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O T T A W A July 23rd, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1459.

Examination of Four New Volute Springs
made by the Eaton Manufacturing Company,
Detroit, Michigan, for the Ram Tank MK IV.

(Copy No. 7.)

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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made by the Eaton Manufacturing Company,
Detroit, Michigan, for the Ram Tank MK IV.

Origin of Request and Object of Investigation:

On July 5th, 1943, under Requisition No. 551, A.E.D.B. Lot No. 340, Report No. 101, Test No. 4, Prof. J. U. MacEwan, Consultant to Director of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario, submitted for examination four new volute springs manufactured by the Eaton Manufacturing Company, Detroit, Michigan. These had been obtained via the Montreal Locomotive Works, Montreal, Quebec.

The following information was desired:

1. Load-deflection curves.
2. Permanent set after loading to complete bottoming.
3. Microstructure of section throughout the springs.
4. Longitudinal and transverse hardness surveys.
5. The amount of decarburization.

Identification Marks on Springs:

The springs as received were marked as follows:

No. 5.	No. 6.
C 95163 A HT 45211 EI 1533	C 95163 A HT-31146 EI 1583

No. 6	No. 8.
C 95163 A HT 50254 EI 1583	C 95163 A HT 31146 EI 1888

Load-Deflection Curves:

Figures 1 to 4 (Pages 4-7) show the loading curves and permanent set immediately after bottoming. Since these curves appeared to be slightly different than previously recorded, an estimate of the stored energy* was made. The stored energy in Latrobe (American Locomotive Company, Latrobe, Pa.) springs was also calculated. These results are shown in Table I.

TABLE I.

No.	Stored energy in EATON springs, foot-pounds.	No.	Stored energy in LATROBE springs, foot-pounds.
5	4,605	1	4,041
6	4,580	2	4,201
7	5,631	3	3,776
8	4,674	4	4,221

It is apparent that the Eaton spring is capable of handling heavier loads, without bottoming, than the Latrobe spring. This may be due to a difference in design, rolling, or pre-stressing method.

* The stored energy is the work, in foot-pounds, necessary to bottom the spring.

Microstructure:

According to the results of research carried out at the Watertown Arsenal (Report No. 451/10), inclusions in steel have a greater effect on spring life than has either alloy content or rolling practice. For this reason, photographs of the inclusions in the spring steel are included in this report (see Figures 5 to 8, Page 8). A normal amount of inclusions is shown to be present.

Figures 9 to 12 (Page 9) show the structure of the steel and the thickness of the decarburized zone in the four samples.

Hardness Surveys:

Hardness surveys were carried out as requested.

Figures 13 to 16 (charts, Pages 10 to 13) show results of the longitudinal surveys, and Figures 17 to 20 (charts on Page 14) the results of the surface-to-surface surveys.

(Pages 4 to 14 now follow, containing charts and photo-micrographs. Text is resumed on Page 15.)

Figure 1.

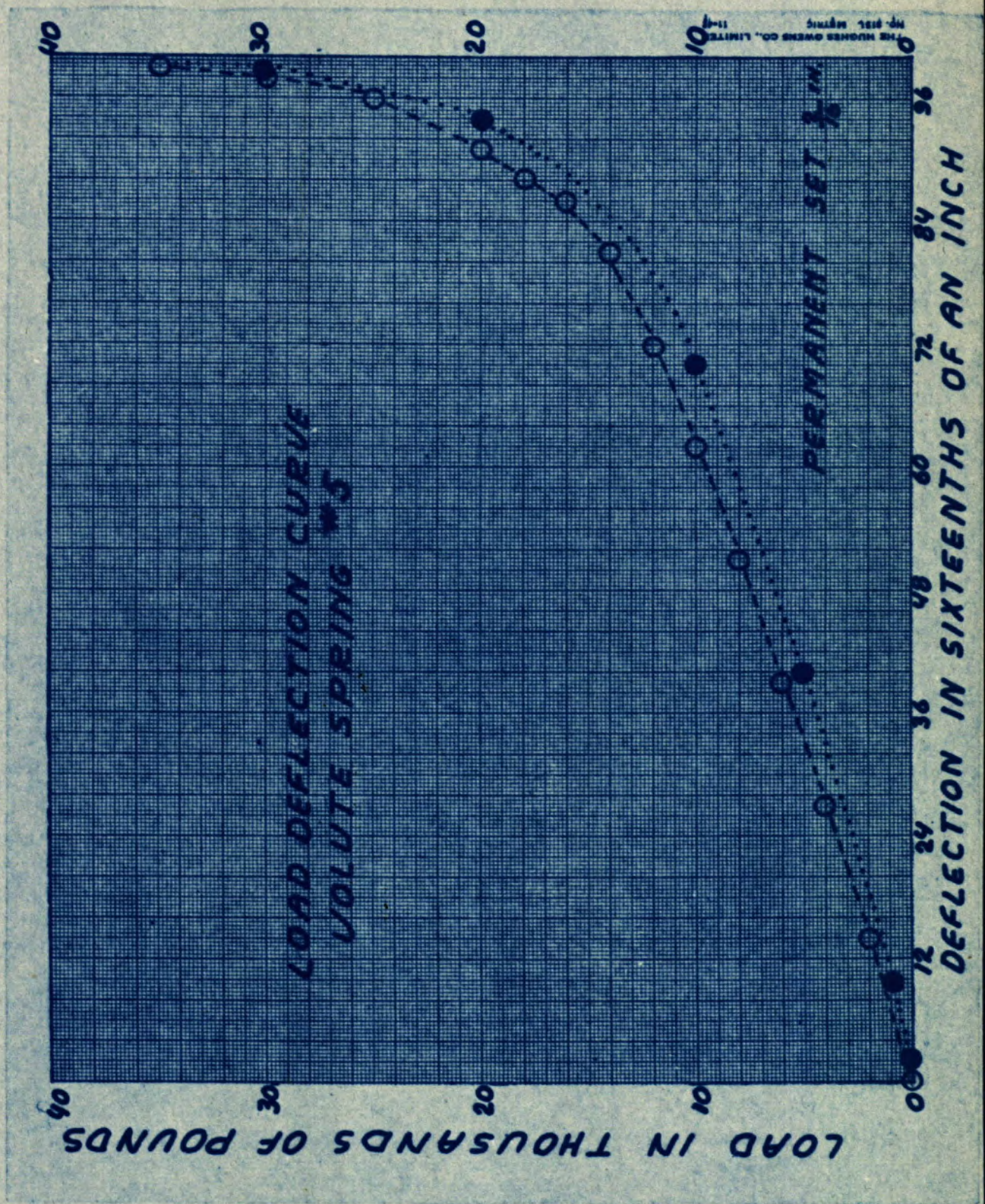
LOAD DEFLECTION CURVE
VOLUTE SPRING No 5
PERMANENT SET
LOAD IN THOUSANDS OF POUNDS
DEFLECTION IN SIXTEENTHS OF AN INCH
0
10
20
30
40
12
24
36
48
60
72
84
96

Figure 2.

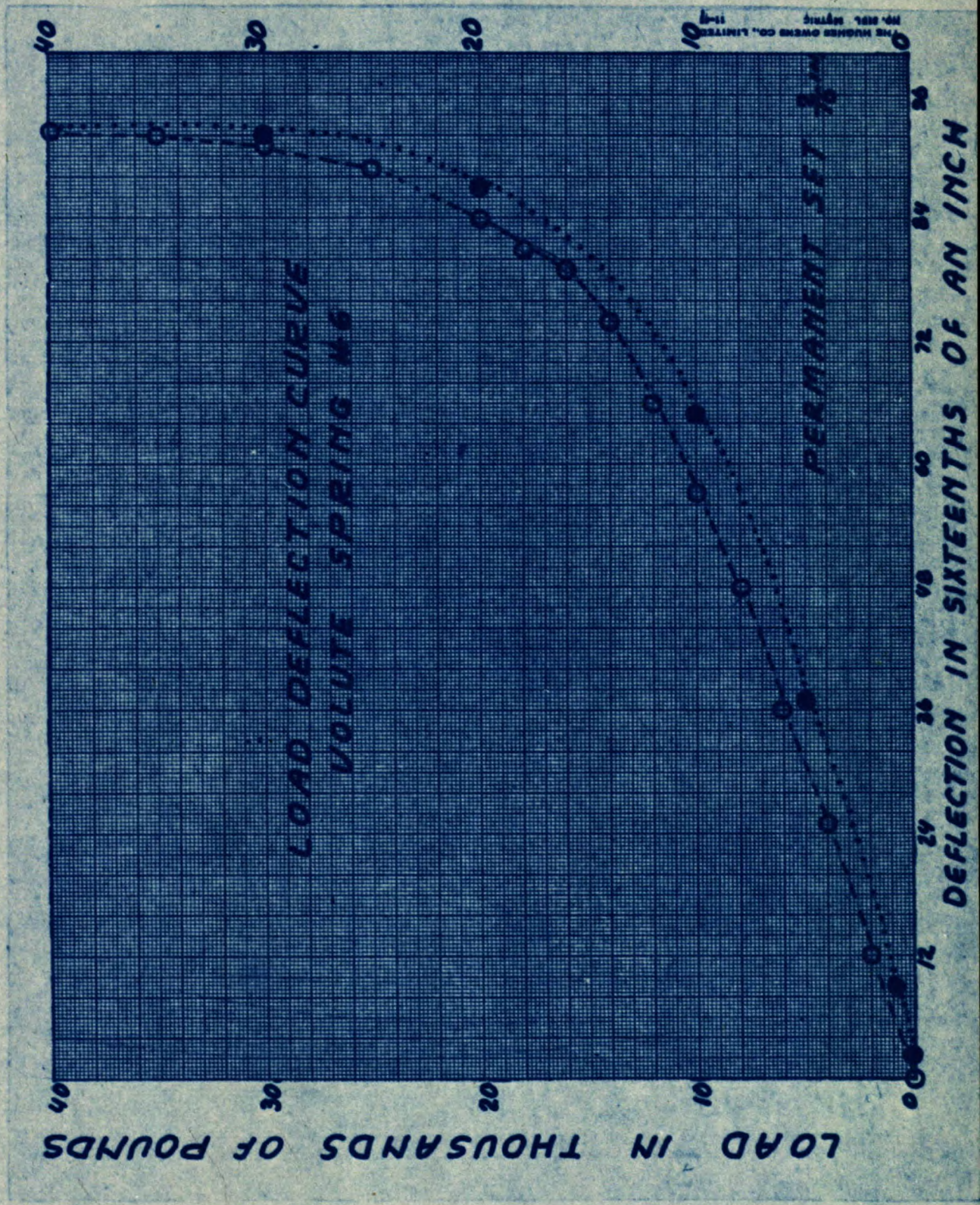
LOAD DEFLECTION CURVE
VOLUTE SPRING M6
PERMANENT SET
LOAD IN THOUSANDS OF POUNDS
DEFLECTION IN SIXTEENTHS OF AN INCH
40
30
20
10
0
8
16
24
32
40
48
56
64
72

Figure 3.

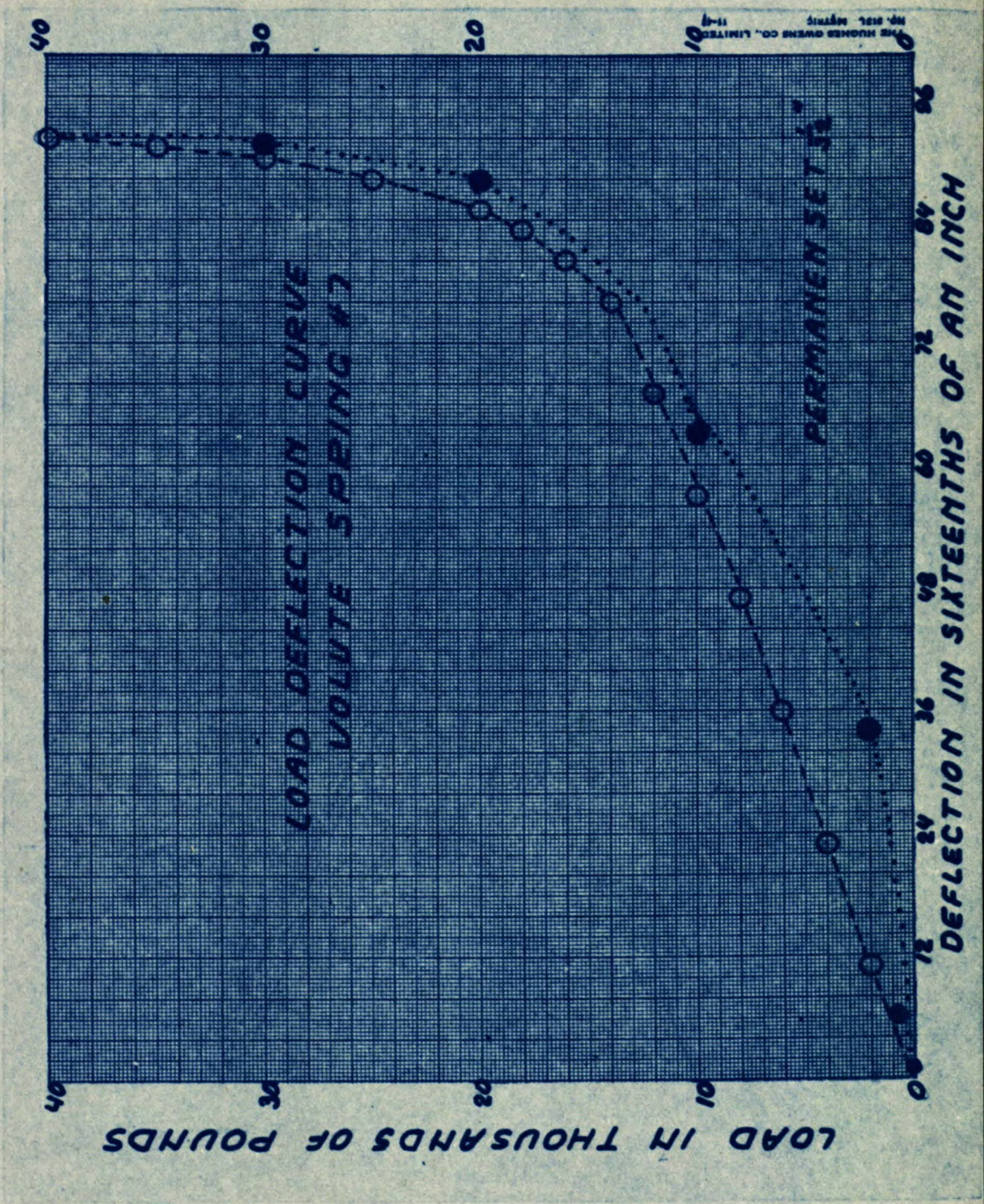
LOAD DEFLECTION CURVE
VOLUTE SPRING #7
PERMANENT SET 1/16"
LOAD IN THOUSANDS OF POUNDS
DEFLECTION IN SIXTEENTHS OF AN INCH
40
30
20
10
0
48
36
24
12

Figure 4.

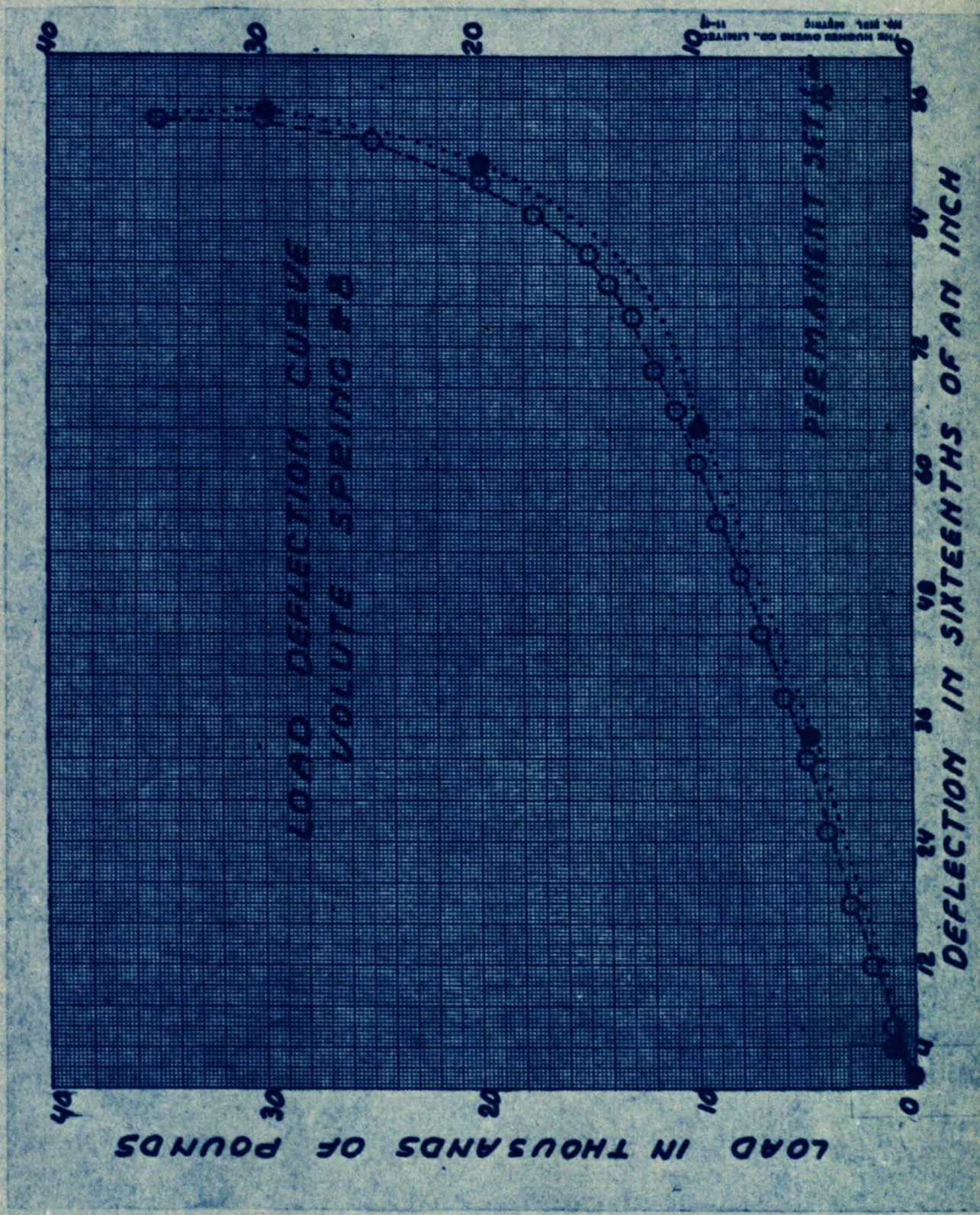
LOAD DEFLECTION CURVE
VOLUTE SPRING No 4
PERMANENT SET
LOAD IN THOUSANDS OF POUNDS
DEFLECTION IN SIXTEENTHS OF AN INCH
40
30
20
10
0
32
28
24
20
16
12
8
4
0

Figure 5.

Spring 5.

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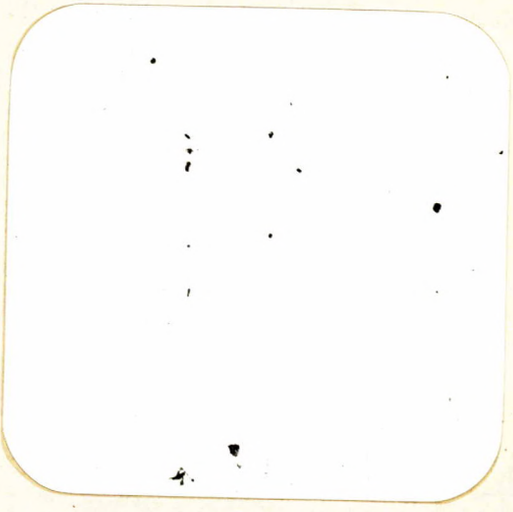
Figure 6.



Spring 6.

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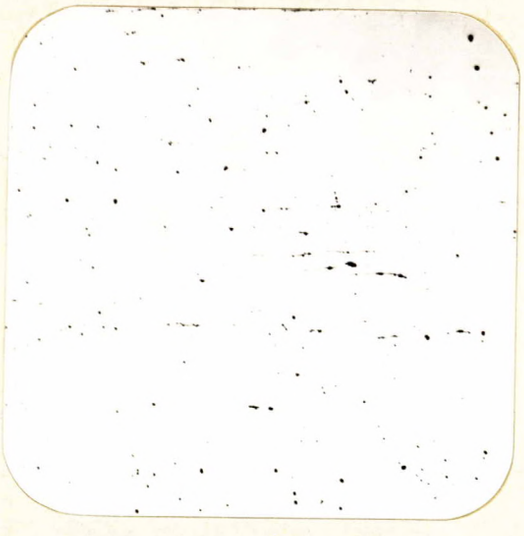
Figure 7.



Spring 7.

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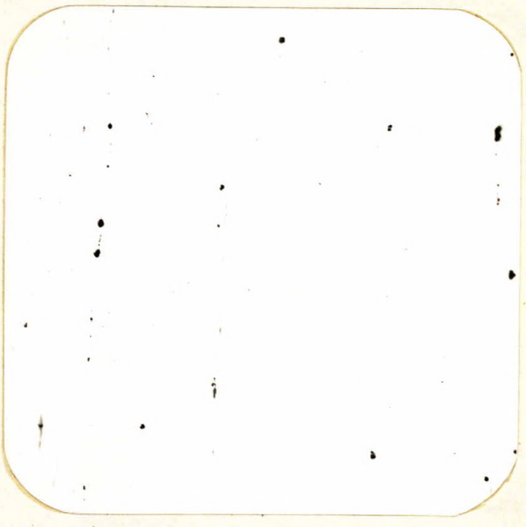
Figure 8.



Spring 8.

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PHOTOMICROGRAPHS SHOWING INCLUSIONS.

X100, unetched.

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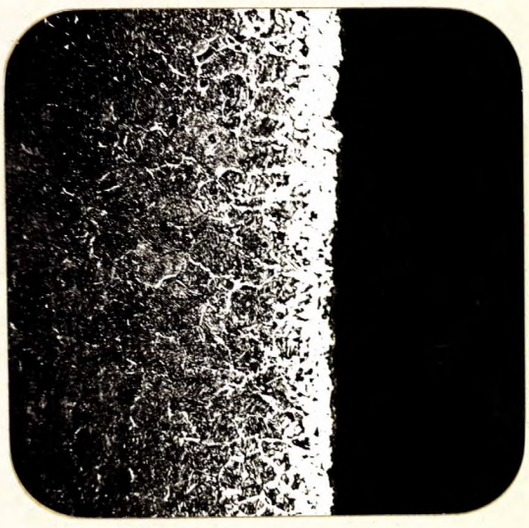
Figure 9.

Spring 5.

Figure 10.



Spring 6.

Figure 11.

Spring 7.

Figure 12.

Spring 8.

PHOTOMICROGRAPHS SHOWING DECARBURIZED ZONES.

X100, nital etch.

Figure 13.

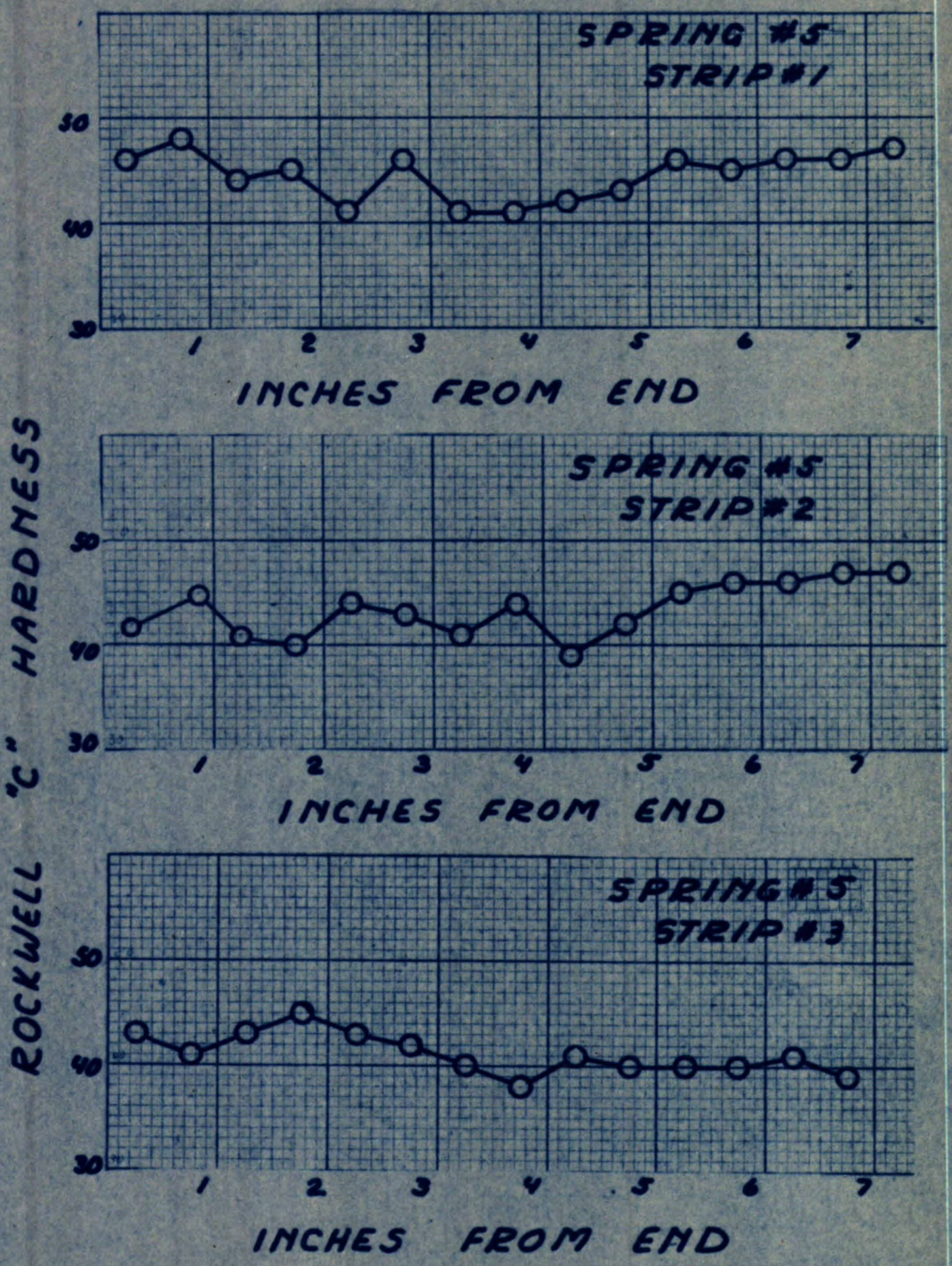

SPRING #5
STRIP #1
50
40
30
1
2
3
4
5
6
7
INCHES FROM END
ROCKWELL "C" HARDNESS
SPRING #5
STRIP #2
40
30
INCHES FROM END
SPRING #5
STRIP #3
50
40
30
INCHES FROM END

Figure 14.

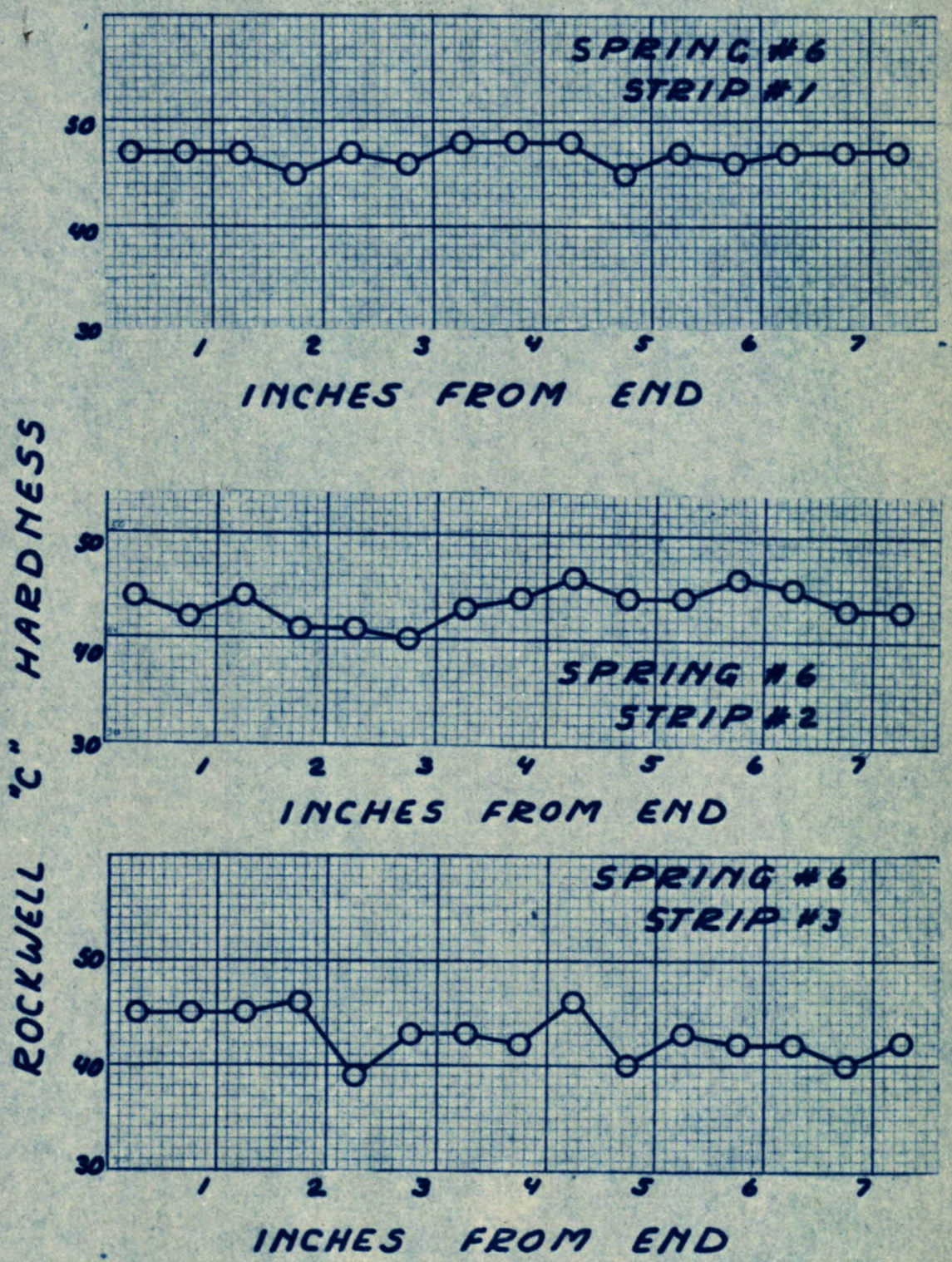

SPRING #6
STRIP #1
50
40
30
1
2
3
4
5
6
7
INCHES FROM END
ROCKWELL "C" HARDNESS
SPRING #6
STRIP #2
INCHES FROM END
SPRING #6
STRIP #3
INCHES FROM END

Figure 15.

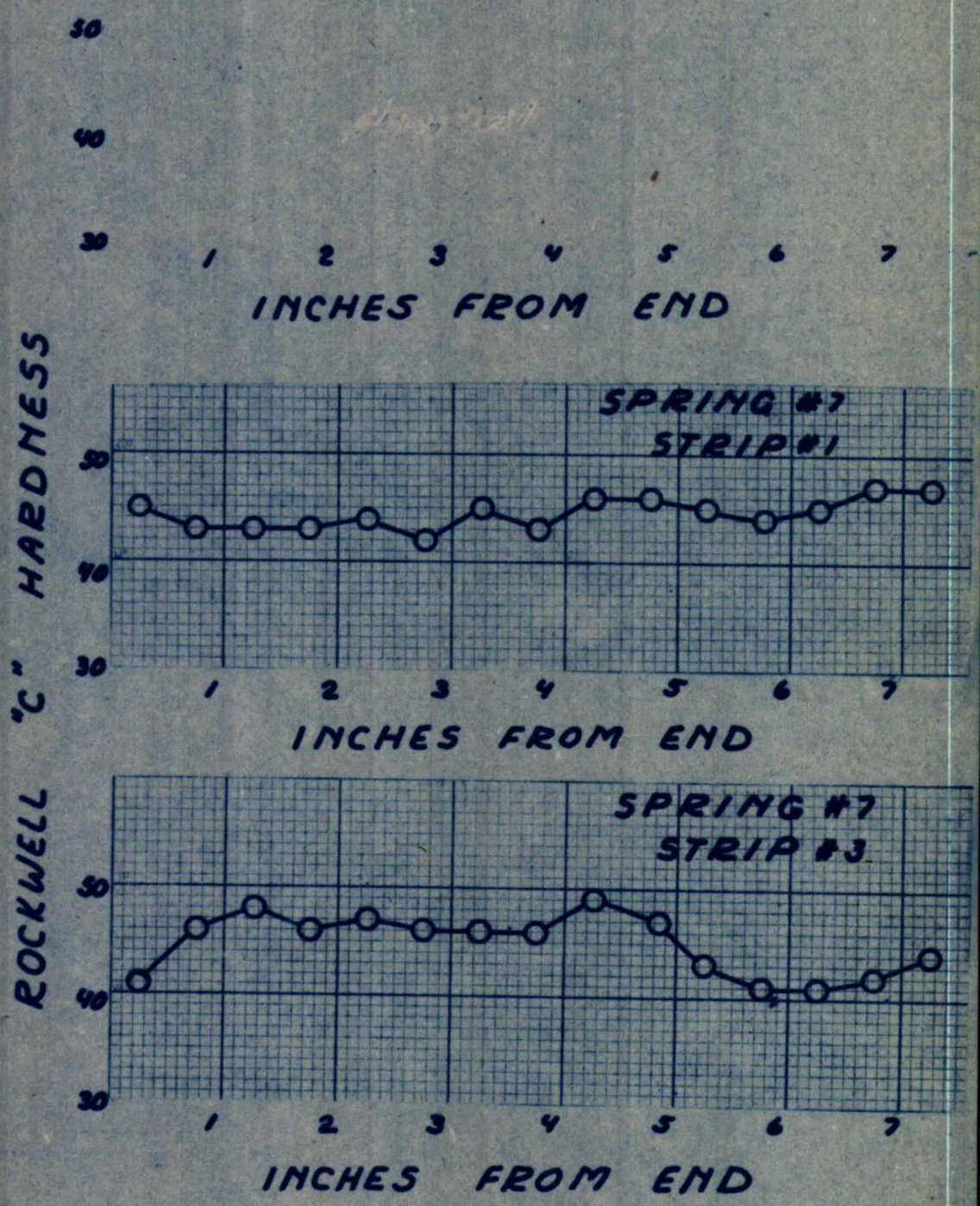

50
40
30
1 2 3 4 5 6 7
INCHES FROM END
ROCKWELL "C" HARDNESS
SPRING #7
STRIP #1
40
30
1 2 3 4 5 6 7
INCHES FROM END
SPRING #7
STRIP #3
50
40
30
1 2 3 4 5 6 7
INCHES FROM END

Figure 16.

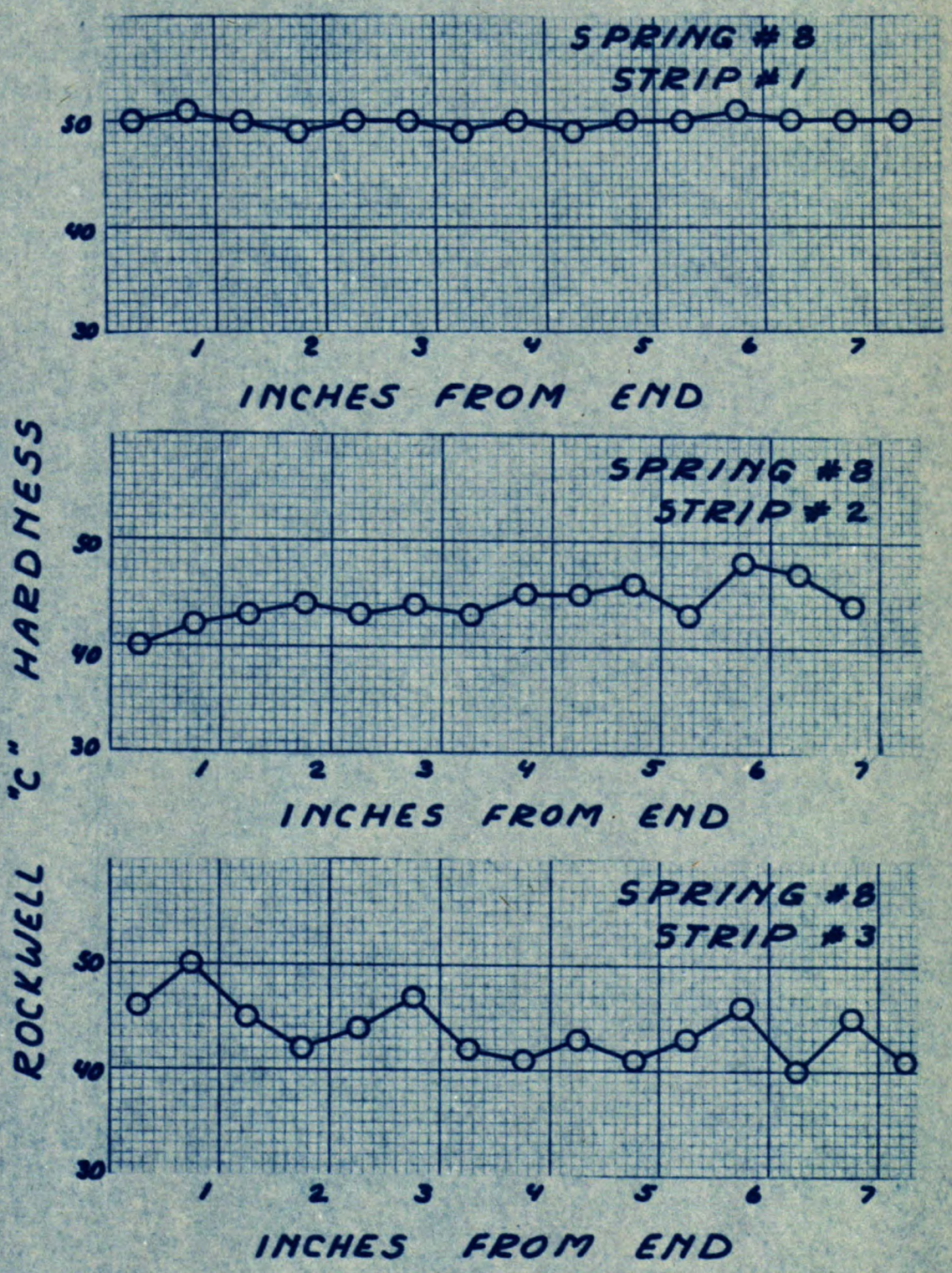

SPRING #8
STRIP #1
50
40
30
1
2
3
4
5
6
7
INCHES FROM END
ROCKWELL "C" HARDNESS
SPRING #8
STRIP #2
40
30
INCHES FROM END
SPRING #8
STRIP #3
50
40
30
INCHES FROM END

Fig. 17.

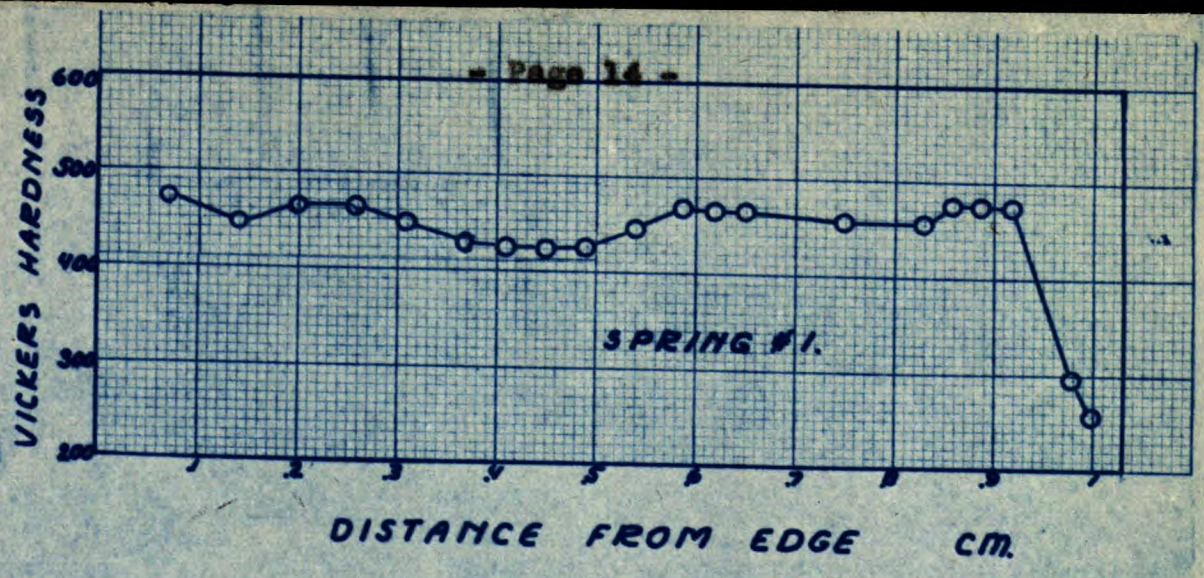


Fig. 18.

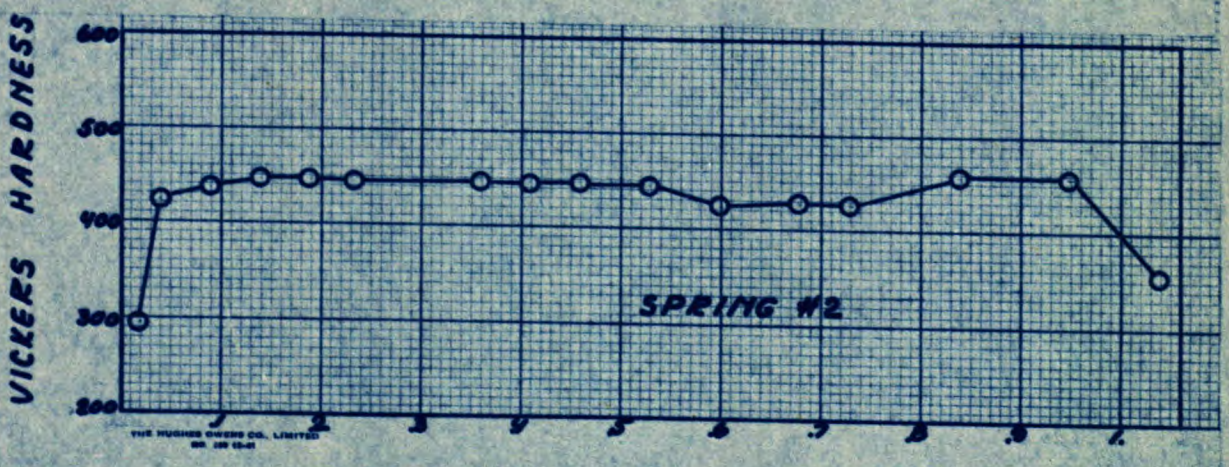


Fig. 19.

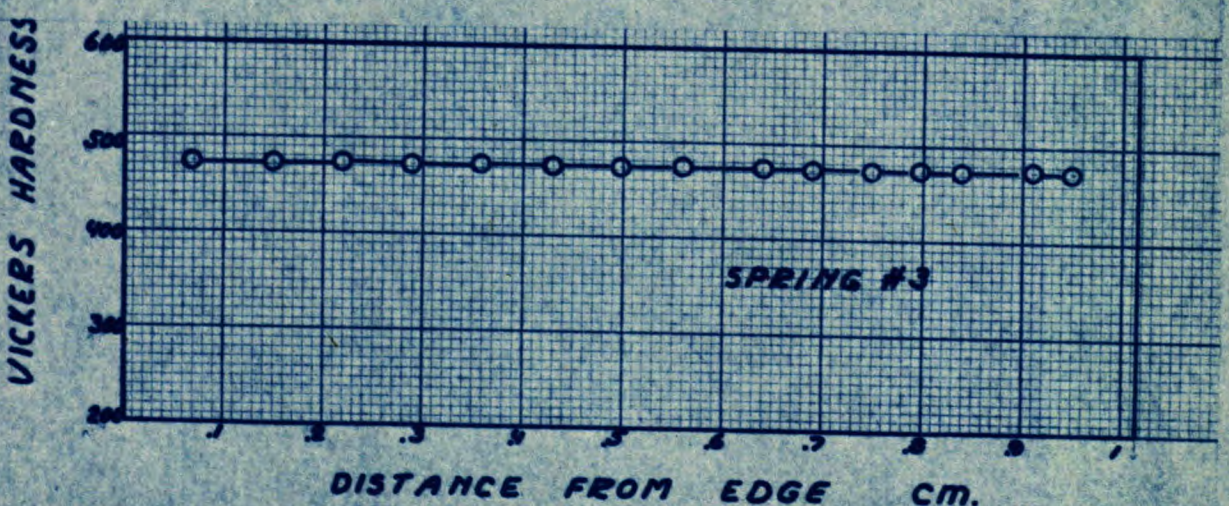
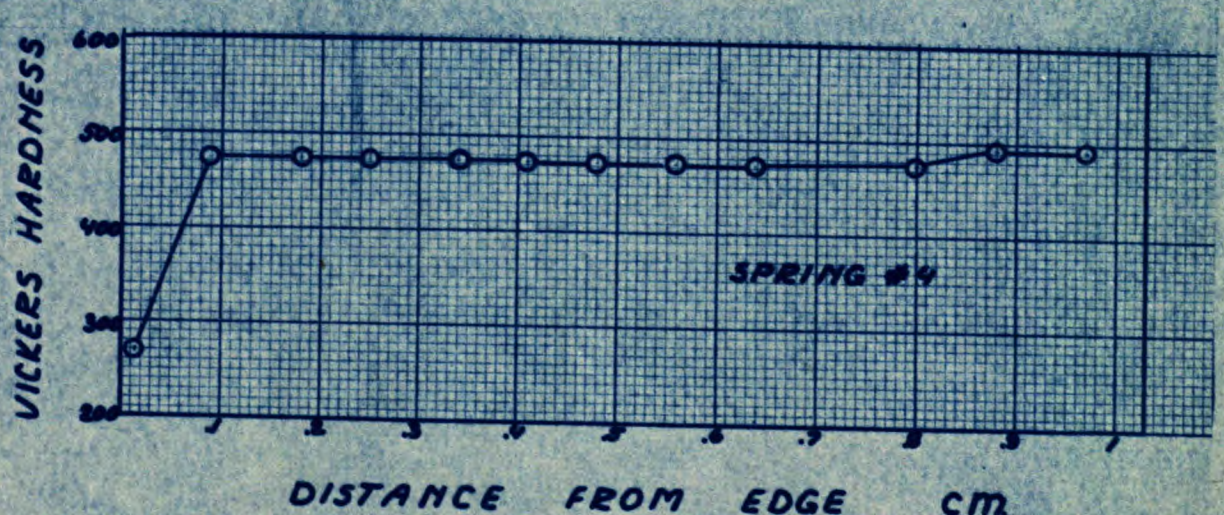


Fig. 20.



CONCLUSION:

Decarburization is limited to about 0.005 inch. This is slightly greater than 0.003 inch, the commercial limit generally applied to springs of this type. A superior method of fabrication is evidenced by a greater capacity to store energy.

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HHF:PES:GHB.