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Aberdeen Proving Ground

MARYLAND

DURABILITY TEST OF TRUCK,

UTILITY, 1/4-TON, 4 BY 4, M151

DEVELOPMENT AND PROOF SERVICES

First Report

OCO Project No. IT-5092

ARMY--OS--ABERDEEN PROVING GROUND, MD--415

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ABERDEEN PROVING GROUND
MARYLAND

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12 June 1958

FIRST PARTIAL REPORT ON DURABILITY TEST
OF TRUCK, UTILITY, $\frac{1}{4}$ -TON, 4x4, M51

FIRST REPORT ON ORDNANCE PROJECT IT-5092

DATES OF TEST: 26 January 1957 - 15 March 1958

ABSTRACT

The object of test was to determine the durability characteristics of the Truck, Utility, $\frac{1}{4}$ -Ton, 4x4, M51. Test operations included all types of terrain, and after 7967 test miles the vehicle was returned to Code A for correction of known deficiencies. Upon return of the vehicle, testing was resumed and the vehicle accrued an additional 22,911 test miles. Correction of deficiencies outlined in this report is imperative and it is recommended that this be accomplished prior to further testing.

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ANNEX

MEMORANDUM REPORTS

(A copy of this Annex is on file in the Technical Library for reference purposes. Copies of the Annex may be furnished to recipients of this report upon request.)

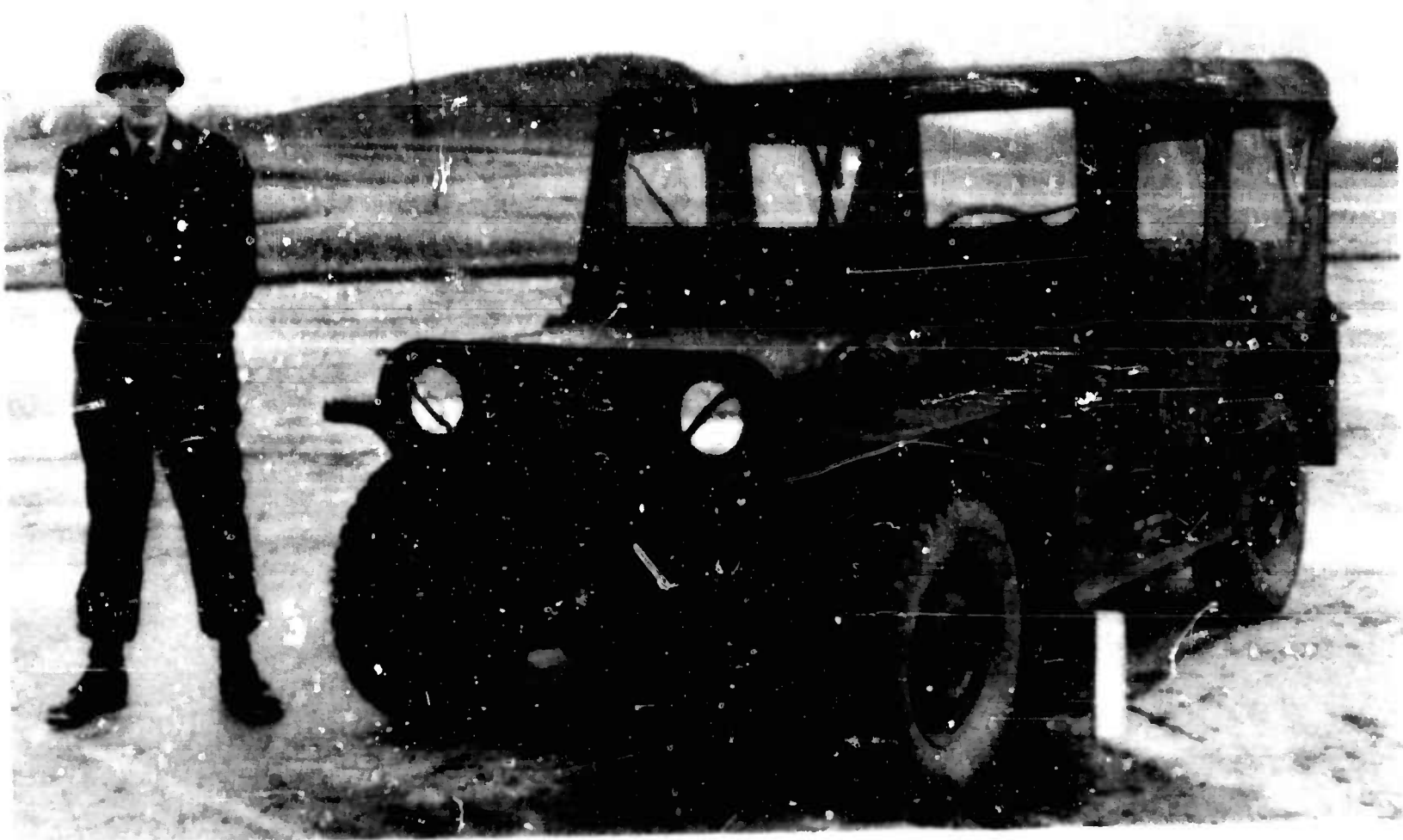


Figure 1 - B23329: Three-Quarter Left Front View of M151.



Figure 2 - B23333 - Right Side View of M151.

1. INTRODUCTION

In 1951, Code "A" was given a concept study contract for a quarter-ton utility vehicle complying with military characteristics of OCM Item 33521. As a result of this study, Code A was awarded contracts to develop and build three prototype vehicles designated XM151. Six XM151 vehicles were built and delivered to the government for testing. Several deficiencies were disclosed during these first tests, and Code A undertook a program to build two new vehicles, designated XM151E1 which would incorporate modifications to correct deficiencies existing in the XM151 vehicles.

One XM151E1 was received at this proving ground on 26 January 1957 and durability testing was initiated; however, due to major component failures it was necessary to return the vehicle to Code A for modifications. After completion of modifications the vehicle was driven from Code A to this proving ground on 9 July 1957. Due to the extent of modifications durability testing was started over.

On 11 July 1957, the XM151E1 was type-classified and designated the M151. This report describes details and results of the durability phase of testing conducted on the M151.

2. DESCRIPTION OF MATERIAL

The M151 is a $\frac{1}{4}$ -ton utility vehicle incorporating independent coil-spring suspension, four-wheel drive, unitized (steel) body-frame structure, magnesium wheels, and 700x16 light-weight nylon tires. Its power train is composed of the following components:

- a. Four-cylinder, overhead-valve, liquid-cooled engine. Manufacturer's rating: 71 hp at 3800 rpm, 128 ft-lb torque at 1800 rpm.
- b. Four-speed selective-type transmission with a single-speed transfer-case serving as a power divider for transmitting power to the front axle during four-wheel drive operation.
- c. Conventional propeller shafts utilizing cardan universal joints.
- d. Drive-through type differentials (Code A design).
- e. Axle shafts driven by ball-and-trunnion universal joints and utilizing constant velocity joints at the front wheels and cardan universal joints at the rear wheels.

Figures 1 through 3 show general views of the M151 with 7-10x15 (steel) wheels and standard weight tires.



Figure 3 - B23332: Three-Quarter Right Rear View of Truck, Utility, $\frac{1}{2}$ -Ton, 4x4, M151.

3. DETAILS OF TEST

3.1 Procedure

Upon receipt of the vehicle at this proving ground, an initial mechanical inspection was performed to assure proper operating conditions. The vehicle was then lubricated, and its center of gravity and weight distribution determined. The ability of the service brakes to stop the vehicle from 10, 20, and 30 mph was determined.

A 22,800 mile durability test was initiated.

It consisted of three 7,600-mile cycles over various types of terrain. One-half of this operation included a towed load. Each cycle of operation consisted of the following:

- a. Churchville cross-country, 1000 miles.
- b. Perryman cross-country, 500 miles.
- c. Belgian Block, 400 miles.
- d. Gravel, 1900 miles.
- e. Paved, 3800 miles.

3.2 Results

The weight distribution of the M151 both with and without rated highway payload was found to be:

<u>Wheel Location</u>	<u>Curo Weight</u>	<u>With 1200-lb Payload</u>
Right Front	635	710
Left Front	640	700
Right Rear	505	1030
Left Rear	<u>515</u>	<u>1055</u>
Total	2295	3495

The cent of gravity of the H151 without payload was located 22 inches vertically above the ground and 56 inches horizontally to the rear of the forward edge of the front bumper.

Performance of the service brakes was as follows:

Vehicle Speed	-	10 mph	20 mph	30 mph
Minimum Stopping Distances, ft.	-	7.2	24.5	53.0

The following durability operation in miles, was accomplished prior to major component failures which necessitated the return of the vehicle to Code A for modifications:

Course	Without Towed Load	With Towed Load
Churchville cross-country	44	8
Perryman cross-country	501	439
Belgian block	201	201
Gravel	1349	1350
Paved	1950	1930
Sub Totals	4039	3928
Total		7967

3.2.1 Phase I. The following deficiencies and failures were observed during the above durability operation. They are listed according to odometer reading at the time of incident and SNL Grouping.

SNL Group 01 - Engine

Odometer 1500 - During an engine tune-up it was discovered that the valve clearance of number 2, 3, and 4 exhaust valves had decreased an average of .002 inch. It was also noted that a crack had developed in the ignition system vent tube at the intake manifold.

Odometer 3587 - Coolant seepage was noted around the head gasket at the left rear, right rear, and left front corners of the engine.

Odometer 6357 - The oil filter container showed evidence of very slight leakage at its base. This was eliminated by tightening the center bolt.

Odometer 7088 - During an engine tune-up it was discovered that the valve clearance had increased an average of .004 inch.

SNL Group 03 - Fuel System

Odometer 1500 - Female part of electrical connection at fuel pump became enlarged thus causing erratic pump operation.

Odometer 1566 - Rubber sleeve covering the wire at the electric fuel pump was broken, allowing the wire to short against the pump housing, and fuel to leak out around the wire.

Odometer 4598 - Two pin holes were found in the fuel pump housing through which fuel was seeping.

SNL Group 04 - Exhaust System

Odometer 2623 - During vehicle operation exhaust fumes were noted in the passenger compartment. These fumes possibly came from the tail pipe and entered the compartment at the lower edge of the rear curtain.

SNL Group 05 - Cooling System

Odometer 4946 - During cross-country operation the fins on front side of the radiator became clogged with mud and required frequent flushing with water to keep them clean and prevent overheating of the engine. Several of the fins were bent against the radiator tubes. This may have resulted from the mounting of the radiator very close to the brush guard; therefore, it affords very little protection. Figure 4 shows general condition of radiator after 7542 miles of durability operation.



Figure 4 - B23807: General Condition of Radiator.

Odometer 6010 - Fan belts became loose thereby causing improper functioning of the generator.

SNL Group 06 - Electrical System

Odometer 340 - Sealed beam unit in right headlight failed.

Odometer 826 - Primary terminal of ignition coil was broken off, making it necessary to connect primary wire using terminal nut without lock washer. At this odometer reading a new oil-pressure-controlled fuel cut-off switch was installed. The new switch contained terminal identification (original one did not) to indicate proper wire connections.

Odometer 826 - An accumulation of oil was found in the bottom of the ignition system housing. It appeared that this oil was coming up around the distributor.

Odometer 1397 - Sealed beam unit in right headlight failed on high beam. At time of failure the unit had been in service 1057 miles.

Odometer 1500 - During an engine tune-up it was observed that the ignition point clearance had decreased to .010 inch and the ignition timing was 3-4° advanced.

Odometer 7088 - During an engine tune-up (to correct engine misfiring) it was found that ignition point clearance had decreased to zero and the distributor shaft had some wobble.

SNL Group 07 - Transmission

Odometer 2048 - Transmission output shaft seal and expansion plug at end of reverse shifting rail were leaking slightly.

SNL Group 08 - Transfer

Odometer 6390 - When making a brake application (during two wheel drive operation) there was a pronounced gear noise in the transfer case. This noise could be eliminated by holding the transfer case shift lever back. This gear noise was the result of incomplete disengagement of the front wheel drive clutch gear, thus when the front and rear propeller shafts assumed different speeds, during a brake application, the front wheel drive clutch gear caused the noise due to lack of clearance.

Odometer 7967 - The transfer case was fractured as a result of a broken spacer on the rear output shaft and/or maladjustment of the front wheel drive control. Figures 5 through 7 show condition of transfer case components after failure. Failed and damaged parts were replaced.

SNL Group 10 - Front Axle

Odometer 0 - During initial mechanical inspection it was found that the right front wheel caster angle was 1½° negative, which was considered excessive.



Figure 5 - B23943: Broken Spacer and Snap Ring Located at Rear of Rear Output Shaft.

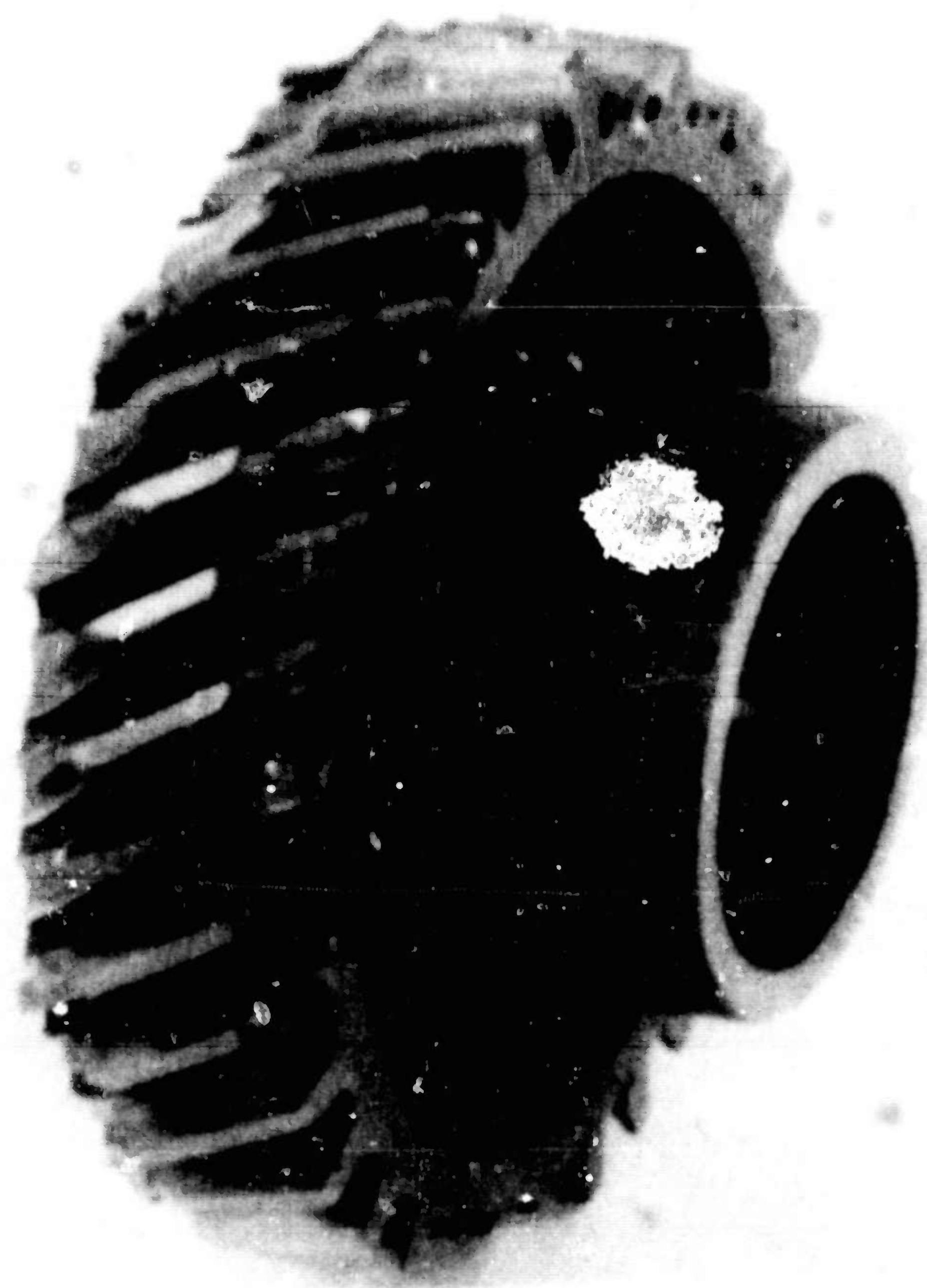


Figure 6 - B23942: Condition of Transfer Case Intermediate Gear



Figure 7 - B23944: Fractured Transfer Case

Odometer 826 - After replacement of the front cross-member, a payload of 800 pounds was installed and the front end alignment was set at 1° positive caster and camber with 1/16 inch toe in. With a 1200-pound payload installed, the caster increased to 1-5/8° positive which was considered excessive.

Odometer 5960 - The front differential began leaking slightly around the input shaft seal.

Odometer 7543 - Inspection of the front constant velocity joint seals and seal seats disclosed that the seals were forced into the seats to the extent that the rear portions of the seats were bent, causing the seals to fuse to the seats. The inner surfaces of the seals were badly damaged. Figures 8 and 9 show damaged seal seat and seal.



Figure 8 - Deformed Seal Seat in Constant Velocity Joint.

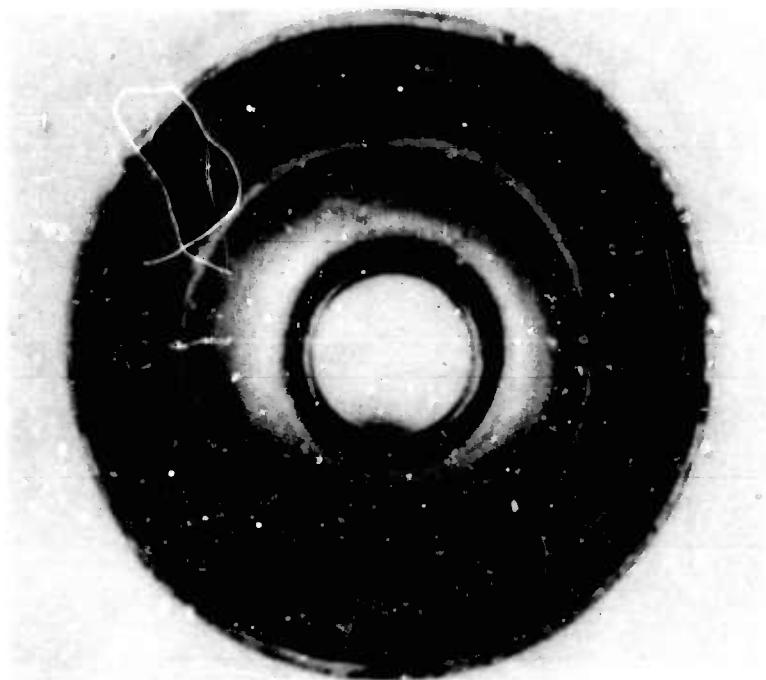


Figure 9 - Condition of Constant Velocity Joint Inner Surfaces. Note that Seal is Fuzed to Seal Seat.

SNL Group 11 - Rear Axle

Odometer 0 - During the initial mechanical inspection it was discovered that the lubricant level in the rear differential was approximately one pint low. It was noted that the lubricant came out through the differential breather.

Odometer 95 - During operation at 25 mph there was a slight discharge of lubricant through the rear differential breather.

Odometer 6420 - The rear differential began to get noisy.

Odometer 7967 - The rear differential case was fractured on the right side between the ring gear and support bearing. This failure could have occurred earlier, resulting in the differential becoming noisy at odometer 6420 (see above). Figure 10 shows fractured case.

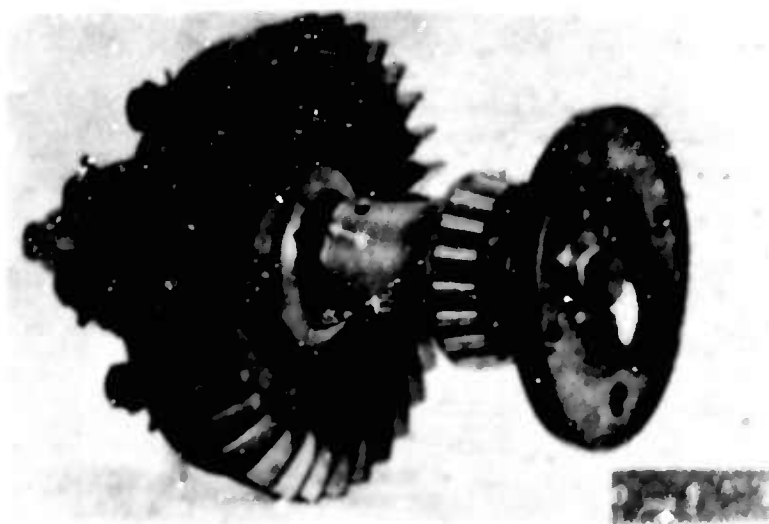


Figure 10 - 124689: Fractured Rear Differential Case.

SNL Group 12 - Brakes

Odometer 0 - During the initial mechanical inspection it was found that the rear brake drums and brake backing plate assembly components were coated with rust. This rust appeared to be caused by condensation.

Odometer 815 - During adjustment of parking brake it was noted that the "guide screw" and "jam nut" were missing.

Odometer 826 - During service brake tests at 30 mph, the right front brake cylinder failed in the area around the two rear cap screws which hold it to the backing plate. The backing plate and the rib section of the rear shoe were bent; the rear piston was deeply scored as a result of this failure. Figure 11 shows failed brake cylinder.

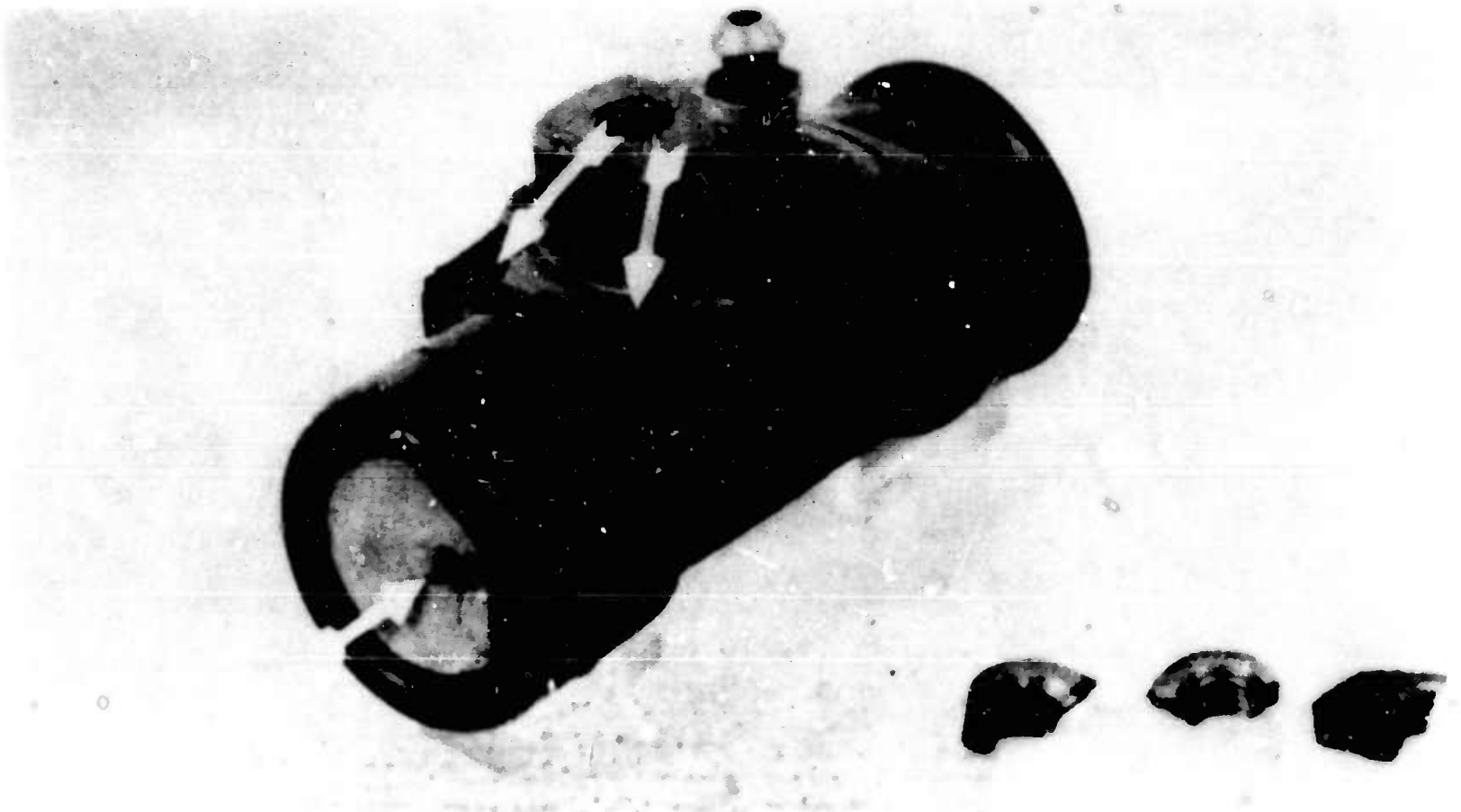


Figure 11 - B23391: Failed Right Front Brake Cylinder

Odometer 5015 - Inspection of rear brake linings disclosed that they were worn to the rivets. The front brake linings showed wear but were in better condition than the rear linings. The excessive wear was attributed to accumulation of dirt in the drums. The accumulation was much greater in the rear drums.

Odometer 7543 - Inspection of rear brake linings disclosed that they were worn to the rivets although the front linings were in relatively good condition. Excessive wear was again attributed to entrance of dirt.

SNL Group 13 - Wheels, Hubs and Drums

Odometer 4598 - The front tires were 85% worn and their outer grousers were excessively cupped (Fig. 12). The rear tires were 60% worn but showed more even wear over entire tread.



Figure 12 - B23663: General Condition of Front Tire at Odometer 4598.

Odometer 6757 - Four out of five tires were worn down to cord.

SNL Group 14 - Controls

Odometer 2048 - Lubricant was leaking slightly around the cover plate and the cross shaft adjusting screw of the steering gear box.

SNL Group 15 - Frame

Odometer 826 - The vertical support brackets of the front cross-member began to bend. Figure 13 shows distortion of these brackets. This cross-member was replaced with one of stronger design.

Odometer 7107 - Cracks were discovered in the front cross-member around the four holes through which the upper control arms bolt. It was also noted that portions of the frame extensions, through which the rear mounting bolts of the front cross-member pass, were broken off. The corresponding front bolt brackets of the extensions were cracked.

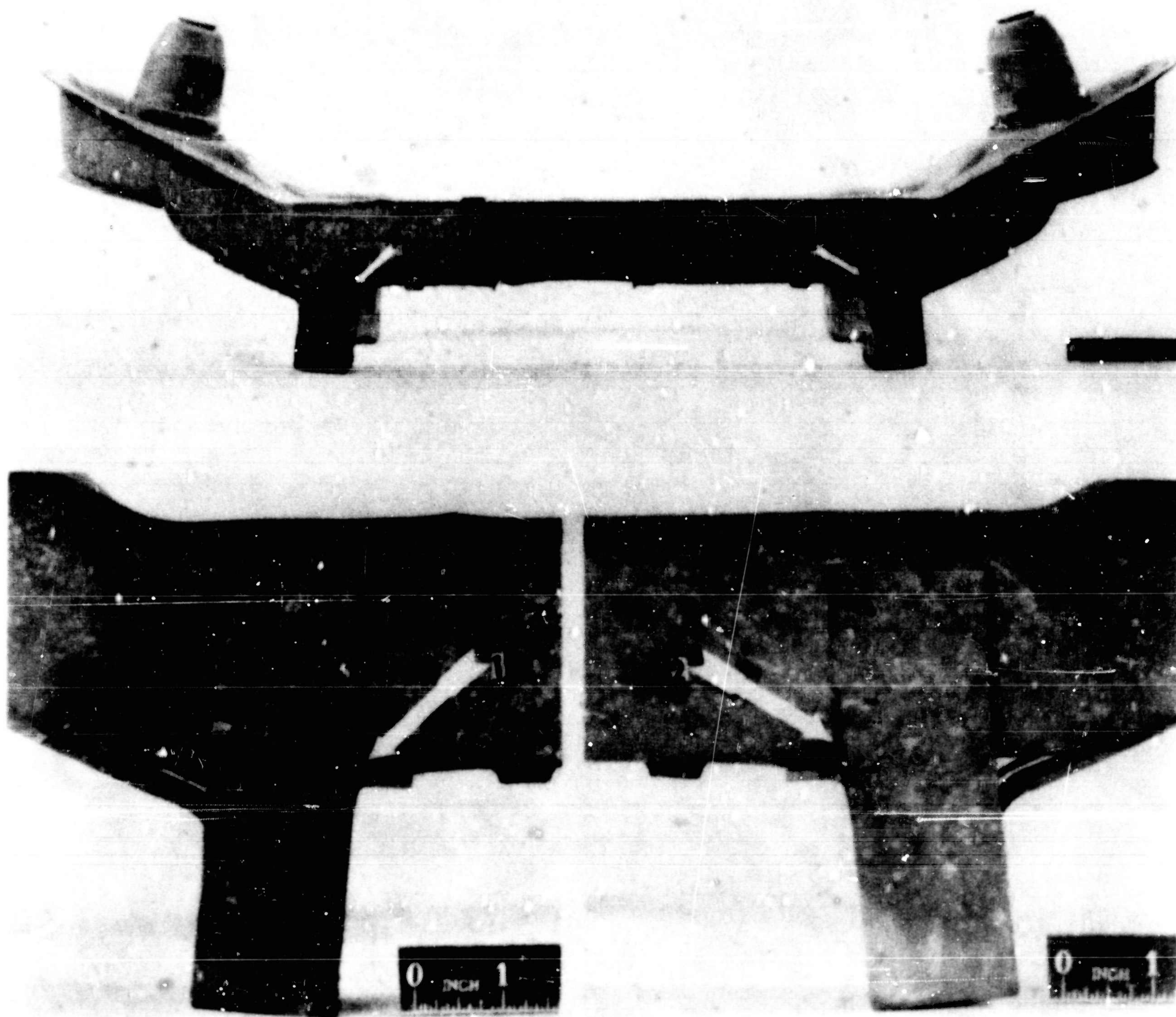


Figure 13 - B23602: Distorted Front Cross-Member

Odometer 7967 - While attempting to pull the vehicle from a mud hole by using the front lifting eyes, the front bumper mounting at the end of the right frame rail failed. This resulted in bending the front differential flange guard (bolted to front bumper and welded to front cross-member) and tearing it loose from the cross-member, thus damaging the cross-member. Figure 14 shows condition of vehicle front end after failure.

SNL Group 16 - Springs and Shock Absorbers

Odometer 4598 - The rubber grommets at top and bottom of rear shock absorbers were badly worn and required replacement. The dust cover on the right rear shock absorber was loose. This was corrected by welding.



Figure 14 - B24168: Failure of Front Portion of Right Frame Rail and Resulting Damage.

Odometer 5960 - At odometer 5668 the upper mounting stud of the right rear shock absorber was found loose in its support bracket. The stud nut was tightened and operation continued. The shock absorber was removed at odometer 5960 after the stud again became loose. It was disclosed that both the stud, and the forward section of the bracket through which the stud fits, was worn, allowing a loose fit.

SNL Group 18 - Body

Odometer 170 - The hold-down latch, located at the rear of driver's seat frame, became disassembled during an attempt to release the seat.

Odometer 300 - The drive shaft tunnel between the driver's and assistant driver's seats became hot while operating the vehicle at a road speed of 45 mph. This condition was attributed to the location of the muffler in the tunnel.

Odometer 6451 - The horizontal portion of the rear differential front mounting bracket failed, allowing the front end of the differential to drop down and resulting in the pulling of the rear propeller shaft out of the transfer case. Upon investigation it was disclosed that the horizontal portions of the two rear mounting brackets had been flexing and had developed cracks.

Figure 15 shows failed front bracket.



Figure 15 - Failed Rear Differential Front Mounting Bracket.

SNL Group 22 - Miscellaneous Body Accessories

Odometers 431, 2979 and 7461 - Speedometer cable failed where it enters transmission. Failures were due to a sharp bend in the cable where it enters the transmission. There was also a tendency for the cable to rub against the transmission floor cover (Figure 16).

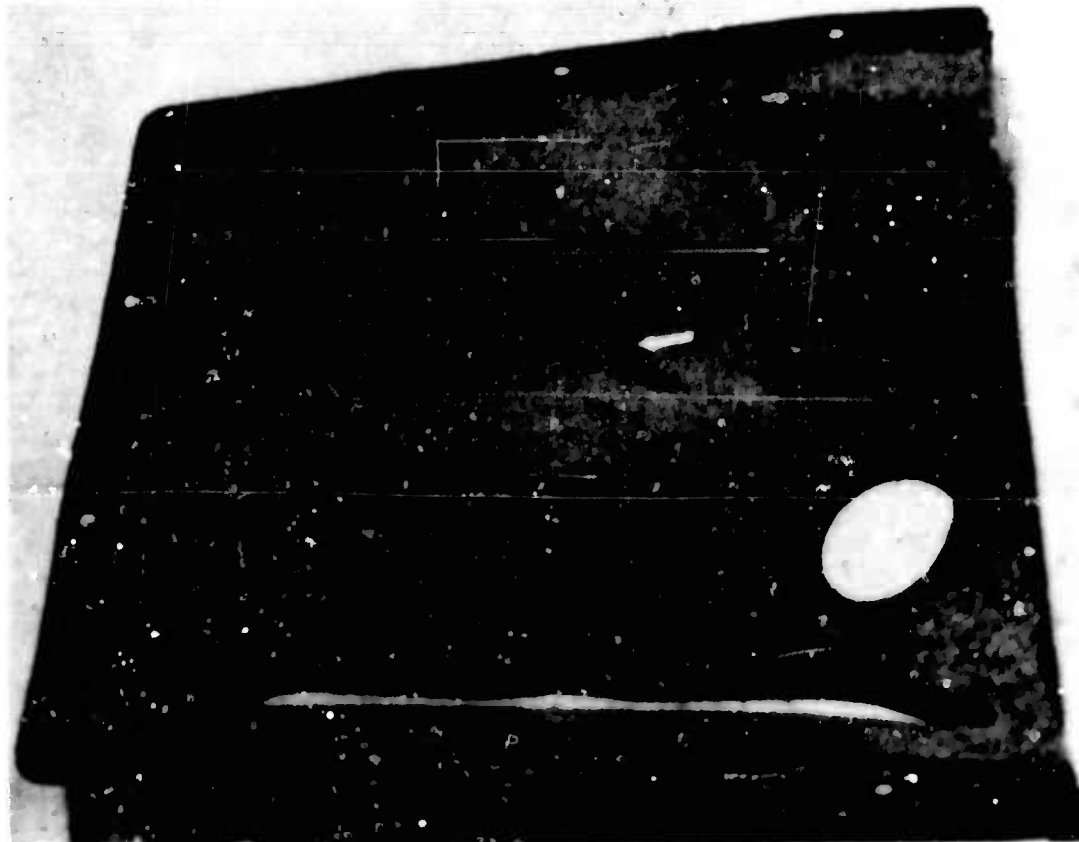


Figure 16 - 123806: Transmission Housing Cover.
Note where Speedometer Cable Rubbed Against Cover.

Odometer 4783 - Windshield wiper hose leaked, apparently due to use of old hose.

Due to the failures of the front portion of the right frame rail, the transfer case, and rear differential case, the vehicle was returned to

Code A after the completion of 7967 miles of durability operation. Code A made modifications to correct the existing deficiencies. The vehicle was returned to this proving ground by APG personnel and durability tests were resumed. During this test the vehicle operated the following mileages:

Course	Without Towed Load	With Towed Load
Churchville cross-country	1500	1431
Ferryman cross-country	750	754
Belgian Block	600	606
Gravel	2956	2745
Paved	7695	3874
Sub Totals	13501	9410
Total		22911

3.2.2 Phase II. The following deficiencies and failures were observed during the last 22,911 miles of durability operation. They are listed by SNL Group. Prior to start of this phase of the test, the odometer was set at zero.

SNL Group 01 - Engine

Odometers 63 and 979 - The oil filter container showed evidence of leakage at its base, due to a loose center bolt.

Odometer 12570 - The oil filter cap fit very loosely into the top of the rocker arm cover due to loss of its sealing gasket.

Odometer 22012 - The oil pan was removed in an effort to find the reason for loss of oil pressure during operation. It was discovered that the screen assembly at the bottom of the oil pump pick-up pipe had broken off. After repairs, oil pressure was normal during all remaining operation.

SNL Group 02 - Clutch

Odometer 21698 - The rod which attaches the clutch pedal to the clutch equalizer shaft broke at its upper end. It was repaired by brazing, and during final mechanical inspection of vehicle (odometer 22911) it was found that the lower end of the rod contained a crack.

SNL Group 03 - Fuel System

Odometer 572 - The main fuel jet cover plug, located adjacent to the vent system fitting at the top of the carburetor, was leaking fuel.

Odometer 580 - The gasket between the fuel pump and fuel tank was broken, thus allowing fuel leakage.

Odometer 1588 - The rubber insulator around the fuel pump electrical wire was slightly torn and had worked loose, resulting in fuel leakage and shorting of the electrical wire against the housing. The insulator was repaired and reinstalled. At Odometer 1880 the insulator was found broken again and was replaced with a new part.

Odometer 1878 - In an effort to eliminate engine misfiring, the carburetor float chamber was opened. It was discovered that the float contained cracks and was approximately one-third full of fuel.

Odometer 10932 - The fuel tank developed a leak in the welded seam at the right rear corner.

SNL Group 04 - Exhaust System

Odometer 9930 - During vehicle operation exhaust fumes were noted in the passenger compartment.

Odometer 22010 - The gasket between the exhaust manifold and exhaust pipe burned out.

SNL Group 05 - Cooling System

Odometer 21600 - During cross-country operation, the radiator fins became clogged with mud and thus reduced the efficiency of the radiator. It was necessary to wash the mud from the radiator approximately once during each hour of operation to prevent engine overheating. It was also noted that a great number of the fins were bent. Figure 17 shows the general condition of the radiator after completion of durability operation (odometer 22911).

SNL Group 06 - Electrical System

Odometer 62 - The engine began to misfire when the vehicle was accelerated to 50 mph. Investigation disclosed poor contact between the rotar-to-distributor cap contact spring. This was corrected by pulling the spring up to insure proper contact. At odometer 1588 the engine began misfiring again and a bad connection between the high-tension wire and distributor was found to be the cause. At odometer 1878 misfiring of the engine was attributed to a poor high-tension wire connection. Engine misfiring reoccurred at odometer 2330 and an investigation disclosed that the terminal lug at the end of the condenser wire was loose. This loose terminal lug was probably the major factor contributing to the deficiencies listed so far under this SNL Group.

Odometer 77 - The fuel pump stopped operating due to poor contact of the wire into the oil-pressure-controlled fuel cut-off switch.

Odometer 572 - Taillight bulb burned out.

Odometer 580 - The fuel gage sending unit to fuel tank gasket leaked around the sending unit flange.

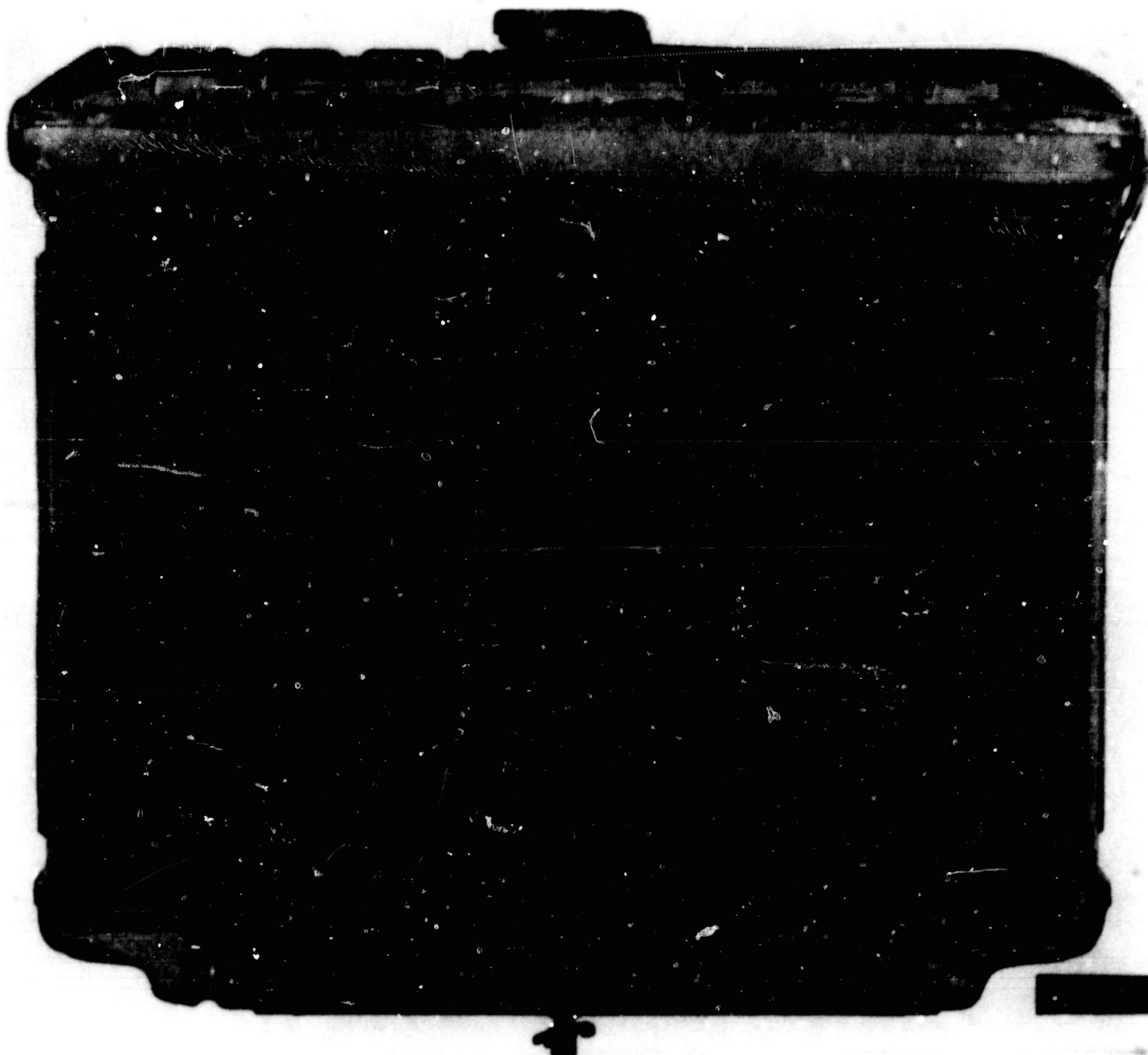


Figure 17 - B28718: Condition of Radiator at Conclusion of Test.

Odometer 1612 - The generator adjusting bracket broke due to under-design.

Odometer 2553 - Sealed-beam unit in left headlight failed on low beam.

Odometer 8893 - The engine stopped during operation and would not start. After changing the ignition points, condenser, and spark plugs, the engine could be started but misfired at high speeds. The condenser was replaced with a modified condenser from an M38A1 and normal operation was resumed. At odometer 9278 the manufacturer provided a complete distributor which had been adjusted at the factory.

Odometer 22911 - During the final mechanical inspection it was discovered that the plastic cases of the batteries were bowed inward on their longitudinal sides. The deflection of the battery case side panels varied from 1/8 inch to 3/16 inch. This distortion results from the location adjacent to the muffler, as is verified by the fact that the inside battery (located nearest the muffler) had the greater distortion.

SNL Group 07 - Transmission

Odometer 1550 - The transmission became very difficult to shift into and out of 3rd and 4th gears. When disassembled and inspected, the following was disclosed:

- a. The input shaft roller bearings were badly worn. The portion of the output shaft which contacts these bearings was excessively worn. The input shaft bearing surface contained circular grooves and the thrust washer contained a circular groove worn by the roller ends.
- b. The forward roller bearings of the cluster gear assembly had flats worn on them, thus indicating that they had not been rotating. The portion of the shaft contacting these bearings was excessively worn. The rear bearings of this assembly were pitted, and the shaft in this area was pitted and worn.
- c. The cluster gear thrust washers were scored and contained metal particles. The thrust surfaces of the gear were scored.
- d. The 3rd and 4th gear synchronizer clutches were worn irregularly on the inner surfaces, indicating that they were cocking during operation.

Figures 18 through 22 show condition of the severely damaged transmission components.

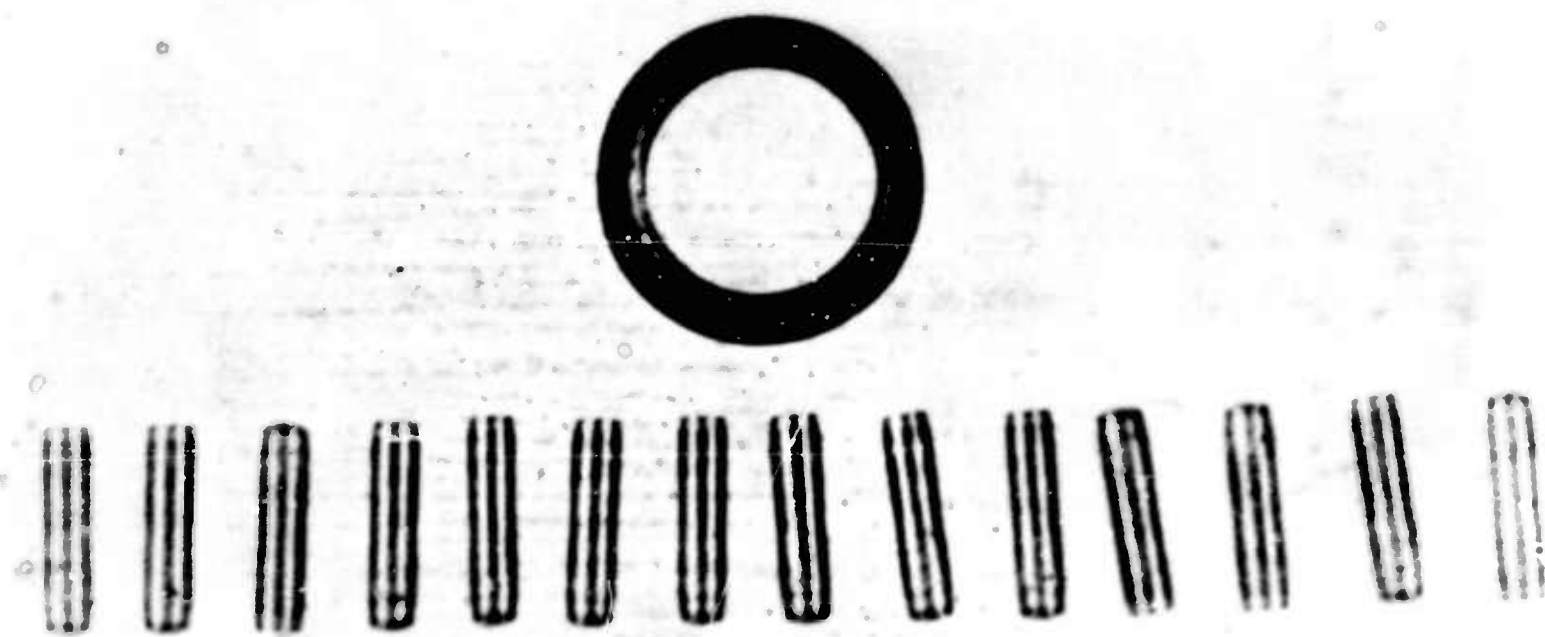


Figure 18 - B26007 (top): Thrust Washer and Needle Bearings from the Front of Transmission Output Shaft. Note Tapered Wear.



Figure 19 - B26007 (Bottom): Front Portion of Transmission Output Shaft. Note excessive wear of bearing surface.

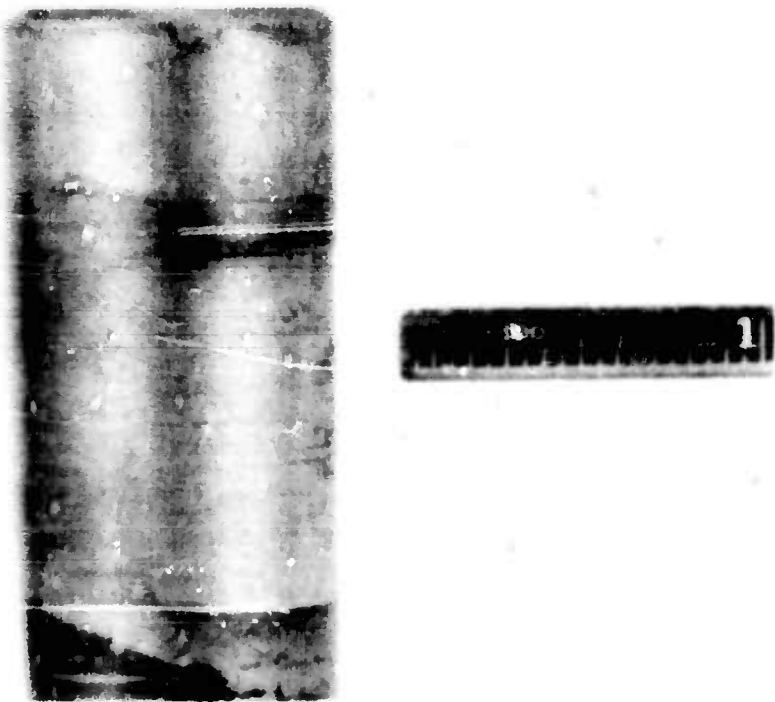


Figure 20 - B26008 (Top): Front Roller Bearing Surface of Transmission Cluster Gear Shaft.

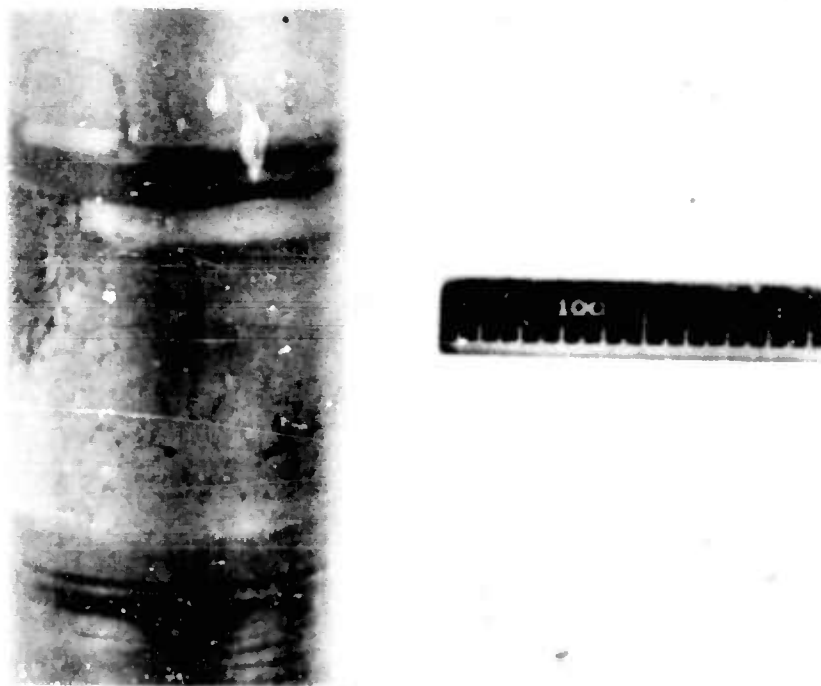


Figure 21 - B26008 (Bottom): Rear Roller Bearing Surface of Transmission Cluster Gear Shaft.

Odometer 22911 - During final mechanical inspection slight lubricant leakage was noted at mating surface of the power take-off opening cover plate.

SNL Group 08 - Transfer

Odometer 10518 - Lubricant began flowing from the rear end of the intermediate gear shaft in the transfer case. An investigation disclosed that the expansion plug at the forward end of the shaft had come out and dropped into the case. A new plug was installed at the rear end of the shaft so that if it came out it would not drop into the case.

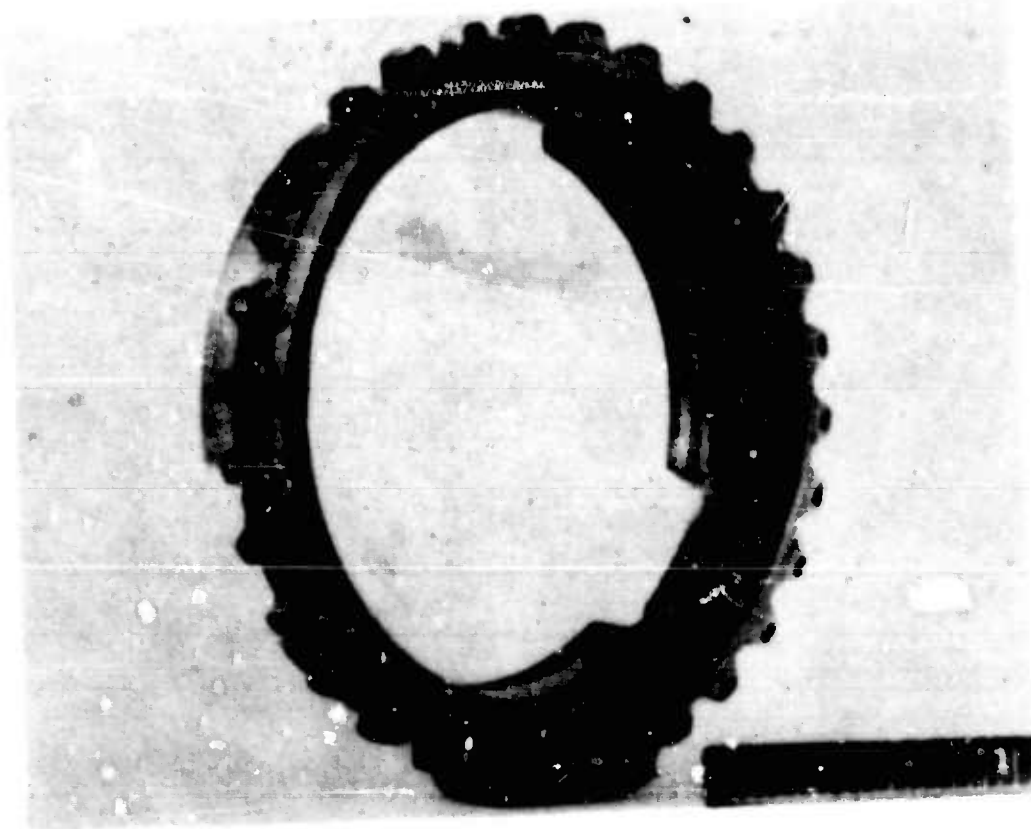


Figure 22 - B26005: Third and Fourth Gear Synchronizer Clutch. Note Irregular Wear on Inner Surface.

Odometer 19767 - The welch plug located in the center of the transfer-case rear output shaft yoke was slightly cocked, thus allowing lubricant to leak past it. The plug was repositioned and the mating surface of the plug and yoke was silver-soldered. At odometer 22911 it was noted that this plug was again leaking.

Odometer 22911 - During the final mechanical inspection it was discovered that the upper forward portion of the intermediate gear shaft was fatigued. Several of the needle bearings, which support the intermediate gear on its shaft, were pitted. This needle bearing damage resulted from flaking of the fatigued intermediate shaft. The bore of the intermediate gear showed slight metal pick-up. Figure 23 shows fatigued intermediate gear shaft.

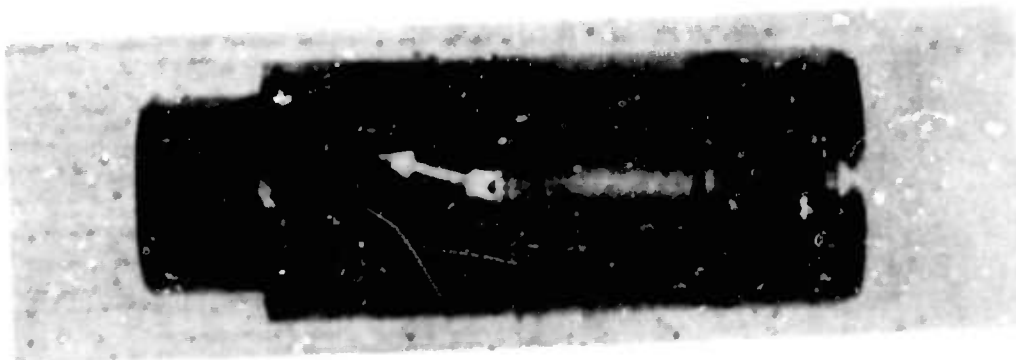


Figure 23 - B28716: Fatigued Transfer-Case Intermediate Gear Shaft.

Odometer 22911 - During the final mechanical inspection it was noted that the snap ring which retains the rear support bearing on the rear output shaft was partially out of its groove and slightly bent, thus allowing movement of the bearing and the spacer located between the bearing and snap ring. This movement resulted in the breaking of the spacer into several pieces. The bearing cage was damaged by fragments of the spacer.

SNL Group 09 - Propeller Shafts

Odometer 125 - A drive line noise was noted at all speeds but was most pronounced between 40 and 60 mph. At odometer 563 the front and rear propeller shafts were removed and the universal joints disassembled. There was evidence of wear and one needle bearing was missing from the rear joint of the rear propeller shaft. An M38A1 universal joint needle bearing was substituted for the missing bearing. The drive line noise was not eliminated but became less pronounced as operation continued.

Odometer 15167 - The rear universal joint of the rear propeller shaft failed due to brinelling of the cross journals. At this time the front universal joint of the rear propeller shaft was replaced as there was slight brinelling of the cross journals.

Odometer 19068 - The rear yoke of the rear propeller shaft failed.

Odometer 19767 - The front and rear universal joints of the front propeller shaft had considerable play due to brinelling of the cross journals. The front propeller shaft assembly was therefore replaced.

Odometer 22911 - During the final mechanical inspection it was found that the universal joint cross journals of the front propeller shaft were brinelled. The front cross was in better condition than the rear. The universal joints of the rear propeller shaft were slightly worn.

SNL Group 10 - Front Axle

Odometer 1878 - The front suspension lower ball joints were slightly worn. At odometer 22911 they were worn considerably.

Odometer 2063 - All differential output flange bolts were loose.

Odometer 22,200 - The rear shim between the lower left front control arm shaft and front cross-member fell out during operation. The control arm shims are slotted and installed from the below. Therefore, if one of the bolts loosens, a shim can fall out. During the final inspection, at odometer 22,911, it was noted that the lock washer was missing on the lower left rear bolt. This could have resulted in the earlier loss of the shim.

Odometer 22,911 - Final inspection of the front differential disclosed the following:

- a. Right and left carrier bearing seals contained slight amounts of dirt.
- b. Pinion bearing cup was slightly etched.
- c. Outer lip of pinion shaft rear seal was cut. It appeared that this damage was sustained during assembly.
- d. Pinion shaft front seal was slightly worn.

Odometer 22,911 - Inspection of the front wheel drive shaft assemblies disclosed spline play between the left constant velocity joint and wheel drive shaft.

SNL Group 11 - Rear Axle

Odometer 2063 - All differential output flange bolts were loose and were tightened. At odometer 8438 these bolts were again loose and one bolt was missing from the left side. The bolts were tightened and the missing bolt was replaced. At odometer 17098 the right output flange bolts were loose and were tightened.

Odometer 9930 - The right rear wheel drive shaft failed at the cardan joint while accelerating the vehicle in first gear. It appeared that the joint cross-failed first and then the companion flange broke (Fig. 24).

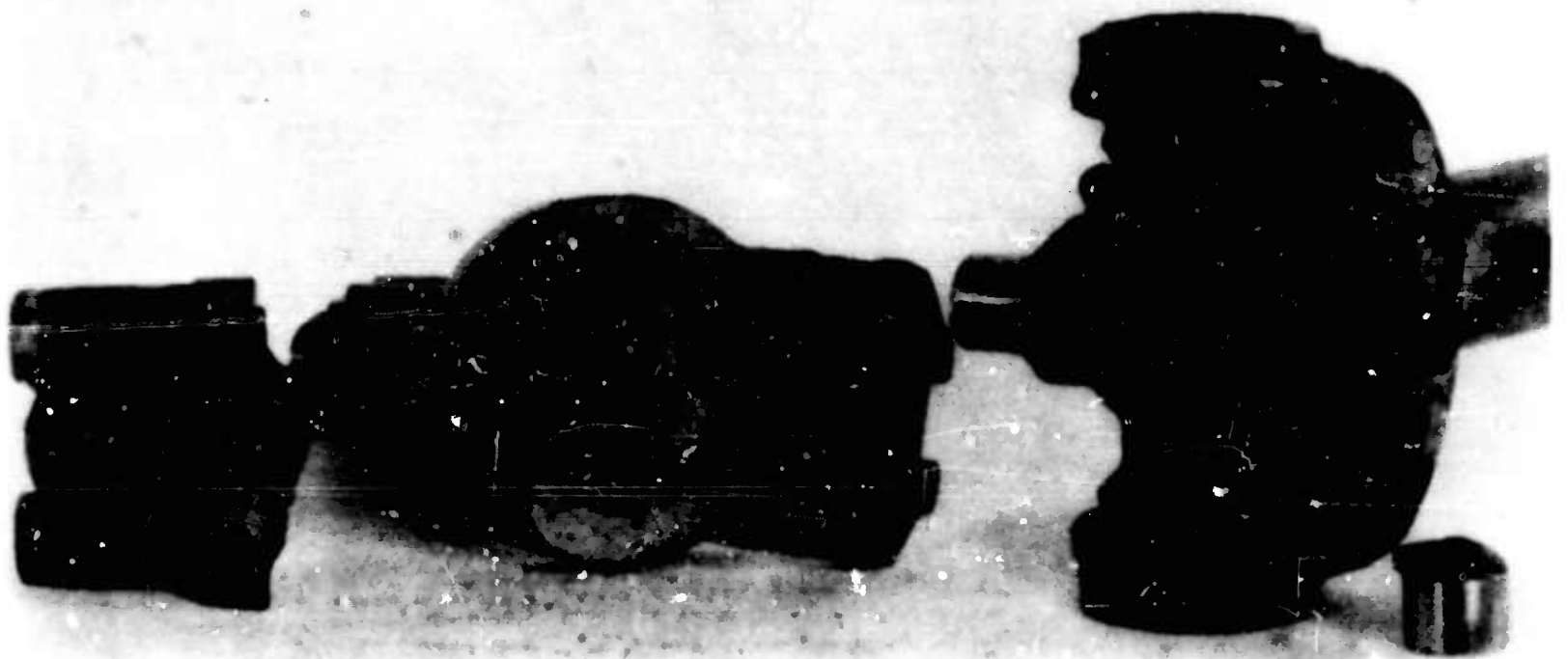


Figure 24 - B26905: Failed Cardan Joint from Drive Shaft of Right Rear Wheel.

Odometer 10,298 - The left rear wheel drive shaft failed at the cardan joint while accelerating the vehicle in first gear. The drive shaft yoke and companion flange broke (Figs. 25, 26). There was evidence that the companion flange contained a crack prior to failure.



Figure 25 - B27251 (Top): Failed Drive Shaft Yoke from Left Rear Wheel.

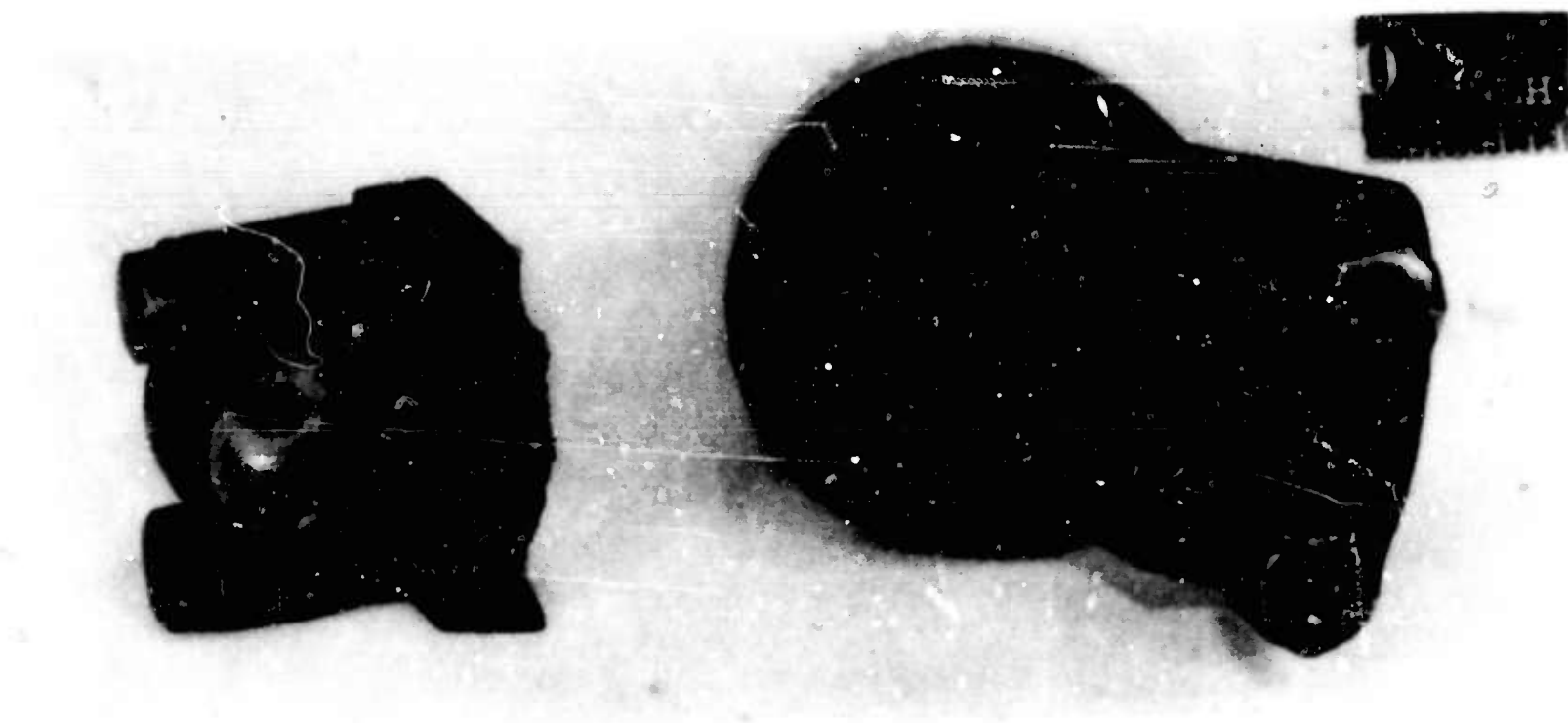


Figure 26 - B27251 (Bottom): Failed Drive Shaft Companion Flange from Left Rear Wheel.

Odometer ,329 - Magnafluxing of the rig rear suspension arm revealed cracks at the base of the suspension arm webs to wheel spindle flange. It was also noted that the left rear suspension arm contained cracks in the same area and that the metal sleeves of the suspension arm bushing were rusted to the bolts and the rubber grommets were torn. The suspension assemblies were replaced with used parts furnished by the manufacturer. All arm bushings were replaced with new parts. At odometer 12570, while negotiating a left turn, the right rear suspension failed in the wheel spindle flange below the web section (Fig. 27). Magnafluxing of the left suspension assembly disclosed cracks in the web section of the spindle flange. The rear suspension arm assemblies removed at odometer 11329 were modified by welding gussets in the angles between the arms and spindle flanges and then were installed on the vehicle.

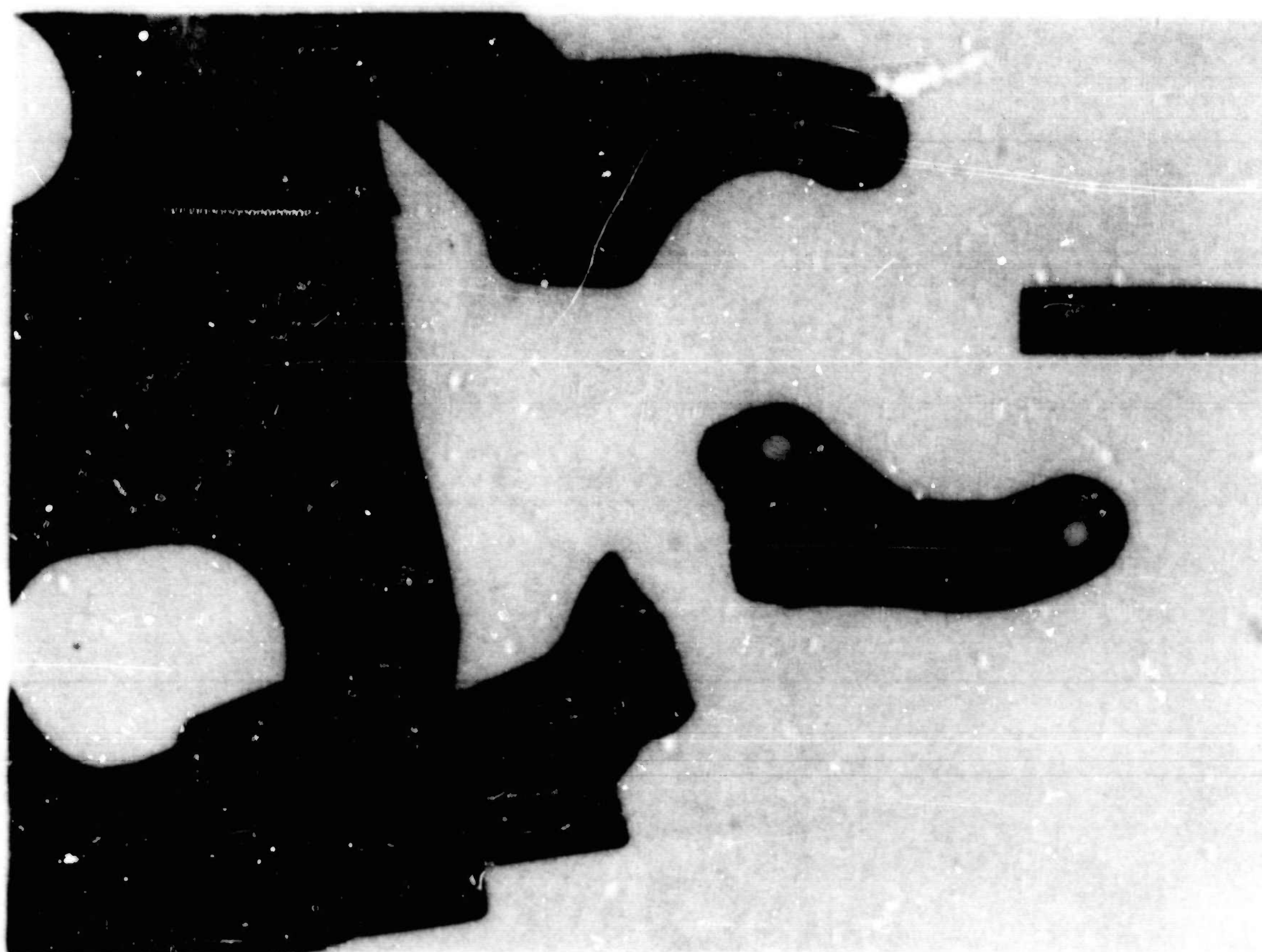


Figure 27 - B27628: Failed Arm Assembly from Right Rear Suspension

Odometer 22,911 - Final inspection of the rear differential disclosed the following:

- a. Drive sides of the ring gear teeth showed some indication of scrubbing action. It also appeared that the engagement of the ring and pinion gears was somewhat excessive.
- b. Both pinion shaft tapered roller bearings were slightly worn.
- c. The pinion shaft bearing cup was slightly etched.
- d. The pinion shaft front seal retainer was deformed along its lower edge and contained a hole in this area. This damage was the result of stones which struck the retainer during operation. The outer lip of the front seal was worn and the universal-joint flange shield was bent.
- e. Pinion shaft rear seal contained dirt between its lips.
- f. Spider pinion gears were in good condition; however, caked lubricant was found in the root areas of the teeth. This caked lubricant condition was also noted in the root areas of the "long-side" bevel gear teeth.
- g. The roller surfaces and bearing races of both carrier bearings were slightly etched.
- h. Right and left carrier bearing seals contained slight amounts of dirt.

1. The general color and condition of the part indicated that considerable heat was generated in the rear differential during operation.

Odometer 22,911 - Inspection of the rear wheel drive shaft assemblies disclosed the following:

- a. Left - The cardan joint cross had a chip out of one journal at its outer end.
- b. Right - The cardan cross journals were excessively brinelled and there was a chip out of one at the outer end.

SNL Group 12 - Brakes

Odometer 1838 - Investigation of a clicking noise in the right front brake during brake applications disclosed that most of the lining had been torn off the secondary brake shoe and the drum was badly scored (Figs. 28, 29). It was also noted that the brake cylinder boots were broken and brittle. Disassembly of the left front brake revealed cracks in the linings extending outward from the rivet holes.

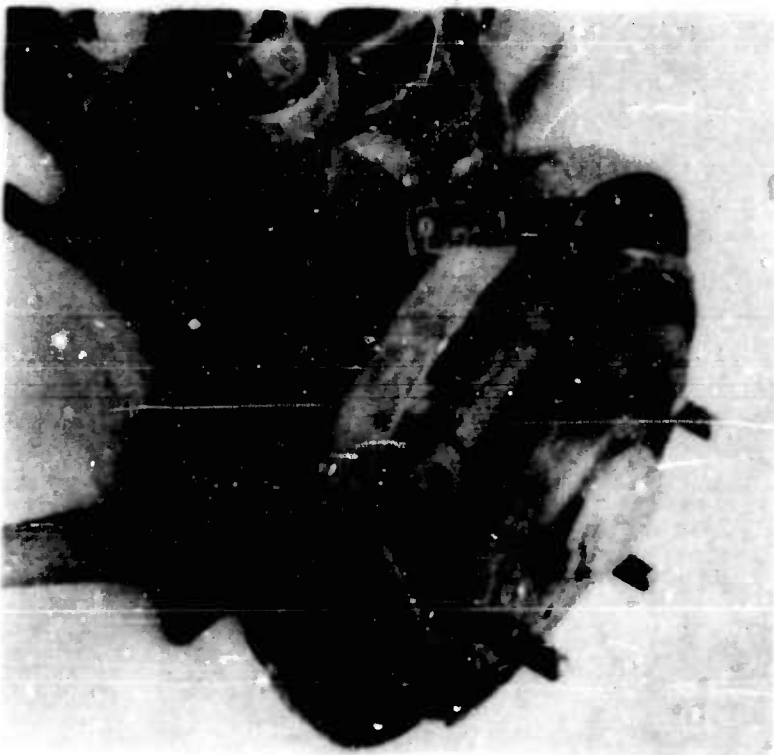


Figure 28 - B26000:
Right Front Brake Assembly.

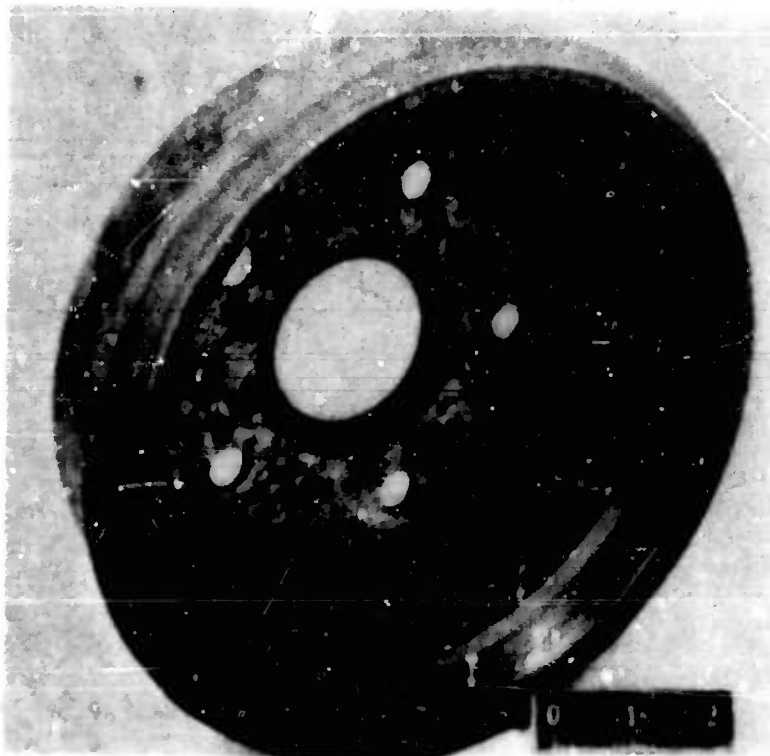


Figure 29 - B26001:
Scored Right Front Brake Drum.

Odometer 8739 - The lining on the left front brake shoes was cracked and approximately half had been torn off the secondary shoe (Fig. 30). The drum was scored and the brake cylinder boots were brittle and broken.

Odometer 9937 - Investigation of brake assemblies disclosed that the left front secondary lining was worn down to the rivets and was cracked (Fig. 31).

Odometer 22,911 - Final inspection of the service brake assemblies disclosed the following:

- a. Left rear - The primary and secondary brake shoe linings were worn down to the rivets. The secondary brake cylinder piston was frozen in the cylinder and there was a slight amount of rust on the inside of the cylinder boot.

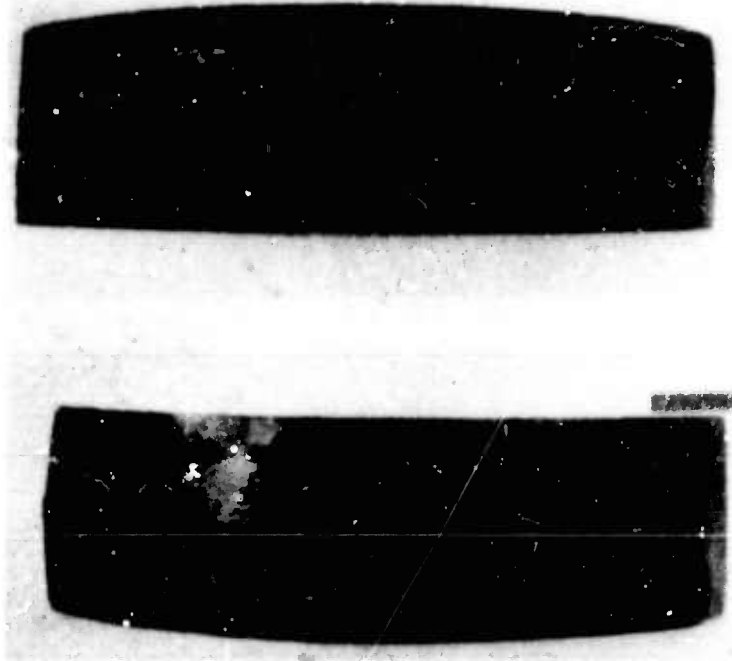


Figure 30 - B26904 (Bottom): Condition of Secondary Brake Lining.

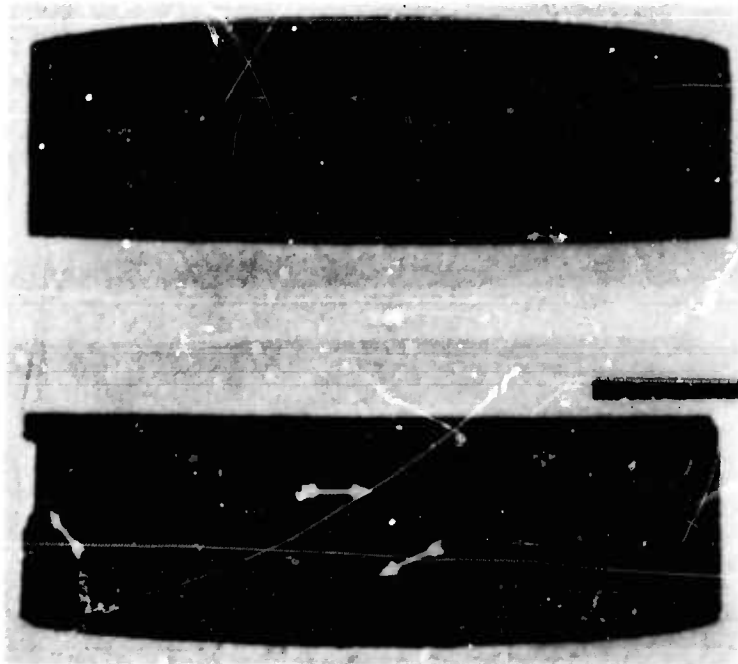


Figure 31 - B26906 (Bottom): Left Front Secondary Brake Lining.

- b. Right rear - The primary and secondary brake shoe linings were worn down to the rivets and several rivets were out of the secondary shoe. The secondary brake cylinder piston was frozen in the cylinder and there was a slight amount of rust on the inside of the cylinder boot.
- c. Right front - The hardened insert at the shoe end of the secondary piston was loose.

SNL Group 13 - Wheels, Hubs, and Drums

Odometer 572 - During a mechanical inspection it was noted that wheel spindle flanges contained a slight coating of rust.

Odometer 795 - While negotiating a right turn the left rear wheel broke in the disked section, thus leaving only the center section of the wheel on the hub (Fig. 32). At odometer 854 the right rear wheel broke in a similar manner while negotiating a left turn (Fig. 33).

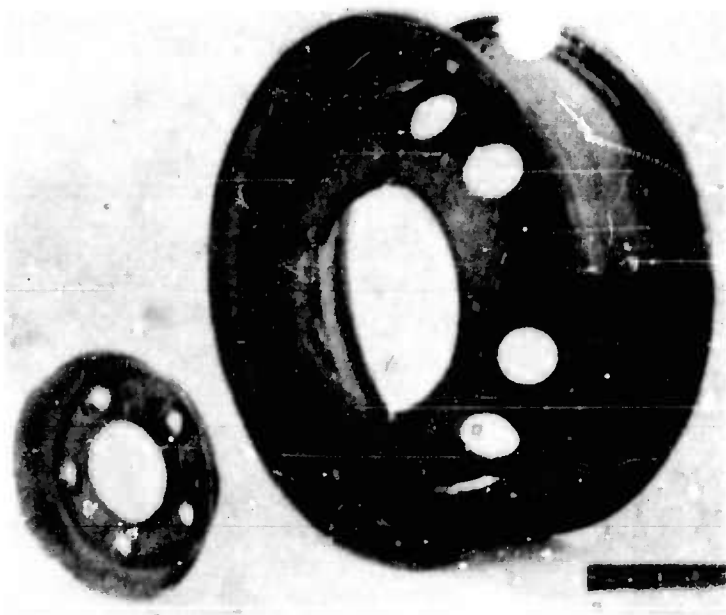


Figure 32 - B25900:
Broken Left Rear (Steel) Wheel.

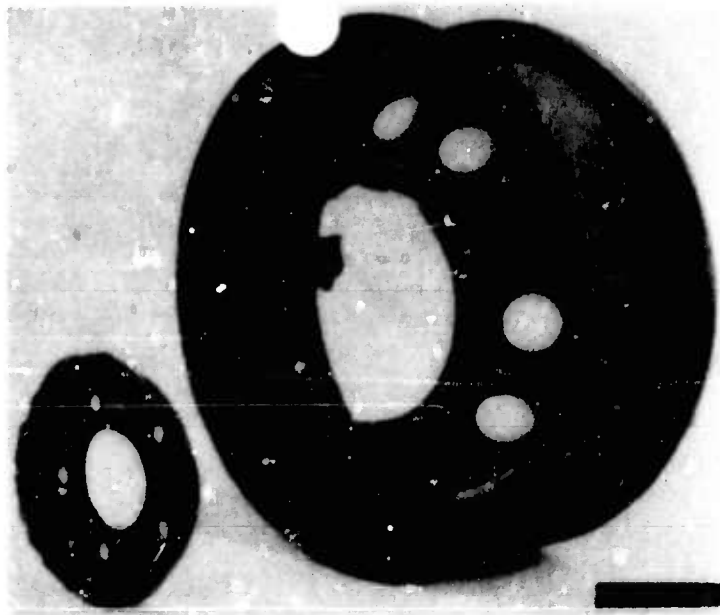


Figure 33 - B25901:
Broken Right Rear (Steel) Wheel.

Odometer 1878 - The 7.10x15 steel wheels originally furnished were replaced by 7.00x16 magnesium wheels and 7.00x16 light-weight nylon tires were installed (Fig. 34). It was necessary to remove the brake drum retaining screws to eliminate interference between the magnesium wheels and the brake drum-to-flange cap screw heads.

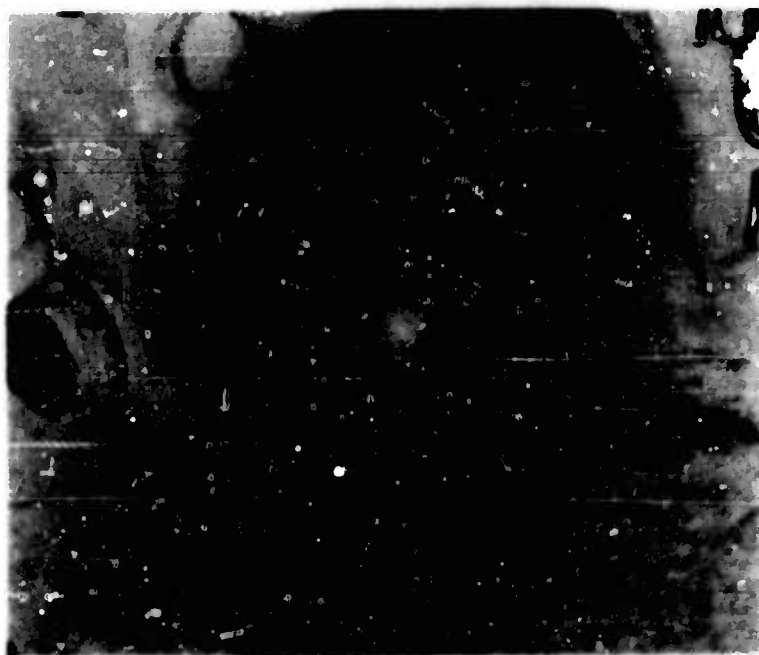


Figure 34 - B27995: Magnesium Wheel

Odometer 5196 - The tread of the left rear tire was worn 100%, therefore its life was 3318 miles. At odometer 5320 the right rear tire tread was worn 100%, therefore its life was 3442 miles. Average rear tire life was 3380 miles.

Odometer 7510 - Both front tire treads were worn 100%, giving a life of 5632 miles.

Odometer 13'86 - Due to the excessive tire wear, new nylon light-weight tires were installed and front tire inflations were increased 5 psi to 20 psi and rear tires were inflated to 25 psi (as during previous tests). Figure 35 shows characteristic wear of front tires after 5,000 miles of paved operation.

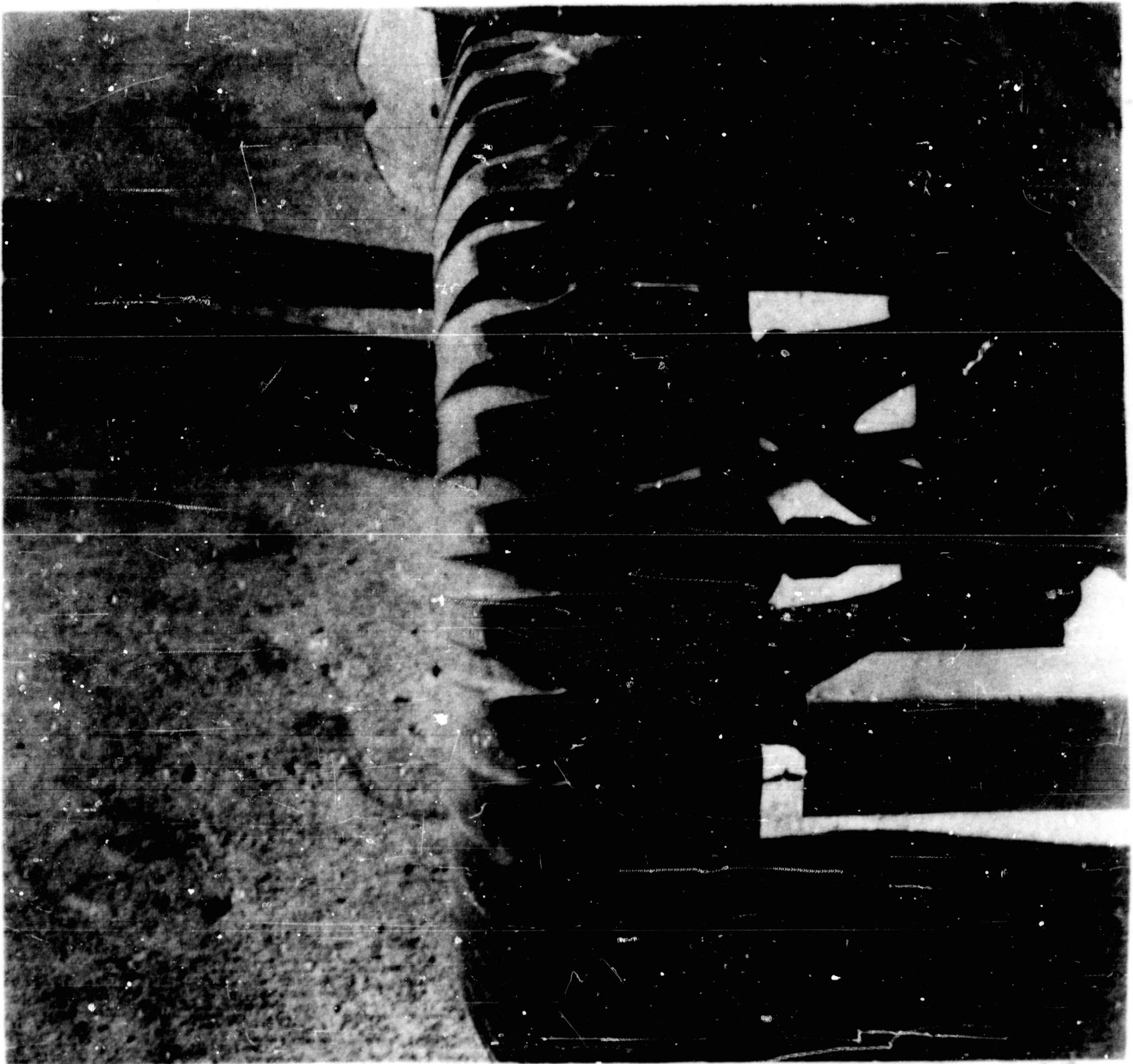


Figure 35 - B27994: Condition of Lightweight Nylon Tire after 5000 Miles of Paved Operation at Right Front Position with 20 psi Inflation Pressure.

At odometer 21,984 (7398 miles of durability operation including 5000 miles of paved road) the right rear tire tread was 100% worn. At odometer 21,388 (8202 miles of similar durability operation) the left rear tire tread was 100% worn. Average life of the rear tire was 8050 miles. At odometer 22,911 (conclusion of durability tests) the front tires still had approximately 1000 miles of wear left, therefore average life was estimated to be 10,725 miles.

Odometer 13,167 - The right rear inner wheel bearing failed as a result of the inner seal failing and allowing dirt to enter the bearing cavity. The seal could have been damaged when the rear suspension failed at odometer 12,570.

Odometer 22,911 - Final inspection of the wheel bearings and seals disclosed the following:

- a. Left front - Inner and outer bearings and seals were slightly worn.
- b. Right front - Inner bearing was water etched. Inner and outer seals were worn.
- c. Left rear - The inner and outer bearings and seals were slightly worn. The outer bearing was in the better condition.
- d. Right rear - The inner bearing and seal were worn excessively. The wheel bearing lubricant contained a considerable amount of dirt. The outer bearing was slightly worn.

Odometer 22,911 - Final inspection of the magnesium wheels (used during 21,033 miles of durability operation) showed the wheels to be in generally good condition except for the following:

- a. The protective coating had worn away from the stud holes and there was some wear of the material around the holes.
- b. There was some wear at the bead retaining flanges where dirt had entered between the flange and the tire bead and worn the protective coating off the flange. In all cases the inner flange was worn more than the outer.
- c. The bead retaining flanges contained several marks and were chipped in a few places from tire irons.

SNL Group 15 - Frame

Odometer 635 - Interference was noted between the left main frame rail and rear differential side cover although the rail had been relieved for passage of the cover bolts. Damage was slight, being limited to some bending of the lower side of the frame rail.

Odometer 21,084 - A small crack developed in the right outer frame rail where it meets the rear suspension front cross-member (Fig. 36).

Odometer 22,911 - Final inspection of the front cross-member showed it to be in generally good condition except for a crack in its upper surface which starts at the hole through which the front wheel brake line function is mounted.

Odometer 22,911 - Final inspection of the frame disclosed the following:

- a. There were several dents in the frame cross-member which supports the transmission (Fig. 37).
- b. The left outer frame rail contained a crack where it meets the rear suspension front cross-member (Fig. 38).
- c. Both rear bump stop brackets were crushed upward against the frame rail (Fig. 39).
- d. The rear suspension rear cross-member contained a crack at its left end where it joins the left outer frame rail (Fig. 40). It also contained cracks around the spot welds which attach rear mounts of the differential to the cross-member. These spot welds were pulling out (Fig. 41).

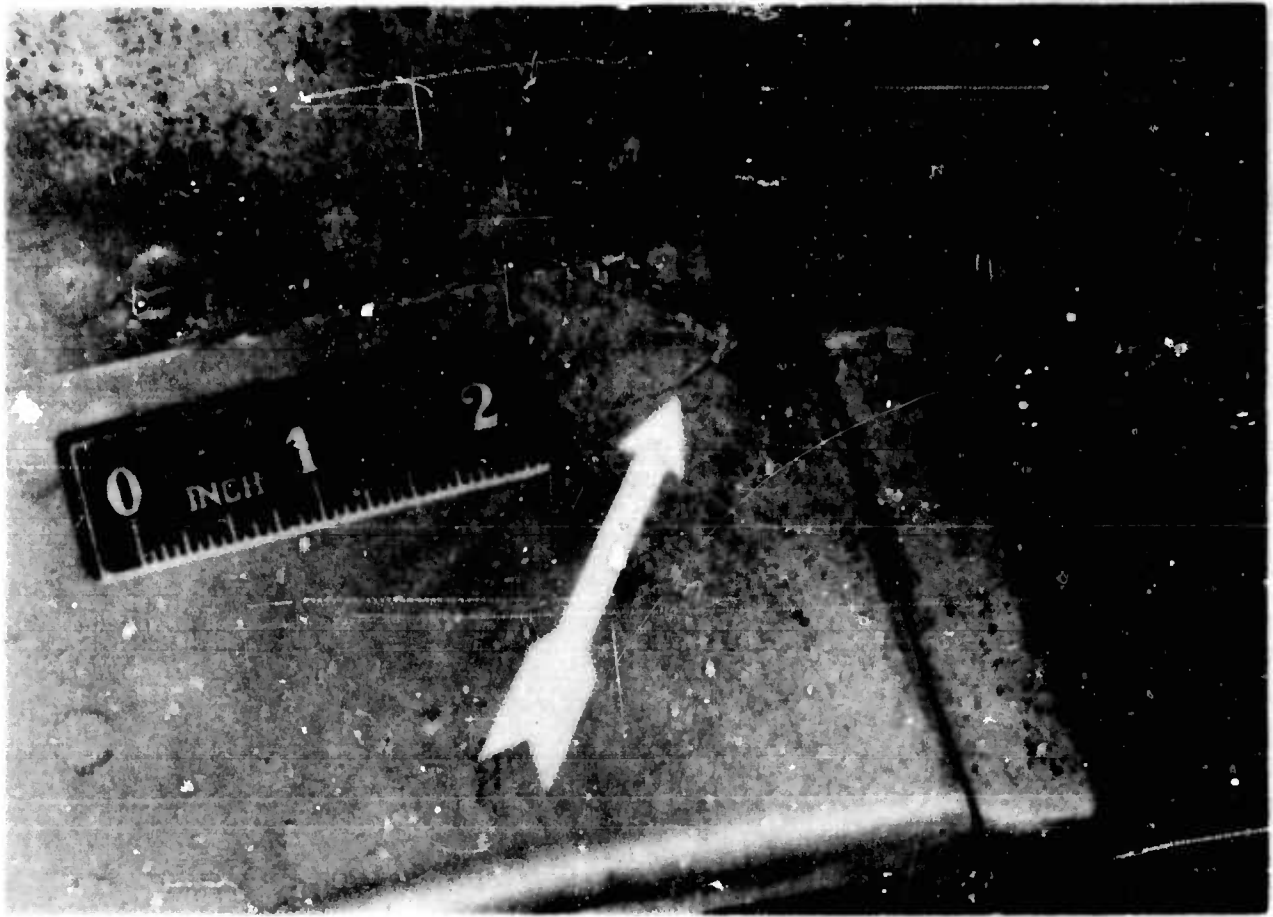


Figure 36 - B28805: Crack in Outer Right Frame Rail.



Figure 37 - B28798: Condition of Transmission-Supporting Cross-Member.

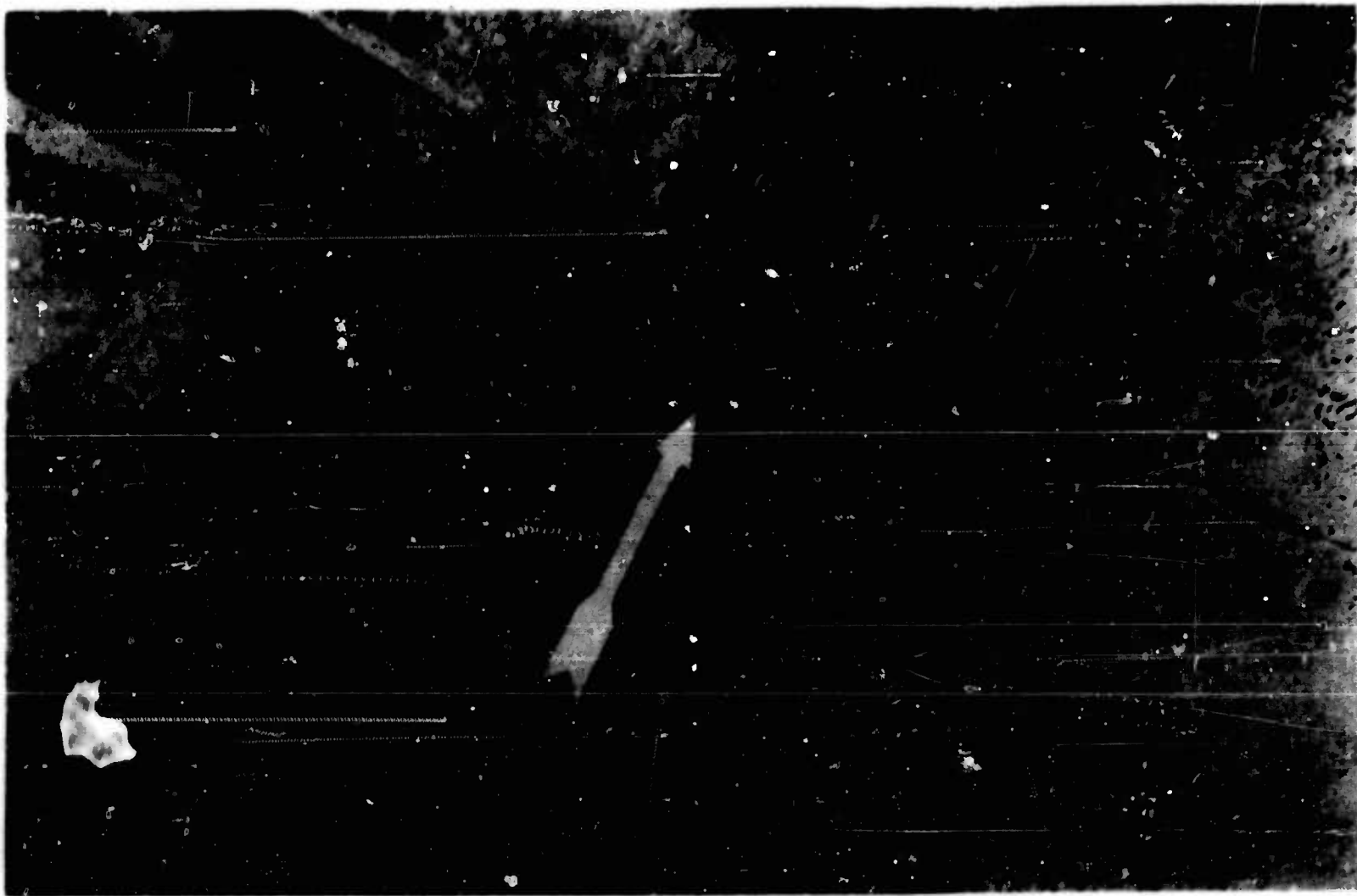


Figure 38 - B28796: Crack in Outer Left Frame Rail.

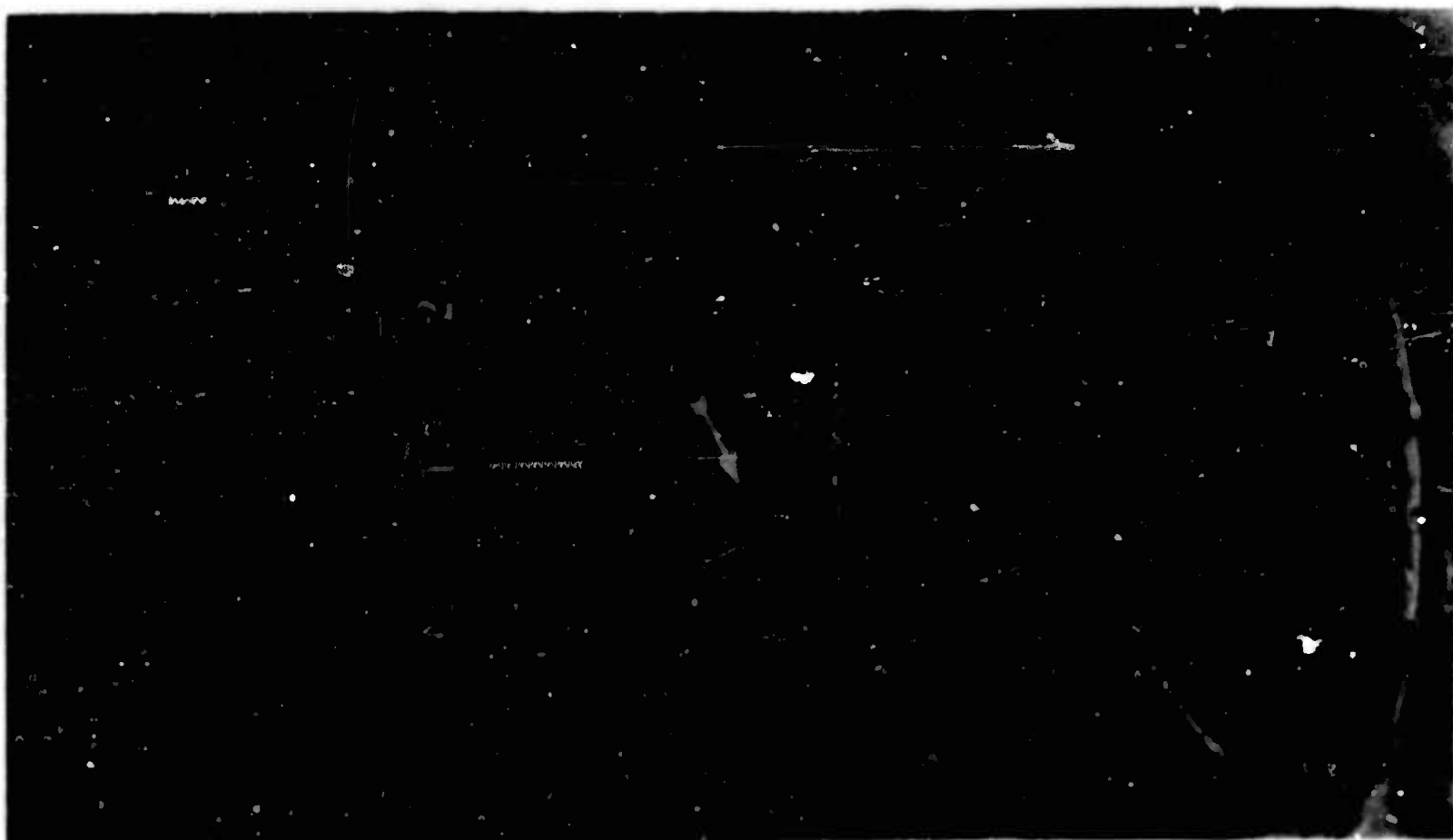


Figure 39 - B28800: Deformation of Left Rear Bump Stop Bracket.

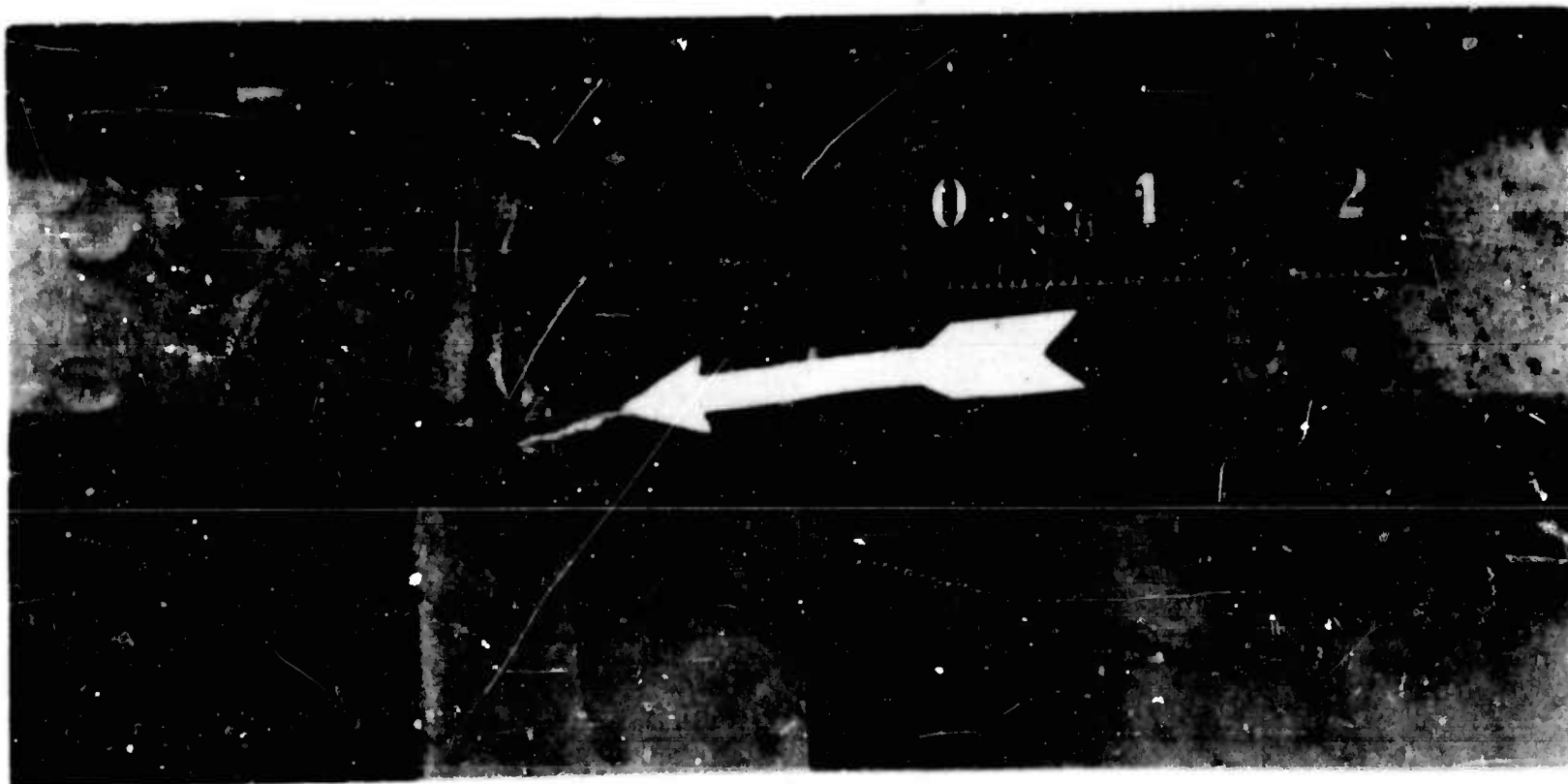


Figure 40 - B28802: Crack at Left End of Rear Cross-Member.

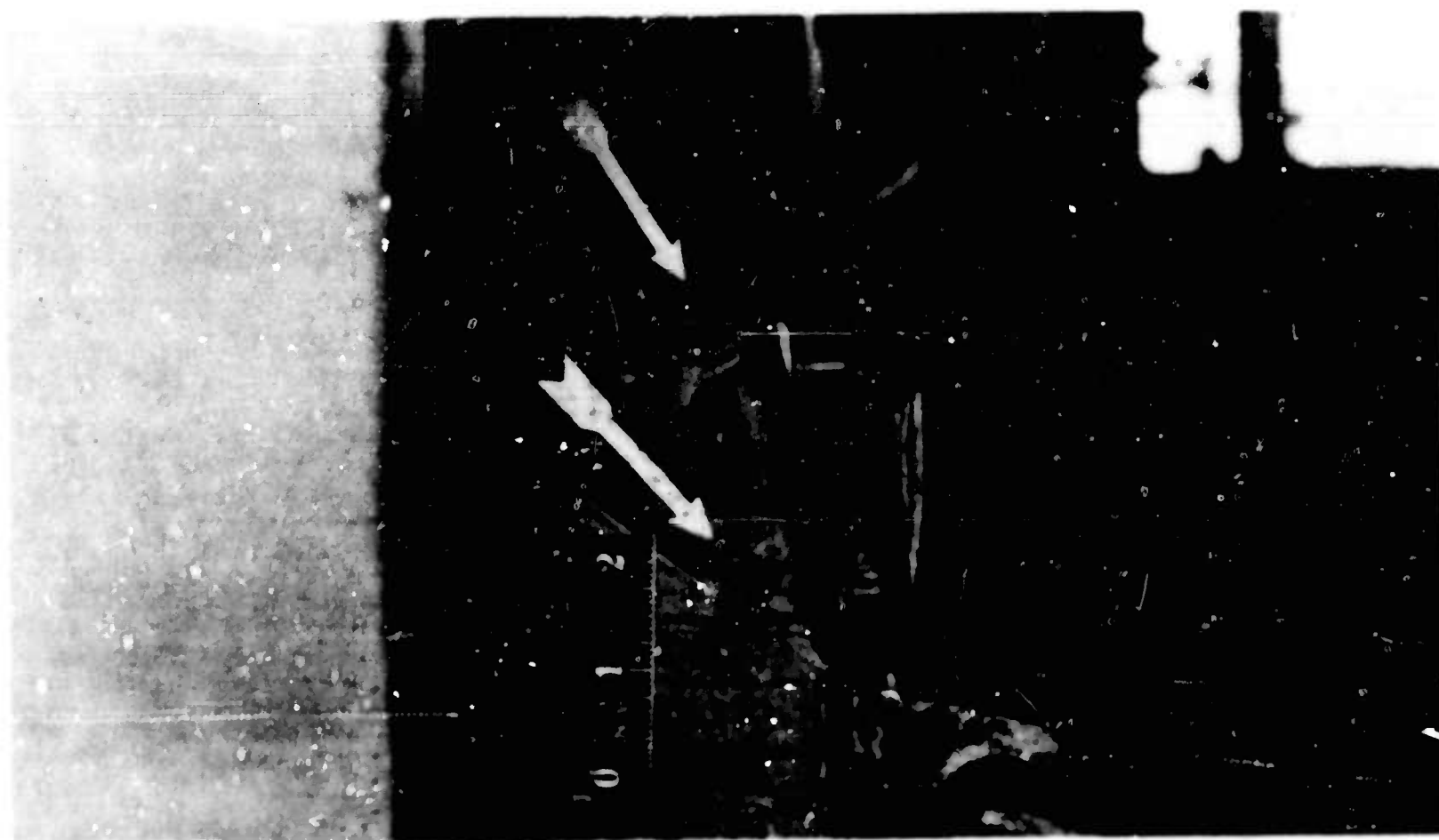


Figure 41 - B28808: Cracks in Rear Cross-Member around Spot Welds which Attach Differential Mount to Cross-Member.

SNL Group 16 - Springs and Shock Absorbers

Odometer 9587 - During hilly cross-country operation the rear shock absorbers appeared to be less effective than during earlier operation. At odometer 11329 both rear shock absorbers were replaced and vehicle ride was improved.

Odometer 11329 - During disassembly of right rear suspension it was disclosed that the lower coil of the spring was broken (Fig. 42).



Figure 42 - B27629: Broken Right Rear Coil-Spring.

Odometer 11797 - The washers under the top mounting nuts of the front shock absorbers began to dish into the rubber insulators below them. At a later date a new washer of thicker design was installed and appeared to be much more satisfactory.

Odometer 13136 - The right front shock absorber developed a slight leak. At odometer 19767 both front shock absorbers were leaking and had lost their resistance. The right rear shock absorber was also leaking but contained slightly more resistance. At odometer 20269 four new shock absorbers were installed.

SNL Group 18 - Body

Odometer 1335 - A periodic inspection disclosed a crack in the floor panel near the center of the body and just to the rear of the front seats. In the area of the crack the floor panels buckled upward. Figure 43 shows the extent of this crack at odometer 22,911.

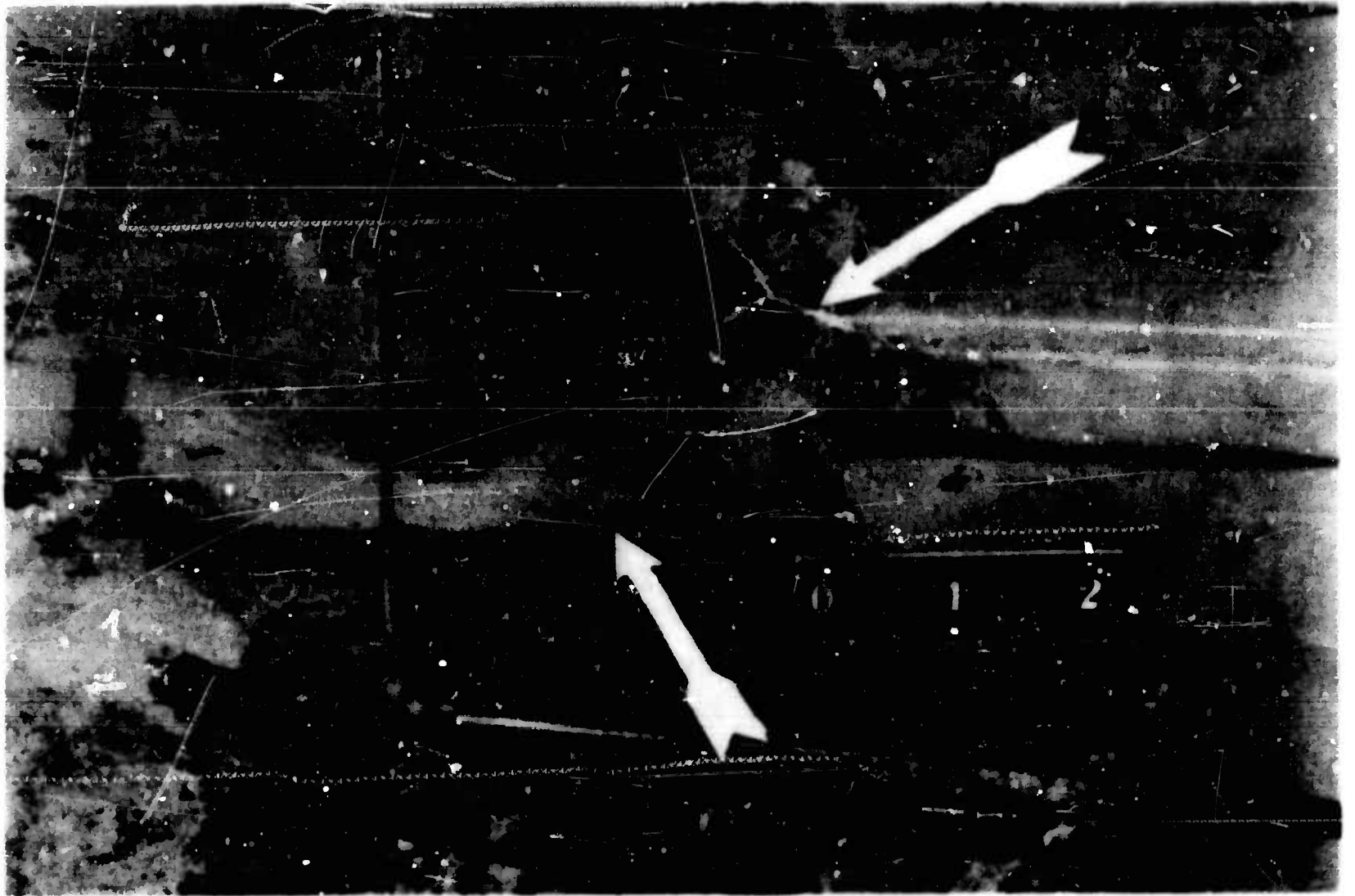


Figure 43 - B28804: Crack in Floor Panel.

Odometer 1335 - The tool compartment door buckled downward slightly and thus could not be held closed by the fasteners provided. It was also noted that the hold-down latches on the rear frames of the front seats were not satisfactory as they would not withstand normal use without becoming disassembled.

Odometer 1761 - The spare tire mounting bracket developed a crack starting in the mounting bracket reinforcement and extending into the rear panel of the body. At odometer 14,160 it was necessary to remove the tire to prevent extensive damage to the panel. Figure 44 shows extent of cracks in the bracket and panel at odometer 22,911.



Figure 44 - B28791: Spare Tire Mounting Bracket.

Odometer 6460 - The left leg of the assistant driver's seat developed a crack in the area of the front cross-bar. At odometer 11308 the seat frame failed at the left weld of the rear cross-bar. The front cross-bar also failed approximately $3/4$ inch from the right weld. The failures are attributed to the fact that the seat hold-down latch was unlatched and thus the seat was allowed to bounce and sway side-ways.

Odometer 8438 - Both rear shock absorber upper mounting brackets developed cracks. Figures 45 through 47 show condition of these brackets at odometer 22,911.

Odometer 8697 - During cross-country operation the ax slid rearward and broke its retaining strap. The bracket which retains the head of the ax was not designed to prevent it from moving to the rear when the vehicle ascends a grade.

Odometer 11362 - A crack developed in the vertical flange of the left rear fender (Fig. 48).



Figure 45 - B28806: Upper Mounting Bracket for Right Rear Shock Absorber.

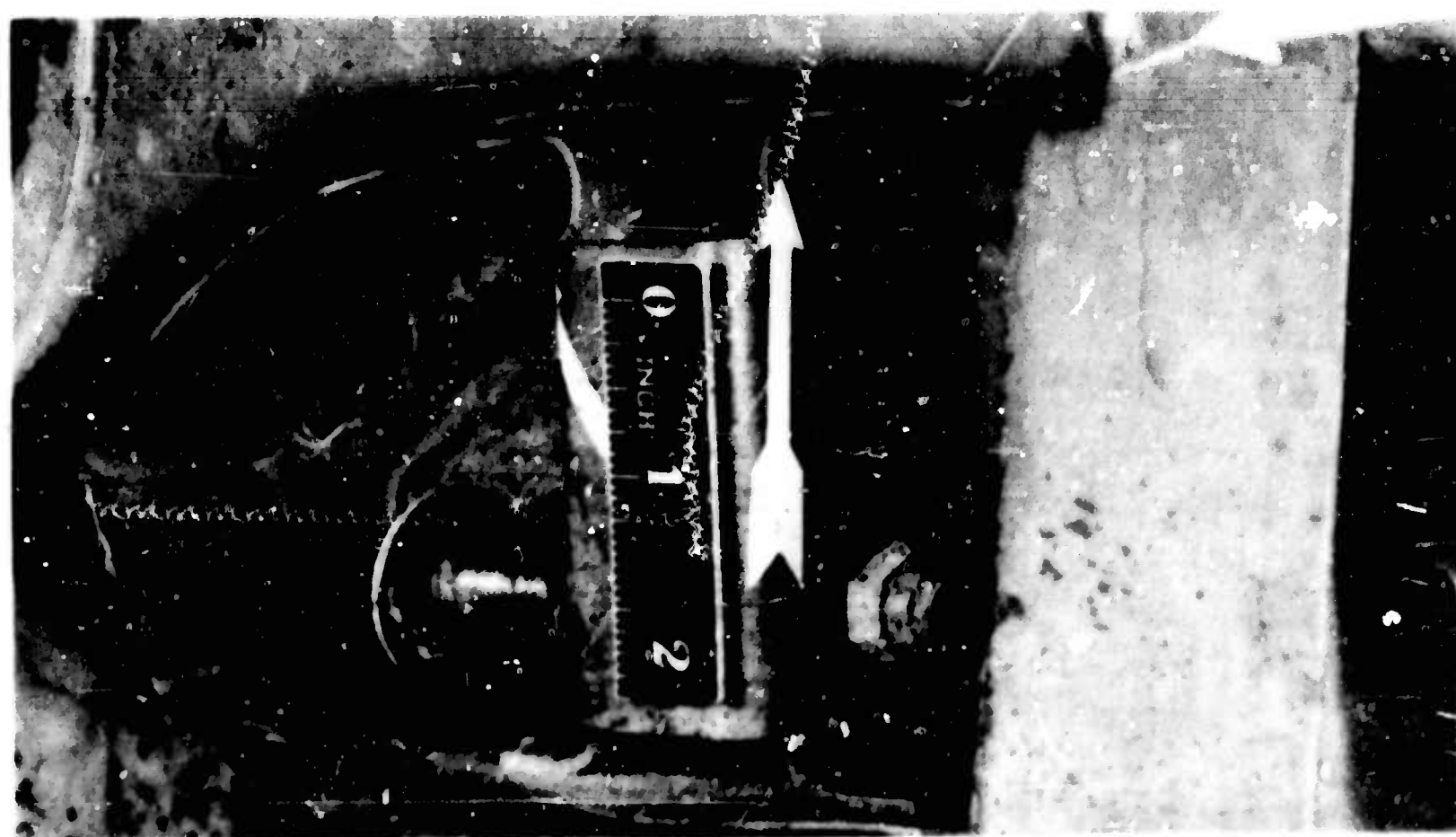


Figure 46 - B28803: Upper Mounting Bracket for Left Rear Shock Absorber.

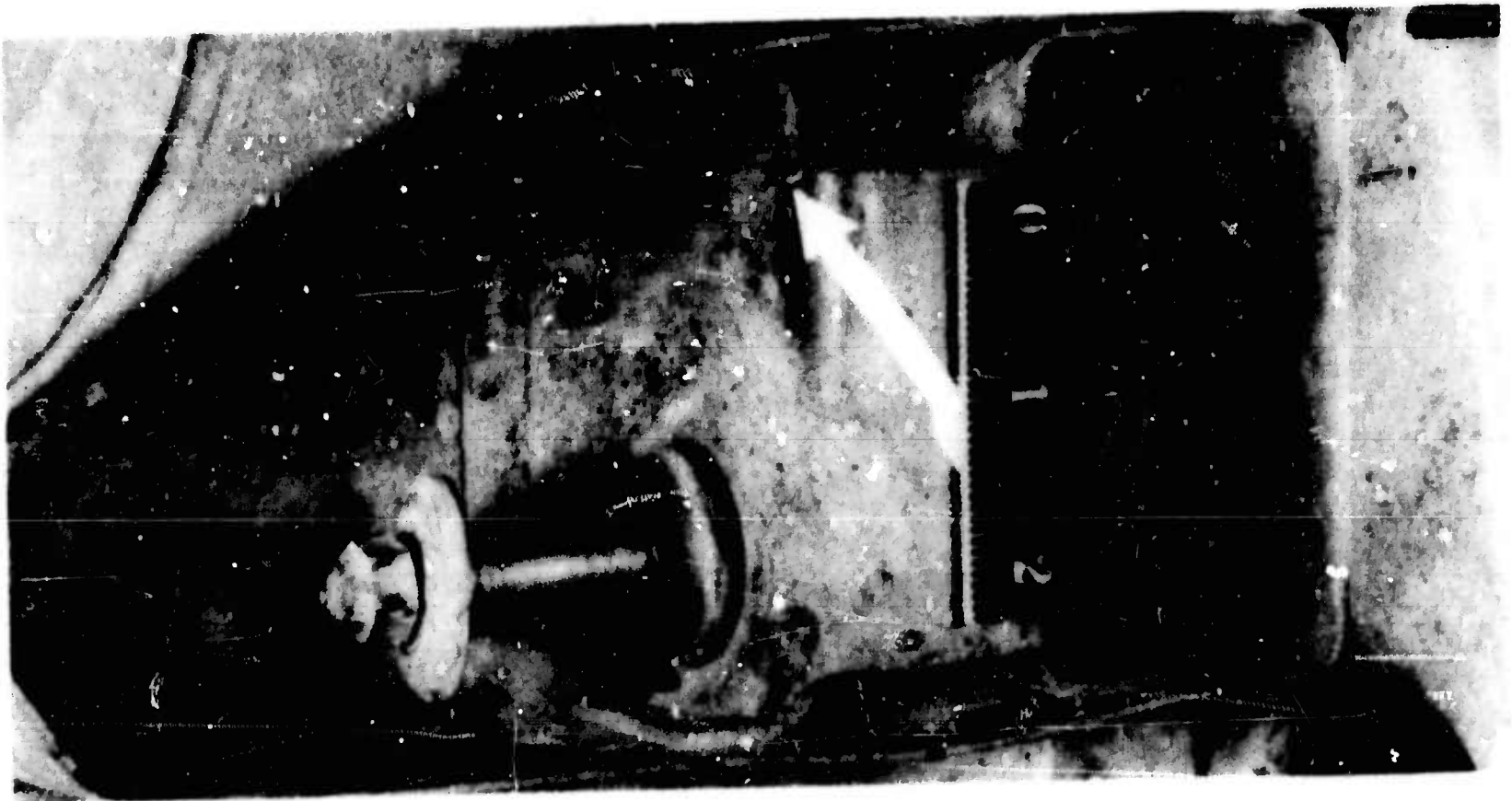


Figure 47 - B28801: Upper Mounting Bracket for Left Rear Shock Absorber.



Figure 48 - B28795: Crack in Left Rear Fender.

Odometer 11362 - A crack appeared in the left side of the windshield, starting at the bottom edge approximately two inches from the left corner and running one inch vertically, then right for about four inches. This crack apparently was due to vibration of the windshield frame.

Odometer 13167 - The three bolts, which attach the rear suspension mounting bracket to the rear cross-member, loosened during Belgian block operation.

Odometer 22,911 - During the final mechanical inspection the following were noted:

- a. The left front fender contained a crack in its lower forward area where it is spot-welded to the longitudinal frame member (Fig. 49).



Figure 49 - B28794: Crack in Lower Forward Area of Left Front Fender.

- b. A crack had developed in the left front fender just below the lower hole through which an air cleaner mounting bracket bolt passes (Fig. 50).

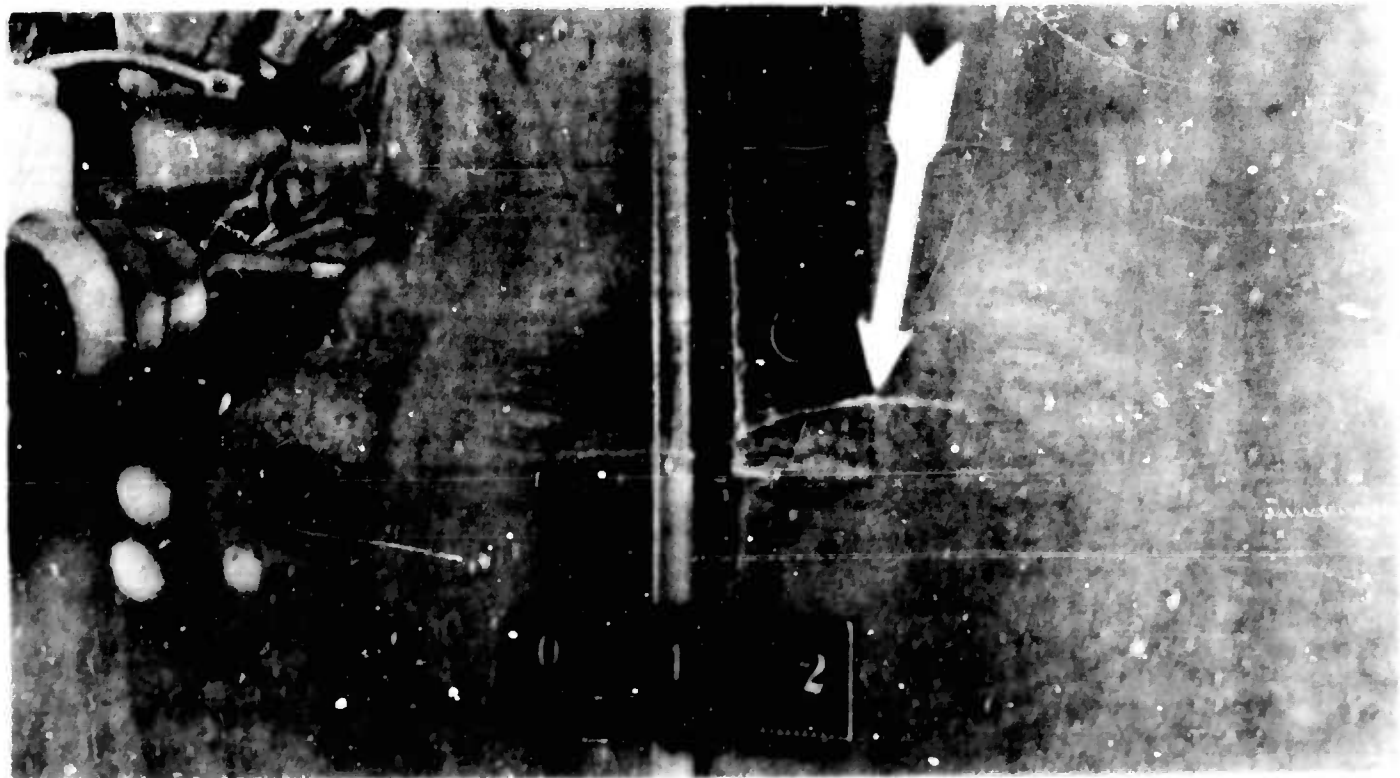


Figure 50 - B28790: Fender Crack in Area of Air Cleaner Mounting Bracket.

- c. The inner vertical panels of the left and right rear wheel wells contained cracks in the areas of the rear seat supports. One rivet was missing from the left seat support (Fig. 51).

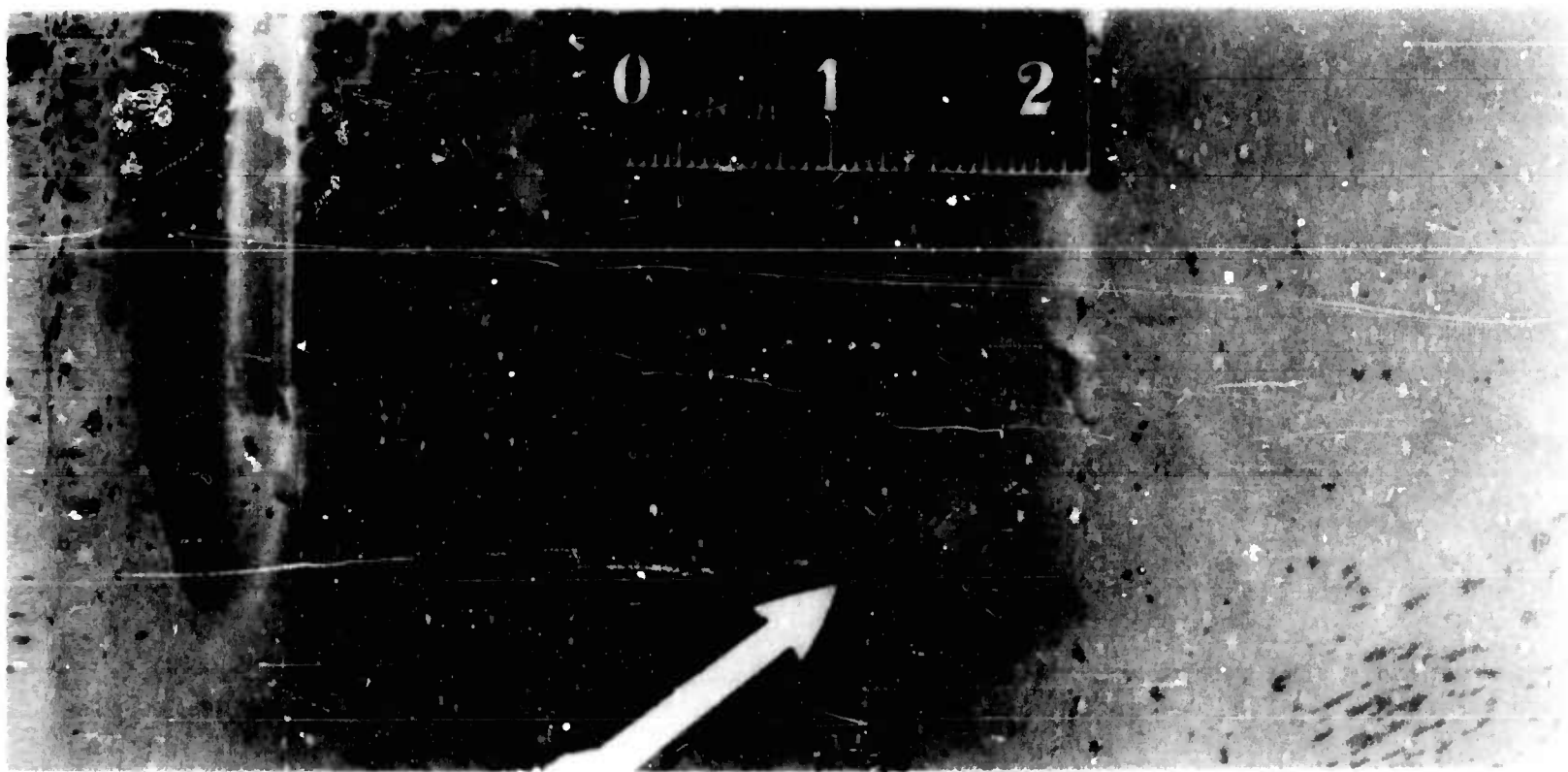


Figure 51 - B28793: Crack in Right Rear Wheel Well Vertical Panel.

- d. The retaining catches for the rear seat-back were deformed to the extent that they were serving no useful purpose (Fig. 52).



Figure 52 - B28810: Deformed Left Catch of Rear Seat-Back.

SNL Group 21 - Bumpers and Guards

Odometer 22,200 - The front differential guard pulled loose from its mounting bolts on the underside of the bumper and was pushed against the output flange of the differential pinion shaft. The guard was bent by hitting some object on the course and as the guard is slotted where it attaches to the bumper, it was pulled away.

SNL Group 22 - Miscellaneous Body Accessories

Odometer 1845 - The speedometer cable failed near the end where it enters the transmission.

3.3 Observations and Discussion

The average fuel and oil consumption rates of the M51 during 22,911 miles of durability operation were 15.8 mpg and 3,273 mpq respectively. These were considered very good since the vehicle was carrying a 1200-pound payload during all operation and towing a 1700-pound towed load during approximately half of the operation.

The location of the fuel tank filler neck is very inconvenient when attempt is made to fill the tank with five-gallon gasoline cans. It was also noted that the left side curtain slightly covered the fuel tank filler neck opening.

The absence of an engine oil pressure gage is somewhat unsatisfactory even though an oil pressure-controlled fuel cut-off switch is incorporated in the fuel system to prevent engine operation on low oil pressure. If the engine is operating erratically, a gage would be very convenient to determine if low pressure is actuating the fuel cut-off switch, and thus causing poor operation.

The constant velocity joints at the front wheels performed satisfactorily during this test, though it is believed that cardan joints such as used at the rear wheels would require less maintenance.

The excessive positive camber of the rear wheel at curb weight gives the vehicle an odd and unstable appearance. Since the changing of the rear coil springs is a very simple operation it is felt that two different sets of springs should be used; one for curb-weight service and the other for payload service.

The parking brake band was in excellent condition at the end of the test. The use of an over-center type parking brake lever instead of the ratchet and pawl type now used would eliminate any unnecessary wear of the brake band due to vehicle operation with brake partially applied.

The life of the service brake linings was considered unsatisfactory. The short life resulted from an excessive amount of dirt entering the brake drums and lack of air circulation around the drums, thus causing the brakes to run warm.

Stowage of the shovel in its proper position on the right side of the vehicle caused interference between the shovel blade and lower edge of the door.

The newly designed windshield hinges installed during the test appeared to give more rigidity to the windshield frame and also made windshield removal easier.

An evaluation of tire chain clearance while using 7.00 by 16 tires with a 1200-pound payload and a 1700-pound (GVW) towed load disclosed the following:

- a. When the vehicle was subjected to full right or left turns, the chain on the front outside tire rubbed against the front suspension upper control arm.
- b. When the vehicle was in the full bump position the left rear tire chain hit the under portion of the fuel tank filler neck canopy.
- c. Clearance between the rear tires and outer forward flanges of the rear fenders was insufficient for rapid installation of tire chains.

The Code B designed voltage regulator operated satisfactorily during the durability test.

The insulation provided in the propeller shaft tunnel reduced the heat in the driver's compartment, however, the insulation was damaged during operation (Fig. 53).

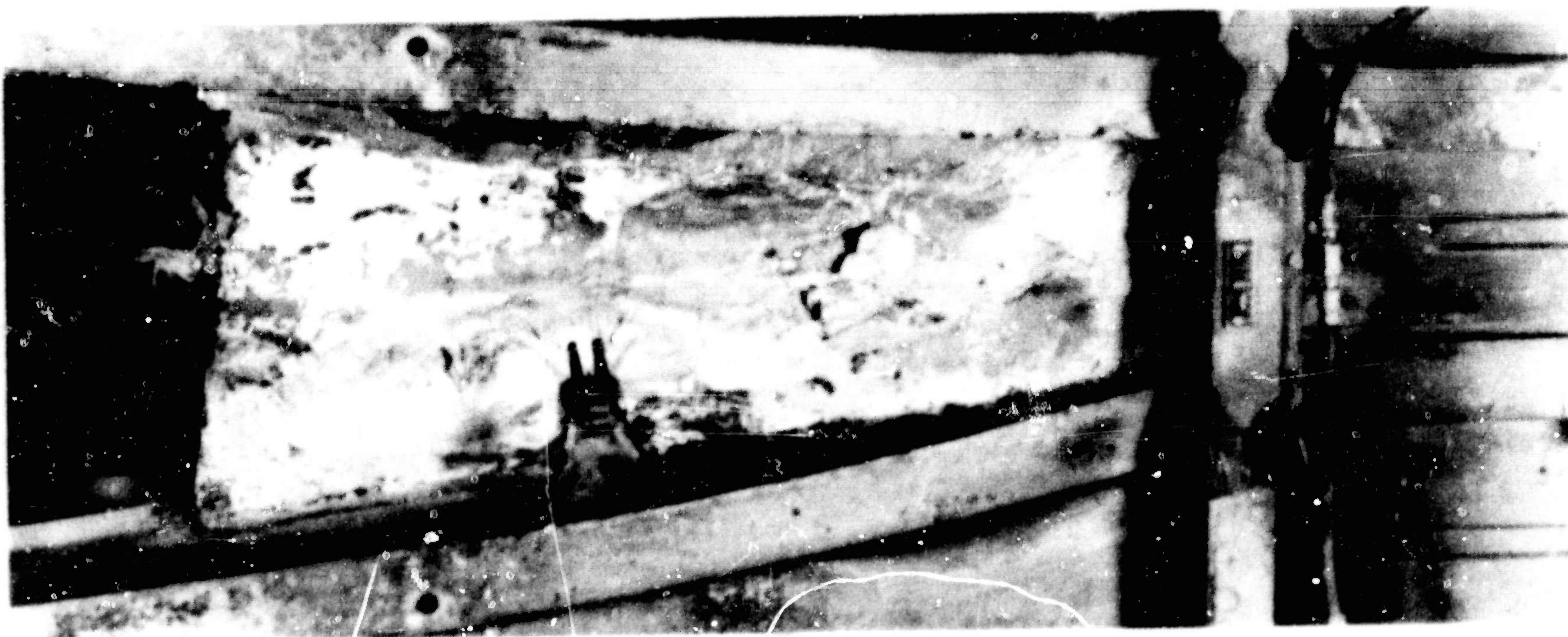


Figure 53 - B28797: Damaged Condition of Insulation in Propeller Shaft Tunnel at Conclusion of Test.

4. CONCLUSIONS

From the results of this durability test it is concluded that:

- a. The oil filter container is not satisfactory due to the loosening of the center bolt during operation, allowing oil to leak past the gasket at the base of the container.
- b. The attachment of the screen assembly to the oil pump pick-up pipe is not strong enough to withstand vehicle operation.

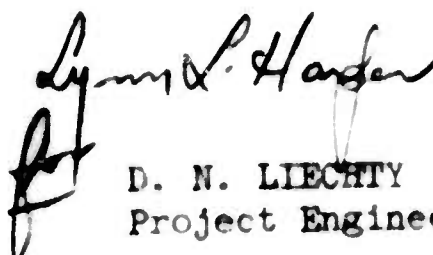
- c. The rod between the clutch pedal and equalizer shaft is not of sufficient strength to withstand the loads imposed on it.
- d. The electric wire to the fuel pump and its rubber insulator are unprotected.
- e. Location of the exhaust system outlet contaminates the crew compartment with fumes.
- f. Protection provided for the radiator is unsatisfactory as the cooling fins become clogged with mud during cross-country operation and are easily bent by dirt and rocks.
- g. The connectors on the electrical wires into the oil-pressure-controlled fuel cut-off switch were not strong enough.
- h. The arm for adjusting the generator and fan belt lacked strength to prevent fracture during operation.
- i. Lack of insulation to protect the batteries from heat radiated from the exhaust system resulted in warpage of the cases.
- j. Assembly of the transmission requires extreme care to prevent leakage of expansion plugs and seals during operation.
- k. The location of an expansion plug at the forward end of the transfer case intermediate gear shaft is unsatisfactory.
- l. The design of the spacer and snap ring on the transfer case rear output shaft is unsatisfactory.
- m. Leakage occurs around the expansion plug in the transfer case rear output shaft yoke.
- n. Fatiguing of the transfer case intermediate gear shaft was unsatisfactory.
- o. The propeller shafts are subject to brinelling.
- p. The use of lock washers on differential output flange bolts did not prevent loosening.
- q. Care is required when installing front wheel alignment shims so they do not fall out of position if the bolts loosen.
- r. The rear axle drive universal joints were subject to failure.
- s. The rear suspension arms as submitted for test were under-designed, but the modified version proved adequate.
- t. The pinion shaft front seal retainer was under-designed.
- u. Service brake lining wear was excessive due to entrance of dirt and lack of air circulation around the drums.
- v. Tire life was satisfactory when inflation pressures were maintained at 20 and 25 psi for the front and rear tires, respectively.
- w. The outer frame rails were under-designed in the areas where they meet the rear suspension front cross-member.
- x. The rear cross-member is under-designed at its outer ends where it joins the outer frame rails and also in the area where the rear supports of the rear differential are spot welded to it.
- y. Leakage and loss of resistance by the shock absorbers is undesirable.
- z. The redesigned version of the front shock absorber mounting washer was superior to the original design.
- a.a. Redesign is required to eliminate cracks in the vehicle floor and distortion of the tool compartment cover.

- b.b The front seat hold-down latches are unsatisfactory.
- c.c The spare tire mounting bracket lacked sufficient strength.
- d.d The rear shock absorber upper mounting brackets and bump stop brackets did not withstand the loads imposed.
- e.e The left front and rear fenders require strengthening in the areas where they developed cracks.
- f.f The rear seat-back retaining catches need modifications to eliminate deformation.
- g-g The fuel tank filler neck requires refinement to eliminate tire chain interference and make filling of fuel tank easier.
- h.h The front differential guard design is unsatisfactory.
- i.i An engine oil pressure gage is a needed instrument.
- j.j The ax bracket is unsatisfactory and the shovel bracket should be relocated to eliminate interference with door.
- k.k The insulation provided in the propeller shaft tunnel lacks durability.

5. RECOMMENDATION


It is recommended that correction of deficiencies outlined in this report be accomplished prior to further testing of the M151.

SUBMITTED:

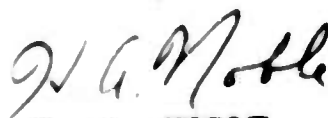

D. N. LIECHTY
Project Engineer

REVIEWED:


C. F. WATERS
Chief,
Transport Vehicles Branch


W. GROSS
Acting Chief,
Automotive Division

APPROVED:


H. A. NOBLE
Assistant to the Deputy Director
for Engineering Testing
Development and Proof Services

APPENDICES

PAGE NUMBER

APPENDIX A: DIRECTIVE CORRESPONDENCEA-1

APPENDIX B: DISTRIBUTION B-1

APPENDIX A

HEADQUARTERS
ABERDEEN TANK - AMBULANCE COMMAND
DETROIT ARSENAL
28251 VAN DYKE AVENUE
CANTON LANE, MICHIGAN

RAPatek/ik/20267

ORDIC-II.51

23 August 1957

ORDER 451.2/91

SUBJECT: Test Directive for M51E1

TO: Commanding General
Aberdeen Proving Ground
Aberdeen, Maryland
ATTN: ORDEG-DPE Mr. C. Waters

1. It is requested that your office furnish a cost estimate for tests consisting of the following phases for the Truck, 1/4 Ton, Utility, 4x4, M51E1.

a. Three cycles of standard durability testing of 7600 miles each with component teardown and inspection at end of each cycle and during each cycle to the extent considered necessary by test engineer.

b. Complete standard engineering test.

c. Mud and sand mobility tests.

d. Summer test at Yuma Test Station including those aspects of engineering testing, road durability, draw bar, dynamometer test and component cooling.

e. Component improvement test, parts of which will be carried on in conjunction with tests in sub-paragraph d above if possible.

f. Climatic test, series consisting of engineering tests, snow mobility and other cold weather engineering and durability characteristics.

2. It should be noted that the above test program was discussed with Mr. D. Mackay of AFV on approximately 31 July 1957 and it was agreed that the testing should be carried out in a sequence indicated above and that in each instance standard tests for the type test listed would be carried out and estimates based upon this.

FOR THE CHIEF INDUSTRIAL DIVISION:

/s/ L. F. Mortenson

L. F. MORTENSON
Chief, Wheeled Vehicle Section

ORDBG-DP-TU

1st Ind

Mr DN Liechty/ed1/23243

ORDBG 451.2/91

SUBJECT: Test Directive for M151R1

USA Ord Development and Proo? Services, Aberdeen Proving Ground, Md.

TO: Commanding General, Ordnance-Tank Automotive Command, Detroit
Arsenal, Center Line, Michigan. ATTN: ORDMC-II.51

Estimated cost of test outlined in basic letter is \$99,389.
This estimate includes complete test as directed except for the first
7600 mile durability cycle which was performed under R&D Project
TT3-732A.

CC

Comptroller's Office

Program Planning Office

26 Sept 57 DN Liechty

____ Harper

____ Waters

____ Gross

ET1000065LCAS42

FM RUECH

DE RUECLA 16

M 111745Z

FM CODETARSENAL CENTERLINE HIGH¹¹

TO CCABERDEENPC MD

DA GRNC

BT

date -----01 Dec 1957

ACTION-----D&P8

TT04421 FOR W GROSS ORDBC-DP-TU FROM ORDMC-II.51 PATEK

THE TEST DIRECTIVE FOR TRUCK, UTILITY, 1/4 TON, 4X4, M151
FURNISHED MR LIECHY AND MR HARPER TO BE HAND CARRIED TO APC ON 14
NOV 57 HAS BEEN ASSIGNED DETROIT ARSENAL PROJECT NR IT-5092 AND
CONSTITUTES WORK DIRECTIVE REQUIRED UNDER PESD

70304021-11-06303-00-0-623

BT

CFN TT04421 ORDBC-DP-TU ORDMC-II.51 1/4 4X4 M151 14 57 IT-5092

70304021-11-06303-00-0-623

11/1746Z