specific gravity 12.8 and the following analysis (wt %).

Tungsten	Titanium	Cobalt	Carbon	Others
75	4	7	7	7

A sieve analysis of a sample of extracted particles gave the results shown in Table 1.

(d) Relative Proportions

To find out the proportions of each component in the assembly, three pieces were cut, weighed, and the steel faces ground off, leaving the composite brazing alloy-carbide, which was then separated with cold concentrated nitric acid.

It was found that the average proportion of carbides in the matrix was 68.7 wt %.

In the whole assembly, the proportion of each component was 20.9% steel, 25.4% brazing alloy and 53.7% carbides respectively. With this high proportion of carbides, even allowing for the high density of tungsten, it will be appreciated that, as can be seen from the microstructures, the carbide particles would be touching each other. This would provide an effective barrier for cutting tools, and would also prevent the carbides from segregating during the brazing operation.

DISCUSSION

In spite of the fact that the appearance of the sample (Figure 2) closely resembles an end section of rolled plate, it is obvious that this method of manufacture must be rejected when consideration is given to the placement of the steel cylinder between the steel surfaces at the hole. The absence of corner welds further excluded a picture frame type of assembly. That the component could have been made by joining together two identical cups (as suggested by the butt welded steel joints) is unlikely since the hole closure itself is in one piece. With the exclusion of these possible methods of manufacture then, it is considered that a reasonable reconstruction of the manufacturing operations might be as follows:

1. Press out two identical steel dishes.

2. Butt weld these together to form an envelope and trim to give one open end. This operation is done with the cylindrical hole closure in position, or it could be inserted through the length of the closure from the open end.

3. Fill the jacket with a mixture of brazing metal powder and tungsten carbide in the ratio 1:2 by weight, and pack to maximum density by vibratory or other means.

4. Complete closure of envelope.

5. Furnace braze at about 960°C (1760°F) under constriction (to stop liquid brazing alloy running out of the hole closures.

This schedule is an approximate one and may in reality include some variation such as pressing, brazing the assembly in the vertical position thus eliminating end closure, welding in the hole inserts to complete closure of these holes, etc.

CONCLUSIONS

1. The sheath material is a mild carbon steel.

2. The matrix is a high strength brazing alloy.

3. The hard drill resistant particles are tungsten carbides.

4. The method of manufacture comprises filling a welded steel envelope with a powdered mixture of carbides and brazing metal, and furnace brazing the assembly.

TABLE 1

Carbide Particles Size

Mesh	% Retained
+ 8	20.8
-8 + 10	31.4
-10 + 14	27.6
-14 + 16	5.8
-16 + 20	4.7
- 20	9.7

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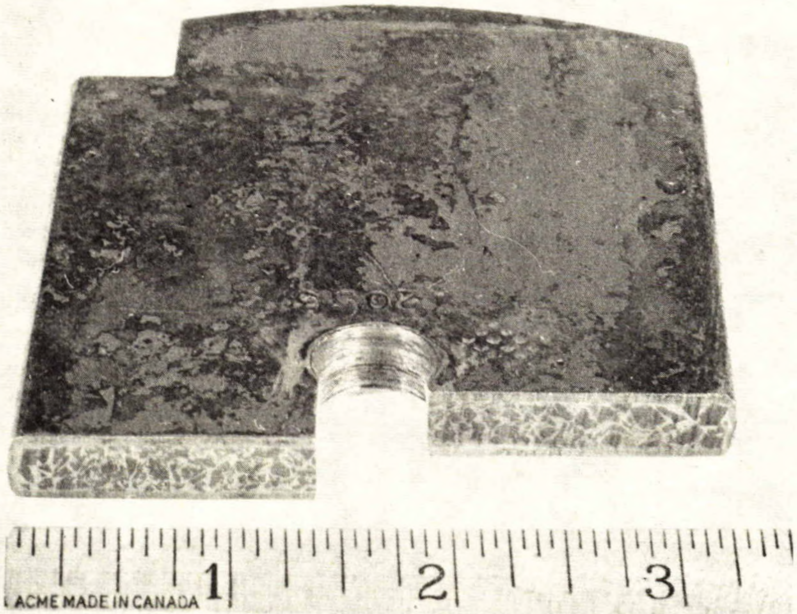


Figure 1. Photograph of the sample.

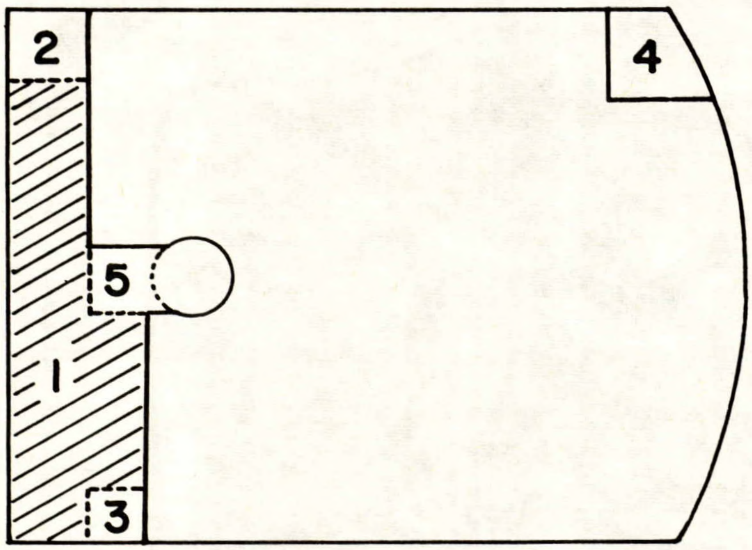
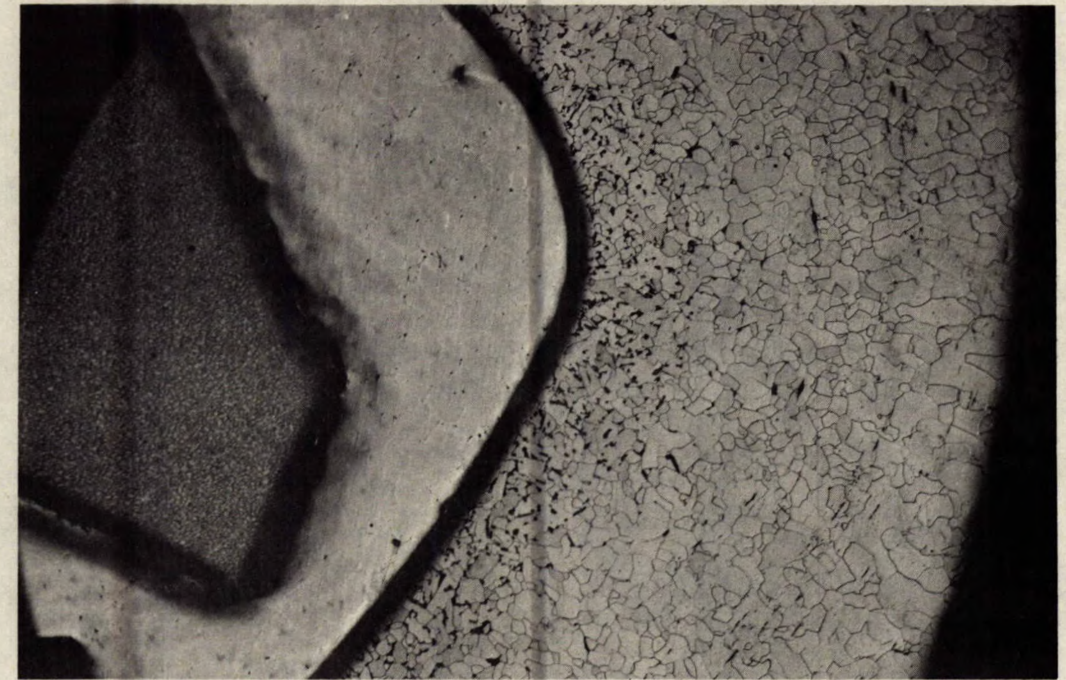


Figure 2. Method of taking samples.

1. Quantitative Analysis samples.
2. Longitudinal edge section, Figure 3.
3. Longitudinal edge section, Figure 4.
4. Close end section, Figure 5.
5. Hole details, Figure 6.



X80, etched 2% nital

Figure 3. Details of a corner.

Figure 4. Longitudinal edge section. X8

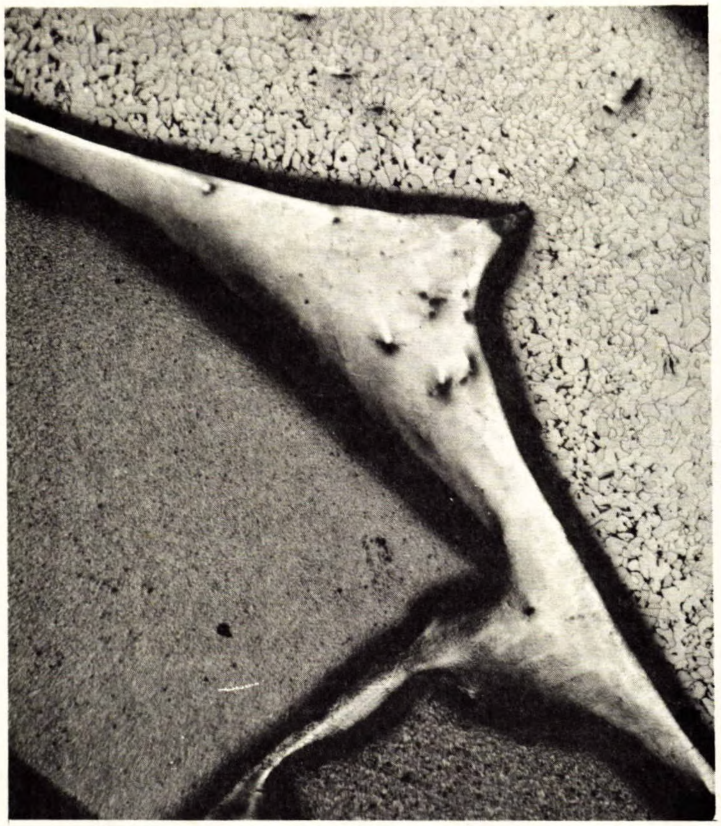


Figure 5.

X80, etched 2% nital

Details of notched area.

Figure 6.

Detail of the hole closure, X8.