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# EXAMINATION OF A COLD PUNCH FOR HORSESHOES (T.I.S. 60864)

by

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PHYSICAL METALLURGY DIVISION

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## SUMMARY OF RESULTS

The material in the punch was a shock-resisting tool steel similar to Atlas Steel's Falcon 6 grade.

The punch contained a longitudinal crack-like defect, which could be harmful, but which was not directly associated with the failure. The failure was caused by bending and impact.

The heat treatment was adequate except for the soft tip, for which no clear explanation was evident.

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## INTRODUCTION

On September 2, 1965, T.I.S. inquiry 60864 was submitted by Dr. H.J. Lips of the National Research Council. This inquiry originated with Mr. B. Lowther, Metal Products, Allen Street, Charlottetown, P.E.I. Accompanying the inquiry were an unfinished horseshoe, a horseshoe nail and a fractured cold punch for horseshoes. It was requested that information be supplied as to how the punch could be improved and where suitable bar stock could be obtained.

## VISUAL EXAMINATION

The "as-received" articles - an unfinished horseshoe, a nail and a punch - are shown in Figure 1.

The punch failed in a manner typical of tool steels that have undergone bending probably accompanied by impact. The pointed end of the punch had bent quite severely.

## CHEMICAL COMPOSITION

The composition of the punch, according to report No. MS-AC-65-1014, and the nominal compositions of three similar steels are as follows:

| | | Composition, Per Cent | | |
|---|---|---|---|---|
| Element | Punch | Alpha Pneu (Crucible) | Falcon 6 (Atlas) | AISI S1 |
| Carbon | 0.53 | 0.55 | 0.55 (nominal) | 0.50 |
| Manganese | 0.28 | 0.25 | 0.25 | - |
| Silicon | 0.48 | 0.25 | 0.30 | - |
| Molybdenum | 0.08 | - | - | - |
| Chromium | 1.04 | 1.25 | 1.50 | 1.50 |
| Vanadium | 0.20 | 0.20 | 0.25 | - |
| Tungsten | 2.34 | 2.75 | 2.00 | 2.50 |

These are shock-resisting grades of tool steels.

## SEMI-QUANTITATIVE SPECTROGRAPHIC ANALYSES

The spectrographic analysis Report No. SL65-148, confirmed that there were no additional elements of alloying quantity other than those shown in the above table.

The composition of the broken punch is similar to that of Alpha Pneu (Crucible), Falcon 6 (Atlas), and AISI S1 steels. This indicates that the material is a shock-resisting tool steel, and, as such, is suitable for use as a cold punch.

## HARDNESS EXAMINATION

Cross sectional and surface hardness surveys showed the hardness range to be 55 to 59 on the Rockwell 'C' scale (555 to 630 Brinell). The lower hardness readings were closest to the point of the punch.

## METALLOGRAPHIC EXAMINATION

Transverse and longitudinal sections of the punch were mounted and polished. These are shown in Figure 2.

The punch contained a defect in the form of a crack extending down one side and penetrating inward to the centre. The origin of the crack was either a centre defect in the ingot (known as pipe or shrinkage) which had not welded during hot processing operations, or a forging split resulting from too low a forging temperature. There was no evidence that this defect contributed to bending of the point, or to the fracture. It is, however, an undesirable defect which could cause or contribute to a punch failure.

The polished specimens were etched in 2% nital revealing the fine martensitic microstructure shown in Figure 3. There was little or no evidence of decarburization.

The first half inch of the punch appears to have been tempered at a higher temperature than the remainder. This could account for the lower hardness reading of 55 $R_c$ in that region. An improvement should be evident if the heat treatment is designed to maintain the hardness near 60 $R_c$. This should be attainable with an oil quench from 1680°F (915°C) followed by a 300 to 350°F (150 to 180°C) temper.

## DISCUSSION

It should be possible to punch the horseshoe material with the least stress on the punch if a matching die or set of holes is placed beneath the shoe. Assuming that this is normal practice, it is suggested that die alignment should be checked. The severe bend at the point probably resulted from a combination of the softer material and some condition in service that contributed to loading that was not axial in direction.

A redesign of the punch might provide a solution to the problem. It could eliminate the long tapered punch in favor of one having a uniform, possibly circular cross section throughout the shank length. The punch end would then be shaped to the required dimension as abruptly as possible.

If a redesign should not prove to be feasible or helpful, there are alternate steels which might be suitable. These include the shock-resisting steels having slightly higher carbon contents that would provide a greater hardness and strength. Such steels are recommended for heavy duty perforating punches.

Cold work steels such as AISI O1 or A2 might be an improvement. These are available from the tool steel manufacturers in various grades under corresponding trade names.

High speed steels, of which AISI M2 is the most used and least expensive, might be a better steel to use if the softening at the tip should be caused by working temperatures. Similar steels are available from tool steel manufacturers under corresponding trade names.

Most tool steels are difficult to heat treat without suitable facilities to control atmospheres, and to provide the high temperatures and the proper quenches required. It is often preferable to have tools commercially made and heat treated where these facilities are lacking.

## CONCLUSIONS

1. The punch failed in a manner typical of a tool steel that has undergone bending probably accompanied by impact.

2. The punch contained a longitudinal crack-like defect which could be harmful but which was not directly associated with the failure.

3. The bent tip of the punch was softer than the thicker section remote from the tip apparently due to the effect of a higher temperature.

4. The material in the punch was a shock-resisting tool steel similar to Atlas Steel's Falcon 6 grade.

5. The heat treatment was adequate except for the softer tip for which no clear explanation was evident.

## RECOMMENDATIONS

1. Check service conditions with reference to alignment, operating temperatures that could soften the punch tip, the possibility of improving the punch design, and the condition of the punch before service with regard to heat treatment and hardness at the tip.

2. If failures persist after remedial measures have been taken, consider the other steels suggested with regard to the service conditions encountered.

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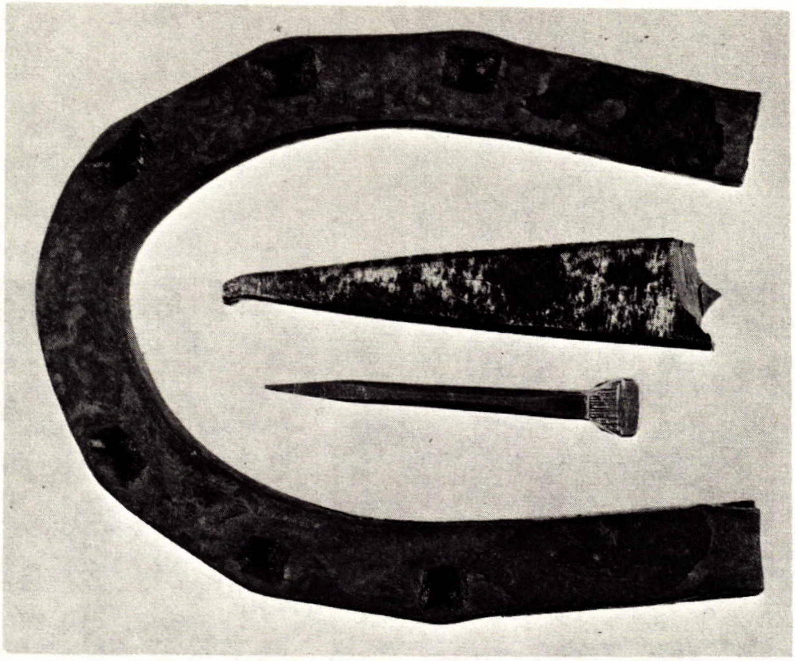
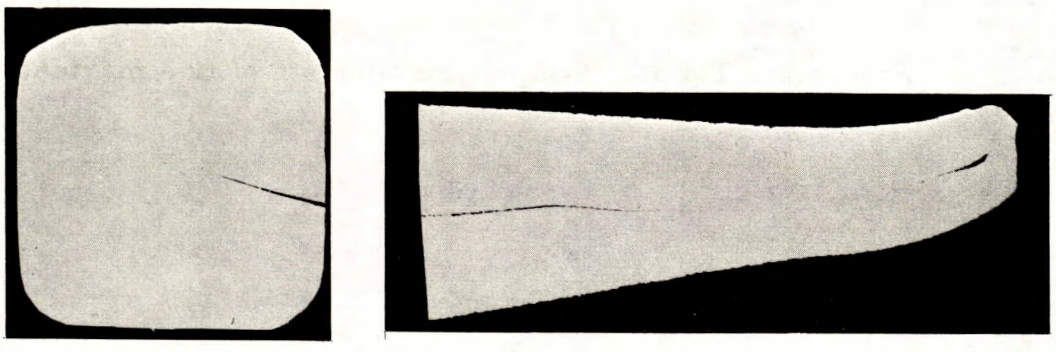


Actual Size

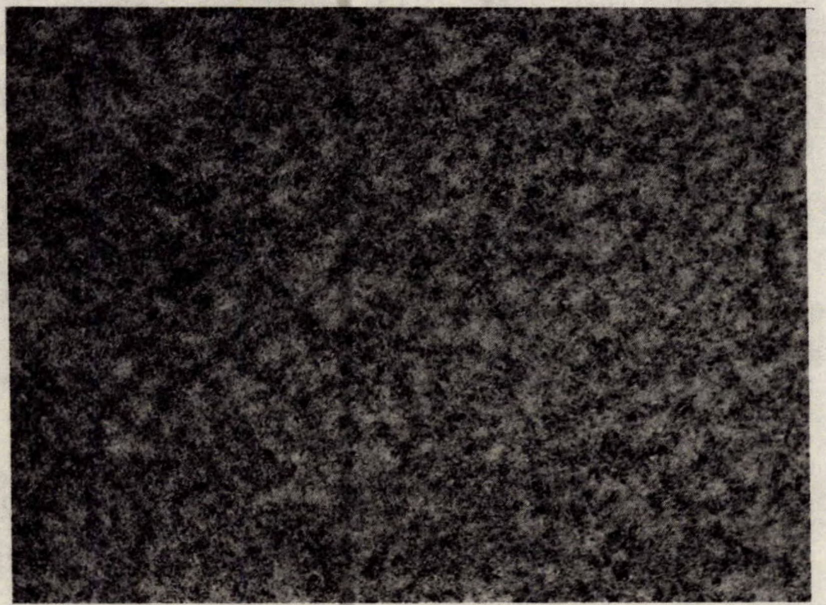
Figure 1. Unfinished horseshoe, nail, and cold punch "as-received".



Transverse    Longitudinal

Approx. X5

Figure 2. Polished sections of cold punch showing location of defect.



X100

Figure 3. The microstructure consists of fine martensite.