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O T T A W A September 20th, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1709.

Comparison of Furnace-Normalized and Induction-Normalized Outer Tubes of Piat Ammunition; Investigation of Commercially Normalized Piat Outer Tubes and Two-Inch Trench Mortar Bomb Tails.

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Origin of Material and Object of Investigation:

On August 30th, 1944, under Requisition No. O.T. 4275, the Inspection Board of United Kingdom and Canada, 70 Lyon Street, Ottawa, Ontario, submitted the following material for comparison of furnace and induction normalizing:

Six (6) lengths of Piat outer tube as received from Page Hersey. Not normalized. Heat VB-9P089.

Also received, for determination of completeness of commercial normalizing, were the following:

Six (6) lengths of Piat outer tube from Page Hersey, normalized at 1625° F. and flared at one end. Length, about 3-7/8 inches.

Six (6) 2-inch trench mortar bomb tails. Normalizing practice unstated.

PIAT OUTER TUBES HEAT TREATED AT P.M.R.L.

Chemical Analysis:

The analysis and specifications are compared below for the Piat tubes.

Element		As found	Specification (in part)
		- Per Cent -	
Carbon	-	0.32	0.28-0.40
Manganese	-	0.65	0.30-0.70
Silicon	-	0.15	0.25 max.
Sulphur	-	0.029	
Phosphorus	-	0.020	

Methods of Testing:

"As Received" Microstructure -

The "as received" structure is shown in Figure 1.

Normalizing -

The normalizing by induction was done with a 30-kilowatt Lepel High Frequency Induction Furnace operating at full power. The time cycle and maximum temperature reached can be adjusted by means of variation in size and shape of coil and by variation in power input. Heating for 15 seconds, to about 1650° to 1700° F., gave the structure shown in Figure 2 (after air cooling).

The furnace normalizing was done by conventional methods. Twenty minutes at 1600° F. gave the structure shown in Figure 3.

Yield and Compressive Strength -

The yield and ultimate compressive strength were determined on an annular section of the tube whose length was about the diameter of the tube. The ends were cut parallel to each other and at right angles to the axis of the tube.

(Continued on next page)

(Methods of Testing, cont'd) -

Hardness -

Vickers hardness numbers were obtained, using a 10-kilogram load.

Results:

Data on Piat Outer Tubes "As Received" and After Heat Treatment in These Laboratories.

Sample	Yield (compression), tons/in.^{2}	Ultimate compressive strength, tons/in.^{2}	Vickers hardness	Remarks
As received	24	37.5	152	Figure 1.
Induction-normalized	26	38	163	Figure 2. Fifteen seconds at 1650 to 1700° F.
Furnace-normalized	26	39	176	Figure 3. Twenty minutes at 1600° F.

Discussion:

Both normalized structures (Figures 2 and 3) met the specifications of 17 to 25 tons/in.^{2} yield (in compression) and 30 to 40 tons/in.^{2} ultimate compressive strength. It can be seen that nearly all the carbides have gone into solution, with a resultant production of a pearlite-ferrite structure on slow cooling. However, in the case of induction normalizing, somewhat higher temperatures were used, which resulted in a coarser structure. Whether or not there is any lowering of the quality of the larger-grained steel for this particular application can only be determined by field tests.

The photomicrographs indicate that the grain size of the laboratory furnace normalizing is about 10 and that of the laboratory induction normalizing is about 6 or 7, so that abnormally coarse structure has been avoided. As far as the

(Discussion, cont'd) -

solution of the carbides is concerned, it would appear that heating to 1700° F. should prove satisfactory.

It may be said that the pearlite-ferrite structure is essentially the same for both induction normalizing and furnace normalizing.

COMMERCIALLY NORMALIZED FIAT OUTER TUBES.

The condition of the commercially normalized Fiat outer tubes supplied can be seen in Figure 4. Here, again, it is seen that nearly all the carbides have gone into solution and that the structure is essentially normalized. The intermediate coarseness of this structure, between that of the laboratory furnace and induction normalizing, indicates that the normalizing has probably been carried on at a lower temperature than in the experiments in these Laboratories.

The tube examined as representative of commercial normalizing can be considered satisfactory.

COMMERCIALLY NORMALIZED 2-INCH TRENCH MORTAR BOMB TAILS.

The tails had been given a normalizing treatment by induction before being submitted for microscopic examination by these Laboratories. The structure developed is shown in Figure 5, which clearly shows that the "normalizing" had not been effective. Many carbide particles are seen, and it is apparent that the process had not been continued long enough or that the temperatures used were too low.

Further normalizing in these Laboratories, by furnace heating for 20 minutes at 1650° F. followed by air cooling,

(2-Inch Trench Mortar Bomb Tails, cont'd) -

resulted in the structure shown in Figure 6. The disappearance of most of the carbides and the formation of the pearlite-ferrite structure can be clearly seen.

GENERAL CONCLUSION:

The examination would indicate that, under proper conditions, acceptable tubing can be produced by induction normalizing. The commercially normalized Fiat tubing examined would bear out this conclusion.

Whether induction normalizing has any advantage in production over furnace normalizing would depend on local conditions.

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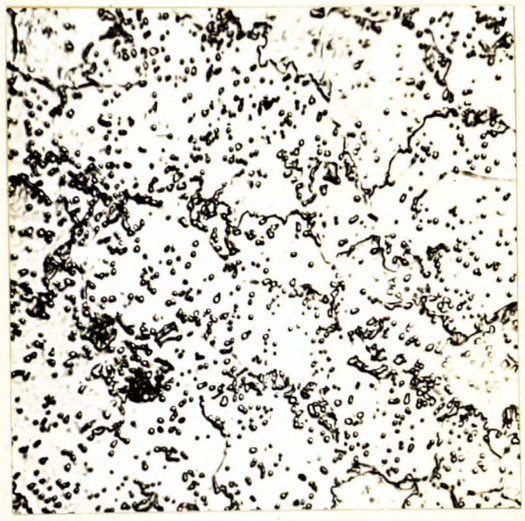
PIAT OUTER TUBES.

Figure 1.



X1000, nital etch.

PIAT OUTER TUBE,
AS RECEIVED.

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Figure 2.

X1000, nital etch.

PIAT OUTER TUBE, AFTER
INDUCTION NORMALIZING TO
ABOUT 1650-1700° F.,
IN 15 SECONDS.

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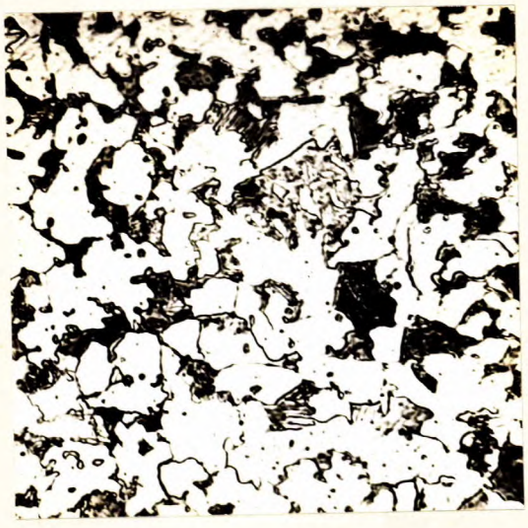
Figure 3.



X1000, nital etch.

PIAT OUTER TUBE, AFTER
FURNACE NORMALIZING AT
1600° F. FOR 20 MINUTES.

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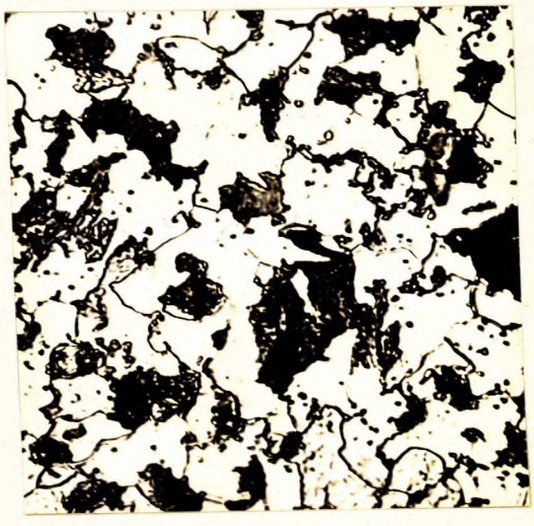
Figure 4.



X1000, nital etch.

PIAT OUTER TUBE, AFTER
BEING COMMERCIALLY NORMALIZED
BY INDUCTION.

Normalizing is
satisfactory.

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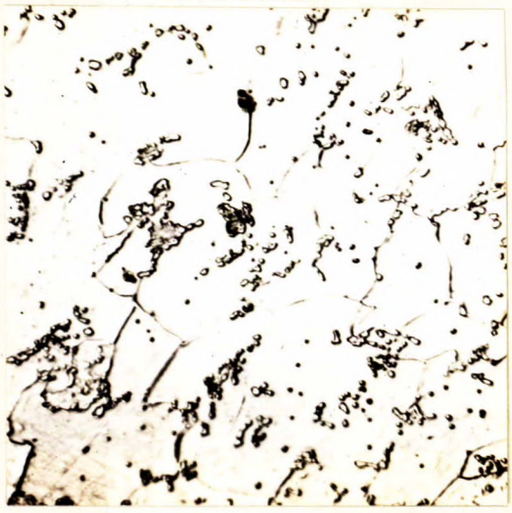
2-INCH TRENCH MORTAR BOMB TAILS.

Figure 5.

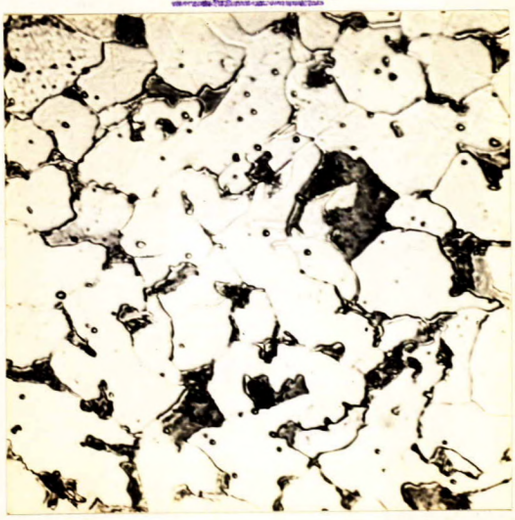


X1000, nital etch.

2-INCH TRENCH MORTAR BOMB TAIL TUBE, AS RECEIVED.

Normalizing had not been completed.

Figure 6.



X1000, nital etch.

2-INCH TRENCH MORTAR BOMB TAIL TUBE, AFTER FURTHER FURNACE NORMALIZING AT 1650° F. FOR 20 MINUTES.

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