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# REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1712.

Further Examination of Broken Snowmobile Bogie Suspension Brackets.

(Subsequent to Report of Investigation No. 1639, dated May 10th, 1944.)

(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals
-
Physical Metallurgy
Research Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

OTTAWA SEPtember 21st, 1944.

# REPORT
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## Further Examination of Broken Snowmobile Bogie Suspension Brackets.

(Subsequent to Report of)
(Investigation No. 1639,)
(dated May 10th, 1944. )

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### Origin of Material and Object of Investigation:

On August 30th, 1944, two snowmobile bogie suspension brackets (see Figures 1 and 2) were submitted, for examination, by Mr. H. J. Stevenson, Assistant Director General, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario. This request may be considered as also covered by Requisition No. 641, AEDB Lot No. 533, Report No. 107 "D", which covered Investigation No. 1639.

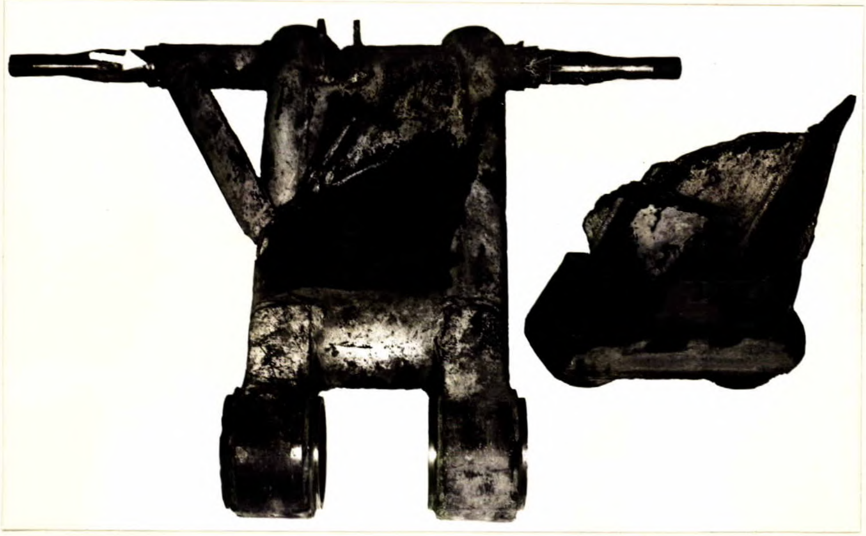
The object of this investigation was to determine the cause of failure and to make recommendations which would eliminate this cause.

Description of Material:

For purposes of identification, the bogie shown in Figure 1 will be called Sample "A" and that shown in Figure 2, Sample "B".

Both of these bogies had been stress-relieved at 1150° F. as recommended in Investigation No. 1639. In spite of this heat treatment, failure in field tests had occurred prematurely. In Sample A, the entire spring seat assembly had been torn off, as shown in Figure 1. A crack in the spindle support tubing (see Figure 3), at the weld junction of this tubing with the bogie arm suspension tubing, was also noted. The position of this crack is indicated by the arrow in Figure 1. A similar crack (see Figure 4) was found in Sample B, the position of which is shown by the white arrow in Figure 2. A crack in the reinforcing plate (see Figure 5) was found at the weld junction of the reinforcing plate and the spring seat plate, as shown by the black arrow in Figure 2.

Figure 1.

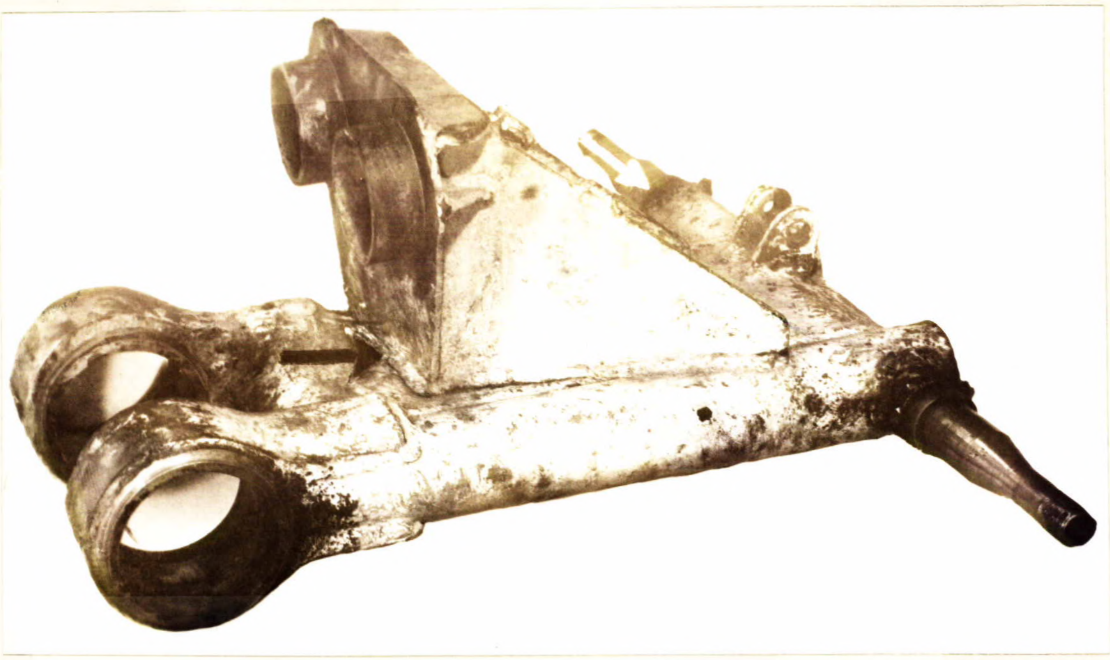


PHOTOGRAPH OF SAMPLE A, SHOWING THE SPRING SEAT ASSEMBLY COMPLETELY TORN AWAY FROM BODY.

Arrow points to crack.

(Description of Material, cont'd) -

Figure 2.

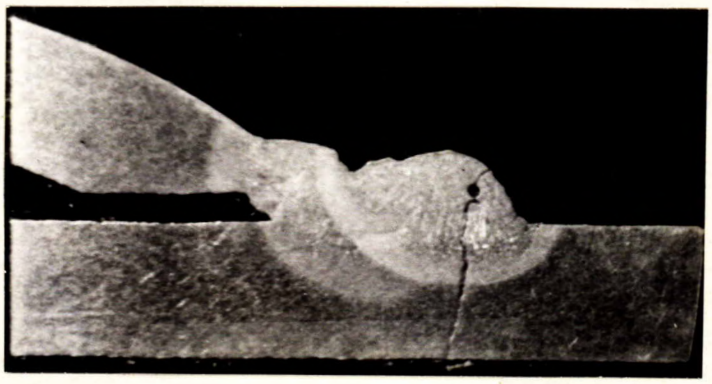


PHOTOGRAPH OF SAMPLE B.

Arrows point to cracks.

-

Figure 3.



X4.

PHOTOGRAPH OF SAMPLE A, SHOWING CRACK IN SPINDLE SUPPORT TUBING (PART NO. B 38417).

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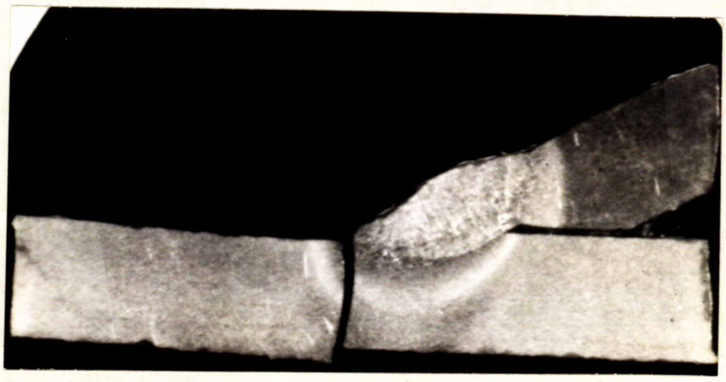
(Dsecription of Material, cont'd) -

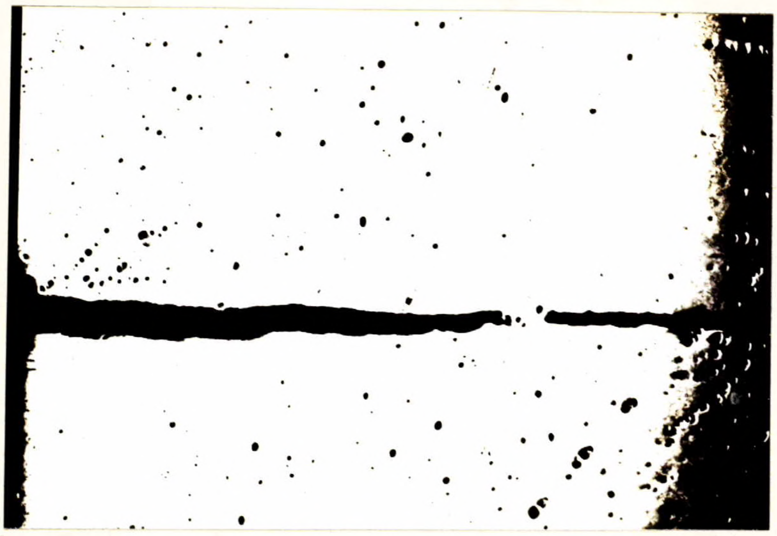
Figure 4.



X4.

PHOTOGRAPH OF SAMPLE B, SHOWING CRACK IN SPINDLE SUPPORT TUBING (PART NO. B 38417).

Figure 5.



X30, unetched.

SHOWING CRACK IN REINFORCING PLATE OF SAMPLE B (PART NO. B 38422).

Note uncracked bridge at centre.

Chemical Analysis:

Samples cut from the various parts of both bogies were chemically analysed. The results are as follows:

SAMPLE BOGIE A.

| Part No.* | | B 38422 | 38500 ND | B 38418 | B 38421 | B 38417 |
|---|---|---|---|---|---|---|
| Specification | | SAE 1020 | SAE 1020 | SAE 1015 or 1020 | SAE 1020 | SAE 1015 or 1020 |
| | | | | - Per Cent - | | |
| Carbon | - | 0.15 | 0.04 | 0.18 | 0.09 | 0.15 |
| Manganese | - | 0.32 | 0.32 | 0.43 | 0.37 | 0.41 |
| Silicon | - | 0.01 | 0.01 | 0.13 | 0.01 | 0.10 |
| Sulphur | - | 0.021 | 0.020 | 0.021 | 0.051 | 0.021 |
| Phosphorus | - | 0.028 | 0.026 | 0.021 | 0.020 | 0.011 |
| Ni, Cr, Mo | - | Nil. | Nil. | Nil. | Nil. | Nil. |

SAMPLE BOGIE B.

| Part No.* | | B 38422 | 38500 ND | B 38418 | B 38421 | B 38417 |
|---|---|---|---|---|---|---|
| Specification | | SAE 1020 | SAE 1020 | SAE 1015 or 1020 | SAE 1020 | SAE 1015 or 1020 |
| | | | | - Per Cent - | | |
| Carbon | - | 0.18 | 0.05 | 0.18 | 0.05 | 0.17 |
| Manganese | - | 0.40 | 0.23 | 0.43 | 0.38 | 0.42 |
| Silicon | - | 0.01 | 0.01 | 0.14 | Nil. | 0.12 |
| Sulphur | - | 0.025 | 0.030 | 0.018 | 0.031 | 0.022 |
| Phosphorus | - | 0.023 | 0.023 | 0.023 | 0.017 | 0.011 |

| * Part No. | | Description |
|---|---|---|
| B 38422 | - | Bogie arm reinforcing plate. |
| 38500 ND | - | Spring seat. |
| B 38418 | - | Bogie arm suspension tubing. |
| B 38421 | - | Spring seat gusset plate. |
| B 38417 | - | Spindle support tubing. |

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Hardness Tests:

Hardness tests were made on the fractured parts of both bogies. The results are as follows:

| | | Bogie A | Bogie B |
|---|---|---|---|
| Spindle Support Tubing - | | (Vickers - 20-kg. load) | |
| Normal zone | - | 146 | 198 |
| Heat-affected zone | - | 155 | 166 |
| Weld metal | - | 236 | 200 |
| Reinforcing Plate - | | (Rockwell 'B') | |
| Normal zone | - | 50 | 56 |
| Weld metal | - | 85 | 87 |

Microscopic Examination:

Sections were cut from the various parts of both bogies and photomicrographs were obtained, in order to check the chemical analyses and to determine the character of the fractures. Figures 6 to 12 are taken from Bogie Sample A, and Figures 13 to 16 were obtained from Bogie Sample B.

Bogie Sample A -

Figures 6, 7 and 8, taken at X250 magnification, show the microstructures of the reinforcing plate spring seat and the bogie arm suspension tubing respectively. Figure 9 shows the microstructure and fracture of the spindle support tubing, whereas Figure 10 shows the same fracture within the weld metal.

Figures 11 illustrates the nature of the fracture of the weld material which was deposited at the junction of the reinforcing plate and the spring seat. Figure 12 clearly shows needles of iron-nitride in this weld material, probably caused by the use of bare electrodes or of electrodes from which the coating has been accidentally removed. This weld material would be very brittle.

Figure 6.

X250, nital etch.

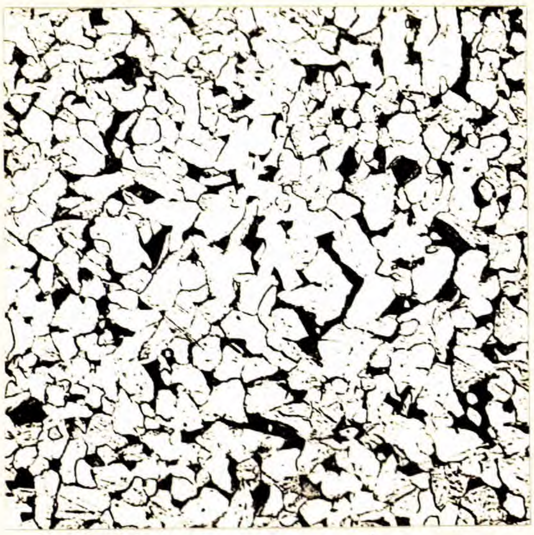
REINFORCING PLATE
(PART NO. B 38422).

Figure 7.

X250, nital etch.

SPRING SEAT
(PART NO. 38500 ND).

Figure 8.



X250, nital etch.
BOGIE ARM SUSPENSION TUBING (PART NO. B 38418).

Figure 9.

X250, nital etch.
FRACTURE IN PINION SUPPORT TUBING (PART NO. B 38417).

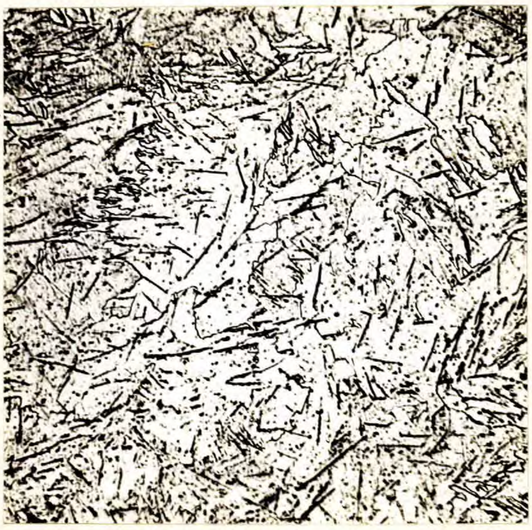
Figure 10.

X250, nital etch.
FRACTURE IN PINION SUPPORT TUBING, THROUGH WELD METAL.
Note absence of distortion at edge of fracture.

Figure 11.

X250, nital etch.
EDGE OF FRACTURE IN REINFORCING PLATE, RUNNING THROUGH WELD METAL.
Note absence of distortion.

Figure 12.



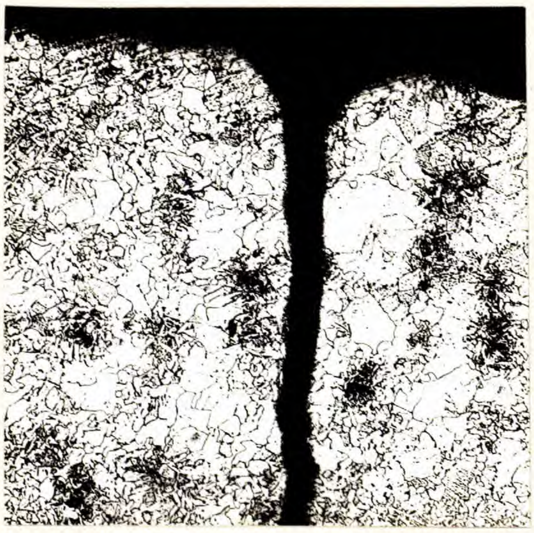
X250, nital etch.
WELD METAL DEPOSITED AT JUNCTION OF REINFORCING PLATE AND SPRING SEAT PLATE.
Note nitride needles.

(Microscopic Examination, cont'd) -

Bogie Sample B -

Figures 13 and 14, taken at X100 magnification, illustrate the character of the fracture and the microstructure in the reinforcing plate. Figures 15 and 16, taken at X250 magnification, show the microstructure of the spindle support tubing at the fracture. These photomicrographs are taken from Bogie Sample B.

Figure 13.



X100, nital etch.

Figure 14.

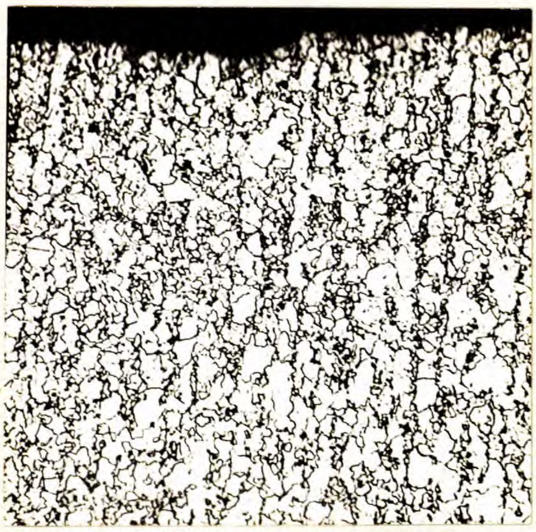
X100, nital etch.

CRACK IN REINFORCING PLATE.

AT SURFACE.
Note absence of distortion.

AT INTERIOR.
Note absence of distortion and uncracked bridge at centre.

Figure 15.



X250, nital etch.

Figure 16.

X250, nital etch.

EDGE OF FRACTURE IN SPINDLE SUPPORT TUBING.

NORMAL ZONE.
Note absence of distortion.

HEAT-AFFECTED ZONE.
Note absence of distortion.

DISCUSSION:

Visual examination of both bogie samples indicates that there are two highly stressed areas in the bracket, as shown by the arrows in Figures 1 and 2. One of these areas is located at the junction of the reinforcing place and spring seat (see black arrow, Figure 2). The other occurs at the junction of the spindle support tubing and the suspension arm tubing (see white arrow, Figure 2). In both samples, cracks were found in the spindle support tubing in identical positions. Examination of the fractured edges of Bogie Sample A reveals a clean, brittle fracture in the reinforcing plate, extending along the edge of the weld at the junction of the reinforcing plate and the spring seat. It was evident that the failure had originated in this area and had then spread to the other parts of the assembly. This opinion is supported by the discovery of a crack in the reinforcing plate of Bogie Sample B in the same location.

Speculation as to the causes of failure offered four possible solutions:

(a) Very low carbon content of materials.
(b) Internal stresses.
(c) Ageing effect.
(d) Fatigue.

(a) Low Carbon Content -

Chemical analyses of the various parts indicated that the carbon contents of the fractured members were in the range 0.15 to 0.18 per cent carbon, which may be considered satisfactory for SAE 1020 steel. However, low carbon steels were encountered in the spring seat plate and in the spring seat gusset plates. Previous reports also showed that low carbon materials were getting into the assemblies. While in this particular examination low carbon steels have not failed their presence is decidedly undesirable, because their lack

(Discussion, cont'd) -

of rigidity would cause an additional load upon the more rigid SAE 1020 steels. There is also the possibility that the low carbon steels might be fabricated into more important stress-bearing members, which would result in even shorter service life.

(b) Internal Stresses -

Assuming that the bogies were subjected to stress-relieving treatments at 1150° F., internal stresses due to welding or other sources have been eliminated. However, the lack of distortion at the fractured edges, as shown by the photomicrographs, leaves some room for doubt as to whether the stress-relieving treatment has been carried out.

(c) Ageing Effect -

Hardness readings do not offer a great deal of support to the possibility that failure may have occurred as a result of increased hardness or ageing.

(d) Fatigue -

Visual and microscopic examination of the fractured members point very strongly to fatigue as being the cause of the failures. Figure 17 is a photograph of the cross-section of a fractured piece of spindle support tubing taken from Bogie Sample A. This may be considered a typical fatigue fracture.

Figure 17.

X5.

FRACTURE IN SPINDLE SUPPORT TUBING TAKEN FROM BOGIE SAMPLE A, SHOWING TYPICAL FATIGUE FRACTURE.

-

(Discussion, cont'd) -

The design of Bogie Sample B differed from that of A in the method of support of the spindle arm. Sample A employed an angle strut as in the regular production, whereas in Sample B a triangular-shaped gusset plate was employed in an effort to eliminate the failure in the spindle support tubing. However, examination revealed a crack in both samples in identical locations.

A closer examination of the position of the cracks indicated that while the angle and gusset plate offered good support in the plane parallel to the axis of the reinforcing tubing, the cracks were caused by stresses at right angles to this plane. Hence, it is suggested that some additional means of support be provided to prevent buckling in this direction.

In order to prevent cracks from occurring in the reinforcing plate, at the junction of this plate and the spring seat plate, it is evident that some additional support should be provided by means of one or two more gusset plates so placed as to avoid interference with the action of the springs.

Since the failures are definitely in fatigue, it may be advisable to subject these highly stressed areas to shot-blasting.

In the event of these brackets being redesigned, and if the materials were available, it would be most advisable to employ steels which have a higher fatigue strength than those being used at present. Such a steel would be SAE 4130 (or one of its NE equivalents).

Examination of the welding reveals no defects to which failures may be attributed. Hardness tests show that the weld material, in most cases, is harder than the parent metal. This could be accounted for by the occurrence of nitride needles caused

(Discussion, cont'd) -

by the use of uncovered electrodes.

It is to be noted that fractures, in nearly every case, occur at the edge of the weld material, and it would appear that the deposited metal acts as a notch effect, which, in the highly stressed areas, results in failure. However, where the stresses are not higher than the fatigue strength of the materials involved, this "notch" effect would not be of any significance.

The presence of iron-nitride needles in the weld metal (see Figure 12) indicates that bare electrodes had been used. This material would be very brittle and could easily be a contributing factor to the cause of failure. It is therefore advisable that care be taken to prevent the use of bare electrodes or of electrodes from which the coating has been accidentally removed.

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CONCLUSIONS:

Failures occurred in fatigue in two members,

(a) the reinforcing plate and

(b) the spindle support tubing,

in two areas which had been stressed above the fatigue strength of the materials involved. These areas are located by the arrows in Figure 2.

RECOMMENDATIONS:

1. The fatigue strength of the steels may be somewhat increased by subjecting the parts to shotblasting. This offers a possibility of salvage of doubtful bogies.

2. The fracture in the spindle support tubing may be eliminated by the use of additional support designed to prevent

(Recommendations, cont'd) -

buckling in the plane at right angles to the axis of the reinforcing tubing.

3. The fracture in the reinforcing plate may be eliminated by the use of additional supporting members between the reinforcing plate and the spring seat plate.

4. Steels having a higher fatigue strength, such as SAE 4130, should be employed, if available.

5. Steels having carbon contents lower than those called for by the specifications should be kept out of the assemblies.

6. Special care should be taken to avoid the use of bare electrodes or of those from which the flux has been accidentally removed.

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AF:GHB.