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REPORT NO. 710/33

ARMOR PIERCING BULLET CORE STOCK

BY

H. G. CARTER

1934

WATERTOWN ARSENAL
WATERTOWN, MASS.

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Report No. 710/33
Watertown Arsenal

October 22, 1934

ARMOR PIERCING BULLET CORE STOCK.

References.

O.O. 471.84/759
W.A. 471.84/4
F.A. 461/1357-1

Material

Six specimens of A. P. Bullet Core Stock were received from Frankford Arsenal for metallurgical study. Their description was given in F. A. 461/1357-1 1st Ind.

Conclusions

1. Specimens 1, 2, 3 were fairly clean.
 - " 4 and 6 were dirty.
 - " 5 was rather dirty, contained many fine inclusions in bands.
2. No appreciable surface decarburization was found.
3. All specimens had a banded high carbon center suggestive of the segregation of piped stock.
4. The metal near the surfaces of all specimens showed only slight banding.

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1. Specimens 1, 2, 3 were fairly clean.
 - " 4 and 6 were dirty.
 - " 5 was rather dirty, contained many fine inclusions in bands.
2. No appreciable surface decarburization was found.
3. All specimens had a banded high carbon center suggestive of the segregation of piped stock.
4. The metal near the surfaces of all specimens showed only slight banding.

5. The structure of cores

1 and 4 were sorbitic and slightly spheroidized.

2, 3, 6 were completely spheroidized.

5 was sorbitic and partially spheroidized.

Specimens

According to Frankford Arsenal letter 461/1357-1 1st Ind., the specimens were selected as follows:-

1. Carpenter Steel Co. Cal. .30 old stock ground to size.

2. Universal Steel Co. Cal. .30 new stock ground to size Heat C 11281.

3. Universal Steel Co. Cal. .30 new stock ground to size Heat C 11282.

4. Carpenter Steel Co. Cal. .50 old stock carburized cold drawn.

5. Carpenter Steel Co. Cal. .50 old stock carburized cold drawn normalized.

6. Crucible Steel Co. Cal. .50 new stock carburized Heat 39417 ground to size.

Chemical Analysis

Core	C	Mn	Si	S	P	Cr	W
1	1.06	.24	.29	.015	.014	.64	4.13
2	1.025	.28	.305	.016	.008	.62	4.08
3	1.065	.29	.28	.014	.010	.60	4.11
4 outside	1.006	.37	.315	.014	.016	.70	4.34
4A center	1.13	.37	.31	.014	.014	.69	4.32
5 outside	.82	.25	.28	.015	.009	.45	4.38
5A center	.985	.25	.275	.016	.015	.47	4.23
6 outside	1.075	.29	.25	.016	.017	.58	3.76
6A center	1.075	.30	.23	.015	.019	.59	3.68

Discussion

Specimens 1, 2, 3 were fairly clean and 4, 5, 6 were rather dirty, however, the amount of dirt was well within the usual commercial limits. No decarburization was found in 1, 2, 3 and 6 but inasmuch as these had been ground to size, decarburization would not be expected unless severe decarburization had taken place in processing. Cores 4 and 5 had a shallow skin of about .80C.

The microstructure of all specimens had a banded higher carbon center suggestive of the segregation of piped stock. The metal near the surfaces showed only slight banding. The banding consisted primarily of long chains of carbides which were larger than the carbides between the chains. The structure of the cores, aside from carbide chains, varies as follows:-

Cores 1 and 4 sorbite with a slight tendency to spheroidize.

Core 5 sorbite partially spheroidized.

Cores 2, 3 and 6 completely spheroidized.

According to Frankford Arsenal letter 461/1357-1 - 3rd Ind. lots 4 and 5 are exhausted, therefore, will not be considered further in this report.

To remove the chainlike carbide segregation in the centers of the cores it will probably require a somewhat

higher temperature than is at present used, namely,
Cal. .30 1480-1500°F, Cal. .50 1500-1520°F. Probably
a double heat treatment may be required, such as

Stock Normalized

1700°F - 1 hr. - air

Machined and Hardened from

1500°F - 1/4 hr. - oil

400°F - 1/2 hr. - air

It is noted in the heat treatment as given by
Frankford Arsenal that the cores are quenched in water
at 70°F. This seems rather drastic. This type of steel
is often referred to as oil hardening steel.

It is believed that the completely spheroidized
cores 2, 3 and 6 will respond to heat treatments much
more readily than core #1 which is sorbitic with little
spheroidization of the carbides.

Respectfully submitted,

H. G. Carter.

Fig. 1

X100 Unetched A.P. Core #1 Fairly clean

MA 6

Fig. 2

X100 1% Nital etched A.P. Core #1

Outside. Fine, uniform, very slightly banded sorbite. No decarburization.

MA 14

Fig. 3.

X100 1% Nital etched A.P. Core #1

Center. Fine banded sorbite. Slightly segregated carbides as chains. See Fig. 13.

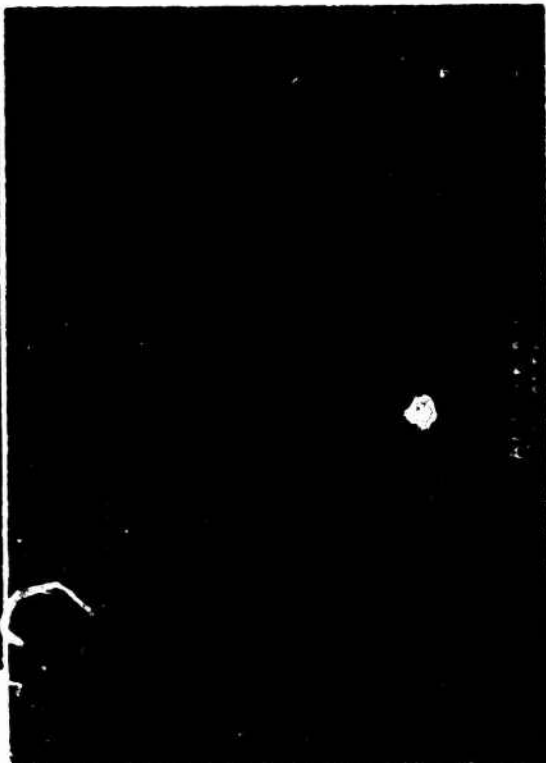
MA 15



1



2



3

Fig. 4

X100 Unetched A.P. Core #2 Fairly clean.

MA 7

Fig. 5

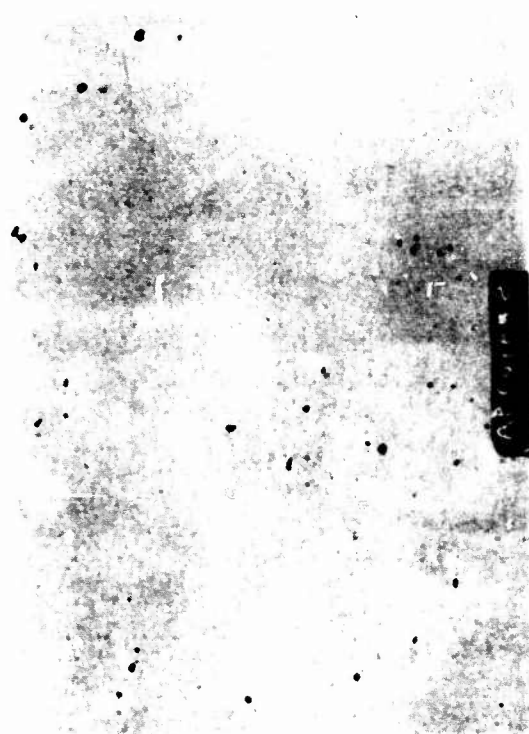
X100 1% Nital etched A.P. Core #2 Outside. Fine uniform. Very slightly banded, completely spheroidized sorbite. No decarburization.

MA 16

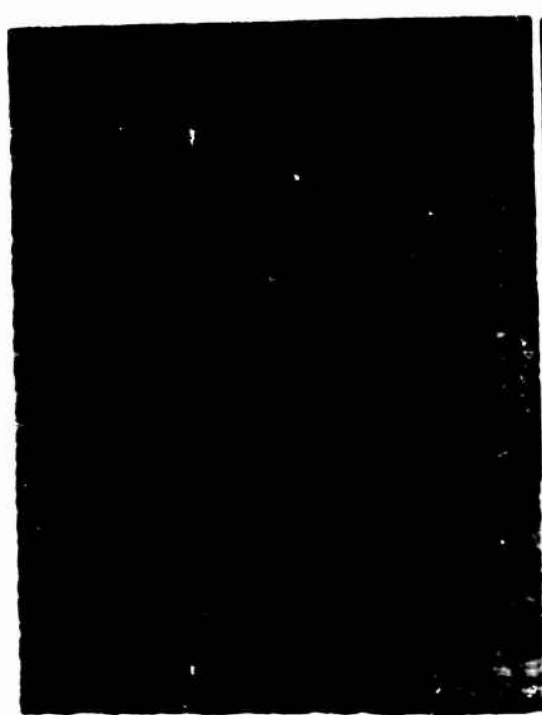
Fig. 6

X100 1% Nital etched A.P. Core #2 Center. Fine, banded, slightly segregated carbide chains, completely spheroidized sorbite. See Fig. 21.

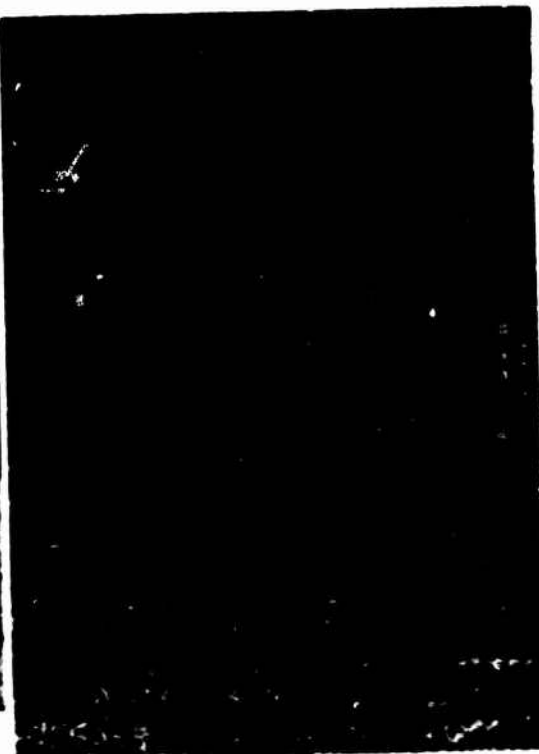
MA 17



4



5



6

Fig. 7

X100 Unetched

A.P. Core #3

Fairly clean.

MA 8

Fig. 8

X100 1% Nital

A.P. Core #3

Outside. Fine, uniform, very slightly banded, completely spheroidized sorbite. No decarburization.

MA 18

Fig. 9

X100 1% Nital

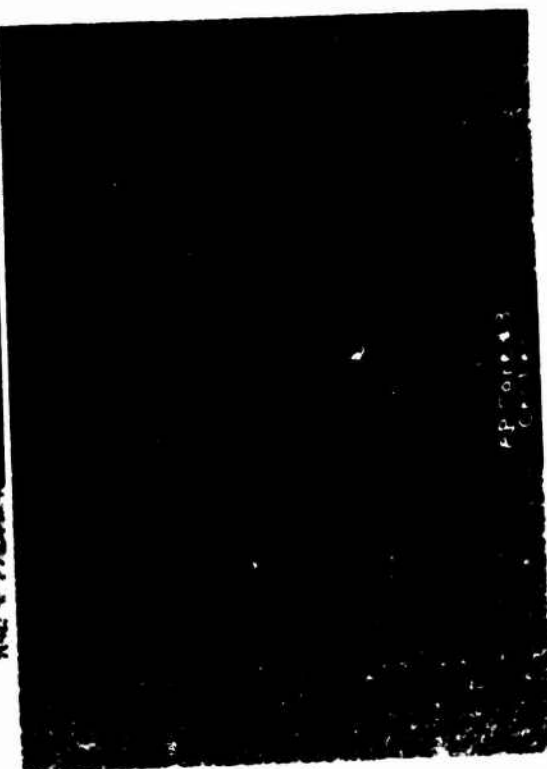
A.P. Core #3

Center. Fine, banded, slightly segregated carbide chains, completely spheroidized sorbite. See Fig. 21.

MA 19

APR 1964

7



8

9

Fig. 10

X100 Unetched A.P. Core #4 Dirty.

MA 9

Fig. 11

X100 1% Nital etched A.P. Core #4 Outside. Fine, uniform, very slightly banded sorbite. Decarburized .005" to .80 C.

MA 20

Fig. 12

X100 1% Nital etched A.P. Core #4 Center. Fine banded sorbite considerably segregated carbide chains.

MA 21

Fig. 13

X1000 1% Nital etched A.P. Core #4 1/2 O.C. Slightly spheroidized sorbite. Numerous carbide segregates.

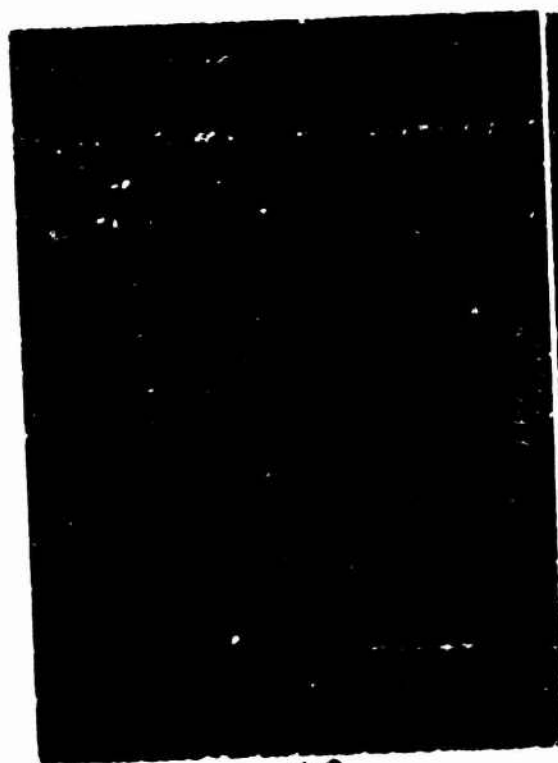
MA 26



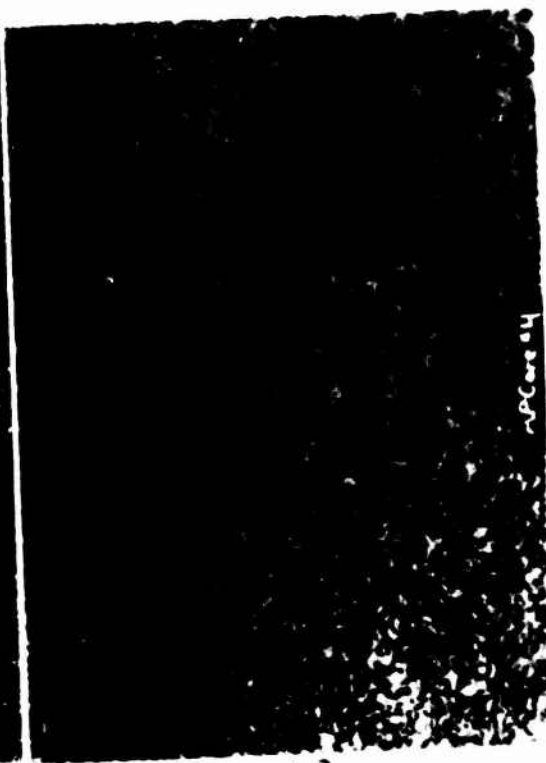
10



11



12



13

Fig. 14

X100 Unetched

A.P. Core #5

Fairly dirty. Many
fine banded inclusions.

MA 10

Fig. 15

X100 1% Nital

A.P. Core #5

Outside. Fine, uniform,
very slightly banded
sorbite. Decarburized
.007" to .80 C.

MA 22

Fig. 16

X100 1% Nital

A.P. Core #5

Center. Fine banded
sorbite considerably
segregated carbide chains.

MA 23

Fig. 17

X1000 1% Nital

A.P. Core #5

1/2 O-C. Partially
spheroidized sorbite.
Numerous carbide
segregates.

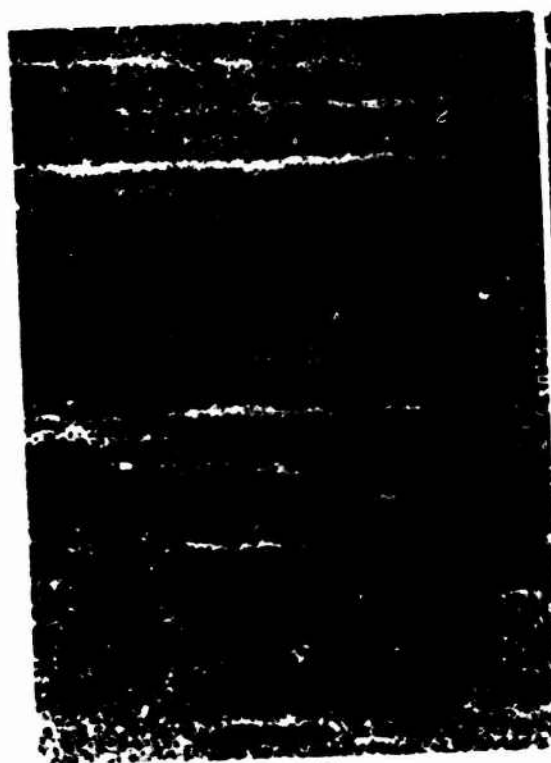
MA 27



14



15



16



17

Fig. 18

X100 Unetched A.P. Core #6 Dirty.

MA 11

Fig. 19

X100 1% Nital etched A.P. Core #6 Outside. Fine, uniform, very slightly banded sorbite. No decarburization.

MA 24

Fig. 20

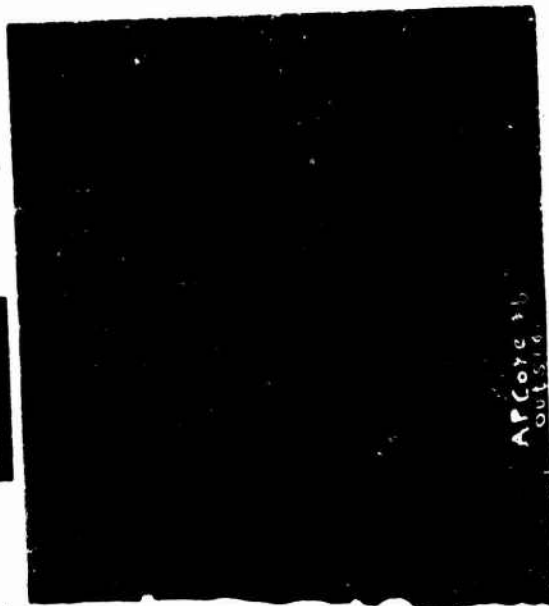
X100 1% Nital etched A.P. Core #6 Center. Fine, banded, sorbite. Slightly segregated carbide chains.

MA 25

Fig. 21

X1000 1% Nital etched A.P. Core #6 1/2 O-C. Completely spheroidized sorbite.

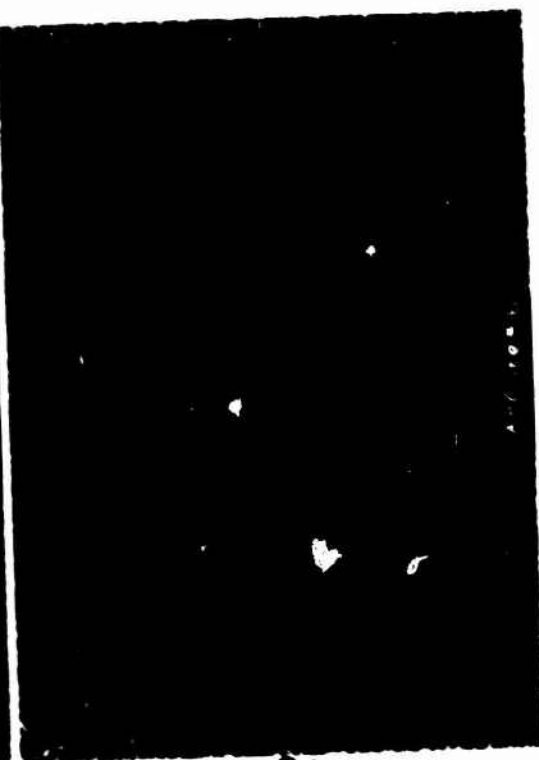
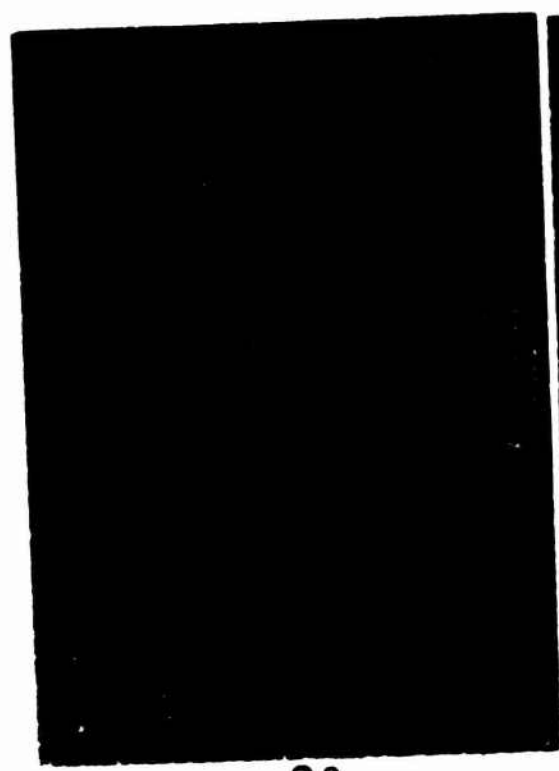
MA 26



AP Core 10
outside

18

19



20

21