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OTTAWA July 15th, 1943.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1445.

Optimum Quenching Speed and Temperature
for a Heat of Gun Steel.

(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

O T T A W A July 15th, 1943.

R E P O R T

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ORE DRESSING AND METALLURGICAL LABORATORIES.

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Abstract

A previous report (Investigation No. 1427, June 11th, 1943) recorded the cooling rate obtained in the quenching of a 3.7-inch gun tube in accordance with usual production practice. This report records attempts made to determine the ideal cooling rate for the steel in this barrel, and the following conclusions are arrived at:

1. The optimum quenching temperature for this heat of steel lies between 1600° and 1650° F.

2. The optimum quenching speed is indicated as 5° F. per second or faster, although there was not sufficient material for test to establish this definitely.

3. The physical properties of the gun tube whose cooling rate on quenching was recorded would be improved if the cooling rate could be increased from 3.1° F. per second to 5° F. per second.

Origin of Request:

The investigation into the ideal cooling rate for the steel in the 3.7-inch gun barrel reported on in Investigation No. 1427, June 11th, 1943, was undertaken at the request of Mr. R. Backs, Superintendent of Gun Shop, Dominion Foundries and Steel Limited, Hamilton, Ontario.

Analysis of Steel in the Gun Tube:

		Per cent
Carbon	-	0.28
Silicon	-	0.31
Manganese	-	0.75
Sulphur	-	0.020
Phosphorus	-	0.010
Nickel	-	0.76
Chromium	-	2.19
Molybdenum	-	0.48
Boron	-	None detected.
Aluminium	-	" "
Vanadium	-	" "

Cooling Curves:

Test bars were machined from the muzzle end of a 3.7-inch gun tube, tangential to the bore. Thermocouples were welded to these bars. After two hours at 1650° F., the bars were quenched by air blast, still air, lime, and furnace cool. The cooling rates so obtained were of the order of those obtained in production quenching.

The cooling curves obtained are shown in Chart 1, on Page 3.

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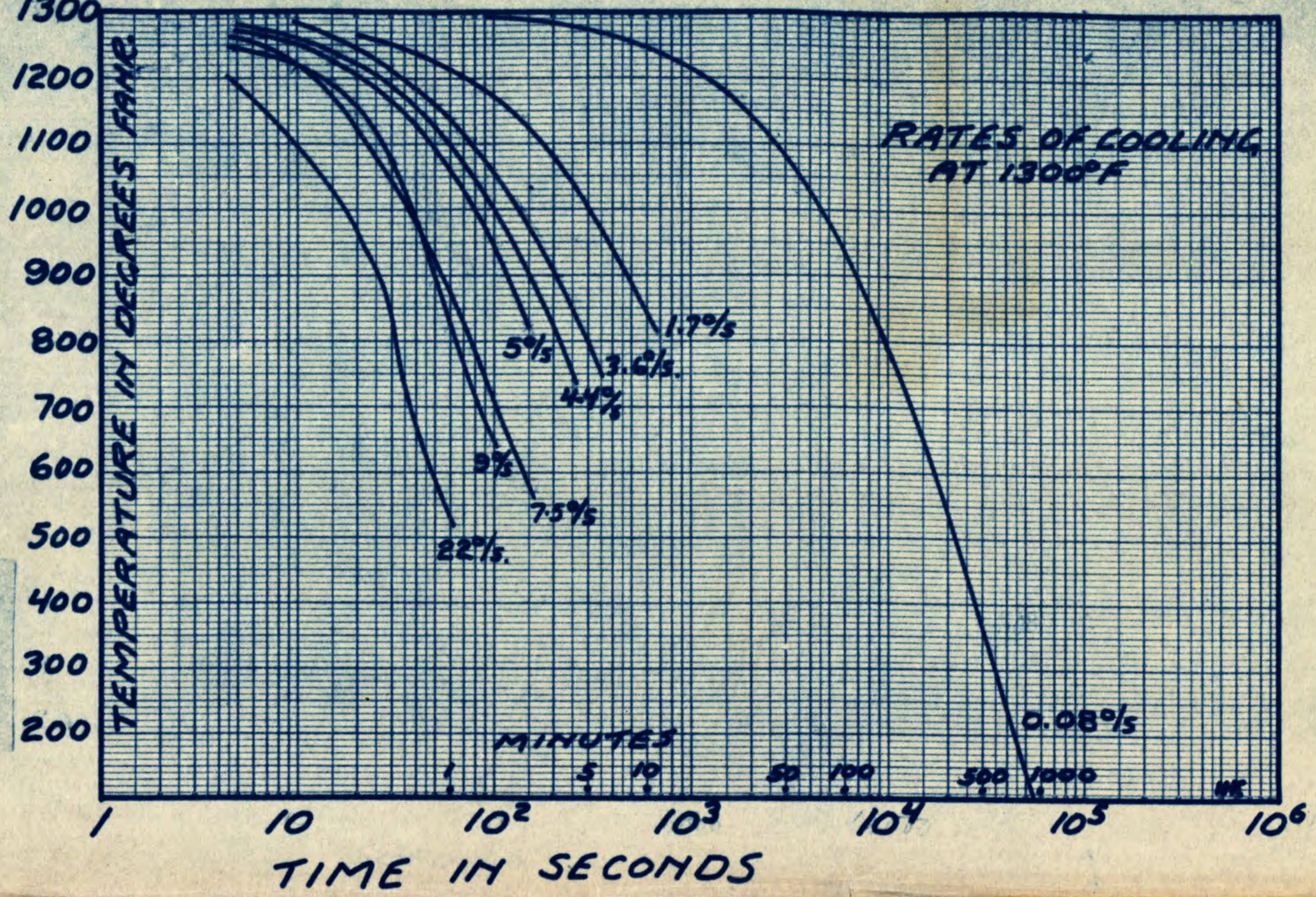
(The next page, Page 3,)
(comprises Chart 1.)

COOLING CURVES OF TEST BARS CUT FROM 3·7 INCH GUN



Physical Properties:

All bars cooled in air were tempered at 1170° F. for two hours. The bars cooled in lime (1.7° F. per second) and in the furnace (0.08° F. per second) were not tempered. Chart 2 (on Page 5) gives the physical test results. Cooling rates slower than 2° F. per second give low yield points. Cooling rates faster than 5° F. per second give fairly good physicals. Unfortunately, there were not enough test bars to establish a definite relationship.

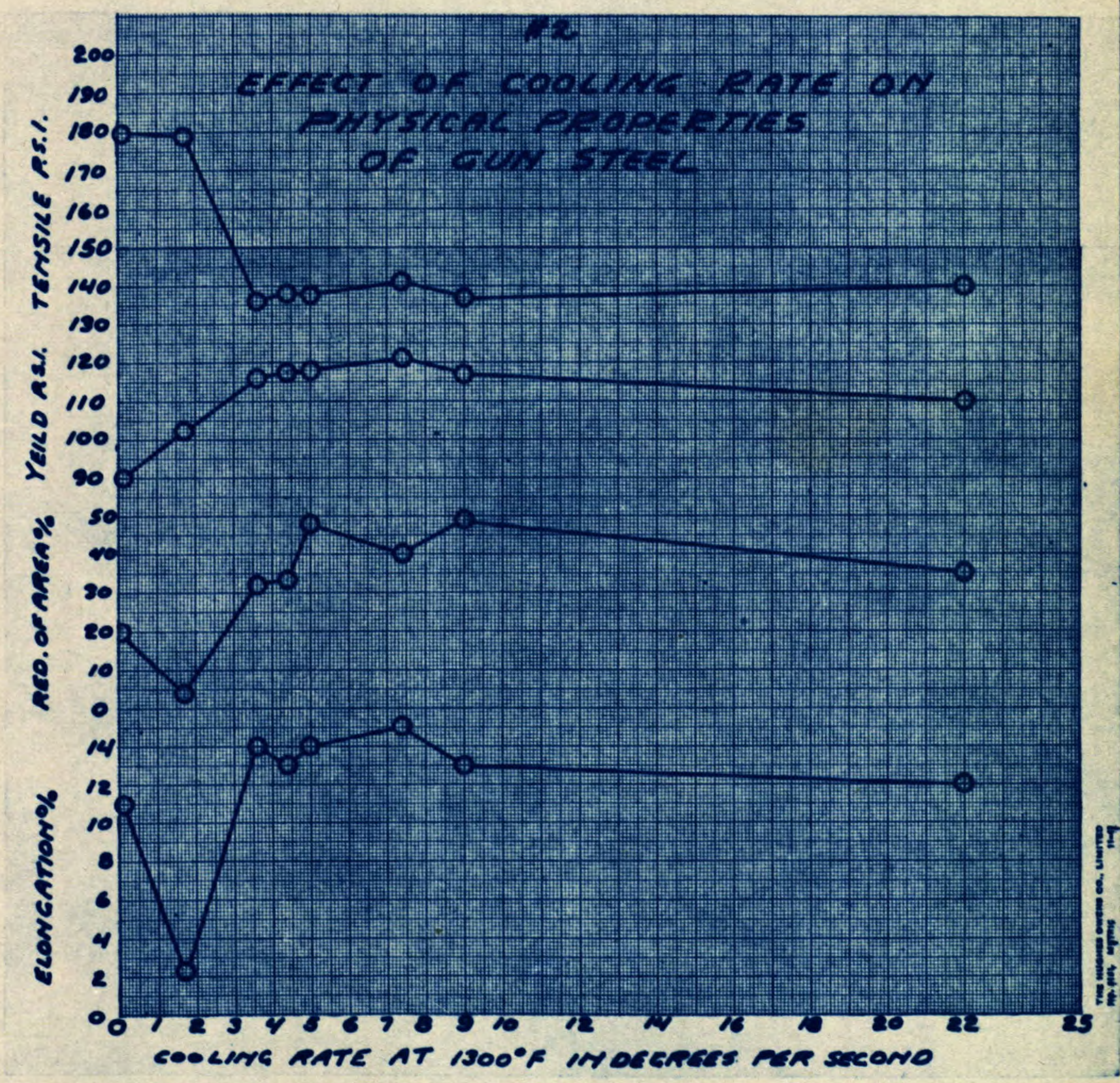
The cooling of the gun recorded was 3.1° F. per second. This rate produces reductions of area slightly less than those obtained at 5° F. per second or faster.

Quenching Temperature:

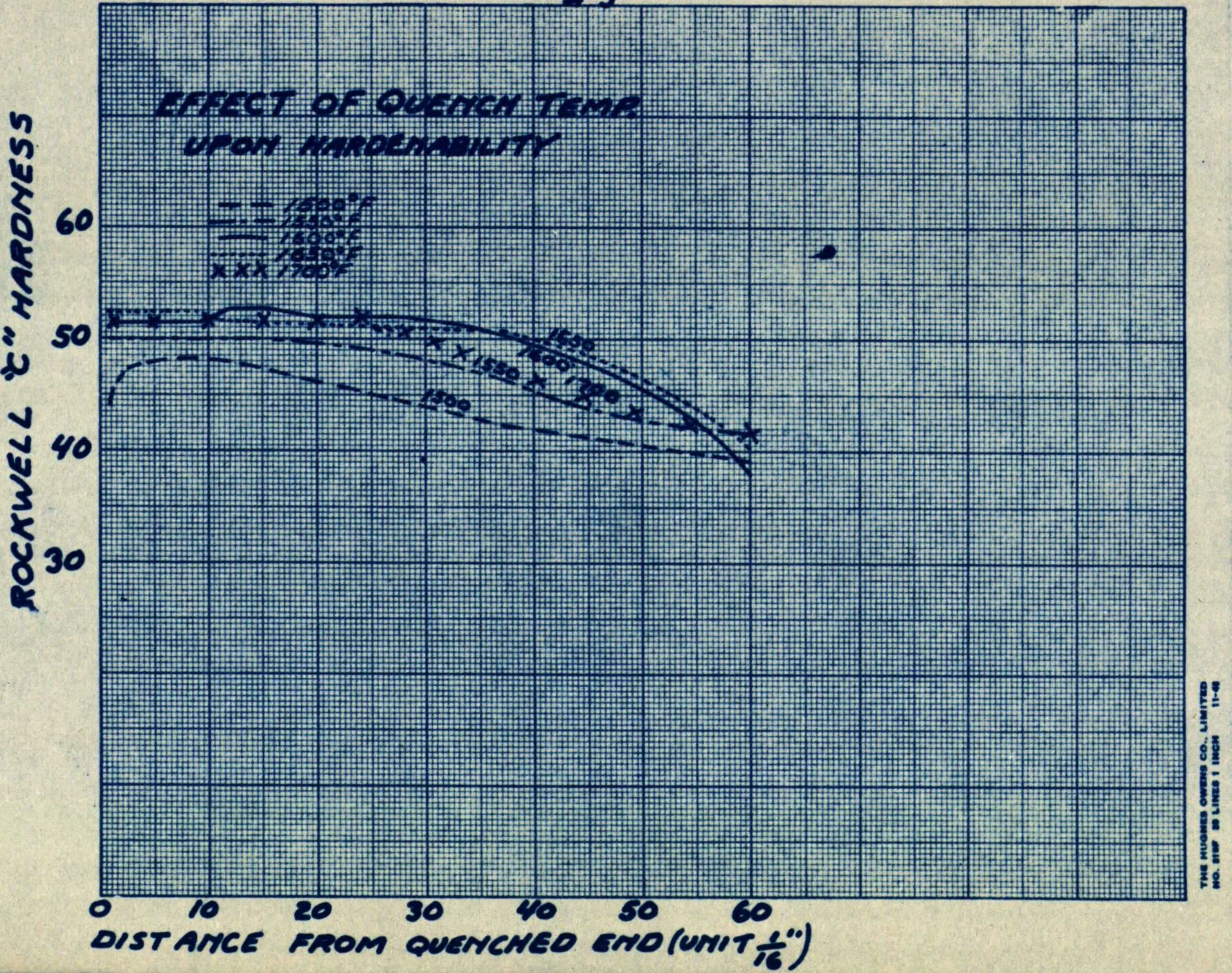
Hardenability test bars were held for two hours at various temperatures. These results are shown on Page 6, by Chart 3.

Below 1600° F., maximum hardness on quenching is not developed. It is to be expected that low yield strengths would result from a quenching temperature below 1600° F. With quenching temperatures above 1650° F. there is no increase in hardenability.

(Pages 5 and 6, following,)
(contain Charts 2 and 3.)
(Text continues on Page 7.)


#2
EFFECT OF COOLING RATE ON
PHYSICAL PROPERTIES
OF GUN STEEL
TENSILE P.S.I.
YEILD P.S.I.
RED. OF AREA %
ELONGATION %
200
190
180
170
160
150
140
130
120
110
100
90
50
40
30
20
10
0
14
12
10
8
6
4
2
0
0 1 2 3 4 5 6 7 8 9 10 12 14 16 18 20 22 25
COOLING RATE AT 1300°F IN DEGREES PER SECOND

#3


EFFECT OF QUENCH TEMP.
UPON HARDENABILITY
1500°F
1550°F
1600°F
1650°F
XXX 1700°F
1650
1600
1550
1700
1500
ROCKWELL "C" HARDNESS
60
50
40
30
0
10
20
30
40
50
60
DISTANCE FROM QUENCHED END (UNIT 1/16")
THE HUGHES OWENS CO. LIMITED
NO. 2197 20 LINES 1 INCH 11-48

RECOMMENDATIONS:

It is probable that an improvement in physical properties would result if a more rapid cooling rate were obtained. The gun for which the cooling curve is known was quenched from 1560° F. Its cooling rate was 3.1° F. per second. A higher quench temperature would result in faster cooling.

An idea of the physical properties which will result from a certain cooling rate could be obtained by building a cooling box. The test bar would be quenched in a current of air, so that its cooling rate would duplicate actual production conditions.

The box would have a controlled current of air passing through it. It would be necessary to determine the rate of air flow experimentally.

Some thought might be given to the use of quenching media which will remove heat faster than the oil which is used at present.

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