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July 14th, 1943.



R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1446.

Rockwell Hardness Inspection of Homogeneously
Hardened Tank Track Pins of SAE 9255 Steel.

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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Abstract

Production of tank track pins of SAE 9255 steel was commenced by the Cockshutt Plow Company at Brantford, Ontario, on June 23th, 1943. All of the product was tested for hardness. A statistical analysis of the data led to the following conclusions:

1. The hardness of the pins is not under statistical control.
2. There are several assignable causes for the observed variation; these can be discovered and eliminated.
3. Hardness results were not taken in chronological order. Until this is done it is not possible to

(Abstract, cont'd) -

determine whether periodic variation in hardness occurs.

4. Decarburization was one cause of lack of control on hardness tests.
5. When the decarburization is eliminated there still remain other assignable causes of variation which will prevent hardness from being controlled.
6. The assignable causes for variation are present in the first quenching operation.
7. Some possible assignable causes for lack of control over hardness are:
 - (a) Variation in decarburization on stock.
 - (b) Variation in manual handling from salt to quench; this is the most probable cause of variation.
 - (c) Erratic technique in running hardness tests.
 - (d) Variation in hardenability of stock.
 - (e) Variation in scale on stock.
 - (f) Variation in salt coating on pin going into oil.
 - (g) Improper preparation of surface before taking hardness test.
8. Evidence of the effect of eliminating causes of lack of control can be best observed using control chart methods.

The evidence leading to the above conclusions will be found in the body of the report.

Origin of Request:

This work was undertaken, in connection with the manufacture of homogeneously hardened tank track pins of SAE 9255 steel, at the request of Mr. G. H. Gibbs, of the Directorate of Production, Automotive and Tank Production Branch, Department of Munitions and Supply, Ottawa, Ontario. The production of these pins was undertaken by the Cockshutt Plow Company, Brantford, Ontario. Two members of the staff of these Laboratories are carrying out tests for the company. The first pins made, beginning June 28th, 1943, were tested for Rockwell hardness, and these results were statistically analysed.

Process Variation:

Charts Nos. 1, 2, and 3 (on Pages 4, 5, and 6) show the production pin hardness results from June 28th to July 1st, inclusive. Hardness is not under control.

There are few long runs above and below the average.

The assignable causes for lack of control might

be:

- Erratic manual transfer into quench.
- Salt and sludge sticking to pins.
- Variation in decarburization.
- Rough surface.
- Erratic testing technique.

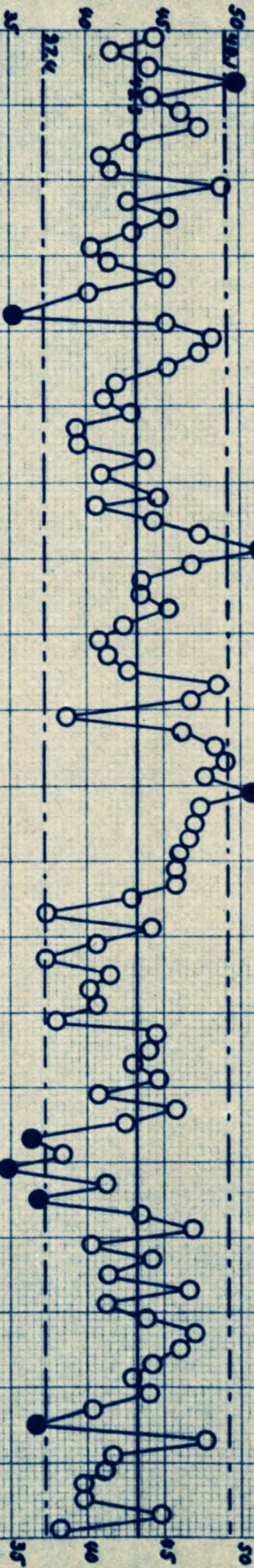
(Charts Nos. 1, 2, and 3 follow,
(comprising Pages 4, 5, and 6.)
(Text continues on Page 7.)

CHART #1

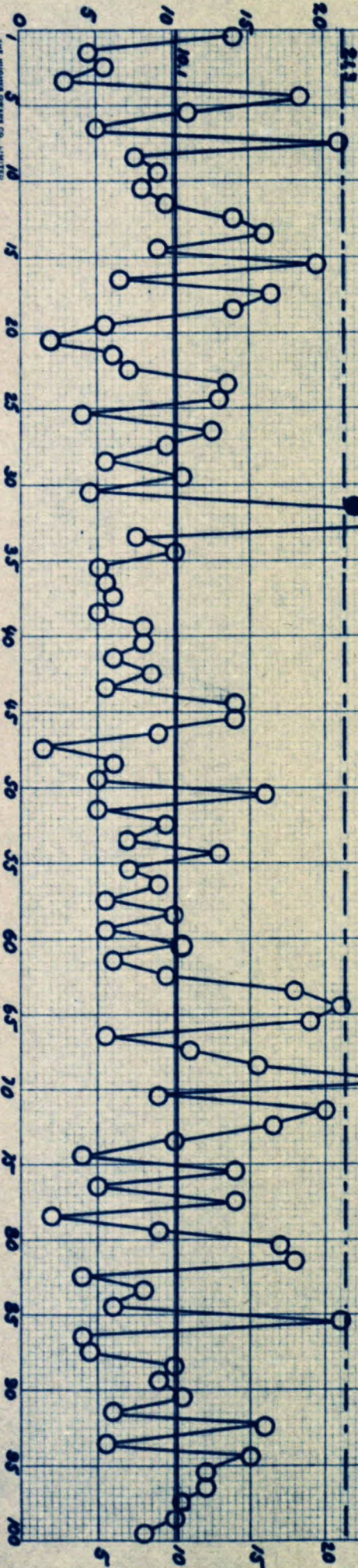
CONTROL CHART - GROUPS OF 5
PRODUCTION OF PINS
100% INSPECTION

RUNS ABOVE AND BELOW AVERAGE	
LENGTH	NUMBER
1	26
2	6
3	2
4	4
5	2
6	2
7	1
11	$\frac{1}{44}$

AVERAGE



RANGE



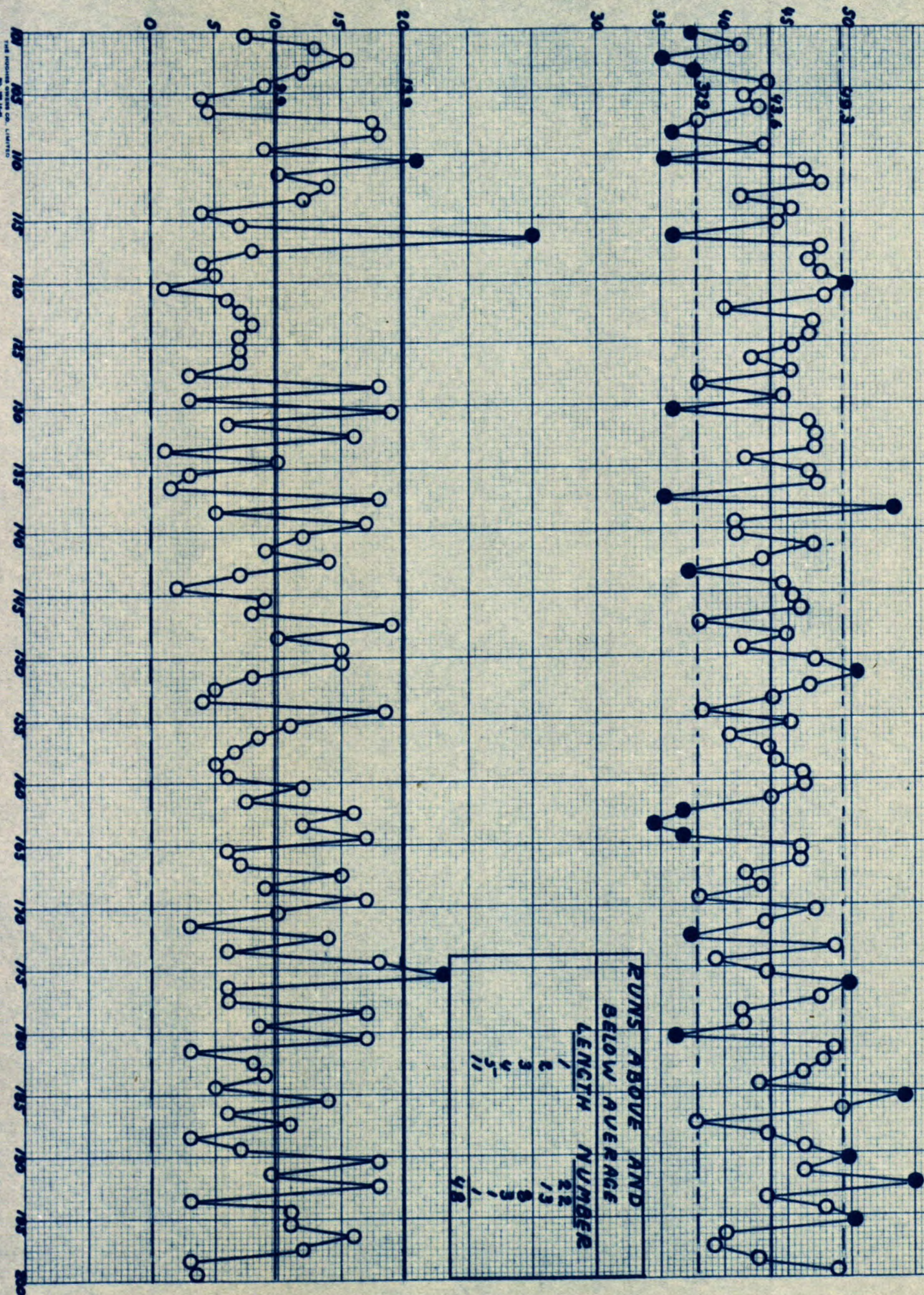
100% INSPECTION

JUNE 28

JUNE 29

CHART #2

CONTROL CHART - GROUPS OF 5
PRODUCTION OF PINS
100% INSPECTION



THE PRODUCTION CHART CO. LIMITED
NO. 200 12-48

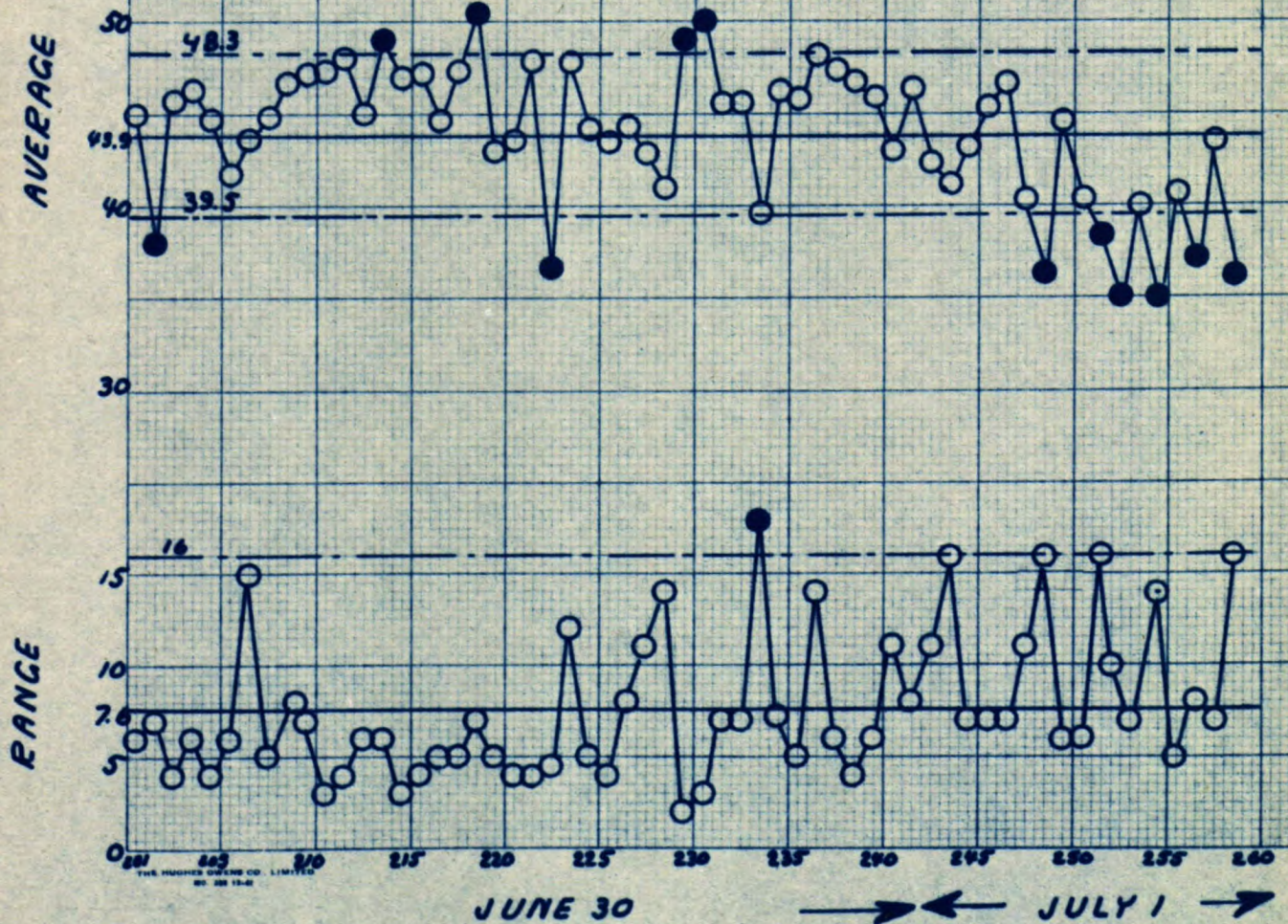
JUNE 29

JUNE 30

CHART #3

CONTROL CHART - GROUPS OF 5
PRODUCTION OF PINS
25% INSPECTION

RUNS ABOVE AND BELOW AVERAGE	
LENGTH	NUMBER
1	10
2	4
3	2
4	1
6	1
9	1
12	1
	<hr/> 22



Effect of Surface Condition:

Chart No. 4 (on Page 8) shows the averages of hardness results obtained at the surface and at depths of 0.005 and 0.010 inch.

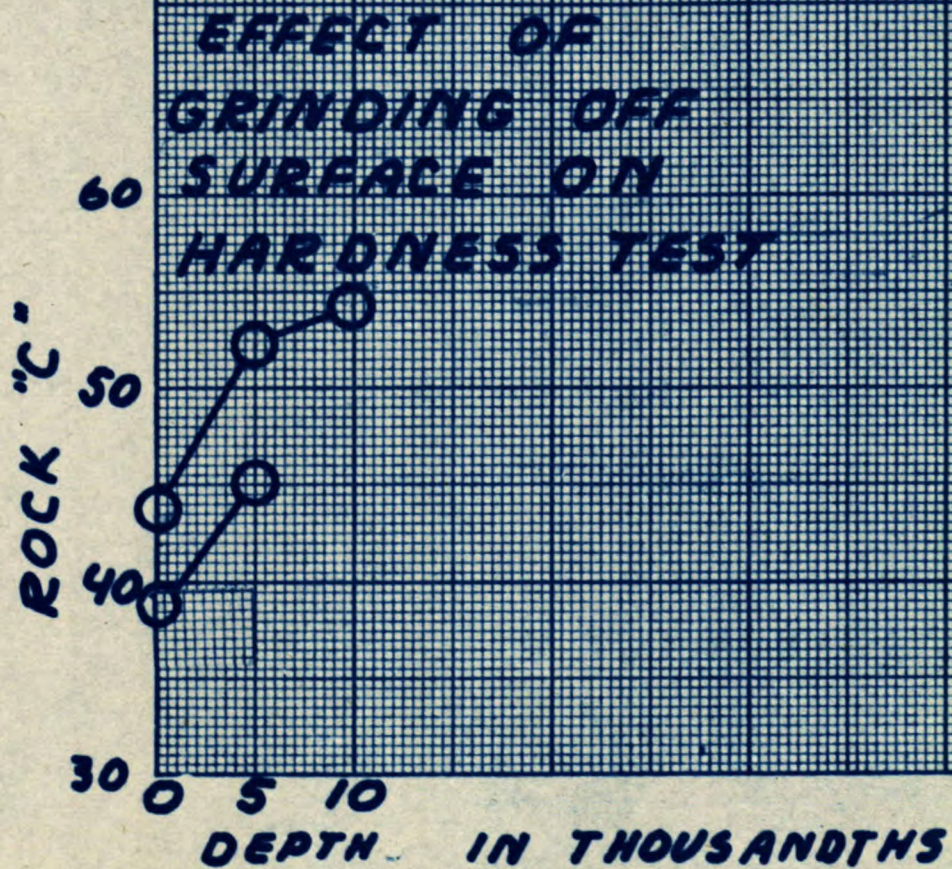
Chart No. 5 (on Page 9) shows frequency distributions of surface and core readings on the same lot of pins. Note that surface readings spread out over four class intervals and that core readings are contained in three class intervals.

In Chart No. 6 (on Page 10) the surface and core readings are plotted in control chart form. Note that core hardness has narrower control limits than surface hardness. This is proof that surface decarburization is one assignable cause of variation. However, core hardness is badly out of control. This indicates that other causes of variation also exist. From this evidence, we are led to suspect:

- Erratic manual transfer to quench;
- Salt and sludge sticking to pins;
- Erratic testing method; or
- Hardenability variation in stock.

{ Charts Nos. 4, 5, and 6 follow, }
{ comprising Pages 8, 9, and 10. }
{ Text continues on Page 11. }

CHART #4



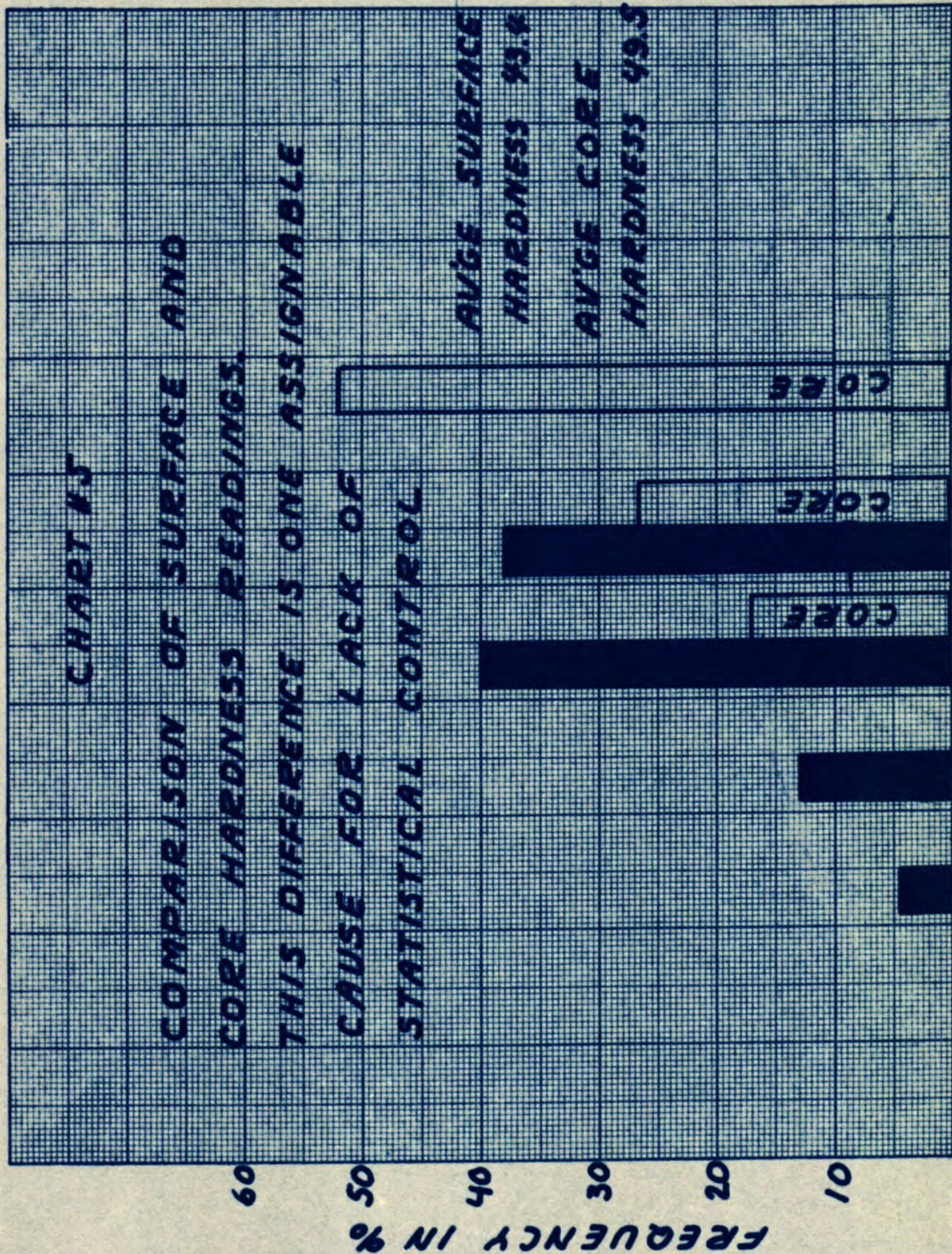
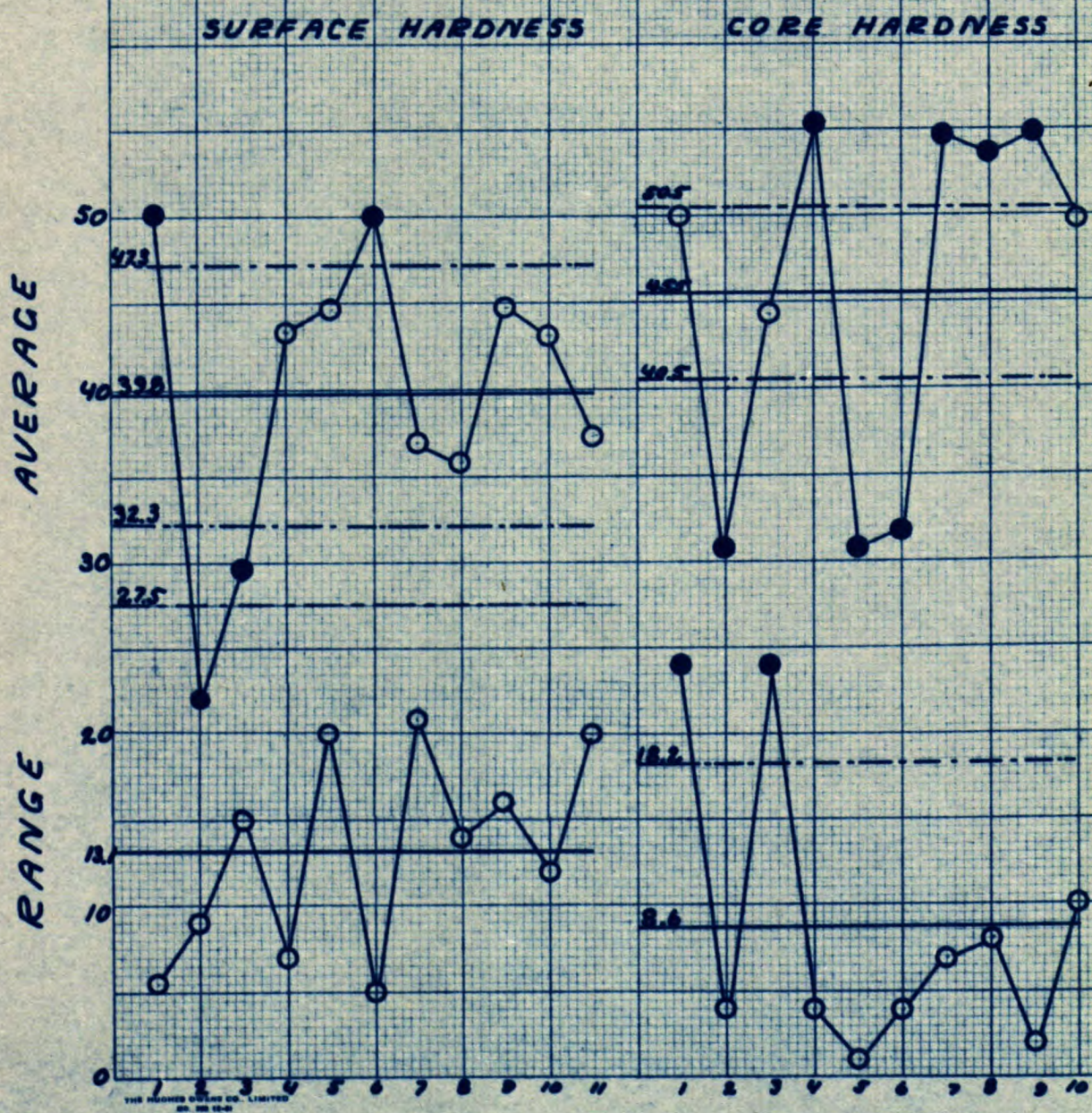


CHART #6

CONTROL CHART FOR SURFACE
AND CORE OF PINS - SHOWING
THAT CORE HARDNESS IS OUT
OF CONTROL - GROUPS OF 5.



Steps in Heat Treatment:

Chart No. 7 (on Page 12) shows distribution of hardness after each heat-treating operation. Note that the variation in test results is present after the first operation. Subsequent operations reduce the high values and leave the low values unchanged.

Chart No. 8 (on Page 13) shows hardnesses of 24 pins treated on July 6th, 1943. Each group gives average and range of four readings on a pin. Lack of control is evident. After the first treatment, four pins are out of control. This pyramids to 6 out of control after the second treatment, and 9 out of control after the final treatment.

(Charts Nos. 7 and 8 follow,
(comprising Pages 12 and 13.)
(Text continues on Page 14.)

CHART #7
 ROCKWELL HARDNESS AT EACH
 STAGE IN HEAT TREATMENT

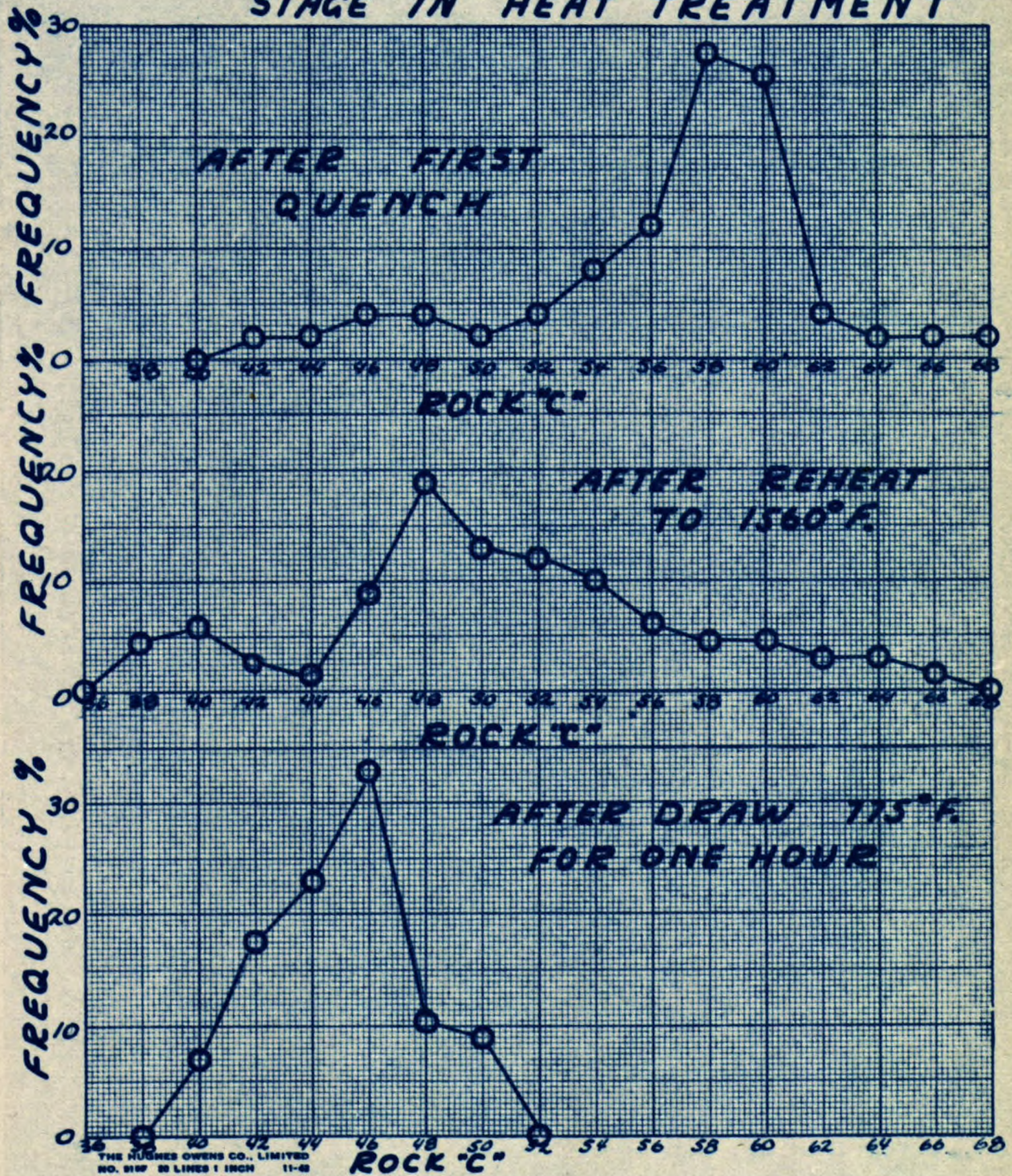


CHART #8

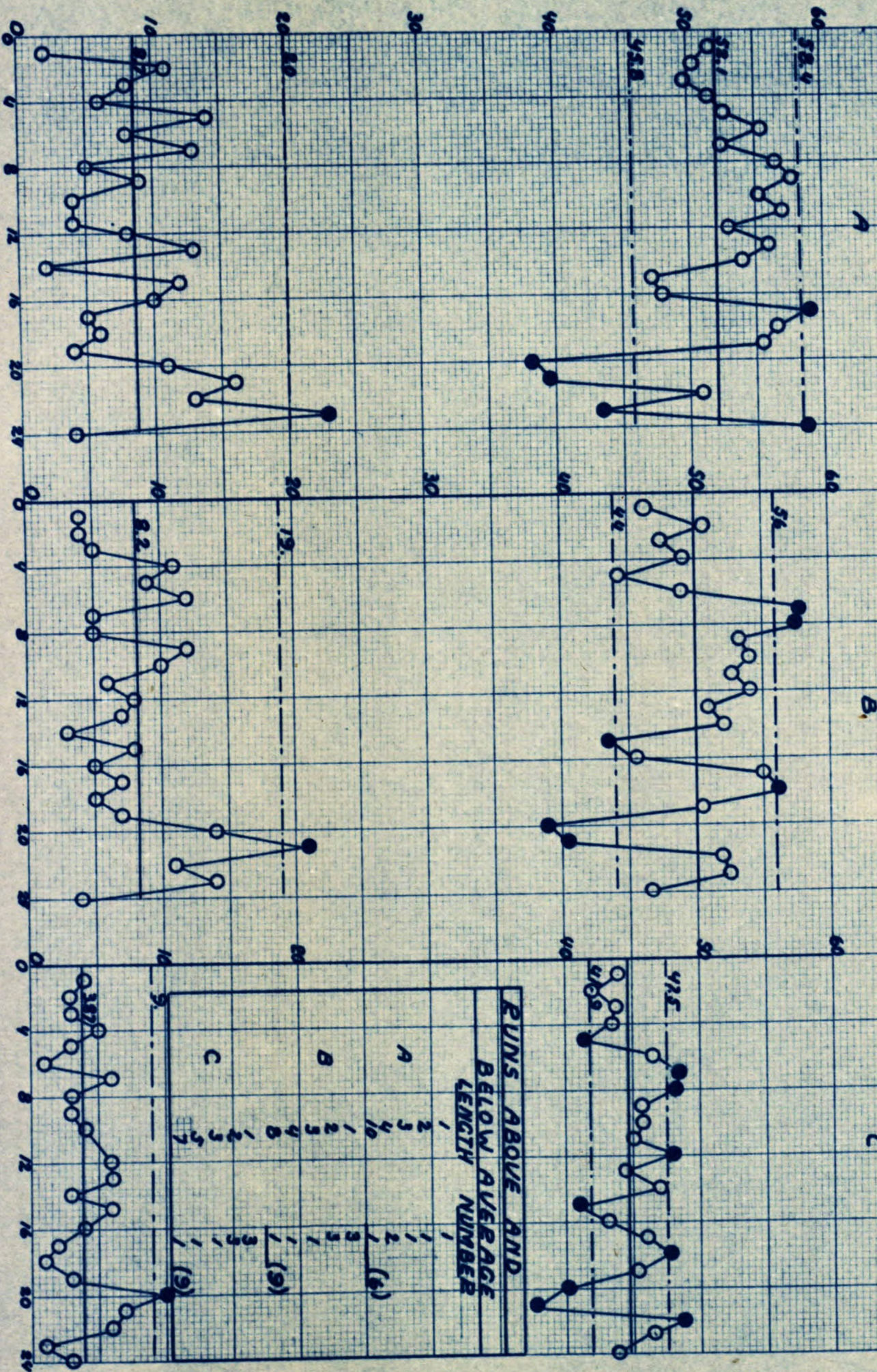
201-100-100
JAN 1950
JAN 1950

CONTROL CHARTS — GROUPS OF 4 READINGS

29.3% CYANIDE FOR 1 HOUR AT 1640°
OIL QUENCHED

REHEATED IN 25% CYANIDE FOR 23 MINUTES
OIL QUENCHED

DRAWN AT 775°
FOR 1 HOUR.



PIN NUMBER

DISCUSSION:

Assignable causes for variation are present in the process examined. It is to be expected that these will be discovered and eliminated. When the process is under statistical control, a Quality Control Chart Inspection Method can be instituted.

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HMF:GMB.