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OTTAWA May 1st, 1944.

# REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1632.

Examination of an English-Made P.I.A.T. Bomb.

(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals,
—
Ore Dressing
and Metallurgical
Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

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### Origin of Material and Object of Investigation:

On April 19th, 1944, an English-made P.I.A.T. bomb was received (Analysis Requisition No. O.T. 4172) from the Inspectorate of Materials, Inspection Board of the United Kingdom and Canada, Ottawa, Ontario. An accompanying letter (File No. 12/4/1, Investigation No. 79), signed by Mr. R. O. McGee for Mr. J. M. Gilmartin, I.O.M., for Inspector of Materials, requested:

(1) Chemical analysis of the outer and inner tubes, with particular attention to the carbon content and any residuals such as nickel, chromium, molybdenum, etc.

(2) Microscopic examination of inner and outer tube

(a) in longitudinal section,

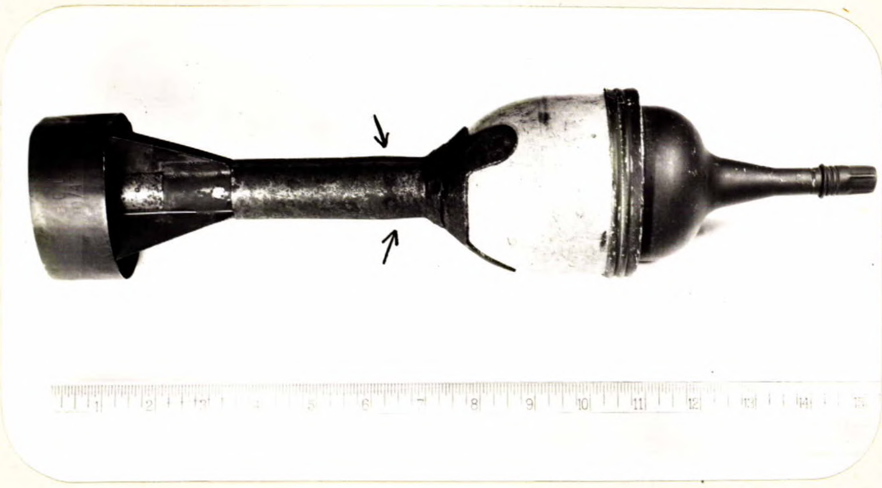
(b) around the flare of the outer tube, avoiding spot-welded areas.

(3) Tensile tests of each tube, if possible.

## Macroscopic Examination:

A photograph of the bomb was taken. This is shown in Figure 1. Note the arrows pointing to the bulge in the tube. This bomb had been fired in test.

Figure 1.



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## Chemical Analysis:

Samples for chemical analysis were obtained from both the inner and the outer tube. The results are given below in Table I:

TABLE I. - CHEMICAL ANALYSIS.

| | | INNER TUBE | OUTER TUBE |
|---|---|---|---|
| | | - Per cent - | |
| Carbon | - | 0.06 | 0.29 |
| Silicon | - | None determined. | 0.22 |
| Sulphur | - | 0.049 | 0.035 |
| Phosphorus | - | 0.010 | 0.033 |
| Manganese | - | 0.29 | 0.69 |
| Nickel | - | Trace. | 0.13 |
| Chromium | - | Nil. | Nil. |
| Molybdenum | - | Trace. | 0.01 |

## Mechanical Testing:

Micro tensile bars were prepared for the Hounsfield tensometer. Two bars were taken from the outer tube and two from the inner tube. Yield strength and ultimate strength were

(Mechanical Testing, cont'd) -

the only values recorded from these bars. The results of these tests are presented in Table II. It will be noted that there is very poor agreement between these bars. This is probably due to the fact that sections of the tubes were flattened to obtain these bars, thereby work-hardening the steel.

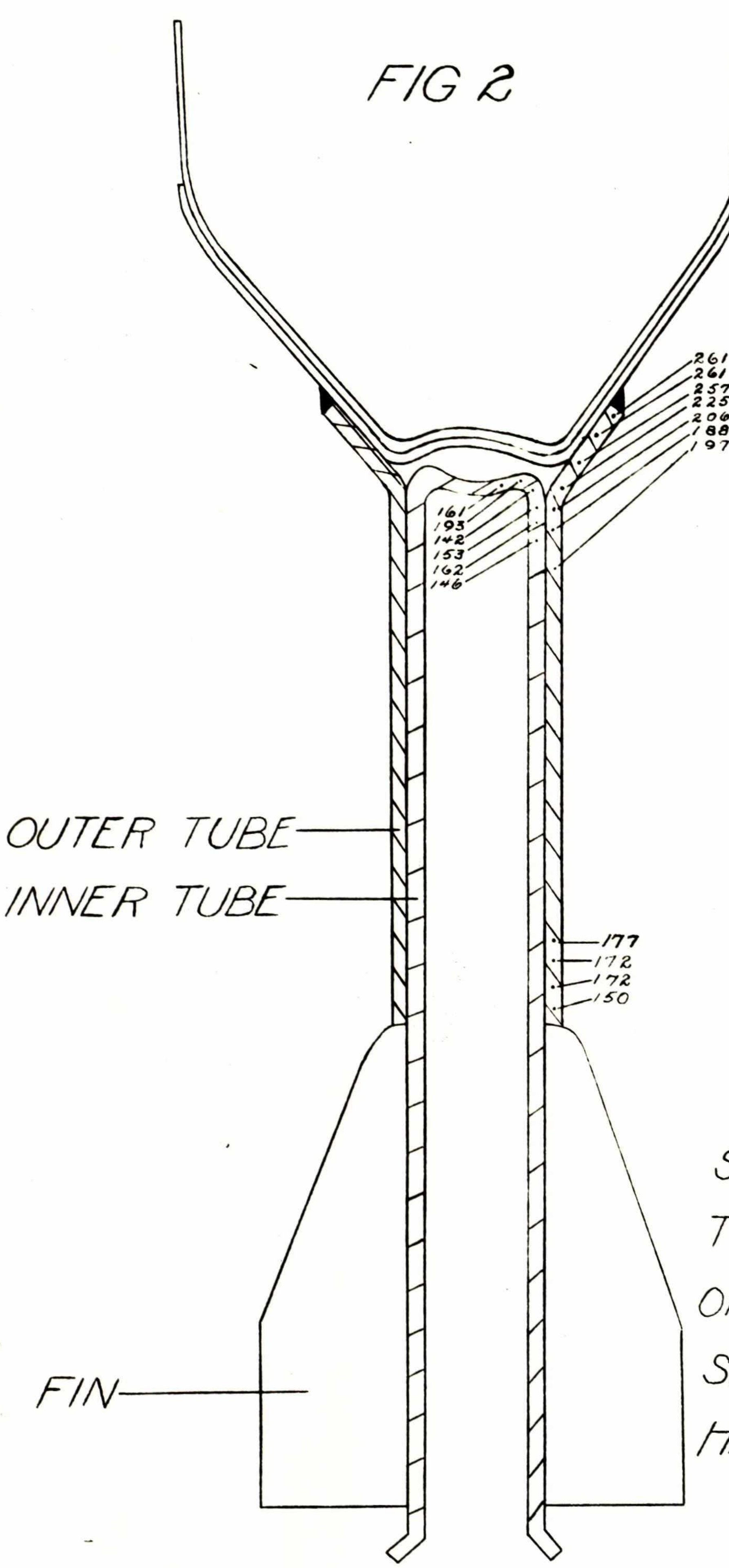
TABLE II. - TENSILE TESTS.

| | INNER TUBE | | OUTER TUBE | |
|---|---|---|---|---|
| | Tensile strength, p.s.i. | Yield strength, p.s.i. | Tensile strength, p.s.i. | Yield strength, p.s.i. |
| Bar No. 1 - | 55,500 | 38,500 | 90,000 | 70,000 |
| Bar No. 2 - | 58,800 | 46,200 | 86,400 | 62,000 |
| Average - | 57,150 | 42,350 | 88,200 | 66,000 |

Hardness tests were carried out on the specimens used for metallographic examination. Two longitudinal specimens were obtained from the outer tube, one at the flared end and one at the opposite end. One specimen was obtained from the inner tube, from the closed end. Hardness tests were made using the Vickers pyramid hardness test with a 20-kilogram load. The results are shown in Figure 2, a sectional sketch of the tube assembly. It will be noted that the hardness of the outer tube increases at the flared end, indicating that the outer tube has not been normalized after flaring. The hardness distribution in the specimen from the inner tube does not permit of any interpretation.

(Figure 2 follows, on Page 4.)
(Text continues on Page 5. )

FIG 2




SKETCH OF TAIL TUBE ASSEMBLY OF P.I.A.T BOMB SHOWING VICKERS HARDNESS VALUES

Metallographic Examination:

Two longitudinal sections were obtained from the outer tube for examination, one from the flared end and one from the opposite end. Care was taken to avoid spot-welded areas in the flared end. One longitudinal section was obtained from the closed end of the inner tube, for examination.

Figure 3 is an unetched photomicrograph, at a magnification of 100 diameters, of the metal in the outer tube. Note that there is a fairly large number of elongated inclusions.

After polishing, the samples were etched in 4 per cent picral. The structure so revealed in the flared end of the outer tube is shown, at a magnification of 100 diameters, in Figure 4. The structure in the opposite end is shown in Figure 5 at X100 magnification. Note the similarity in structure and the decarburized zone at the surface.

Figure 6 is a photomicrograph, at a magnification of 2,000 diameters, showing the structure of the pearlite in the outer tube metal. Note that this pearlite is in part distinctly lamellar.

Figure 7 is a photomicrograph at 100 diameters of the specimen taken from the inner tube after etching in 4 per cent picral, and shows the structure at the surface. Note here that there has been some carburizing of the metal.

Discussion of Results; Conclusions:

The nature of the data obtained from the tensile testing is such that it should not be given too much weight, as there was a certain amount of cold work done on the bars during their preparation.

The hardness testing shows that after the flaring of the outer tube no subsequent normalizing treatment was

(Discussion of Results and Conclusions, cont'd) -

used.

The steel used for the outer tube is not particularly clean. However, it might be satisfactory for this application.

The outer tube has been decarburized to some extent during fabrication. The inner tube has been slightly carburized.

The steel in the inner tube is in the annealed condition. This is necessary, since steel of this analysis is subject to strain ageing and embrittlement if used in the cold-drawn condition.

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Figure 3.

X100, unetched.

PHOTOMICROGRAPH SHOWING INCLUSION CONTENT OF OUTER TUBE METAL.

Figure 4.

X100, picral etch.

PHOTOMICROGRAPH SHOWING STRUCTURE OF OUTER TUBE METAL AT FLARED END.

Note decarburized zone.

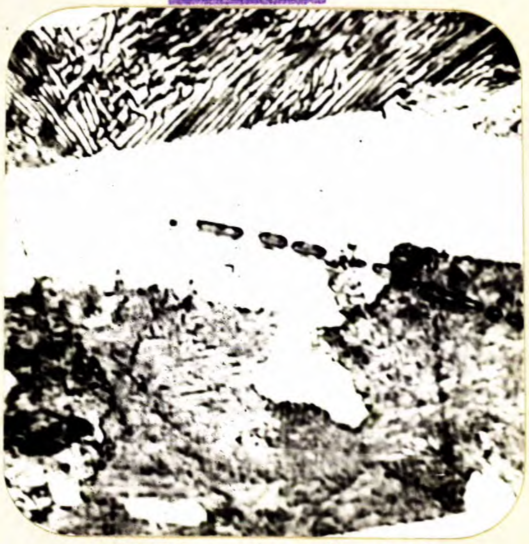
Figure 5.

X100, picral etch.

PHOTOMICROGRAPH SHOWING STRUCTURE OF OUTER TUBE AT END OPPOSITE FLARED END.

Note decarburized zone.

Figure 6.



X2000, picral etch.

PHOTOMICROGRAPH SHOWING STRUCTURE OF PEARLITE IN OUTER TUBE METAL.

Figure 7.

X100, picral etch.

SHOWING GRAIN SIZE OF METAL IN INNER TUBE AND ALSO CARBURIZED ZONE AT SURFACE OF INNER TUBE.

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