

59007

CHEVROLET SPRING AND BUMPER

LIVONIA, MICHIGAN

The effect of Shot Peening with Cut Wire Shot versus
Cast Steel Shot on the Fatigue Life of Coil Springs.

OCTOBER, 1959

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METALLURGICAL DEPARTMENT

HISTORY

There is no question of the beneficial effect of shot peening on the fatigue life of coil springs. The question of type of shot peening material which will result in the best fatigue life, however, has been a controversial issue. This report attempts to evaluate the effect of peening with cut wire shot versus cast steel shot on the fatigue life of coil springs. Two identical production shot peening machines from the same manufacturer were used for this evaluation. An attempt was made to keep as many variables constant as possible.

Chevrolet Front Coil Spring, part no. 3758760 was investigated.

SUMMARY

The test results indicate:

1. The fatigue life of coil springs peened with cut wire shot is superior and more consistent than that of springs peened with cast steel shot.
2. The peening intensity of cut wire shot is greater than that of cast steel shot.
3. The shot coverage of cut wire shot is slightly less than that of cast steel shot.
4. The load, rate, and other physical properties, other than fatigue, appear to be similar for the two types of peening media.
5. Springs peened with cut wire shot have a brighter and cleaner appearance than those peened with cast steel shot.

SHOT PEENING DATA

| | Shot Peen Machine #1 | | Shot Peen Machine #2 | |
|-------------------------------|-------------------------|------------|-------------------------|------------|
| | 1st. Wheel | 2nd. Wheel | 1st. Wheel | 2nd. Wheel |
| Horse Power | 30 | 30 | 30 | 30 |
| Amperes | 37-44 | 37-44 | 37-44 | 37-44 |
| Shot Wheel Speed | 2,160 RPM | 2,170 RPM | 2,170 RPM | 2,180 RPM |
| Shot Wheel Size with vanes | 19" | 19" | 19" | 19" |
| Spring Conveyor Speed | 20' / Min. | | 20' / Min. | |
| Rotation of Coil Spring | 60 RPM | | 60 RPM | |

Machine #1 - contained .035" Cut Wire Shot.

Machine #2 - contained 330 Cast Steel Shot.

SHOT PEENING INTENSITY*

Almen Arc Height (A-2 Strip)

Machine #1 - .035" Cut Wire Shot - .015 - .0185"

Machine #2 - 330 Cast Steel Shot - .014 - .016"

* Range of twenty individual strips.

CHEMISTRY OF SHOT

| | Carbon | Manganese | Sulfur | Phosphorus | Silicon |
|---------------------|----------|-----------|----------|------------|----------|
| .035" Cut Wire Shot | .62 | .72 | .03 | .01 | .20 |
| Spec: | .45-.75 | .60-1.20 | .05-Max. | .04-Max. | .10-.30 |
| 330 Cast Steel Shot | 1.09 | .70 | .03 | .03 | .70 |
| Spec: | .85-1.20 | None | .05-Max. | .05-Max. | .35-1.00 |

SHOT HARDNESS RANGE *

Rockwell "C" (converted from 50gm.KHN)

.035" Cut Wire Shot - 48-54

330 Cast Steel Shot - 36-52

* approximately 50 individual pieces checked.

SHOT DENSITY

(Grams per cubic centemeter)

.035" Cut Wire Shot - 7.8

330 Cast Steel Shot - 7.1 - 7.7

SHOT SIZE"NEW SHOT"

.035" Cut Wire Shot - .034 - .038"

| 330 Cast Steel Shot | <u>Screen No.</u> | <u>Dia. of Opening</u> | <u>Percent Retained</u> | <u>Spec:</u> |
|---------------------|-------------------|------------------------|-------------------------|--------------|
| | 14 | .0555" | 0% | 0% |
| | 16 | .0469" | .3% | 5% |
| | 20 | .0331" | 86.7% | 80% |
| | 25 | .028" | 10.7% | 11% |
| | Pan | ---- | 3.7% | 4% |

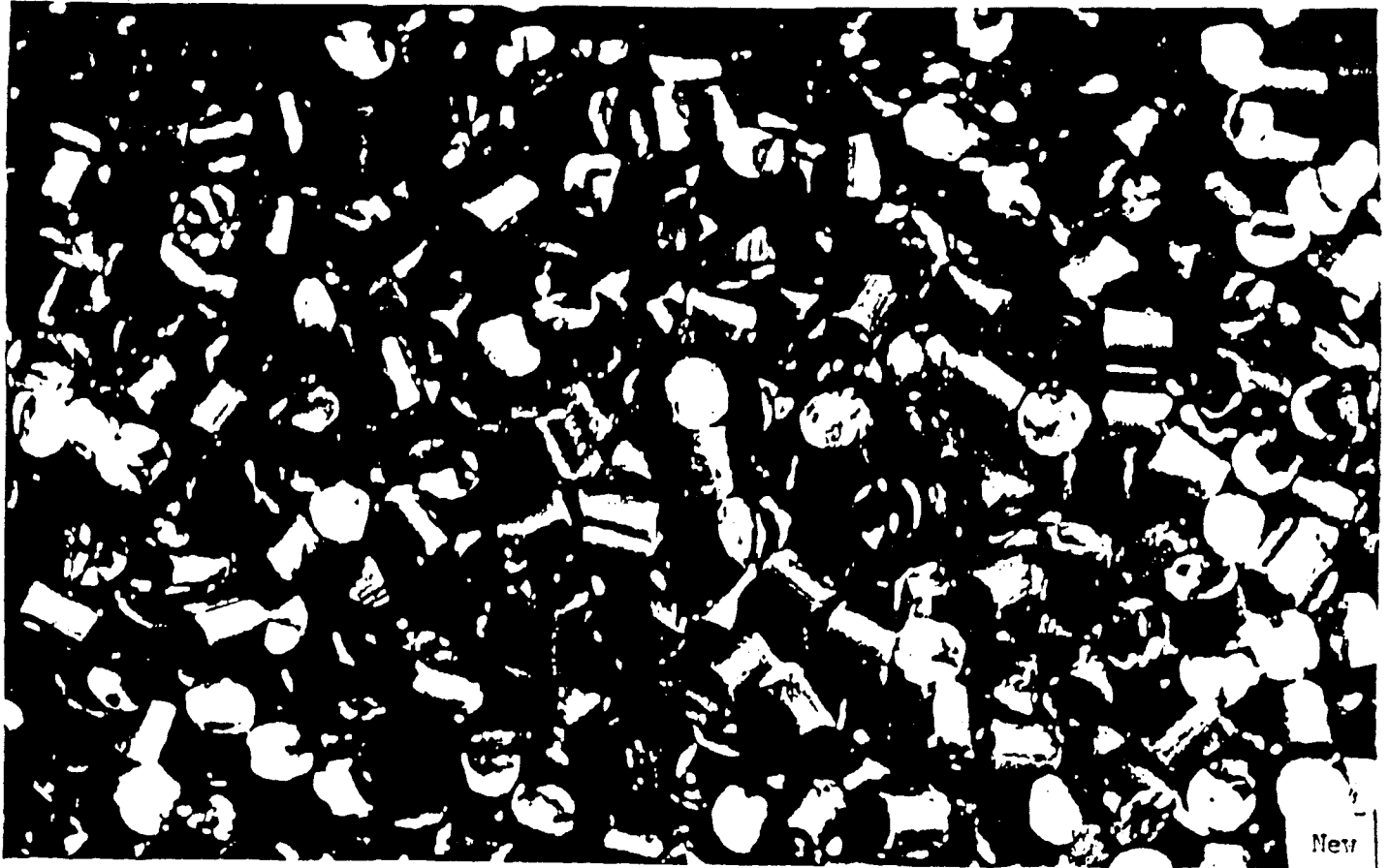
The attached Macro's #1 and #2 show the appearance of the shot "as received" and after use.

Macro #1 - shows Cut Wire Shot.

Macro #2 - shows Cast Steel Shot.

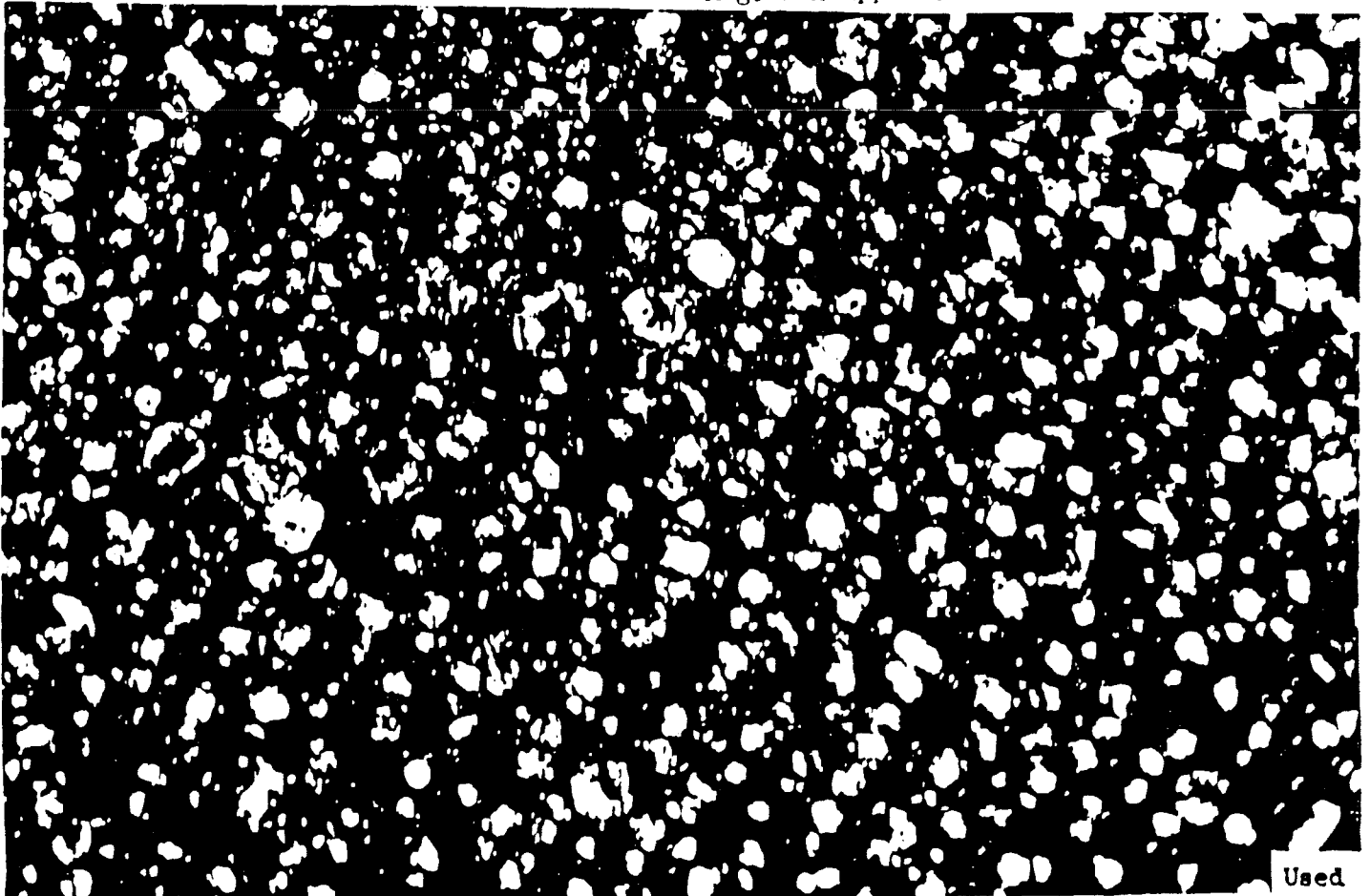
"USED SHOT" FROM PEENING MACHINE

| .035" Cut Wire Shot | <u>Screen No.</u> | <u>Percent Retained</u> | <u>Spec:</u> |
|---------------------|-------------------|-------------------------|--------------|
| | 14 | 0% | 0% Max. |
| | 16 | 0% | 5% Max. |
| | 20 | 86.5% | 80% Min. |
| | 25 | 9.1% | 11% Max. |
| | Pan | 4.4% | 4% Max. |
| 330 Cast Steel Shot | 14 | 0% | 0% Max. |
| | 16 | .3% | 5% Max. |
| | 20 | 86% | 80% Max. |
| | 25 | 10% | 11% Max. |
| | Pan | 3.7% | 4% Max. |

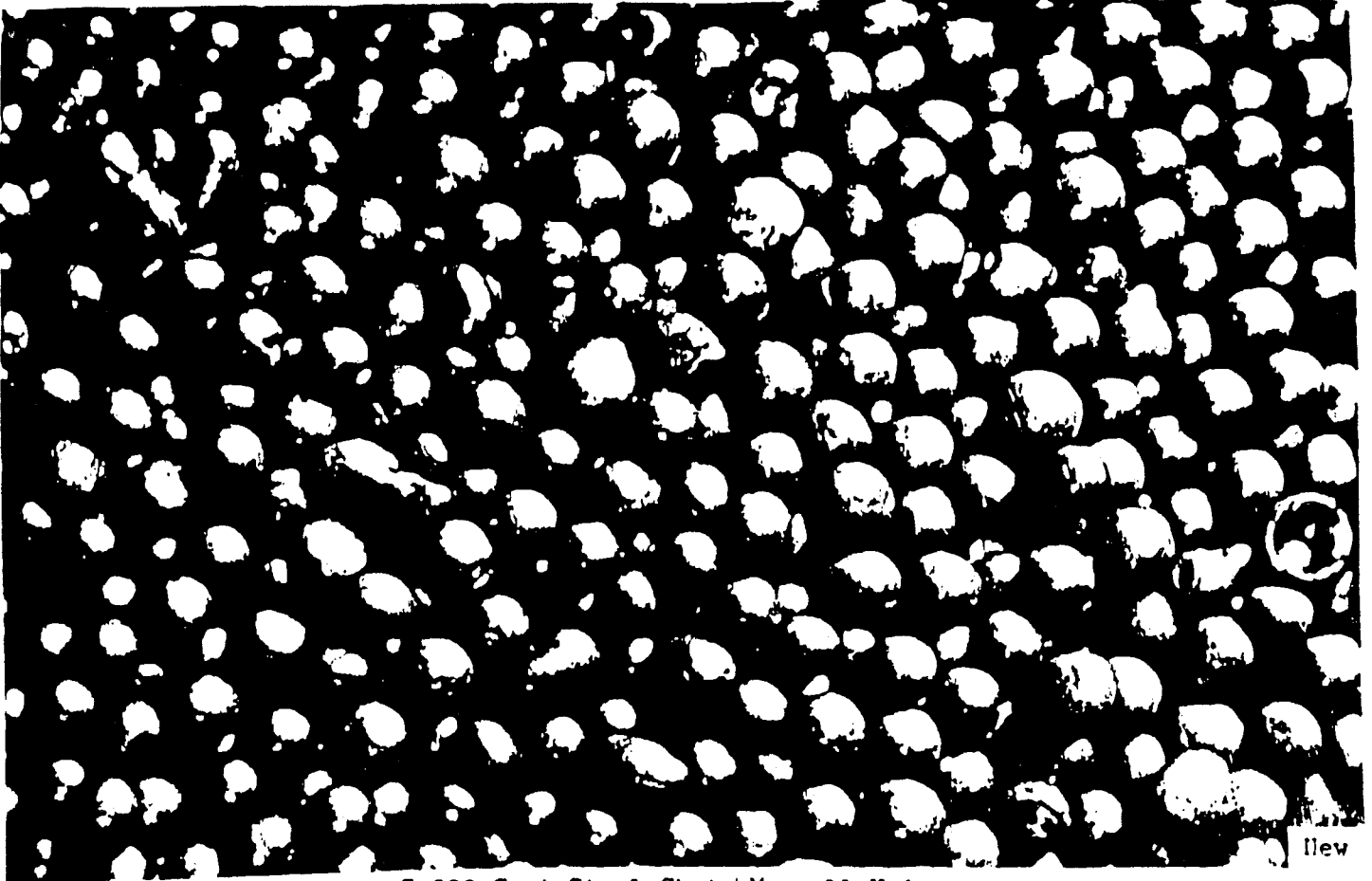


New

.035" Cut Wire Shot Mag. 11X Approx.

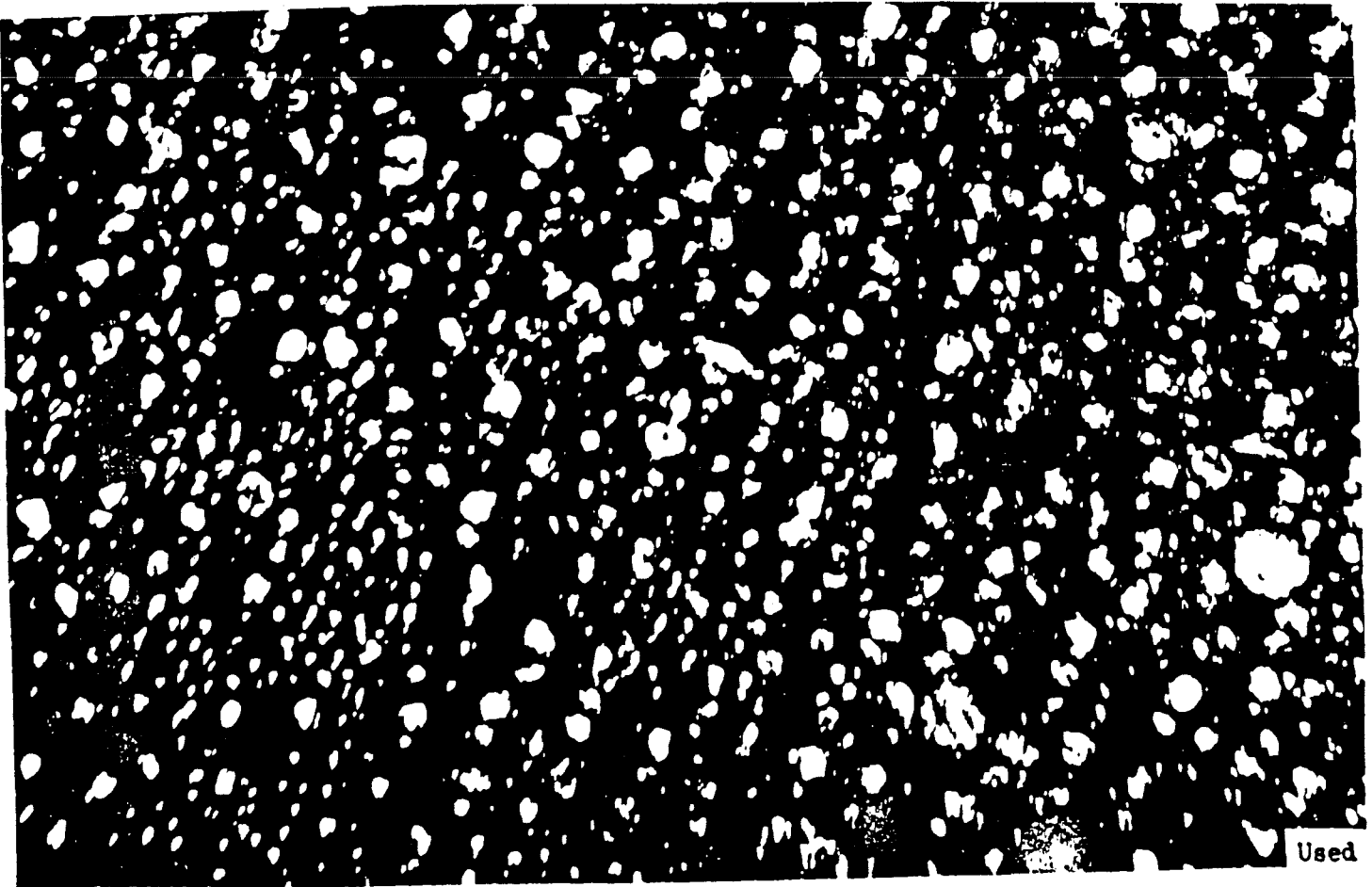


Used



S-330 Cast Steel Shot | Mag. 11 X Approx.

New

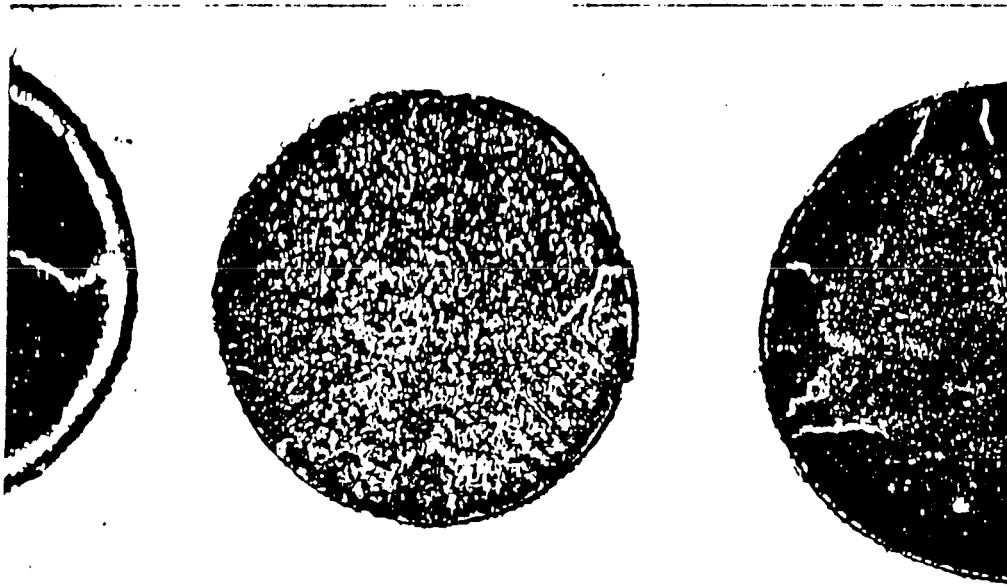


Used

PHOTOMICROGRAPH330 Cast Steel Shot "As Received"

The photomicrograph below illustrates the cracks present in a large percentage* of the cast steel shot. The cracks are rather numerous and result in early fracture of the shot and high usage. Porosity and massive carbide areas in the cast steel shot were also noted, however, the percentage was not very large.

Note cracks in Cast Steel Shot



Nital Etch

Mag. X75

* 43% of the cast steel shot contained cracks in several lots of twenty pieces checked.

COIL SPRING DATA

All the coil springs tested were made of AISI-A-5160 hot rolled steel.

A typical chemical analysis of these springs is shown below.

| | | Spec: |
|------------|------|----------|
| Carbon | .59 | .55-.65 |
| Manganese | .88 | .75-1.00 |
| Chromium | .79 | .70-.90 |
| Phosphorus | .019 | |
| Sulfur | .021 | |
| Silicon | .23 | |

The hot rolled coil bars were heated to 1620°F for coiling and were direct free quenched after coiling at 1500-1550°F in oil at 165°F. The draw temperature was 760°F.

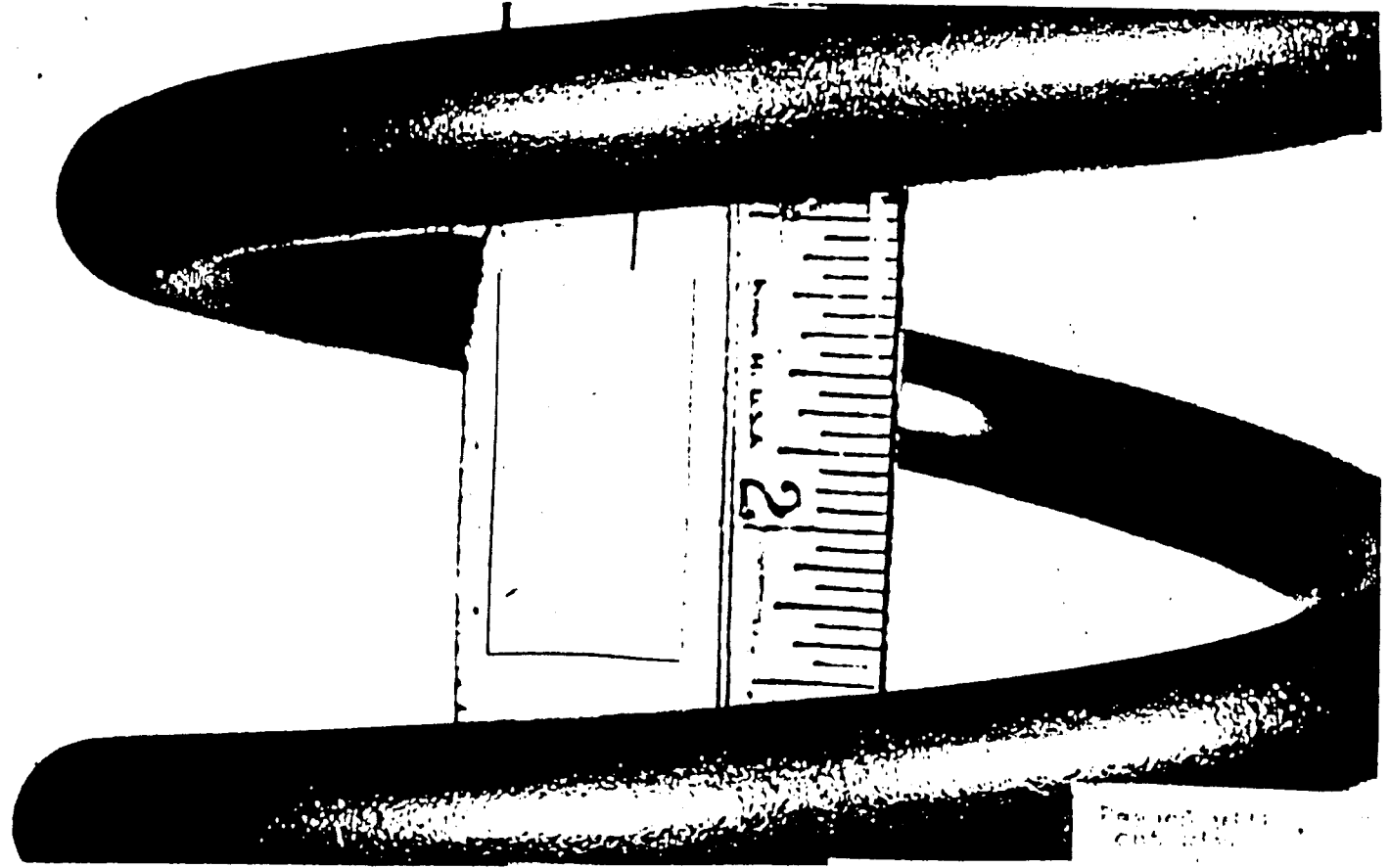
The coils checked 2.40 Brinell (BHN-653) as quenched and 2.80 Brinell (BHN-477) after the draw.

After heat treating, the coil springs were shot peened as noted.

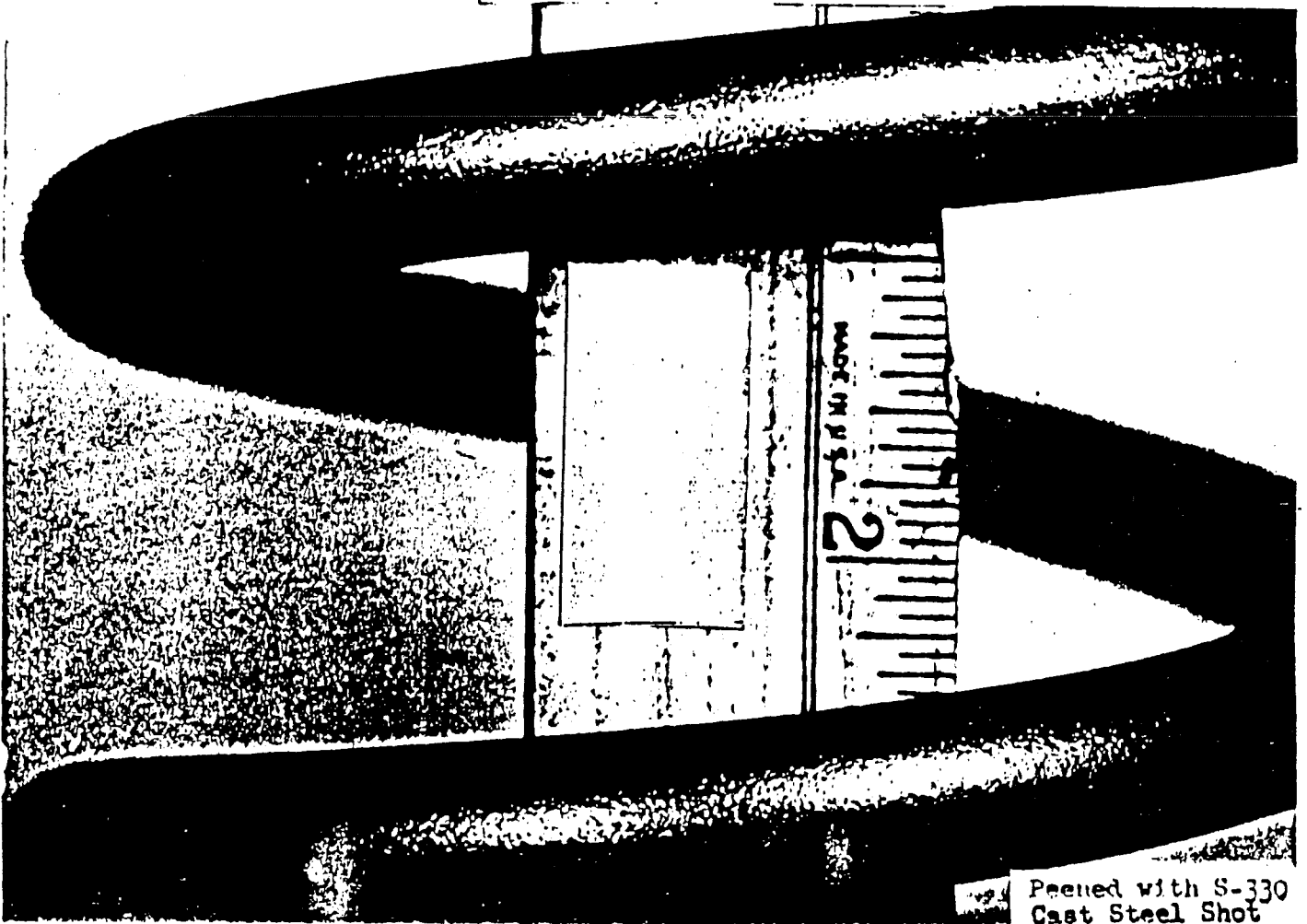
The attached Macrograph #3 shows a typical surface of a spring shot peened with "Cut Wire Shot" versus "Cast Steel Shot."

The springs peened with "Cut Wire Shot" are much cleaner and brighter in appearance than those peened with "Cast Steel Shot." This is especially true after the shot has been in use for several weeks or more.

The attached Macrograph #3 shows the effect of peening on the surface of the spring from the two shot mediums but does not depict the difference in appearance as noted.



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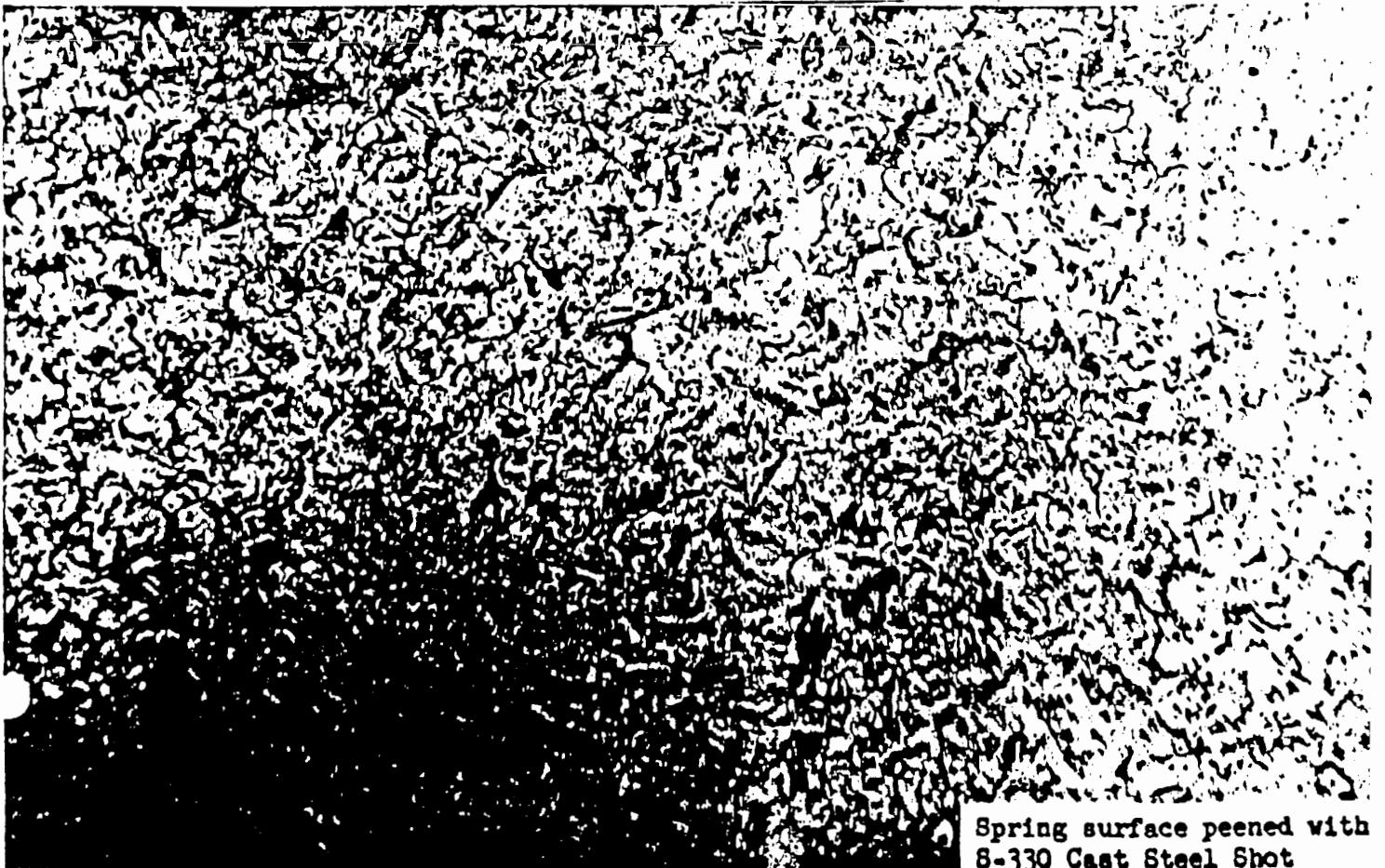
Peened with S-330
Cast Steel Shot

MACRO # 4



Spring surface peened with
.035" Cut Wire Shot

FAX FILM MAG. 12 X Approx.



Spring surface peened with
8-330 Cast Steel Shot

COIL SPRING DATA continued:

The attached Macro #4 shows a "Fax Film" coverage of the spring surface after peening with .035" Cut Wire Shot versus 330 Cast Steel Shot.

The coverage by both mediums is good and very much alike.

As a general rule, it has been our experience that the shot coverage is slightly better with the use of Cast Steel Shot. This could be due to the fact that the cast steel shot has a greater tendency to crumble or fall apart into fines.

Shot Coverage * (Fax Film of peened springs)

| | |
|---------------------|--------|
| .035" Cut Wire Shot | 75-95% |
| 330 Cast Steel Shot | 80-95% |

*Range of 50 springs.

FATIGUE TESTING DATA

Range of 50 Springs tested.

Spec:

| | | |
|-----------------------------|----------------------|----------------|
| Free Height of Spring | 20 19/64 - 20 39/64" | |
| Preset Height | 7 37/64" | |
| Free Height after Preset | 18 52/64 - 19 29/64" | |
| Load At 10.3" | 1908 - 1984# | 1885 - 1985# |
| Load At 11.67" | 1532 - 1615# | |
| Load At 8.67" | 2330 - 2444# | |
| SAE Deflection Rate | 268 - 285#/in. | 265 - 285#/in. |
| Fatigue Test Minimum Height | 8.02" | |
| Fatigue Test Maximum Height | 14.469" | |
| Fatigue Travel | 6.449" | |

LOAD LOSS

| | |
|------------------|--------|
| 30 cycles | 5-14# |
| 10,000 cycles | 12-29# |
| 100,000 cycles | 32-34# |
| 1,000,000 cycles | 37-56# |

Note: The spring data was not affected by the two different shot peening media.

FATIGUE TEST RESULTS

SPRINGS PEENED WITH .035" CUT WIRE SHOT

VERTICAL TESTING - 250 STROKES PER MINUTE
SPRINGS COMPRESSED TO MAX. LOAD HEIGHT

| Spring No. | No. of Cycles | Failure | Fax Film | Brinell Hardness | | Micro-Structure | |
|------------|---------------|---------|----------|------------------|------|-----------------|----------------------|
| | | | | Surface | Core | Surface | Decarburization Core |
| 1 | 1,000,000 | None | 75-80% | 2.85 | 2.85 | Partial | .008" Sorbite |
| 2 | 1,000,000 | None | 75-80% | 2.85 | 2.85 | | |
| 3 | 1,000,000 | None | 75-80% | | | | |
| 4 | 1,000,000 | None | 70% | | | | |
| 5 | 1,000,000 | None | 70-80% | | | | |
| 6 | 1,000,000 | None | 70-80% | | | | |
| 7 | 1,000,000 | None | 70-80% | | | | |
| 8 | 1,000,000 | None | 70-75% | | | | |
| 9 | 1,000,000 | None | 90% | 2.75 | 2.75 | Partial | .002" Sorbite |
| 10 | 1,000,000 | None | 85-90% | 2.80 | 2.80 | | |
| 11 | 1,000,000 | None | 85-90% | 2.75 | 2.75 | | |
| 12 | 1,000,000 | None | 90% | | | | |
| 13 | 1,000,000 | None | 90% | 2.75 | 2.80 | | |
| 14 | 1,000,000 | None | 90% | 2.75 | 2.80 | Trace | Sorbite |
| 15 | 1,000,000 | None | 85-90% | | | | |
| | | None | 90-95% | 2.80 | 2.80 | Trace | Sorbite |

Note: None of these springs had magnaflux indications before or after fatigue testing.

FATIGUE TEST RESULTS

SPRINGS PEENED WITH 330 CAST STEEL SHOT

VERTICAL TESTING - 250 STROKES PER MINUTE
SPRINGS COMPRESSED TO MAXIMUM LOAD HEIGHT

| Spring No. | No. of Cycles | Failure | Fax Film | Brinell Hardness | | Micro-Structure | | |
|------------|---------------|--------------------|----------|------------------|------|-----------------|-----------------|---------|
| | | | | Surface | Core | Surface | Decarburization | Core |
| 16 | 1,000,000 | None | 75-80% | 2.80 | 2.80 | Trace | to .006" | Sorbite |
| 17 | 1,000,000 | None | 75-80% | 2.85 | 2.85 | | | |
| 18 | 1,000,000 | Failed - 4th. Coil | 80% | 2.80 | 2.80 | Trace | to .005" | Sorbite |
| 19 | 316,000 | Failed - 2nd. Coil | 75-80% | 2.85 | 2.85 | Trace | to .001" | Sorbite |
| 20 | 1,000,000 | None | 75-80% | | | | | |
| 21 | 1,000,000 | None | 70-80% | | | | | |
| 22 | 327,000 | Failed - 2nd. Coil | 75-80% | | | | | |
| 23 | 279,600 | Failed - 2nd. Coil | 85% | 2.75 | 2.75 | Trace | | Sorbite |
| 24 | 467,700 | Failed - 4th. Coil | 85% | 2.75 | 2.75 | Trace | | Sorbite |
| 25 | 1,000,000 | None | 85% | | | | | |
| 26 | 520,600 | Failed - 4th. Coil | 85-90% | 2.75 | 2.75 | Trace | to .003" | Sorbite |
| 27 | 1,000,000 | None | 80-85% | | | | | |
| 28 | 1,000,000 | None | 80-85% | 2.80 | 2.80 | | | |
| 29 | 1,000,000 | None | 75-85% | 2.80 | 2.80 | | | |
| 30 | 1,000,000 | None | 80-85% | 2.75 | 2.80 | | | |

Note: None of these springs had magnaflux indications before or after fatigue testing.