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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. 1644.

Examination of T.45 Steel Tubing for Fuselage of Anson V Aircraft.

(Copy No. 10.)

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Source of Material and Object of Investigation:

On May 4th, 1944, Air Commodore A. L. Johnson, for Chief of the Air Staff, Department of National Defence for Air, Ottawa, Ontario, sent in four samples (referred to herein as A, B, C, and D) of T.45 steel tubing used in fabricating the 'B' section of Anson V aircraft fuselages. In a letter (File No. 938DD-5-5(AMAE DAI)) accompanying the material, the following information and requests were submitted:

(1) Difficulties were reported in the welding of these tubes.

(2) The material is ostensibly T.45 or T.35 tubing; but it is permitted to supply SAE X4130 steel tubes or tubing manufactured to U.S. Specifications AN-T-3 or AN-T-33 (NE 8630).

(3) Chemical analysis and mechanical tests were requested in order to establish whether the tubes conformed to the specification.

(4) Sample Tube A represents the trouble encountered in welding. A full metallurgical examination of this specimen was requested.

(5) Tubes A, B and C failed the flattening test but D met it.

(6) Some eight to ten thousand feet of tubing are at present in quarantine and a further quantity has been incorporated in complete fuselages.

Chemical Analysis:

Samples cut from the four tubes were chemically analysed. The results obtained, along with specification requirements for the approved steels, are listed in the following table:

TABLE I.

Sample	C	Mn	Si	P	S	Cr	Mo	Ni
	- Per Cent -							
A	- 0.45	0.85	0.29	0.030	0.022	1.07	0.22	N.d.
B	- 0.26	1.21	0.24	0.023	0.030	-	-	-
C	- 0.31	1.22	0.25	0.019	0.032	-	-	-
D	- 0.31	1.22	0.24	0.021	0.032	-	-	-
T.35, T.45 Specified*	- 0.30	1.75	-	0.05	0.05			-
X4130 steel specified for AN-T-3	- (0.25 to 0.35)	(0.40 to 0.60)	-	0.04 max.	0.05 max.	0.80 to 1.10	0.15 to 0.25	-
NE 8630 steel specified for AN-T-33	- (0.27 to 0.03)	(0.70 to 0.90)	-	0.040 max.	0.040 max.	0.40 to 0.60	0.15 to 0.25	0.40 to 0.60

* Percentages in T-35 are maximum allowable.

Mechanical Properties:

Full-sized tubes were tested in tension and the results obtained, along with specified mechanicals, are listed in the following table:

TABLE II.

Sample marked No.	Size of tubing, inches	Ultimate stress, p.s.i.	0.2 % proof stress, p.s.i.	Elongation, % in 2 in.	Flattening test
A	1.00 OD x 0.039 WT	128,500	106,000	4.0*	Failed.
B	1.00 OD x 0.039 WT	111,900	102,000	15.0	"
C	0.750 OD x 0.038 WT	119,100	109,400	15.0	"
D	0.751 OD x 0.038 WT	120,200	109,000	15.5	Passed.
BSI, T.35		78,400	67,200	--	ID closed to 6T
BSI, T.45		100,000	89,000	--	ID closed to 6T
US AN-T-3		N95,000	75,000	10/15	
US AN-T-33		N95,000	75,000	10/15	

* The low elongation is due to the presence of a weld in the gauge length.

(Continued on next page)

(Mechanical Properties, cont'd) -

Bend Tests -

Specimens cut from the four tubes all passed the bend test.

Hardness Test -

Vickers hardness tests on the tubes gave the following results:

TABLE III.

Tube		Vickers Hardness Number
A	-	289
B	-	247
C	-	254
D	-	254

A survey of the hardness of the welded section of the tubing was also carried out, and the following results were obtained:

TABLE IV.

Location of Readings		Vickers Hardness Number
0.50" from weld	-	627
0.40" " "	-	592
0.30" " "	-	649
0.20" " "	-	649
0.10" " "	-	620
Weld metal	-	224
" "	-	256
0.15" from weld	-	642
0.30" " "	-	579
0.40" " "	-	606
0.75" " "	-	260
0.90" " "	-	283
1.00" " "	-	319
1.15" " "	-	297
1.30" " "	-	302
1.60" " "	-	297
2.00" " "	-	309
2.30" " "	-	297
2.60" " "	-	297
3.00" " "	-	304

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Microscopic Examination:

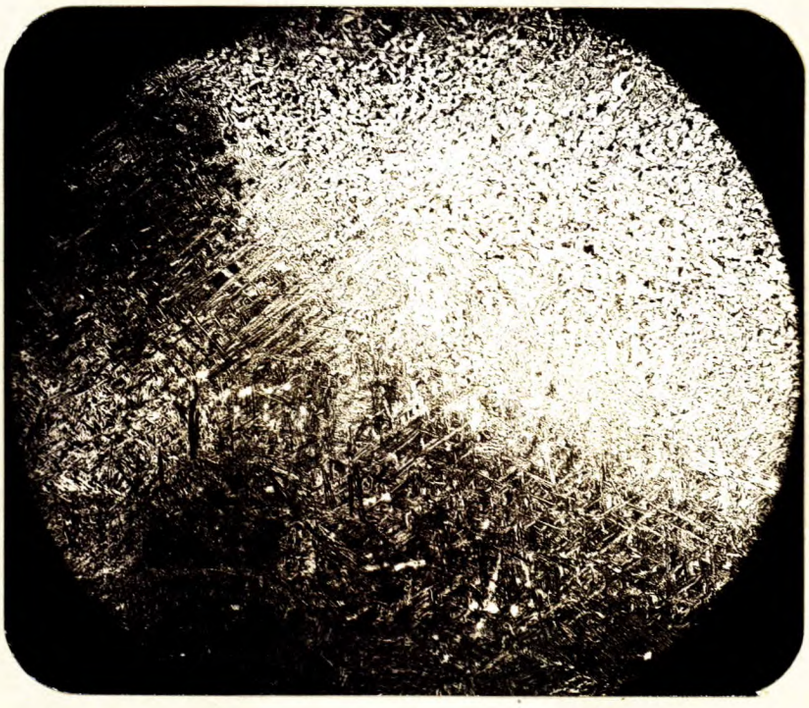
Sections of the welded Tube A were taken in the weld zone. These and cross-sections of Tubes A, B, C and D were mounted in bakelite, polished, and then examined under the microscope in the unetched condition. The weld metal and the parent metal

(Microscopic Examination, cont'd) -

of all tubes were all found to be fairly clean.

The steel specimens were then etched in a solution of 2 per cent nitric acid in alcohol and re-examined. Figure 1 is a photomicrograph, at X100 magnification, showing the microstructure of the weld and parent metal at the transition zone of the weld.

Figure 1.



X100, etched in
2 per cent nital.

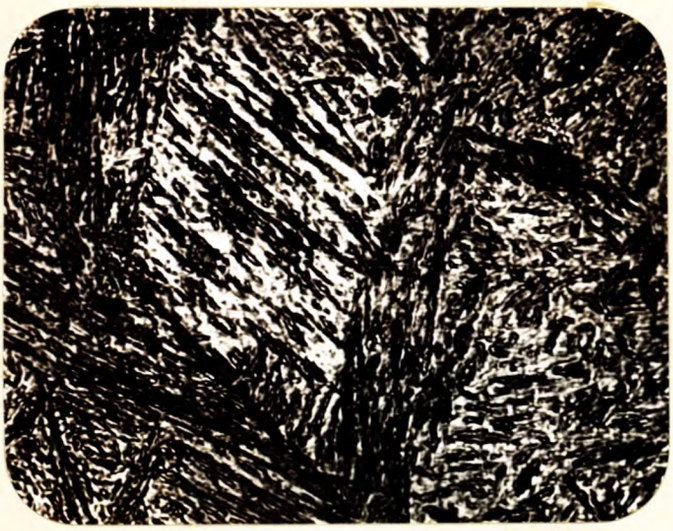
MICROSTRUCTURE OF WELD AND PARENT METAL AT TRANSITION ZONE.

Figure 2 is a photomicrograph, at X1000 magnification, showing the coarse martensitic structure of parent metal in the heat-affected zone adjacent to the weld metal. Figures 3, 4, 5 and 6 show respectively, at X1000 magnification, the nital-etched structures of Tubes A, B, C and D. Tube A's microstructure is finely spheroidized pearlite with little "free" ferrite. The other tube structures show considerable "free" ferrite. The pearlite in these tubes is also spheroidized, with the spheroidization probably being less

(Microscopic Examination, cont'd) -

pronounced in Tube D.

Figure 2.



X1000, etched in
2 per cent nital.

MICROSTRUCTURE OF PARENT
METAL IN HEAT-AFFECTED
ZONE OF TUBE A.

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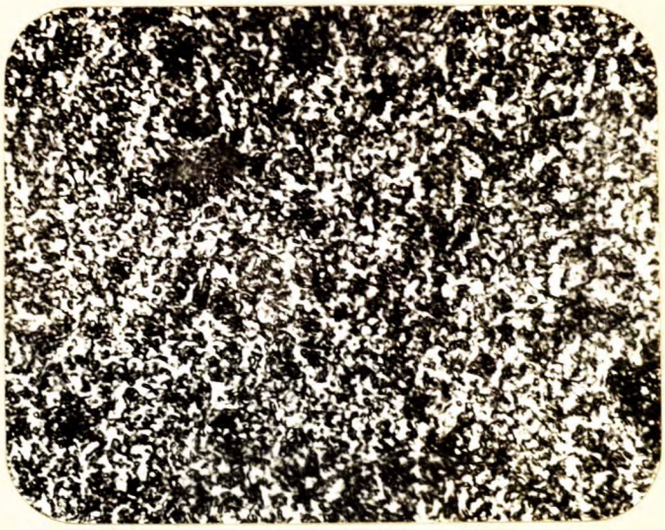
Figure 3.



X1000, etched in
2 per cent nital.

MICROSTRUCTURE OF PARENT
METAL IN ZONE WHICH
HAD NOT BEEN HEATED,
TUBE A.

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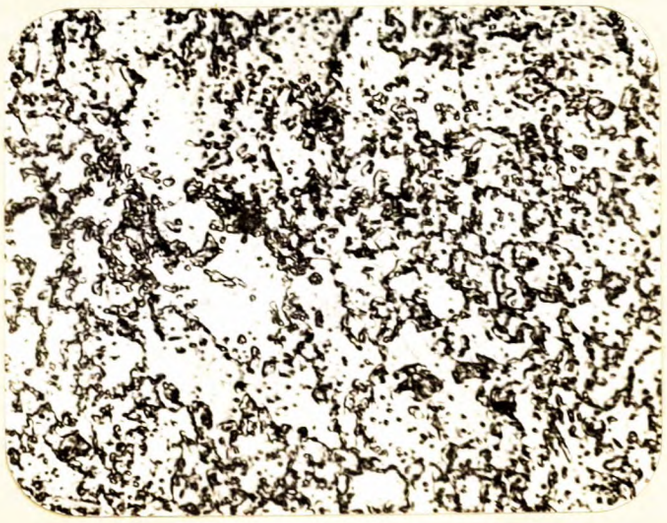
Figure 4.



X1000, etched in
2 per cent nital.

MICROSTRUCTURE OF TUBE B.

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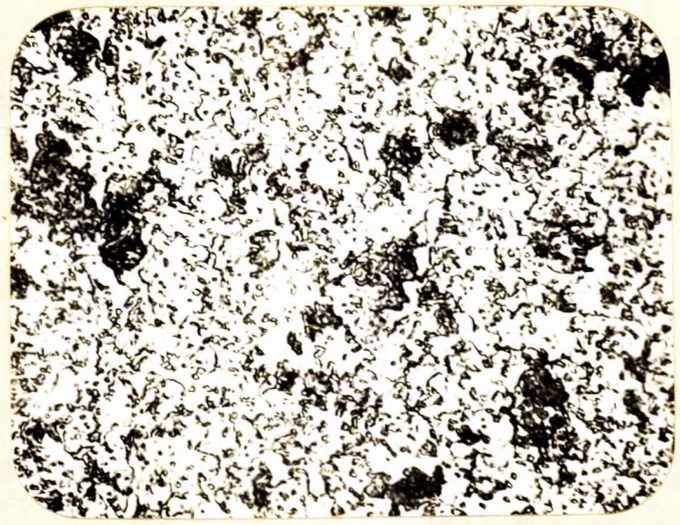
(Microscopic Examination, cont'd) -

Figure 5.



X1000, etched in
2 per cent nital.

MICROSTRUCTURE OF TUBE C.

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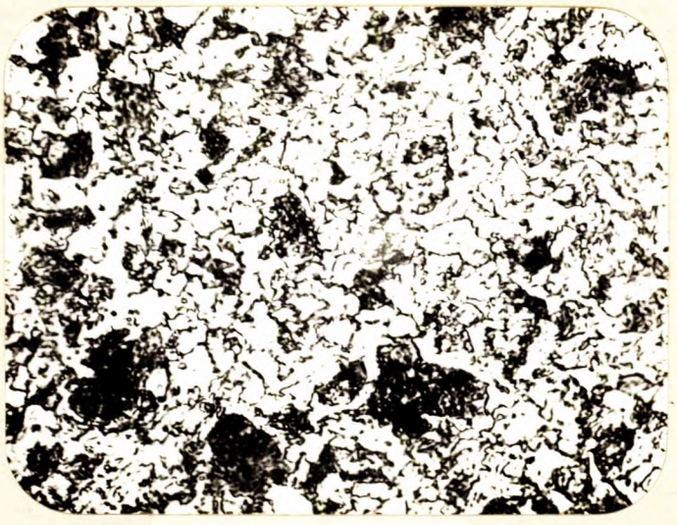
Figure 6.



X1000, etched in
2 per cent nital.

MICROSTRUCTURE OF TUBE D.

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Discussion of Results:

The compositions of the Tubes B, C, and D are within the limits specified for T.45 steel tubing, except for the carbon contents of Tubes C and D which are just outside the upper limit. This is not considered as sufficient reason for rejection. The composition of Tube A does not comply with any of the specifications given in Table I. The steel used in making this tubing is similar in composition to an SAE 4140 steel. Hardness and microscopic tests at the welded section revealed that the steel is air-hardening. In view of the alloy content present, the carbon content is considered to be too high for fabrication by welding unless it is possible to heat-treat after welding. The mechanical properties of all four tubes conform to Specification T.45. It is true that only one sample passed the flattening test, but they all meet the requirements of the bend test, a substitute for the flattening test. The spheroidized pearlite of the "as received" non-welded material indicates that the material was drawn at quite a high temperature. The small amount of ferrite in Tube A indicates that this tube was cooled fairly rapidly prior to the draw.

RECOMMENDATIONS:

1. Tubing A should not be used for Anson V fuselages.

2. Tubing A should not be used in welded assemblies unless the material can be given a subsequent draw heat treatment.

3. Sample Tubes B, C, and D are considered satisfactory for use in welded Anson fuselages.

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NBB:GHB.