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WAL TN 381/16

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# WATERTOWN ARSENAL LABORATORIES

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## FRACTURED LEAF SPRINGS — METALLURGICAL EXAMINATION

WAL 381/16

TECHNICAL NOTE NO. WAL TN 381/16


BY

E. L. REED


DECEMBER 1959






WATERTOWN ARSENAL
WATERTOWN 72, MASS.

Springs

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ABSTRACT

At the request of Mr. F. J. Moynihan, Motor Transportation Office, samples of broken leaf springs were examined. These samples were approximately 2-3/4" long, 3" wide, and 3/8" thick. The springs had been in service about five years on a five-ton truck which distributed salt on the Arsenal roads during the winter months. The samples had a very heavy coat of corrosion on both surfaces and several had transverse cracks extending almost the width of the spring. Failure by stress-corrosion or corrosion-fatigue was indicated.

E. L. Reed

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Metallurgist

APPROVED:

J. F. Sullivan

J. F. SULLIVAN
Director
Watertown Arsenal Laboratories

## MATERIALS AND TESTS

Samples of broken springs, together with a leaf spring "as received" from the manufacturer, were submitted for metallurgical examination. The examination involved visual, radiographic, chemical, hardness, and metallographic tests.

## RESULTS AND DISCUSSION

### 1. Visual Examination

Broken Leaf Springs - A very heavy coat of corrosion products was present on both surfaces of the springs. Many of the samples were cracked, these cracks running across the width of the spring. An examination of the fractures which were corroded indicated that these fractures were of the fatigue type.

Leaf Spring, "As Received" - Considerable scale from the heat-treating process was on the surfaces of the spring. More scale was present on one face of the sample than the other face. A coat of reddish-brown paint was evident on the spring. Several indentations were present on one surface at both ends of the leaf spring.

### 2. Radiographic Examination

No cracks were revealed in the sample "as received" or on the broken samples examined.

### 3. Chemical Analyses

The chemical analyses of the broken springs and the "as received" spring are given below:

| | C | Mn | Si | Cr | V |
|---|---|---|---|---|---|
| Broken Spring | .52 | .91 | .33 | .87 | .06 |
| "As-received" Spring | .62 | .89 | .26 | .80 | .06 |
| ASTM Spec. | .48/.53 | .70/.90 | .20/.35 | .80/1.10 | .15 min. |

This is a chromium-vanadium spring steel. Slight variations in carbon and vanadium are noted as specified in ASTM Specification A60-49.

### 4. Brinell Hardness

The Brinell hardness values determined on cross-sections of the leaf springs are given below:

| | | |
|---|---|---|
| Broken Spring | - | 429 |
| Spring "As received" | - | 444 |

These hardness values are acceptable according to ASTM Specification A 147-51 - 1959.

5. Metallographic Examination

Broken Leaf Springs - The springs were made from a commercial grade of steel. Typical segregations of elongated nonmetallic inclusions are shown in Figure 1. A study of the microstructure of the springs indicated the grain size varied from ASTM #1 to #6 (Figures 2 and 3). The microstructure of the broken springs consisted of fairly coarse tempered martensite (Figure 4). Corrosion products were present on the surfaces of the spring which had a maximum thickness of 0.06". Also, severe pitting was present on the surfaces of the springs. This pitting extended into the cross section in some cases to a depth of 0.020"; Figure 5 illustrates a typical surface corrosion deposit and pitting extending into the cross-section. Such pitting could easily act as stress risers which would promote failure in service conditions. Figure 6 shows a typical pit at the surface of a failed spring and the corrosion of metal below the pit. A study of the crack systems indicate that the cracks followed the grain boundaries in many cases. Such a condition is occasionally present in the steels subjected to stress corrosion.

Leaf Spring, "As Received" - The steel base is also dirty, containing segregated elongated nonmetallics similar to the broken springs (Figure 1). The grain size was found to be ASTM #3 to #6 (Figure 7). Since the grain size of this spring was smaller than some of the broken springs, it is apparent that there were variations in the quenching temperature of the various spring stock. Some of the springs were undoubtedly overheated in heat treatment. Figure 8 illustrates the microstructure of the spring which consists of medium size tempered martensite. A slight decarburization of 0.005" was present on the surface; this amount of decarburization is not considered harmful.

## RESULTS OF INVESTIGATION

1. The surface of the broken leaf springs showed general corrosion and severe pitting as a result of contact with salt mixtures. It is believed that failure occurred by stress corrosion.

2. The springs are made of a commercial heat of chromium-vanadium steel containing segregations of nonmetallics and slight variations in carbon and vanadium as specified in ASTM Specification A60-49.

3. Considerable scale resulting from heat treatment is present on the surface of the leaf springs "as received."

4. Some of the leaf springs were overheated in heat treatment resulting in large grain size which may lower the fatigue limit.

5. The Brinell hardness of the leaf springs is acceptable (429 to 444).

6. A small amount of decarburization is present on the surface of the "as received" spring (0.005") which is not considered harmful.

## RECOMMENDATIONS

1. In the procurement of leaf springs, it is recommended that such springs be furnished by the manufacturer free from all types of scales, such as hot mill scale or scale resulting from heat treatment which may be removed by shot-blasting or shot-peening.

2. Since it has been known that large grain size lowers the fatigue limit of springs, it is recommended that leaf springs shall be heat treated by the manufacturer to promote a fine uniform grain size according to ASTM Specification A 147-51.

3. In order that the surfaces of the springs be protected from the action of salt, it is recommended that they be sprayed with cadmium or zinc metal at this installation before assembly. This procedure would protect the surfaces of the springs against salt corrosion more efficiently than lubricants and other coatings. Before metal spraying it is essential that the paint on the spring be removed by abrasive blast cleaning.

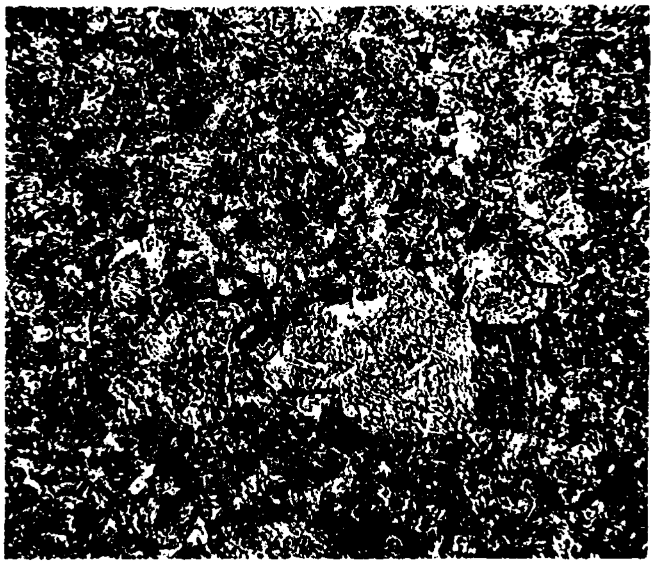
4. It is recommended after distributing salt on the roads that the recently instituted practice of washing off the salt accumulation in the truck and on the underbody of the truck be continued.

PICRAL ETCH X100

FIGURE I: TYPICAL SEGREGATED NONMETALLICS IN BROKEN AND "AS RECEIVED" SPRINGS

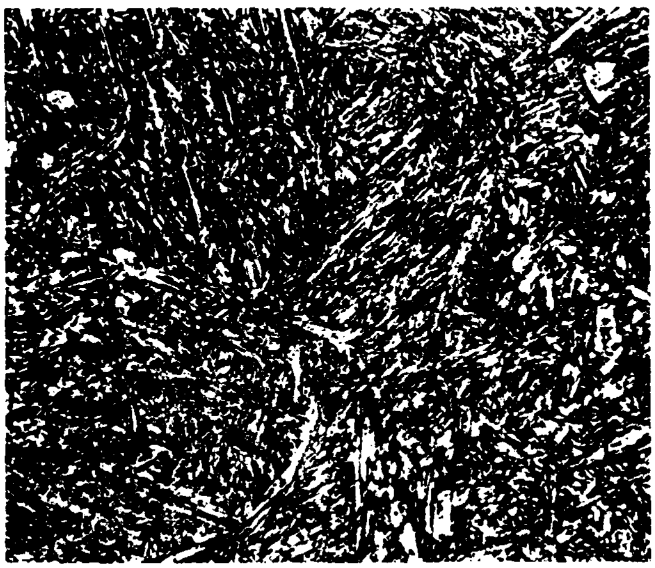
VILELLA ETCH X100

FIGURE 2: ASTM GRAIN SIZE NOS. I TO 3, BROKEN SPRING



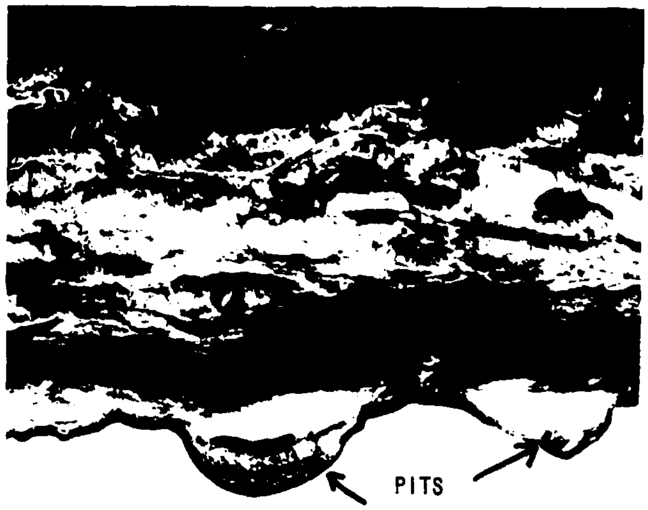
VILELLA ETCH X100

FIGURE 3: ASTM GRAIN SIZE NOS. 1 TO 6, BROKEN SPRING



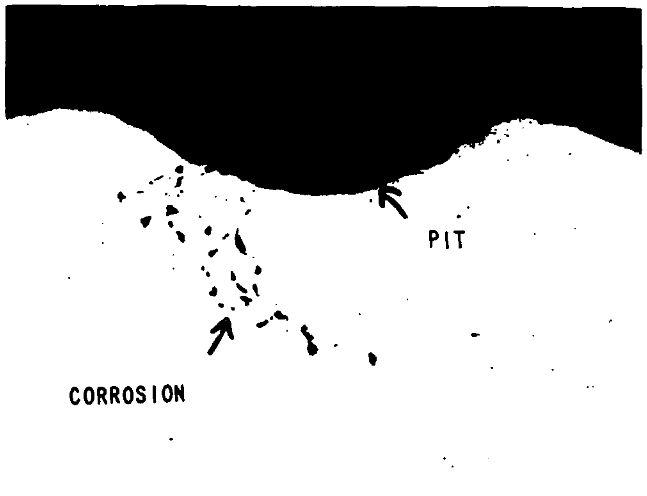
PICRAL ETCH X1000

FIGURE 4: COARSE TEMPERED MARTENSITE IN BROKEN SPRING




UNETCHED X100

FIGURE 5: SURFACE CORROSION DEPOSIT AND PITTING ON SURFACE OF BROKEN SPRING

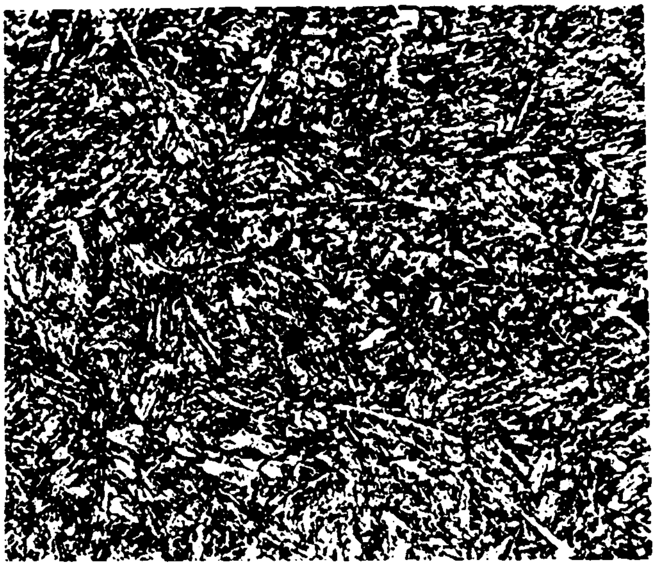



UNETCHED X100

FIGURE 6: TYPICAL PIT ON SURFACE OF BROKEN SPRING AND CORROSION OF STEEL BELOW PIT

VILELLA ETCH X100

FIGURE 7: ASTM GRAIN SIZE NOS. 3 TO 6 IN "AS RECEIVED" SPRING



PICRAL ETCH X1000

FIGURE 8: COARSE TEMPERED MARTENSITE IN "AS RECEIVED" SPRING

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