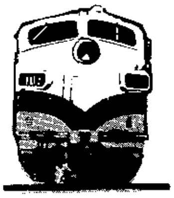
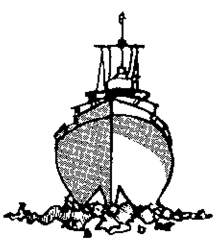


# NATIONAL TRANSPORTATION SAFETY BOARD



WASHINGTON, D.C. 20594

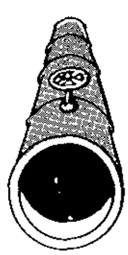


## RAILROAD ACCIDENT REPORT

### DERAILMENT OF A BURLINGTON NORTHERN FREIGHT TRAIN

### BELT, MONTANA

### NOVEMBER 26, 1976



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15. Supplementary Notes

16. Abstract

About 2:55 p.m. on November 26, 1976, 24 cars of Burlington Northern freight train Extra 5743 East derailed at Belt, Montana. Twenty-two persons were injured as a result of the accident and two persons are missing. About 200 people were evacuated because of subsequent fires and explosions. Five houses, a Farmers Union Cooperative facility, and several other buildings were destroyed or damaged. Nineteen motor vehicles were destroyed and Belt Creek was contaminated. Damage was estimated to be $4,540,000.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of an overloaded rail section which originated in an undetected transverse fissure.

17. Key Words

Liquefied petroleum gas (LPG); head shields; hazardous materials; inclusion; transverse fissure; control cooled; internal defects; dynamic loading; tank car rocketing; 90-pound rail.

18. Distribution Statement

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: September 29, 1977

# DERAILMENT OF A BURLINGTON NORTHERN FREIGHT TRAIN AT BELT, MONTANA, NOVEMBER 26, 1976

## SYNOPSIS

About 2:55 p.m. on November 26, 1976, 24 cars of Burlington Northern freight train Extra 5743 East derailed at Belt, Montana. Twenty-two persons were injured as a result of the accident and two persons are missing. About 200 people were evacuated because of subsequent fires and explosions. Five houses, a Farmers Union Cooperative facility, and several other buildings were destroyed or damaged. Nineteen motor vehicles were destroyed and Belt Creek was contaminated. Damage was estimated to be $4,540,000.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of an overloaded rail section which originated in an undetected transverse fissure.

## INVESTIGATION

### The Accident

About 1:40 p.m., on November 26, 1976, Burlington Northern (BN) freight train Extra 5743 East departed from Great Falls, Montana, eastward 1/ on the single-track mainline for Mossmain, Montana. The train consisted of 5 locomotive units and 121 cars. Inspections and brake tests performed before the train departed, and numerous inspections made by the crewmembers en route, disclosed no defects.

About 2:55 p.m., the train was moving at 38 mph as its locomotive passed the station at Belt, Montana, 26.5 miles south of Great Falls. The engineer did not observe any defects in the track as the train approached and crossed a bridge over Castner Street. A few moments later, the fireman looked to the rear of the train and saw a boxcar derail near the bridge. He reported this to the engineer and then saw more cars derail, including several tank cars. The derailment initiated an emergency brake application. The locomotive and 28 cars stopped about 3,002 feet south of the point of derailment, 3,493 feet south of the Belt station, and 3,000 feet from the north end of the bridge. (See figure 1.) Twenty-four cars, the 29th through the 52nd, derailed. None of the crewmembers were injured in the accident.

1/ This direction is related to BN timetable directions. At Belt a BN eastbound train is traveling southward geographically.

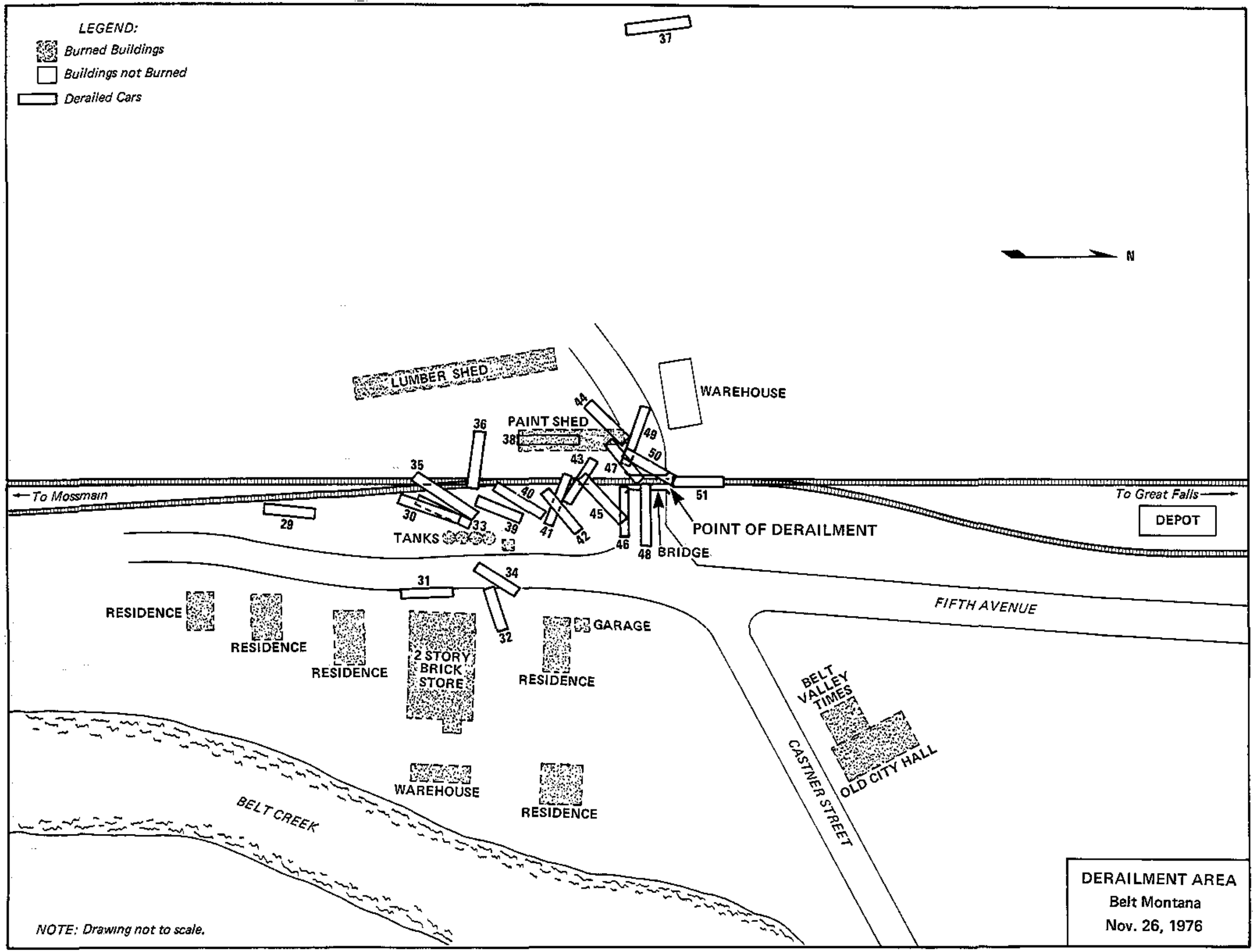


Figure 1. Plan view of accident site.

The initial derailment occurred at the north end of the overpass which carries the single track over Castner Street. The old City Hall building and a newspaper office were about 300 feet northeast of the point of derailment on Castner Street. On the east side of the tracks in the derailment area there were a two-story brick store which belonged to the Farmers Union Cooperative, a warehouse, and several dwellings. In addition, there were four vertical, above-ground, 16,000-gallon tanks for gasoline and fuel oils, two 500-gallon butane tanks, and several small propane tanks. Belt Creek is about 400 feet east of the accident site. A warehouse, a paint storage shed, and a lumber storage shed were on the west side of the tracks. (See figure 1.)

A tank car derailed to the east side of the track where it struck and punctured one 16,000-gallon tank containing gasoline, which was 42 1/2 feet from the track structure. The gasoline immediately ignited. At the same time, the tankhead of the 37th car, a tank car loaded with liquefied petroleum gas (LPG), was punctured. The escaping gas was ignited and the punctured tank immediately rocketed about 400 feet to the west.

Cars No. 40, 41, 42, 43, and 45 were tank cars loaded with No. 6 fuel oil. Several of the tanks were punctured in the derailment and fuel oil spilled onto Castner Street under the bridge. The punctures were made by impacts between the tanks and various car parts during the derailments. The oil ignited and began to flow down Castner Street toward the center of town.

About 1 1/2 hours later, the 34th car, loaded with LPG, which was ruptured and being impinged by fire, exploded. Several firefighters received minor burns and were knocked down when the tank car ruptured. Parts of this car came to rest near the Farmers Union Cooperative building on the east side of the main track.

One 33-foot piece of the east rail was broken into 13 pieces. The first break was 47 inches north of the bridge and the second break was 11 feet 10 3/4 inches south of the first. (See figure 2.) Wheel battermarks on the receiving ends of the broken pieces indicated a number of wheels passed over the breaks before the rail was displaced and allowed the cars to derail. The rail was manufactured by the Bethlehem Steel Company in 1909 and was first laid in a track in 1911. It was installed at Belt about 3 years before the accident.

The track was constructed of 90-pound, 33-foot-long rails of various origins and ages which exceeded 50 years. The rails were connected with 4-hole, 24-inch joint bars. Each rail had 12 rail anchors. Each rail rested on 7 1/2-inch by 10 1/2-inch, single-shoulder tie plates which were laid on twenty 7-inch by 9-inch by 8 1/2-foot crossties per rail length. The rail was secured by two track spikes per tie plate. The track was ballasted with crushed stone.

During the week prior to the accident, a track gang had "smoothed up" the track in the area, which included raising the east rail between the bridge and the switch south of it.

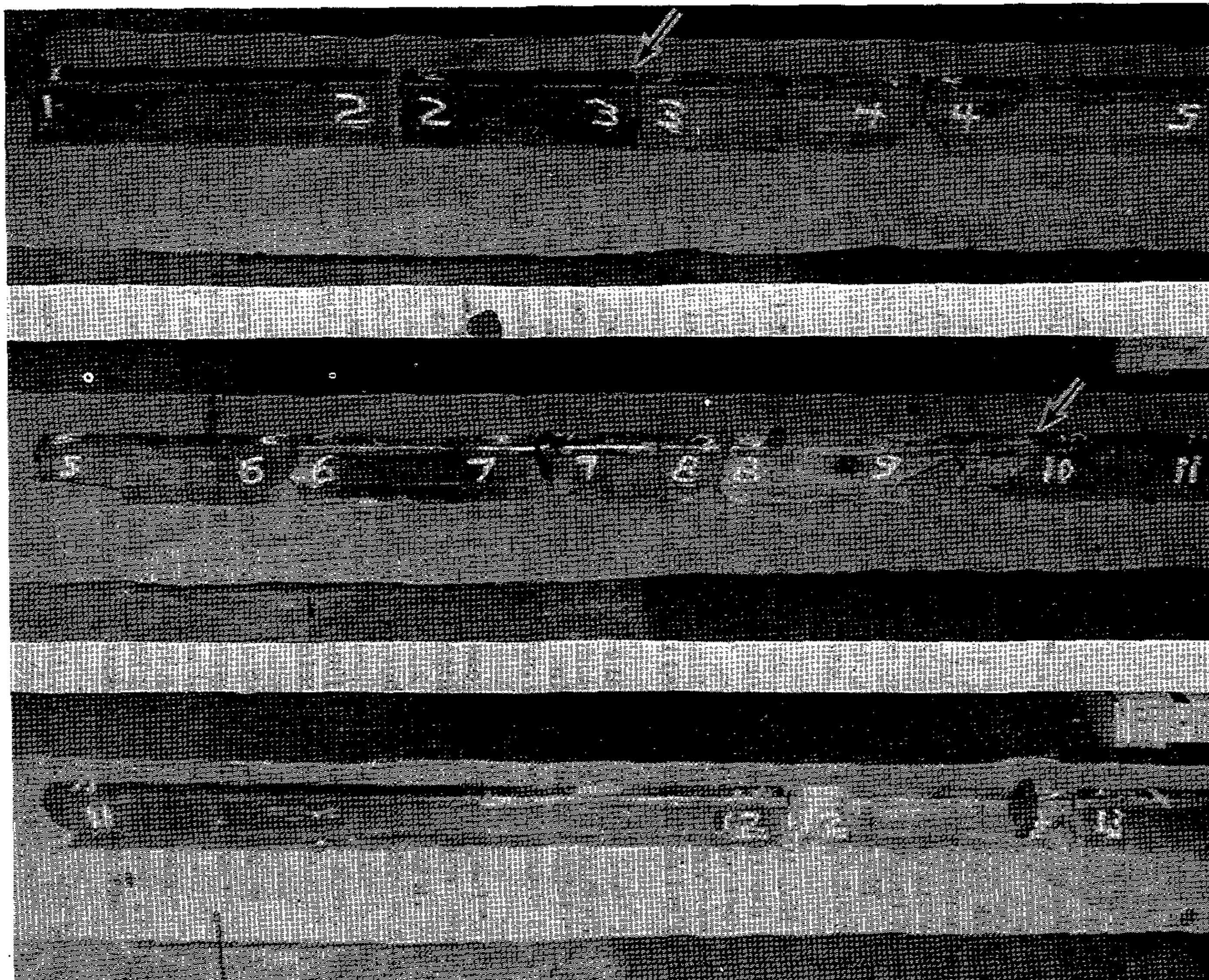


Figure 2. Broken sections of 33-foot rail. Arrow indicates point of initial failure.

A track inspector riding a Hy-Rail car had inspected the track in the area earlier in the day and found no defects. The track had been inspected by a magnetic rail defect detector car on July 29, 1976, and by an ultrasonic defect detector car on August 4, 1976. During these inspections several other rails manufactured in 1909, which were near the bridge, were found to contain internal defects. No defects were found in the east rail at the bridge.

BN requires inspection of the track by a track inspector or a track foreman three times per week. This exceeds the requirement of the Federal regulation which requires only one track inspection per week for Class 3 track. Searches for internal rail defects are not required because no passenger trains operate on this line.

A southbound train approaching Belt moves around a 2° curve to the right for 960 feet and then moves on straight track for 1,066 feet to the point of the derailment and for 1,593 feet farther south. There is a 0.60 percent descending grade for about 5 miles approaching Belt. Dynamic braking is usually employed descending into Belt. The north end of the bridge carrying the single track over Castner Street in Belt is located 495 feet south of the station. Sidings are located along the main track north and south of the bridge.

## Injuries to Persons

| Injuries | Crewmembers | Passengers | Other |
|---|---|---|---|
| Fatal | 0 | 0 | 2 missing |
| Nonfatal | 0 | 0 | 22 |
| None | 6 | 0 | |

## Damage

Sixteen of the 24 derailed cars were destroyed and the others were heavily damaged. About 270 feet of track and two switches were destroyed and the bridge was damaged.

Five houses were destroyed and several others were damaged. Several commercial buildings, including the Farmers Union Cooperative's entire bulk fuel storage plant, were destroyed. That plant consisted of a general store, garage, warehouse, four vertical, above-ground, 16,000-gallon tanks, two 500-gallon butane tanks, and several small propane tanks. Two of the large tanks contained gasoline, one contained heating oil, and one contained diesel oil. The lumber storage shed and paint warehouse along the west side of the track were destroyed. The newspaper building and the old City Hall in the center of town were destroyed by fire. Nineteen motor vehicles were destroyed and several were damaged.

Highway access to the west and south of the accident site was hampered because Castner Street was blocked by derailed cars and fire. Telephone communications in the area were interrupted for several hours.

Damage-related costs were estimated as follows:

| | |
|---|---|
| Equipment | $ 500,000 |
| Track | 40,000 |
| Property | $4,000,000 |
| Total | $4,540,000 |

Train Information

The 34th, 37th, and 51st cars of the train were tank cars loaded with LPG, and were not equipped with head shields. The cars complied with U.S. Department of Transportation (DOT) specifications for the transport of this liquid. The 34th and 37th cars were provided with F-type couplers, and the 51st had a standard E-type coupler. The 41st, 42nd, 43rd, and 45th cars were tank cars loaded with fuel oil.

The locomotive consisted of five units with the following specifications:

| Type | Weight (Pounds) | Axles |
|---|---|---|
| U-33-C | 363,600 | 6 |
| SD-45 | 368,000 | 6 |
| GP-30 | 362,700 | 4 |
| GP-38 | 250,000 | 4 |
| GS-9 | 249,000 | 4 |

Method of Operation

Trains are operated in this territory by timetable and train orders. The maximum authorized speed is 40 mph. Normal daily traffic consists of one freight train in each direction. No passenger trains operate over this line.

Meteorological Information

At the time of the accident the temperature was about 13° F, and in the following 8 hours it dropped to 8° F. The sky was cloudy with a northwest wind of about 20 mph. About 4 inches of snow was on the ground.

Fire

Fire erupted immediately after a tank car collided with the trackside fuel storage tank. Fifty-foot-high flames enveloped derailed cars and buildings within a 300,000-square-foot area around the tank in less than 2 seconds. In a rolling motion the fire advanced eastward toward Belt Creek and spread out to the north and south. Several explosions occurred as the fire burned the derailed cars and nearby buildings. The fires burned for over 12 hours. (See figure 3.)

Figure 3. Aerial view looking south.

The Belt Fire Department quickly responded and directed its attention to the fire advancing on Castner Street toward the town. The old City Hall and a newspaper building were on fire when the fire department arrived. Fire equipment from other localities arrived and the Great Falls National Guard Fire Chief took charge. Trucks dumped earth on Castner Street to dike the fuel oil fire. The dike diverted the oil into Belt Creek, which became contaminated. Disaster planning for assisting in a catastrophe of this nature had not been made with neighboring fire department. However, by 3:15 p.m. 12 fire departments within 30 miles of Belt were responding.

The train crewmembers first unsuccessfully attempted to contact the nearest railroad dispatcher by radio and by telephone. The conductor then instructed the crew to move the remainder of the train southward and place it on a siding.

Initially none of the non-railroad emergency service personnel were informed of the hazardous commodities on the train nor of the location of the waybills. The railroad crewmembers left the scene about 3:15 p.m., and left the waybills in the caboose. The conductor notified a dispatcher of the accident about 3:20 p.m., and made arrangements to move the rear portion of the train to Great Falls. This was the first information that the BN had received about the derailment. When the firechief requested the waybills and information from the railroad dispatcher, he was told that the caboose and undamaged cars had been removed to Great Falls.

About 4:30 p.m., a sound like gas venting to the atmosphere was heard in the main fire area but firemen were unable to determine whether it was from a tank car or one of the propane tanks near the Cooperative's buildings. At 5:30 p.m., a tank car ruptured and a 1,000-foot-diameter fireball spread over the town. At least 10 firemen were within 200 feet of the tank car, but only one firefighter was injured. Parts of the tank were blown 500 feet away.

The hazardous materials on the train were not identified until about midnight when BN officials arrived at the scene with information about the train's cargo.

## Survival Aspects

Because of the low outside temperature most residents along Fifth Avenue were indoors at the time of the derailment.

The initial blast damaged the door of a garage on the Cooperative's premises, exposing its eight occupants to a 4- to 6-foot wall of flame. Two of the occupants did not escape with the other six by a rear exit and are missing.

Flames engulfed a house just north of the Cooperative within 10 seconds after its occupants fled.

## Tests and Research

The 13 pieces of the broken rail which initiated the derailment were analyzed at the BN laboratory at St. Paul, Minnesota. The chemical composition of the steel conformed closely to American Railway Engineering Association specifications except for slight deviations above maximum carbon and phosphorus content. The failed sections exhibited classic transverse fissures which had progressed from inclusions in the railhead. The inclusions extended throughout the lengths of the failed section of rail. The transverse fissure at the initial break did not exhibit the sudden or rapid growth rings normally associated with those transverse fissures which exhibit those types of growth. (See figures 4 and 5 and appendix A.)

According to the State Fire Marshall's office the four oil storage tanks, the two 500-gallon butane tanks, and an electric pump used for bulk transfer complied with the Uniform Fire Code. Each of the storage tanks contained an 8-inch escapement for explosive venting with a weak seam weld in the roof. The four vertical tanks were enclosed by a 3-foot-high, 6-inch-thick reinforced concrete firewall.

The tankhead of the 37th car, which was punctured in the derailment, was recovered near a storage tank. An examination disclosed that the puncture was near the top of the head, approximately 12 inches above the horizontal center line. Because of the nature of the puncture it could not be determined definitely what effect a Federal Railroad Administration (FRA)-designed head shield would have had.

## Other Information

The Federal Track Safety Standards, 49 CFR 213.237, require that a continuous search for internal defects be made of all jointed and welded rails in Classes 4 through 6 at least once a year. Such inspection is to be made in Class 3 track only when passenger trains operate on it.

## ANALYSIS

The battermarks on the fractured surfaces of the broken rail indicate that the rail broke under the wheels of the passing train and that a few wheels passed over the two breaks before the rail was displaced and allowed the cars to derail. If the rail had been broken before the train began to move over it, the locomotive and first 28 cars would have battered the ends of the fractured rail to a much greater degree. Furthermore, the track inspector probably would have discovered the break during his inspection earlier in the day.

As soon as the rail separated and allowed the 29th car to derail, the deceleration of the first cars to derail and those immediately behind them--both from the emergency braking and the deceleration of the derailed wheels--initiated the buckling of the train and the random derailment and dynamics of the following cars. Since the track was on a fill, there was nothing to keep the derailed cars in line and on the roadbed. Consequently, the momentum of the rear cars still on track caused derailment to both sides of the track and random excursions of the cars.

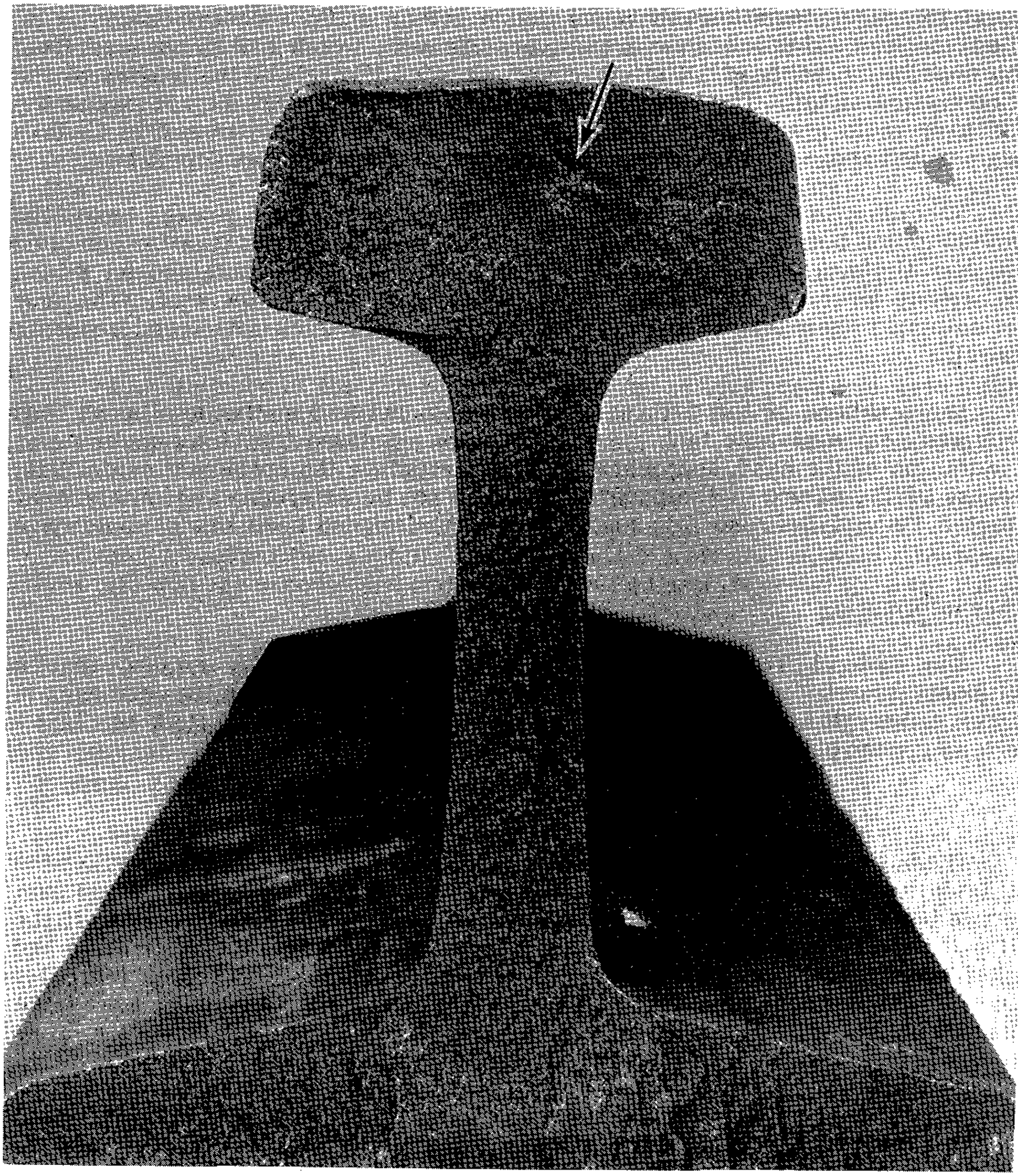

Figure 4. Cross-section of rail section showing nucleus of initial failure.

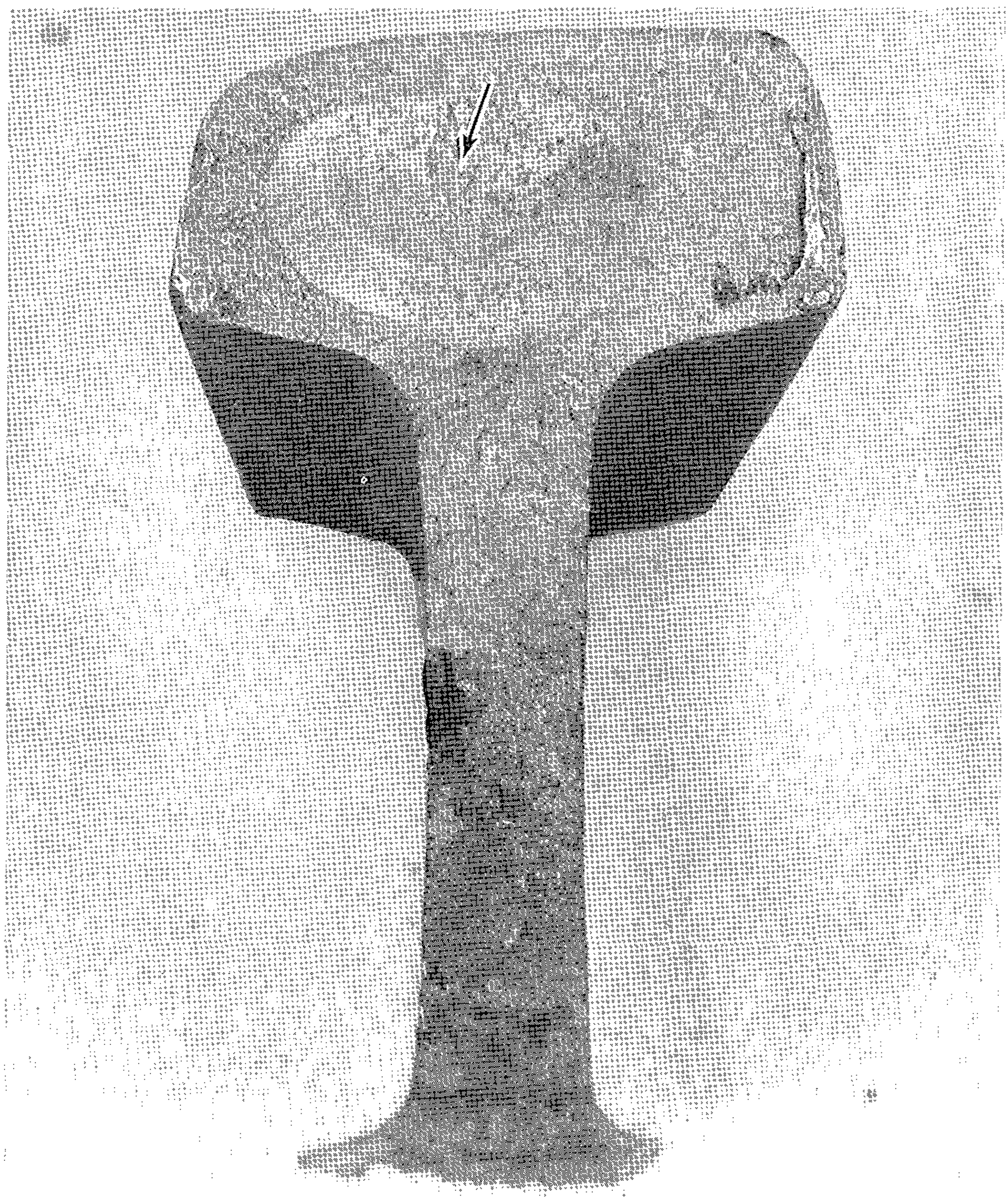

Figure 5. Cross-section of failed rail showing transverse fissure.

For each 10 pounds of rail section, a rail should support a maximum load of about 3,000 pounds per wheel. 2/ The locomotive of Extra 5734 East, like most others used today, placed loads on the rail in excess of 30,000 pounds per wheel, which is about 3,000 pounds per wheel or 11 percent more than what the 90-pound section should carry. The development of transverse fissures is related in part to heavy wheel loads through dynamic forces. 3/ It is not known to what extent the additional loads from dynamic braking of the heavy locomotive contributed to the failure of the rail.

The chemical composition and type of steel and the amount of rail flexing are factors which must be considered. The imperfect support of the rail, particularly where the roadbed met the bridge abutment, allowed constant flexing of the rail. The low temperature might have been a factor in the fracture of the steel.

Considering that this rail had been in service 25 years before the "control-cooled" rail manufacturing process was adopted by American steel mills, it was predictable that fissures would develop and grow rapidly to critical size. The detection of a number of internal defects in other similar 90-pound rails in the area before the accident also should have indicated to the BN that service failure of this rail was probable.

The number and appearance of the transverse fissures in the broken rail suggest that at least some of them should have been detectable when the detector tests were made in July and August. The inclusion in the head of the rail should have been detectable also. BN should review the capability of its rail flaw detection testing, its quality control, and the analysis of its findings. A review of the history of this 90-pound rail, its overstressing by heavy wheel loads, and the tendency of such rail to develop transverse fissures under such service suggest that the rail should have been removed from mainline service.

Federal Track Safety Standards, 49 CFR 213.237, Inspection of Rail, did not require BN to make an annual "continuous search for internal defects" in the rail at Belt. However, BN tested the rail inductively and ultrasonically 4 months before the accident without a positive indication that internal defects (transverse defects or inclusions) were present. Those inspections would have complied with 49 CFR 213.237(a) and (b) for any class of track, but the inspections did not detect the internal defect from which the failure originated.

This accident suggests that the regulations for inspection of rail should be more specific in their requirements. They should consider the many variables which affect the development and growth of internal defects. These variables include, but are not restricted to, chemical composition of the rail; the type, age, and the service life of the rail; the condition of the roadbed and resultant rail

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2/ William G. Raymond, et al., Elements of Railroad Engineering, (New York: Wiley, 1942).

3/ Dr. William W. Hay, "Track Structures for Heavy Wheel Loads," 12th Annual Railroad Engineering Conference Proceedings: Effect of Heavy Axle Loads on Track, Federal Railroad Administration, October 1975.

flexing; and the size and frequency of wheel loads relative to the size of the rail section. The interval of test should consider the past frequency of defect development.

Federal regulations do not require the testing of Class 3 track for rail defects unless passenger trains use the track. This accident suggests that the criteria for testing for internal defects should include not only the class of track but also the class of service to which the track is subjected. In this case the tests in July and August would have complied with Federal regulations even though they did not detect the inclusions and any fissure which might have been there.

In the confusion and fire which followed the derailment, firefighters were unable to determine what the tank cars contained. There was no evidence of an effective BN emergency procedure to notify firefighters of the descriptions and locations of the hazardous materials in the train.

The BN dispatcher learned of the derailment 2 hours before the 5:30 p.m. tank car explosion, and more than 8 hours before the contents of the 11 hazardous materials cars were identified to the firemen. However, he was not able to tell the firechief what was involved because he did not have that information when he first spoke with the firechief about the accident. During a subsequent communication, the dispatcher advised firemen that Christmas trees were involved. The Safety Board, following its investigation of an accident at Glen Ellyn, Illinois, in May 1976, recommended that the Department of Transportation (DOT):

> "Require by regulation that persons performing train dispatching functions maintain a record of trains and cars that are carrying hazardous materials and of current methods of, and procedures for, containment of these materials in the event of a mishap and communicate this information to public safety officials immediately after they learn of a train accident."

Even though the Belt fire department had no formal procedure for marshalling assistance in such emergencies, it cannot be concluded that it adversely affected the outcome of the operation. When the initial derailed car ruptured the gasoline tank, the subsequent ignition of the gasoline and the rapid spread of the fire was inevitable. The response of the neighboring fire departments was as rapid and as effective as could be expected, given the disruption of the telephone service.

The two presumed fatalities are attributed to the gasoline fire that resulted from the impact of a tank car with a gasoline storage tank. The massive property damage resulted from the gasoline fire and the ignition of the LPG that leaked from the 37th car. The presence of other flammable products on the train sustained the fires for approximately 12 hours.

Five persons were burned when the 37th car was punctured near the top of a tankhead, and escaping LPG ignited. The explosion of the 34th car during the fire also increased injury and damages. However, it was not possible to determine whether head shields and shelf couplers could have changed the outcome of the accident because of the variety of damage to the tank cars. Protective head shields and insulation to reduce such losses have been addressed by new regulations issued by the DOT's Materials Transportation Bureau on September 9, 1977.

## CONCLUSIONS

### Findings

1. The defective rail broke under movement of train Extra 5743 East.

2. The 90-pound rail was subjected to more weight than was contemplated in its original design.

3. The rail failure originated in a transverse fissure.

4. The detector car inspection of the rail on July 29, and on August 4, 1976, did not detect the inclusion or any internal defects in the rail at that time.

5. Burlington Northern's track inspection practice exceeded requirements of Federal regulations for Class 3 track that is not used by a passenger train; however, a detectable defect initiated the derailment.

6. The lack of knowledge of the hazardous materials on the train placed the emergency forces in jeopardy.

7. The absence of a documented cooperative emergency arrangement between the Belt fire department and the neighboring fire departments did not significantly affect the final outcome of the catastrophe.

### Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the failure of an overloaded rail section which originated in an undetected transverse fissure.

## RECOMMENDATIONS

As a result of this investigation the National Transportation Safety Board made the following recommendations:

. . . . .to the Federal Railroad Administration:

> "Revise 49 CFR 213.237, Inspection of Rail, to insure the discovery of internal defects in all tracks, Classes 3 to 6, inclusive, before those defects develop into failures. (Class II, Priority Followup) (R-77-29)"

. . . . .to the Burlington Northern:

> "Evaluate the capability of its internal rail defect testing program and make the necessary changes to insure that internal defects are detected before they develop to the failure stage. (Class II, Priority Followup) (Class II, Priority Followup) (R-77-30)

> "Relegate rail section of 100 pounds or less, made of noncontrol-cooled steel, to locations where service failures will not result in catastrophic derailments. (Class II, Priority Followup) (R-77-31)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ KAY BAILEY
Acting Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ WILLIAM R. HALEY
Member

September 29, 1977

APPENDIX A

BURLINGTON NORTHERN INC.
OFFICE OF ENGINEER OF TESTS

Upon Future Reference
Kindly Refer to Report Number

GENERAL TEST REPORT NO. 595-76

ST. PAUL,MINN. December 18, 1976

SAMPLE Failed Rail - Derailment, Belt, MT.

FROM ---- SPECIFICATION NO. ----

G.S.K. REGN. NO ---- P.A. ORDER NO. ----

SENT IN BY Mr. J. Bone, St. Paul TEST REQUEST NO. ----

Mr. B. G. Anderson:
Attn. R. G. Brohough:

In reference to verbal conversation with Mr. J. Bone, the Laboratory received and examined the failed 90-lb rail involved in derailment at Belt, Montana.

Attached Photograph No. 13276 exhibits the failed sections.
Identification - Bethlehem 1909

Initial failure occurred at Section 3 on Photograph No. 13276 from a transverse fissure which had progressed from inclusions in rail head. Attached Photograph No. 13276A exhibits nucleus of initial failure. Leading batter on subsequent sections confirms nucleus. It was evident this rail length had inclusions throughout as noted at Sections 2 and 10. Attached Photograph No. 13276 B exhibits the transverse fissure which had also progressed at Section 10.

| Chemical Analysis of Rail | | AREA SPECIFICATION | | |
|---|---|---|---|---|
| | Failed Rail | 81-90# | 91-/120# | 121#-over |
| Carbon - % | 0.83 | .64-.77 | .67-.80 | .69-.82 |
| Manganese - % | 0.82 | .60-.90 | .70-1.00 | .70-1.00 |
| Sulfhur - % max. | 0.023 | .05 | .05 | .05 |
| Phosphorus - % max. | 0.051 | .04 | .04 | .04 |
| Silicon - % | 0.133 | .10-.125 | 10-.25 | 10-.25 |

Rail conforms closely to specification, except for slight deviation above maximum carbon and phosphorus content.

Inclusions were produced in rail at manufacture and,whenever present, it is common to be found throughout rail length or lengths of same heat. However, due to service life, failure cannot be considered a manufacturer's defect.

Rail will be held at Como Laboratory pending your disposition.

/s/ Dole H. Propp
ENGINEER OF TESTS

File: 020.11

cc: R.E. Taylor
J. A. Bichsel

5 Extra Copies Each
PHOTOGRAPH