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HIGHWAY-RAILROAD ACCIDENT REPORT

Adopted: September 18, 1968

WATERLOO, NEBRASKA, PUBLIC SCHOOL
SCHOOL BUS
UNION PACIFIC RAILROAD COMPANY FREIGHT TRAIN
ACCIDENT
WATERLOO, NEBRASKA
OCTOBER 2, 1967

NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
WASHINGTON, D. C.
20591

F O R E W O R D

This report of facts and circumstances and determination of probable cause by the National Transportation Safety Board arises from an investigation conducted by the Federal Railroad Administration, the Nebraska State Patrol, from observations at the scene by a Member of the Safety Board the day after the accident, and further investigations by the Board. The recommendations made herein, however, are recommendations of the Safety Board

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SYNOPSIS

At 8:10 a.m. on October 2, 1967, a school bus carrying 13 children to school, traveling east on County Road 29 near Waterloo, Nebraska, was driven across an unprotected highway grade crossing 1/ and was struck by a westbound Union Pacific railroad train. The train, composed of a locomotive, 96 empty freight cars and a caboose, was traveling at 56 m.p.h.

The locomotive struck and held the right rear quarter of the bus, dragging it backward, and then deflected it into a communications pole. The rear of the bus body was disintegrated. Four of the children on the bus were killed and the other nine injured. There were no other fatalities or injuries in the accident.

As the locomotive approached the crossing, sounding its horn, the engineer saw the school bus approach the crossing, stop momentarily, and then proceed across the double set of tracks. The horn was sounded continuously, the bell was ringing automatically, and the white, fixed, double-sealed-beam headlight was burning. When the engineer realized the bus was not going to stop again before crossing the tracks, he applied the train brakes in emergency. After striking the bus, the locomotive came to a stop 2,150 feet beyond the crossing.

According to the school bus driver, as he approached the crossing he stopped the bus momentarily, and looked in both directions. He opened the bus loading door, did not see or hear any approaching train, and proceeded

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1/ For the purpose of this report, "unprotected highway grade crossings" are those crossings where there are no devices installed or watchmen in attendance for the purpose of advising motorists and pedestrians of the approach of trains.

across the tracks in low gear as required by the Nebraska school bus standard. He did not know the bus was struck by a train until he got out of the bus after the accident and saw the train on the nearby tracks. The rays of the rising sun, bearing 12° to the right of the road, were shining almost directly into his eyes and his vision was impaired by the bright sun. He was not wearing sunglasses. Photographs taken of the school bus after the accident revealed that a transparent sun visor was in the down position.

The children on the bus said they did not hear or see the approaching train until it was just a few feet from striking the bus.

A witness heard the horn and saw the headlight of the approaching train, saw the school bus approaching the crossing, saw the "dust" from the sand being dropped by the locomotive braking system, saw the sparks fly from the locomotive wheels as the brakes were applied, and saw the locomotive strike the school bus. He could not state whether the school bus had stopped before entering the grade crossing.

The probable cause of this accident was the failure of the school bus driver to ascertain that there was a train approaching the grade crossing and to hold his vehicle until the way was safe for passage.

Contributing causes of this accident were the selection of a school bus route which required passage over an unprotected railroad grade crossing; the lack of guidelines for the selection of school bus routes, including required analysis of routes for hazards and adoption of procedures for apprising drivers of existing hazards and how to handle them; the direct and reflected glare of the sun which created a vision problem in the bus; the low audibility of the train horn within the bus while the door was open or closed; and the absence of any warning device to advise the driver of the approaching train.

Possible contributing causes of this accident were the height of the stop sign and the "2 TRACKS" advisory sign which could have obstructed the driver's view of the approaching train; the lack of contrast between train headlights and bright daylight which reduced the effect of the headlight as a visual attention-getting warning system; and the speed of the train in excess of a railroad order requiring a slower speed for traffic flow purposes.

I. FACTS AND CIRCUMSTANCES

A. Description of Accident

1. Events to Moment of Impact

The school bus was being used to transport school children to the Waterloo Public School, which is located near the crossing of County Road 29 over two main line tracks of the Union Pacific Railroad Company, one-quarter mile northwest of Waterloo, Nebraska. The last regular stop for the school bus prior to the accident was made at a home located 1,500 feet west of the crossing. It then continued east on County Road 29 to the crossing.

As he approached the crossing, the bus driver stated that he could not see ahead very well due to the glare of the sun and that he had the windshield sun visor down. He was not wearing sun glasses.

He stopped the bus "with its front at the stop sign at the crossing" (located 30 feet from the nearest rail), opened the boarding door to his right, and did not hear the sound of the horn coming from the approaching train. Due to the angle of approach of the bus to the crossing, he was not able to see along the tracks through the open door. He was able to see the highway viaduct located southeast of the crossing (1,384 feet), but he did not see the approaching train. (Refer to Illustration No. 2.) He claimed that after making the stop, opening and closing the door, he proceeded to drive the bus over the crossing in low gear. He neither saw nor heard the approaching train and did not know a train was involved until he got out of the bus after the accident and observed the train standing on the tracks.

As the bus crossed the westbound tracks, he felt the back end sliding off the road to the left. The noise from the engine of the bus had a tendency to drown out other noises. He intimated that this noise prevented him from hearing the train horn.

The engineer and front brakeman were in the control compartment at the front of the first locomotive. According to the engineer, the headlight was burning, the locomotive bell was ringing automatically, and the prescribed signal on the locomotive horn was sounded as the train approached and moved over two street crossings at grade in Waterloo. These warning devices were still being operated as the train neared the highway viaduct, located 1,384 feet southeast of the crossing, and throughout the approach of the train to the crossing.

When the locomotive was in the vicinity of the highway viaduct, both the engineer and front brakeman saw the school bus come into view from behind some trees along the county road from their left. The engineer said that the bus was slowing down and then stopped at the eastbound main line track. The bus started across the tracks right into the path of the train. The engineer was blowing the horn and when he saw that the bus was not going to stop again, he slammed on the emergency brake. At this point, the locomotive was approximately three railroad car lengths from the crossing, according to the engineer. (See Appendix #1.) The engineer's first impression was that the locomotive was going to hit the bus "dead center," but he later felt that the train must have slowed somewhat because it struck the bus just forward of the right rear wheel. The locomotive of the train came to a stop 2,150 feet beyond the crossing.

The engineer states that his eyes were on the bus continuously, and he was sure that the door of the bus was not opened when the stop was made.

Three of the children who were on the bus were interviewed by a deputy county attorney on the day of the accident. One boy, aged 13, stated that the bus slowed down to almost a complete stop before crossing the tracks, that he first knew there was a train on the tracks when it was within eight or nine feet of the bus, and that he never heard a horn or a bell, but he did see a light on the train. He said there was not much noise within the bus. Two younger boys, aged 10 and 11, both stated that the bus did stop. Another boy, aged 6, was interviewed by an attorney and a deposition was taken more than 5 months after the accident. He stated that the bus stopped for the crossing, that the door was not opened, he heard the train horn two times, and he saw the train when it was very close -- before it hit the bus.

There is one known witness who was not involved in the accident. He is a truck driver who was driving a cattle truck southeast toward Omaha on U. S. Route 275 which runs parallel to the Union Pacific tracks for a portion in the vicinity of the accident.

The witness had just stopped his truck on the right shoulder of the road and was standing outside of the truck when his attention was attracted by the sound of a train horn. He could not see the train at that time, but after he heard the horn several times, he saw the headlight of the locomotive and then the locomotive approaching from under the viaduct. He looked to see why the horn was being blown and noticed the school bus approaching the crossing from his right. The witness, who at one time had been a railroad track hand, stated during his first interview on the day of the accident that he first heard the train horn when the train was "about 200 yards" past the viaduct as it was approaching the crossing. At another time during the same interview, he stated that he first heard the horn when "10 to 15 cars" had passed under the viaduct. He estimated the speed of the approaching train to be 50 to 60 m.p.h. He indicated that he saw the dust from the sand being dropped by the locomotive and the "fire" from the wheels when the train was 300 to 400 feet from the crossing. During a later interview, he stated that he saw the dust when the train was about halfway from the viaduct to the crossing (approximately 700 feet). The truck driver saw the train hit the bus, but he could not state whether the school bus had stopped before entering the grade crossing.

The witness stated that he was "behind the crossing," 500 to 600 feet from the point of the collision, meaning that he was on the opposite side of the crossing from the train as it was approaching. The school bus driver said he did not see the train or its white, twin, fixed, sealed-beam headlights. The truck driver witness, who was at least 500 feet further away, with the sun coming from his left, saw the train and its headlights quite clearly.

2. Impact Dynamics and Sources of Injury

In this accident, at the moment of impact, the school bus[1/] was proceeding east in low gear at a speed of about seven to nine m.p.h., while the train was proceeding northwest at a speed of approximately 56 m.p.h.

1/ See page 12 for a complete physical description of the school bus.

The train thus impacted the bus at a glancing angle while the bus was moving in a direction which tended to carry it forward and away from the point of impact. (See Illustration No. 3). At impact, forces were generated by friction and by direct physical engagement, abruptly halting the forward motion of the bus while accelerating its rear end in the direction of travel of the train. The bus was then rotated so that the longitudinal axis of the bus first became parallel with the train, and the rotation continued until the bus had achieved a significant backward velocity and the rear of the bus was turning away from the train.

During this rotational and pulling movement, the rear structure of the bus was being destroyed by detailed contacts with portions of the proturberances on the front of the train. Significant separation and disintegration of the vehicle structure occurred during the rotational and backward movement sequence of the collision.

At a time after the bus had commenced its rotation, the left-hand side of the bus struck and broke off a vertical wooden support of a crossbuck sign beside the road, producing a localized collapse which did not invade the passenger compartment. After the rotation had progressed to a sufficient degree, the bus became disengaged from the front of the train, and after some additional rotation away from the axis of the train's movement, the rear end of the bus struck a communications pole beside the right-of-way. This impact stopped the backward motion of the bus in approximately 18 to 24 inches. The front end of the bus had been pulled approximately 6 feet from the shoulder of the road at the time the bus stopped against the pole. (See Illustration No. 3).

When the impact with the pole occurred, a large portion of the rear of the bus, including the side, window posts, floor, rear seats, and emergency door, continued backward away from the direction of the train. This portion had been loosened and partially detached by the initial impact and appeared to have rotated around the relatively rigid pole. At least four seats and other components of the bus were projected approximately 50 feet to the rear of the bus, or were dropped there by the train.

The detached wreckage included the entire floor aft of the rear axle, portions of the right rear side of the bus, the backwall, including the emergency door, and four seat frames. The left end of the backwall separated from the left sidewall of the bus along a near-vertical line. The metal fasteners were torn out with minimal localized distortion of the sheet metal.

The backwall of the bus is connected to the roof by a curved sheet metal header panel. This header panel, almost entirely undistorted, was completely separated from the backwall due to pulled out rivets and was left hanging from the roof by only a few rivets.

The floor in the detached wreckage was made up of two rectangular sections. Each section carried two seats. The abutting sections of the floor were fastened to the frame rails, but not to each other. Under impact, these sections retained their general shape, but separated from the rails and from each other. The left ends of these floor sections separated from the left side wall of the bus without causing any appreciable distortion.

As a matter of engineering structural principles, distortion of separate adjoining parts in a structure which has been heavily stress loaded indicates that forces have been transmitted between the parts during the stress loading and that the different parts carried a proportion of the load applied. Conversely, lack of distortion within a part means that the part was not subjected to the high load; that the fastenings were weak; and that the full integrated structural strength was not obtained.

Part of the bus structure, including one windowpane, at least one window post, and longitudinal structure was struck and held by the front of the locomotive and remained there after the impact. (See Illustration No. 4.) Detailed areas of the train caused specific forms of damage. The first point of contact between train and bus was at the outermost vertical edge of the fourth post from the front door of the bus. The next contact was the front surface of the right footboard of the locomotive which struck the right rear dual wheel of the bus, catching and indenting the rim. This rim contact created the forceful pull on the bus frame to the rear, rotating the main chassis of the bus.

The body of the bus forward of the initial point of impact was relatively intact and showed little deformation. Windows were mostly unbroken, except for the very large curved glass windshield which was supported in a rubber mounting gasket around its entire periphery and was expelled from its frame. (See Illustration No. 1.)

The left wall of the bus was bent away from the impacting force of the train, but the rear frame of the bus was bent toward the train impact point. This difference was the result of the second impact of the rear of the bus against the communications pole. It is deduced that the frame rails of the bus were not deflected from their normal position by the train impact, and that part of the destruction caused by the train impact was limited to the added-on body of the bus.

This bus was constructed as a separate body mounted on a modified truck chassis, and the body of the bus was made of much lighter materials than the chassis frame. The Board has observed that this mode of construction is typical of current practices in school bus manufacture.

With few exceptions, the sheet metal sections of the body did not fail internally, but separated along their lines of connection. The most frequent form of failure was the pulling out of rivets.

Spacing between rivets varied from two inches to as much as nine inches between rivets, as measured on another bus of the same model, so that the full strength of joining was not obtained. Welds in body structure which failed included some which had been welded over only a portion of the available length of contact. The majority of failures at welds were through welds, not in parent metal, again accompanied by little or no distortion of nearby structures. The wreckage includes numbers of highly significant examples of failures in which the general shape of sheet metal remained, but the parts have separated. (See Illustrations No. 5 and No. 7.).

The bus was equipped with a so-called "impact rail" of 14-gauge steel which extended fore and aft along the sides of the bus directly below the line of the windows. This rail on the left side of the bus also failed without distortion at a joint and appeared not to have lent any support in the crash.

The sources of physical injury to the children could not be pinpointed. The acting coroner's report indicated only that all four fatalities resulted from "massive internal injuries," and there were no autopsies. Consequently, there is no evidence or available record to indicate the nature or source of the injuries of those killed or injured. The forward end of the bus underwent relatively low accelerations. The four fatally injured children were seated in the rear of the bus which was disintegrated and which underwent relatively high acceleration as a result of direct impact.

B. Description of the Accident Site

1. The Public Highway

County Road 29 is a two-lane gravel-surfaced highway, 14 to 16 feet wide. It is straight for 1,500 feet west and 350 feet east of the crossing. The highway at the scene runs due east and west and intersects the railroad at a 33° 42' angle. The average grade of the eastbound road is 2.3% ascending for 250 feet before the crossing, increasing to 4.4% (2.6°) in the last 100 feet. (See Illustration No. 3.)

The effective width of the gravel roadway between the tracks is 14 feet 10 inches. There is a slight leftward curving of the highway within the crossing. Heavy planking is laid on both sides of the rails on each track, two exterior and one interior, and the area between the planks of each track is paved with bituminous material. There was a shallow hole in the paving of the westbound track approximately 1 foot wide near the center of the roadway. At the edge of the roadway between the two tracks, there is a slight but abrupt dropoff to the level of the ties.

2. The Railroad Right-of-Way

The accident occurred on part of the Nebraska Division of the Union Pacific Railroad Company which runs between Council Bluffs, Iowa, and Grand Island, Nebraska. In the area of the accident, it is a double track line. The train was traveling on the right-hand track relative to its direction of travel. The two sets of tracks at the scene are approximately 20 feet apart.

The tracks run straight and level in a west northwest direction as they approach the crossing. They pass under a viaduct for U. S. Highway 275 at a point 1,384 feet east southeast of the crossing. There are no view obstructions along the railroad right-of-way from the viaduct to well beyond the crossing.

In the area, train traffic is directed by the signal indications of an automatic block-signal system, supplemented by a visual and audible automatic signal system in the cabs of locomotives.

3. Warnings Provided to Motorists at the Highway Grade Crossing

This was an unprotected highway grade crossing. There was a railroad approach warning sign lying on the ground to the right of County Road 29, 380 feet west of the crossing. In its displaced position, this sign was not visible to approaching vehicles. A stop sign is located 6 feet to the right of the highway and 30 feet west of the nearest rail when measured in a parallel plane to the roadway. A standard crossbuck sign bearing the words "RAILROAD CROSSING" is located 4 feet to the right of the highway and 24 feet 7 inches from the nearest rail. At approximately half the height of the crossbuck post, there is attached a two-level sign indicating "2 TRACKS" in black letters on a white background. Two similar signs are installed on the opposite side of the crossing. (See Illustration No. 2).

There was no stop line displayed on the highway at the crossing. The regulation stop sign was 22 inches in diameter and mounted on a metal post. The top of the sign was 7 feet 4 inches above ground level.

4. <u>Vision at the Grade Crossing</u>

As eastbound traffic on County Road 29 approaches the crossing, the view of trains approaching from the east southeast is obstructed by trees to the right until the train reaches a point 320 feet from the crossing. The view is then partially restricted by bushes to a point within 170 feet of the crossing. The view is then fairly clear except for partial restriction by a row of communications poles (which are approximately 100 feet apart) located along the right-of-way. The nearest pole is 90 feet from the crossing when measured on a parallel plane with the highway. As a vehicle moves toward the crossing, the view becomes increasingly restricted due to the venetian blind effect provided by the alignment of the poles to a point less than 90 feet from the crossing. In the last 90 feet before the crossing, the view down the tracks in the direction from which the train was approaching is unobstructed for over 1,400 feet except by the stop sign, the crossbuck post, and the "2 TRACKS" sign on the crossbuck post. (See Illustration No. 2.) Both the stop sign, which was installed diagonally to the direction of the highway, and the crossbuck would have completely blocked the bus driver's view of the approaching train if he happened to stop the bus so that either was in the path of his view toward the approaching train.

At the time of the accident, the sky was clear and the road and track surfaces dry. There was no haze reported in the area.

The altitude of the sun was 8° above the horizon in the direction of 12° south of east. This placed the sun 12° to the right of the straight-ahead line of vision of the driver, and would have required the sun visor's lower edge to be no higher than 8° above the driver's eye level to shade his eyes. The visor would have to have been even lower to insure placing the eyes in shadow while the bus was moving.

According to U. S. Weather Bureau observations made approximately 15 miles from the scene at 7:52 a.m., on October 2, 1967, the sky was clear, visibility was 9 miles, the temperature was 65°, and the wind was from the north northeast at 11 miles per hour.

C. Condition and Type of School Bus and Train

1. The School Bus

The school bus was a standard type of school bus, having the engine mounted in front under an extended hood. The chassis was a 1964 International Schoolmaster, model 1603, with a wheel base of 217 inches. It was equipped with an International 8-cylinder V304 engine with a certified net horsepower of 180, and a four forward speed manual transmission. The low gear and reverse were not of the synchronized type, so that it would have been difficult to shift from a higher gear to the lowest gear without stopping the bus. It was also equipped with a two-speed differential at the rear axle.

The body of the school bus was manufactured by the Carpenter Body Works, Inc., Mitchell, Indiana. It was a model CV2409 designed to seat

54 passengers, three to a seat in two rows of nine seats each. There was an aisle 12 inches wide through the full length of the passenger section of the body, and two doors, one of the folding type at the right front for boarding and alighting, and one at the rear center for emergency use. Both doors opened outward.

According to the body plans provided by the manufacturer, the eyes of an "average" driver would be 23 inches from the windshield on a horizontal plane and 41½ inches from the top of the floor when he is seated with the seat in the center position. The curved untinted glass windshield was built in two sections with a mounting divider in the middle. Each curved side joined the body at a point 7 inches rearward of the center mounting divider. The windshield was also designed and installed to have a curving slant progressively inward toward its attachment to the body near the roof, having a maximum angle 16° 45' from the vertical.

As related to the accident scene (assuming that the bus was stopped with its axis parallel to the direction of the roadway in the area of the stop sign), the driver had a clear area of visibility through the right-hand windshield in the direction from which the train was approaching by looking to the right at approximately a 30° angle.

Considering the direction of travel of the bus as the reference axis at the driver's eyes, the center mounting windshield divider was 22° to the right, and then there was an area of clear visibility from 22° to 69° to the right.

Photographs of the bus after the accident showed a tinted, transparent plastic sun visor extended downward. A larger opaque visor was turned upward.

It could not be determined from available evidence whether the sun visor was adjusted to its lowest position or whether the lowest position was adequate to shield the driver's eyes.

The bus hood was painted with a high gloss yellow paint, providing a highly reflective surface. The varied curvatures of the surfaces on the hood provided many points of angular orientation that would result in some reflection of the sun's rays into the driver's eyes. (See Illustration No. 7.)

2. The Freight Train

The train, designated by Union Pacific as Extra 708 West, consisted of a diesel-electric locomotive, 96 empty boxcars, and a caboose. The gross weight of the train was 2,981 tons.

The locomotive consisted of two diesel-electric units bearing company numbers 708 and 711, coupled for multiple operations and controlled by the engineer from his position in the lead unit, number 708. Locomotive Unit No. 708, a model GP (for general purpose) 30, is known as a road-switcher type. It is designed to develop 2,500 horsepower and was built in 1963 by the Electro-Motive Division of the General Motors Corporation. It is the hooded type construction with the engineer's position located 13 feet from the front end in the right side of the cab. It was equipped with twin, white, sealed, fixed-beam headlights.

Both ends of such a general purpose or road-switcher locomotive are designed to permit it to be used in switching service; consequently, numerous exposed appliances and appurtenances are attached to the ends to facilitate the picking up, setting out, and switching of cars. No change had been made in the frontal configuration of unit 708 since it was received from the manufacturer.

The air horn on the locomotive was mounted on top of unit 708 at the rear. There were three trumpet bells in the horn assembly, two long bells facing the rear and one short bell facing forward. The parts list provided by the locomotive manufacturer indicates that such an arrangement is standard, but does not indicate any particular placement for the horn assembly on the locomotive. The placement is determined by the purchaser.

Instructions issued by the manufacturer of the horn indicated that the horn assembly could be installed in any desired arrangement. The horns on unit 708 were originally installed on top of the cab at the front, but were moved to the rear so that they would be kept warm by the heat from the engines in order to prevent their freezing. Horn arrangements on the locomotives operated by the Union Pacific vary. Some have the two long bells pointing forward and the short bell facing rearward. The Board has no evidence concerning the acoustical effectiveness of the horns facing in either a forward or rearward direction. This aspect was not explored by the R. C. Coffeen Company in their analysis which is discussed later on in this report.

During the Federal Railroad Administration investigation of the accident, the location, assembly, and audibility of the horn on unit 708 were reviewed. Inspection of the horn assembly revealed all parts in good working order. Standing and running tests under weather conditions comparable to the time of the accident were made. The horn was heard by persons standing in the open at a distance of three-quarters of a mile away.

On the day following the accident, the horn of a similar locomotive approaching the crossing where the accident occurred could not be heard by persons (including an observing Member of the National Transportation Safety Board) seated in a similar bus with the door closed until the train was within 400 to 500 feet of the crossing.

The R. C. Coffeen and Associates, Consulting Engineers in Acoustics and Audio, conducted a "Locomotive Whistle Sound Analysis" at the request of the Union Pacific Railroad Company for the purpose of investigating locomotive whistle sound, school bus noise, and school bus outside-to-inside sound transmission loss as these items relate to the freight train - school bus accident which occurred at Waterloo, Nebraska.

According to their report, dated February 1968, calibrated recordings were made of a locomotive whistle sound as the locomotive approached and passed the grade crossing at which the accident occurred while the locomotive was moving at 58 m.p.h. The same locomotive involved in the accident was used in this test. Also, calibrated recordings were made of the noise generated by the idle of the engine of a 1964 International 54-passenger school bus.

The report indicated that the data collected and its analysis strongly support the proposition that the bus driver, with the bus door closed, could hear the train whistle for a period of approximately 6 seconds or 510 feet prior to the locomotive's arrival at the crossing. With the front door of the bus open, the whistle could be heard for a period of approximately 13½ seconds or 1,150 feet away.

An airbrake test and car inspection were made on the train at 4:30 a.m. on October 2, 1967, at Council Bluffs, Iowa, several hours before the accident.

All brakes were found to be functioning properly according to the Union Pacific personnel who made the test and inspection. Shortly after the accident, the train was moved to a siding and the brakes were tested and inspected by an inspector of the Federal Railroad Administration. He discovered one car with inoperative brakes and six cars which had excessive brake piston travel. The inspector reported the brakes as being 93% effective which is in excess of the minimum 85% requirements of the Federal regulations. This means that brakes were operating on 93% of the cars, and does not relate to effectiveness designed into the individual car brakes when operating. During the emergency stop, the train separated between the 39th and 40th car due to an unknown cause.

D. The Bus and Train Operations Involved

1. The School Bus Operation

The school bus was owned and operated by the Waterloo Public School, Waterloo, Nebraska. The principal of the public school supervises the operation of the single school bus used for transporting school children to and from school and to special activities. The principal reports to a Board of Education which is responsible for the operation of the public school.

2. The School Bus Route

The route used to pick up the 13 children who were on the bus at the time of the accident involved stops at four locations. The route traversed two unprotected highway grade crossings, The crossing at which the accident occurred was approached in the morning while traveling almost directly toward the sun. The approximate distance of this portion of the route was 3 miles. The route could have been modified to avoid both unprotected highway grade crossings. The alternate route would increase the length of the route an additional 7½ miles. The alternate route is based on the use of the U. S. Highway 275 Viaduct over the Union Pacific Railroad tracks located near the school.

3. The Train Operation

Extra 708 West, following the required brake examination and tests, was prepared and ready to leave Council Bluffs at 4:35 a.m. on the morning of the accident, but was held due to difficulties involving another train 5 miles to the west. After more than a 2-hour delay, it left the yard's limits at 7:40 a.m.

Union Pacific's Train Order No. 4, dated October 2, 1967, at 3:43 a.m., directed the conductor and engineer of Extra 708 West not to exceed 50 m.p.h. from Summit to Grand Island. Waterloo is located between Summit and Grand Island. The purpose of the speed limitation was to provide a uniform flow of traffic.

Two days after the accident, the speed recorder and speed indicator were removed from locomotive unit 708 and calibrated to determine their accuracy. The tests, made by a Union Pacific Airbrake Foreman, "showed the speed indicator and speed recorder to be accurate."

An analysis of the speed-recorder tape taken from the recorder on unit 708 indicated that the train was operated at speeds in excess of 50 m.p.h. prior to the accident. This was contrary to the speed restrictions imposed by the train order. The tape indicated that the train was being accelerated and had reached a speed of 56 m.p.h. immediately prior to the emergency application of its brakes at the accident scene.

E. The Operating Experience and Conditions of the Engineer, Brakeman, and School Bus Driver

1. Engineer and Brakeman

The engineer, Glenn D. Peterson, was 47 years of age and had been employed 19 years by the Union Pacific Railroad Company. He was requalified physically by examination on January 18, 1967. His employment record with the company indicates that he has never been the subject of any disciplinary action since the time of his first employment in 1945.

The brakeman, Weldon L. Nybbelin, was 48 years of age and had been employed by the Union Pacific Railroad Company for 32 years. He was last requalified physically on June 30, 1967. His personnel record also indicates no disciplinary action taken by the company.

According to their time records, both the engineer and front brakeman had been on duty continuously for 4 hours 40 minutes prior to the accident, following off-duty periods in excess of 10 hours.

None of the crew was injured in the accident.

2. The School Bus Driver

The driver of the school bus was Thomas McMahon, aged 28, 5 feet 9 inches tall, residing in Waterloo, Nebraska. At the time of the accident, McMahon held a valid Nebraska Operator's License and a State of Nebraska School Bus Driver's Permit which was issued on September 8, 1967.

According to Nebraska Motor Vehicle Department records, McMahon had his annual examination to redetermine his qualifications to drive a school bus on August 17, 1967. The report of examination reveals that he had 20/20 vision in both eyes, was not color blind, and had satisfactory ratings for vertical balance, lateral balance, and stereopsis. He also passed the required test concerning laws and regulations, and driving ability.

On August 25, 1967, McMahon was the subject of a school bus driver's annual physical examination by a licensed physician, as required by the Nebraska Department of Education. The record of this examination indicated that he had 20/20 vision in both eyes, uncorrected, and that he had a horizontal field of vision totaling 180^{o}. The remainder of the examination disclosed no evidence of physical deficiencies.

Mr. McMahon is a high school social studies teacher and had just begun his third year of teaching in Waterloo several weeks before the accident.

Mr. McMahon had been driving the same bus over the same route that was taken the day of the accident since the middle of the 1966-67 school year. He is regarded as a person of excellent character in the community. During an interview, McMahon stated that he had spent the evening before the day of the accident at home with his family and had retired after watching a 10 p.m. television news program.

F. Motor Vehicle and Railroad Traffic at the Crossing

A traffic count taken for a period of 24 hours, beginning at 12:01 a.m. on October 11, 1967, revealed that 147 motor vehicles moved over the crossing. During the 30 days preceding the day of the accident, the average number of daily railroad movements over the crossing was 33.7 trains.

G. Prior Accidents at the Grade Crossing

Mr. Thomas P. Ryan, Director of the Nebraska State Accident Records Bureau, Lincoln, Nebraska, was requested to furnish data concerning previous accidents at the County Road 29, Union Pacific Railroad grade crossing. He explained that the State Accident Records Bureau is relatively new. They have records of all fatal accidents in their system; however, injury and property damage accident records are not available for years prior to 1963. In addition to the subject accident, the records show two prior accidents:

<u>March 8, 1963</u>. Mrs. Leone Kaiser of Waterloo, Nebraska, crossed the Union Pacific Railroad tracks on County Road 29 during the morning hours. As she was crossing the tracks in an easterly direction, her car was struck by a westbound train. The report indicated that Mrs. Kaiser said she could not see the approaching train due to the sun glare on her windshield. She was injured.

<u>June 9, 1964</u>. Mr. Raymond L. Nelson, driving a gravel truck east on County Road 29, was struck and killed by a westbound train as he crossed the Union Pacific Railroad tracks at 1:15 p.m. He had crossed this crossing approximately 14 times that same day. He was following two loaded gravel trucks at the time of the accident. The report indicates that witnesses felt Mr. Nelson's vision was obscured by dust flying from the trucks ahead of him.

II. APPLICABLE LAWS, REGULATIONS, OPERATING RULES, AND STANDARDS

A. School Transportation

1. Nebraska Law

Section 39-724(2) of the Nebraska laws governing the use of public roads requires: "Except at railway grade crossings where a flagman, police officer or traffic-control signal directs traffic to proceed, the driver of any *** school bus carrying any school child *** shall before crossing any track or tracks of a railroad, stop such vehicle within 50 feet, but not less than 10 feet, from the nearest rail of such railroad, and, while so stopped, shall listen and look in both directions along such track for any approaching train and shall not proceed until he can do so safely."

Section 39-729 confers upon the local county boards and State highway departments the right to erect stop signs at railroad crossings where they intersect highways.

The statute further requires that, " *** all vehicles entering or crossing railroad crossings at which stop signs are erected, shall come to a full stop *** ."

Nebraska statutes require that school bus drivers submit annually to an examination conducted by a driver's license examiner of the Department of Motor Vehicles and to an examination by a licensed physician to determine whether they meet physical and mental standards. Persons may not operate school buses in Nebraska unless they possess a special school bus operator's permit issued by the Director of the Department of Motor Vehicles.

The Nebraska State Board of Education is empowered to adopt reasonable standards governing the general design, equipment, color, operation and maintenance of school buses, and to adopt standards for the operators of school buses. The authority is found in section 79-328 of the Nebraska School Laws.

2. Standards

The minimum standards for school buses were adopted by the Nebraska State Board of Education and made effective on January 1, 1962. The standards include minimum requirements for school bus chassis and bodies similar to those recommended by the National Conference on School Transportation.

Nebraska standards concerned with the operation of school buses effective at the time of the accident include one section which deals with "Safe Stops for Railroad Crossings," and states among others, the following requirements:

"1. Use the engine as a brake to slow bus down. Do not coast.

"2. Stop the bus within 50 feet, but not less than 10 feet, from the nearest rail of the railroad crossing.

"3. While stopped, listen and look in both directions for an approaching train.

"4. When safe, proceed across tracks in low gear. Do not shift gears while crossing tracks."

A publication titled "Handbook for School Bus Drivers" (tentative) was distributed early in 1967 by the Nebraska Department of Education. It included many of the standards adopted by the State Board of Education in

1962, with some additions to or changes in the section titled "Railroad Crossings". Portions of the section are quoted as follows:

"Crossing railroad tracks is a hazardous driving maneuver for any vehicle. The situation is even more critical when a school bus must necessarily cross railroad tracks, since the lives of as many as 60 youngsters could be in jeopardy. The safety of these young boys and girls has placed a grave responsibility on each and every school bus driver."

"1. Approach the tracks with caution.

*****

"3. Command the cooperation of your passengers in an effort to control the noise. Demand cooperation if necessary.

*****

"5. After the bus is stopped, open the door, listen, and look in both directions. If the tracks are clear, proceed in a gear low enough to permit crossing the tracks without having to shift.

"6. When two or more tracks are to be crossed, do not stop a second time unless bus is completely clear of first crossing and has 10 feet clearance in front and back."

The Board understands that approximately 4,500 copies of the handbook were distributed and that each school district in Nebraska, including the Waterloo Public School, was sent one or more copies. The contents of this publication had not been adopted by the Nebraska Department of Education and therefore did not carry the weight of a standard or regulation. It was distributed for the purpose of obtaining reactions and comments.

B. Operating Rules of the Railroad

The operating rules of the Union Pacific Railroad Company require that the whistle (horn) of all trains must be sounded when approaching all public crossings. The prescribed sequence of the sounds is two longs, one short, and one long. The duration of the signals must not be less than 10 seconds. (Rule 14.)

Headlights must be displayed, burning brightly at all times, during the day and night. (Rule 17).

The engine bell is required to be sounded when approaching and passing over public crossings. (Rule 30).

Each member of the train crew located in the cab of the locomotive is required to communicate verbally with the other members should any condition arise which may affect the movement of the train. (Rule 34).

Train orders affecting movement of trains must be respected by conductors and engineers of trains affected. (Rule 220(B).

The above operating rules are admistrative regulations of the Union Pacific Railroad. There are no corresponding Federal regulations or Federal authority relating to the above operating situations.

C. Federal Regulations - Transportation

Standards for power brakes on railroads are set forth in the "Code of Federal Regulations Title 49 - Transportation." Chapter I of Part 232 sets forth the minimum requirements as follows:

"§232.1. Power brakes; minimum percentage. On and after September 1, 1910, on all railroads used in interstate commerce, whenever, as required by the Safety Appliance Act as amended March 2, 1903, any train is operated with power or train brakes, not less than 85 percent of the cars of such train shall have their brakes used and operated by the engineer of the locomotive drawing such train, and all power-brake cars in every such train which are associated together with the 85 percent shall have their brakes so used and operated."

III. ANALYSIS OF CAUSAL FACTORS

General

This is a very complex accident, and many significant factors contributed in a causal way to the occurrence of collision and to fatal injury when the collision occurred. A full statement of the facts and circumstances of the accident requires identification of all significant factors and their relationship to the accident. The causal factors are summarized and their relationship is diagrammed in the Causal Factor Outline in the Appendix. This analysis concentrates on causal factors that have the greatest significance in explaining the accident or which are closely related to desirable corrective measures.

School Bus Route Selection

The bus route selected by the school authorities required passage over two unprotected railroad grade crossings. The crossing where the accident occurred was not protected by audible, visual, or mechanical signal devices to warn motorists of the approach of a train. There are many crossings of this type in rural areas.

Because of its low vehicle traffic count, this crossing probably received a low priority consideration for automatic warning signaling devices by authorities; yet it had experienced two accidents in the previous 5 years, against a national average of one accident in 54 years per railroad crossing for all types of crossings.[1/] For any one vehicle which uses a crossing, the density of train traffic is the more significant

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1/ "Factors Influencing Safety at Highway-Rail Grade Crossings," Volume 1, by Alan M. Voorhoos and Associates, January 1967.

measure of hazard, and the hazard could have been reduced by using an available alternate route having no grade crossings.

An alternate route which would have avoided all unprotected grade crossings was not selected. Use of the alternate route would have increased the length of each trip over the route from 3 miles to 10½ miles. Thus, if those responsible recognized the hazard and the possibility of an alternate safer route, an economic judgment still would have been necessary.

The standards for school bus operation adopted by the Nebraska State Board of Education did not include any directions or criteria for route selection, nor did they require an analysis of selected routes for possible hazards. Route analysis and selection has been increasingly recognized as a necessary part of systematic management of school bus operation, but the techniques are not universally employed as yet. Route selection also appears as a factor in that the hazardous crossing on the route coincided with the time of day and direction for sunlight to interfere with vision.

School Bus Driver Did Not See Train

The duration of the stop of the bus at the crossing was short as indicated by the statements of two witnesses and the analysis in the Appendix. Consequently, after the driver had performed the necessary mechanical functions of stopping the bus and preparing to start again, there was very little time remaining for him to overcome the visual problems he encountered and to perform an adequate visual search of the area for an approaching train.

The fact that the driver did not see the train was contributed to by two vision problems. The first problem was a variety of effects from sunlight streaming in from almost directly ahead. This was possibly complicated by direct vision obstructions from the highway stop sign and the "2 TRACKS" sign. In this connection, after the accident, the driver said he could not see very well due to the glare of the sun and analysis indicates this was highly probable. The glare-reducing transparent visor was not the more effective visor of the two visors which could have been brought into play by the driver. The completely opaque visor would have reduced further the contact of the sun with the driver's eyes, but there is no standard which presently controls the characteristics or selection of one or the other visor. Indeed, it may be impossible to reach an objective decision as to which visor was preferable.

The second problem was the upward inclination of the road, tending to move the shadow of the visor and to allow the sunlight to strike directly into the driver's eyes. This has been noted in analysis as a possible surprise factor tending to blind the driver, but there is no way to determine whether this condition actually occurred. The change in angle and other glare problems are diagrammed in Illustration 7. The visor arrangement on the school bus was actually superior to that generally found in most passenger cars and most trucks, and the visor design alone is not considered a cause of the accident.

The reflections from the top of the hood have not been concluded to be a major factor in vision reduction, but they could have contributed to the general glare problem. It has been speculatively proposed in the past[2] that a lower visor to guard against hood top reflections be installed in vehicles, but this has not been done, and other simple corrections are available as indicated in Recommendations.

The front of the vehicle being dusty, it may be presumed that some road dust would have settled upon the windshield of the bus. No observations were made of this factor in the investigation, but even a small amount of dust produces some obscuration of vision when strong light shines upon the dust. This factor is included to explain a small part of the vision difficulty. Installation of windshield washers in buses could help overcome this problem where it exists.

The railroad crossbuck sign has been a standard railroad crossing warning for many years. The post of this sign or the added "2 TRACKS" sign could have directly obscured the driver's vision in the portion of the track from which the train was coming, without obscuring nearer areas of the track. The height of the highway stop sign, approximately 7 feet above the ground, could have similarly blocked his view of part of the track. These two obstructions could have blocked vision if the bus stopped in a certain relationship to the track and the signs.

The Causal Factor Outline notes four problems of the roadway within the crossing which could have occupied the driver's attention, either before or after the bus started. These problems could have been overcome by the driver after he was sure that it was safe to proceed, but would tend to hold the driver's attention after he started to move over the crossing.

2/ Statement of Paul C. Ackerman, Vice President, Chrysler Corporation, on July 8, 1959, before the House of Representatives Subcommittee of Health and Safety of the Committee on Interstate and Foreign Commerce. (p. 65)

A witness, standing in the open, who was located 500 feet to the north of the crossing, facing south and farther from the train than the bus driver, saw the train and its fixed, white, double-sealed beam headlights quite clearly. However, the witness' attention was attracted by hearing the horn and the sun was not in his eyes. A Board Member, present on the day after the accident, at the same time of day, and observing the headlight of another locomotive on the same track, concluded that from the bus driver's point of observation, the train headlight provided very little contrast to the bright daylight and did not possess an attention-getting effect. Daytime use of the headlight for warning purposes is actually a secondary use of a system primarily intended for lighting at night and as a railroad signal during the day.

School Bus Driver Did Not Hear Train

The bus driver said he did not hear the train, although the engineer stated that the train bell was ringing and the horn was being sounded steadily while the bus was in view. The analysis of horn and other sounds reported in the Facts and Circumstances portion of this report establishes that the train was too far away for the driver to hear the horn while the bus was stopped even if the door was open, and that once the door was closed and the bus was moving across the tracks in low gear, the horn could not be heard inside the bus until it was too late for the bus to stop short of the crossing.

Four of the children passengers who were in the bus corroborated this finding, saying they first heard the train horn when the train was within a very short distance of striking the bus; therefore, even though the horn was sounded repeatedly as required by operating rules, it could not have warned the driver. Without the effective influence of the horn, the prevention of the collision relied entirely upon the visual factors which were seriously inhibited in several ways.

The successful accomplishment of the task of assuring safe crossing by the driver required not merely that he look to see whether something could be seen, but also that he realize that his view was not sufficiently clear to see an object if an object were there. At such a time, the absence of a train horn sound, if the driver had frequently heard such horns in the past, might have been unconsciously relied upon to confirm the impression that no train was present.

The importance of the relationship between horn and vision may be indicated by the fact that the witness, outside of his truck and at a distance, was alerted to turn and look toward the train by the horn sounds. No such warning was available to the bus driver inside of the bus. Where a warning system is customarily used but is unreliable, it can create a false confidence. The unreliability of train horns as warnings to vehicle occupants was also pointed out by the Safety Board in its earlier report of the grade crossing accident at Sacramento, California, which occurred February 22, 1967.[3/]

Speed of Train Approaching Crossing

The analysis of the speed recorder tape, taken from the locomotive after the accident, indicated that the train was traveling 56 m.p.h., and accelerating at the time the emergency brake application was made just before the accident. The engineer was under orders not to exceed 50 m.p.h.

3/ NTSB Report of Southern Pacific Railroad Company, Fruitridge Road Grade Crossing-Automobile Accident at Sacramento, California, February 22, 1967. Report released 1/1/68.

during the portion of his run in which the accident occurred. This speed order, however, was for the purpose of regulating the flow of traffic on the railroad and was not established for safety reasons.

Emergency Application of Train Brakes

The engineer did not make the emergency brake application after the bus started beyond the signs until he realized that the bus was not going to stop again before going on the track. Because of the distance involved, there was a period of several seconds in which the driver conceivably could have stopped again before entering the track.

It is not known whether the collision could have been avoided if the train brakes had been applied at the moment the bus started again after having stopped. It is possible to estimate roughly the distance of the train from the point of impact when the bus started (900 to 1,100 feet), but due to the additional complexity of the time delay of brake application, it is not possible to calculate whether an instant application at that time would have increased the time of travel to the crossing sufficiently to miss the bus. The practical decision of when to use train brakes at grade crossings is difficult because it involves estimates of behavior of vehicles and the balancing of the best interests of railroad against those of the driver crossing the tracks.

Collision to Bus Produced Severe Damage and Fatal Injury

By far the most important consequence of the collision was the fatal injury to the four children, so that the causal factors which governed the occurrence of injury are as important as those which led to the collision. The direction of collision was essentially a glancing one.

The injuries within the bus also ranged from fatal to no injury whatsoever, so that the collision was at least partially survivable.

Collision Impact on Bus Produced Severe Acceleration

The impact of the train upon the bus produced severe impact acceleration at the point of contact, the severity of which was governed by the high relative speed between the locomotive and the bus, and the fact that irregularities on the front of the train engaged or hooked the bus structure.

The irregular frontal configuration of the locomotive was not a necessity in its operation on the mainline, and other accidents are on record involving locomotives striking school buses where there was no snagging because fronts of the locomotives were smooth. In this case, however, the engaging irregularities on the locomotive had a value in other operations. The locomotive footboard is a convenience in yard switching. Exterior handrails, as well as the coupler, which also contacted the school bus, have utilitarian functions when the locomotive units are used in switching. Since these irregular appurtenances are not employed on all types of locomotives, and are not a requirement when the locomotive is operating on main lines at main line speed, there is a question whether future locomotive design practices might not reduce this source of collision damage.

School bus passengers ought to enjoy a planned continuous chain of crash protection features. As now understood, this chain includes: (1) the integrity of a school bus body in collisions with types of vehicles which it may meet, including heavy trucks as well as trains; and (2) the interior injury protection features of school bus bodies, such as cushioning and freedom from sharp edges within their interiors. It is necessary that these protective principles function satisfactorily if the children are to be protected.

School Bus Body Integrity

This case provides illustrations of the school bus body integrity, only, since the nature of the injuries is essentially unknown. It is clear that the disintegration of the school bus body would tend to increase injuries. Children riding in the disintegrated portion of this bus would probably have struck many hard and sharp surfaces exposed by the disintegration, would have been unprotected against ejection, and the separation of seats from the floor would have made safer seats or passenger restraints ineffective. All children riding in the disintegrated portion were killed. Thus, it is logical to address recommendations to the integrity problem since crash integrity is a necessity and the causes of disintegration are apparent. The Causal Factor Outline indicates the chain of factors in disintegration, culminating at the problem of weakness of fasteners between structural parts which did not provide full strength to the connections.

In assessing the importance of fastenings designed to the full strength, it is important to realize the engineering principles that structures can be designed to be adequate from the standpoint of resistence to vibration, visible shake, and protection against weather without being joined to develop the fullest strength against final collapse when heavily stressed. A bus body, for example, can resist shake when mounted on a truck chassis operating on normal roads without employing joints designed for fullest strength. The truck chassis provides stiffness to resist gross distortion when moving on irregular roads so that the bus body need only be strong enough to support the windows and door frames, the seats, and to keep the wind and rain from impinging upon the passengers. Collision impact, however, requires a fuller degree of fastening to produce full strength.4/ The Safety Board has been unable to find any evidence that school bus bodies are designed to resist any specific form or degree of collision, nor is this factor now specified by any known specification or standard.

The added number of fasteners required to employ the inherent strength of the sheet metal and to obtain the full strength available from a full joined structure, might double, triple, or even quadruple the number of rivets or bolts used for assembly, dependent upon their location. Added weight of such fasteners is insignificant, but the labor of assembly would be significantly increased. It is not possible to determine the available degree of improvement of the structure without a complete analysis, but it appears that the strength of many of the individual joints in this school bus could have been increased at least several times.

If such changes were made in school buses, there would be a greater opportunity for other methods of interior safety to be effective in future crashes. Interior safety considerations will be injected into near-future school bus design which may lead to regulatory requirements (See Recommendation No. 3 on page 40.)

4/ The Board has observed that the methods of forming school bus bodies noted in this case are not unique to this particular model of school bus but are prevalent in the industry.

IV. CONCLUSIONS AND PROBABLE CAUSE

A. Conclusions

The school bus driver, after stopping at the signs, failed to ascertain that there was a train approaching and drove the bus onto the tracks in front of the oncoming train. The engineer did not made emergency brake application after the bus started beyond the stop sign until he realized that the bus was not going to stop again. It has not been possible to determine completely why the bus driver proceeded across the tracks after stopping, or why he continued in the face of the normal warnings. Some conclusions can be drawn, however.

It is concluded that, as the bus driver reached the crossing, he encountered a difficult problem in maintaining adequate vision due to the direct rays of the sun and lesser indirect reflections from the vehicle hood. If during that time, the sun's rays did shine directly into his eyes, his ability to see objects would be impaired for some undetermined period of time even after he looked away from the sun. He was not wearing dark glasses. Whether or not the driver succeeded in protecting his eyes against the direct rays of the sun, some part of his attention would necessarily have been occupied by this task, tending to distract him from other driving tasks. The time of stopping was momentary.

The audibility of the train horn within the bus was very low and inadequate to provide warning when the bus engine was accelerated in low gear and the door was closed. Nebraska law does not require that the door be opened or maintained open for any period of time. In the circumstances of the accident, moreover, the horn sound could not be heard even if the door was open at the time the bus was stopped at the crossing, due to the distance of the train. Thus, warning by train horn is an unreliable system as a backup for visual sighting, especially when there is no legal requirement that the door be opened. Due to conflicting evidence, no conclusion has been made as to whether the door was opened.

Because it is not known definitely at what point the emergency application of the train brakes was begun, it is not possible to conclude whether the normal 8-second time lag for full effective brake application over the length of the train or the low rate of deceleration achieved by existing brakes advanced the time of the train's arrival at the crossing sufficiently to allow the collision. It is concluded, however, that the stopping rate of the train under emergency brake application did not exceed 37% of the theoretical maximum braking rate achievable on normal rails. The theoretical maximum is that of the highest adhesion obtainable without inducing wheel sliding. (See Appendix #2.) This problem is a shortcoming in the state of the art of railroad braking.

The protuberances on the front of the locomotive are, at times, needed for functional purposes in switching cars, but serve no purpose when the train is engaged only in over-the-road operations. In this case, their existence contributed to the severity of the accident.

The rear structure of the bus disintegrated due to a combination of forces caused by protuberances on the locomotive and low structural strength of the bus. The structural strength of the bus would have been greater if the structural elements and the skin had been more effectively joined. The blow received by the bus is considered not beyond the magnitude of impacts which might be delivered by collision with a truck moving at highway speeds. Although gross injuries might be expected under the degree of disintegration which occurred, no final conclusions can be drawn as to relationship between bus disintegration and the occurrence of fatalities, because the patterns of fatal injury are unknown. It can be concluded, however, that similar disintegration in future collisions to school buses would tend to make ineffective future standards if they are based only upon safety of school bus interiors.

Had the crossing been protected by a flashing signal light, or railroad gates, this accident would probably have been avoided. The low density of vehicular traffic at this crossing might not be considered sufficient to justify the installation of flashing signal lights or automatic railroad gates by most authorities. However, the Voorhees Report indicates that on an average, railroad grade crossings of all types experience one accident involving a vehicle and a train each 54 years. The previous record of two accidents in 5 years was, therefore, far above average and might have led to the provision of protective devices or closing of the crossing, had the unusual record been analyzed. The crossing now has a record of three accidents in 5 years.

B. <u>Probable Cause</u>

The probable cause of this accident was the failure of the school bus driver to ascertain that there was a train approaching the grade crossing and to hold his vehicle until the way was safe for passage.

Contributing causes of this accident were the selection of a school bus route which required passage over an unprotected railroad grade crossing; the lack of guidelines for the selection of school bus routes, including required analysis of routes for hazards and adoption of procedures for apprising drivers of existing hazards and how to handle them; the direct and reflected glare of the sun which created a vision problem in the bus; the low audibility of the train horn within the bus while the door was open or closed; and the absence of any warning device to advise the driver of the approaching train.

Possible contributing causes of this accident were the height of the stop sign and the "2 TRACKS" advisory sign which could have obstructed the driver's view of the approaching train; and the lack of contrast between train headlights and bright daylight which reduced the effect of the headlight as a visual attention-getting warning system.

V. RECOMMENDATIONS

1. The Safety Board recommends that the States not now having a requirement that the door of a school bus be opened for a sufficiently long period while stopped to allow the whistle or horn of a train to be heard at unprotected railroad grade crossings, consider establishing such requirement.

2. The Safety Board again recommends to the Federal Highway Administration and the Federal Railroad Administration that they study the questionable audibility of external sound signals within motor vehicles and to work toward creating a unified system of warnings and reliable reception which could be made effective through Federal regulations or State laws. A similar recommendation was made on January 15, 1968, in the Board's report of a grade-crossing accident which occurred near Sacramento, California.

3. The Safety Board recommends that the Federal Highway Administration consider the need for requirements for structural strength of school bus bodies in connection with its study of desirable standards for protection of school bus occupants. In particular, the Board recommends that program A.1.1.4 of the National Highway Safety Bureau, titled "Design, Fabrication, and Test of a Safe School Bus Interior," be expanded in scope to include consideration of structural integrity and intrusion into the school bus interior.

4. The Safety Board recommends that criteria for school bus operating safety of the Federal Highway Administration, States, and local school governing bodies include school bus routing to avoid grade crossings whenever possible.

5. The Safety Board recommends that when it is absolutely necessary that school buses operate over unprotected grade crossings, provisions should be made for a responsible individual, other than the driver, to alight and determine that no train is approaching, and to signal the driver to proceed over the crossing.

6. The Safety Board recommends that the Federal Highway Administration establish a vehicle safety standard to protect driver vision against external sun glare.

7. The Safety Board recommends that the Federal Railroad Administration, under its authority to regulate railroad brakes, study the existing state of the art of railroad passenger and freight brake systems, and issue descriptive reports of the capabilities of such systems to efficiently stop trains in an emergency.

8. The Safety Board recommends that the National Education Association, the National Professional Driver Education Association, and the Supervisors of Driver Training of the Boards of Education of the several States, review their driver training programs'to insure that, in the normal course of driver instruction for all types of drivers, specific attention be paid to the visual and perceptual task of searching a location of possible hazard to ascertain that the hazard is not present.

9. The Safety Board recommends that the American Association of Motor Vehicle Administrators place greater emphasis on proper grade crossing procedures during the examination process for drivers' licenses applicants.

10. The Safety Board recommends that the Federal Railroad Administration study the visual effectiveness of the white, fixed, sealed-beam headlights on locomotives in contrast with the bright daylight as compared with an oscillating or gyrating headlight unit, a flashing strobe light or other high intensity-type light, possibly of a more contrasting color.

11. The Safety Board recommends that the Office of High Speed Ground Transportation, the Association of American Railroads, railroads operating in the Northeast Corridor, and States having safety regulatory authority over railroads, consider the implications of this accident analysis for logical and necessary train operating speed reductions under restricted visibility wherever tracks cross unprotected grade crossings. The time needed by motor vehicles to cross tracks requires that drivers be able to detect the train at a considerable distance in order to be certain of crossing safely. This distance, as illustrated by this case and others, is already beyond the range of typical present-day train horns when the actual conditions under which the horn is to be heard are considered. Conditions which limit audibility at a distance, including enclosed vehicle passenger compartments, local vehicle noises, and restricted use of horns or bells, are now found so frequently as to be a normally anticipated

situation. As train speeds rise, persons crossing a grade crossing must rely increasingly on ability to see approaching trains in order to determine that it is safe to proceed.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOSEPH J. O'CONNELL, JR.
Chairman

/s/ OSCAR M. LAUREL
Member

/s/ JOHN H. REED
Member

/s/ LOUIS M. THAYER
Member

/s/ FRANCIS H. McADAMS
Member

APPENDIX

1. EMERGENCY APPLICATION OF TRAIN BRAKES

There is a considerable difference in available testimony concerning the distance the locomotive was from the grade crossing at the time the engineer made his emergency application of the train brakes. There is no physical evidence to support a determination. The truck driver witness stated that he saw the "dust from the sand being dropped by the locomotive" (which occurs automatically when emergency application of train brakes is made), and "fire from the wheels when the train was 300 to 400 feet from the crossing." However, during the same interview, the witness also stated he saw the "dust" when the train was about halfway from the viaduct to the grade crossing -- or approximately 700 feet from the crossing. Investigators at the scene after the accident could find no evidence of sand or "dust" on the railroad roadbed to indicate when the sand had been applied to the wheels in the emergency application of the brakes.

The Nebraska State Patrol accident report, dated October 2, 1968, contains a record of a statement by the railroad engineer:

> "Glen Peterson stated train was traveling about 48 miles per hour. When he first seen the bus it was on the left hand side of train and he said it was slowing down and then stopped at the eastbound main line track. Then he started across right into the path of my train. My train was westbound #708. I was blowing my whistle and when I seen he wasn't going to stop I slammed on the emergency brake. I put on the emergency brake approximately 3 railroad car lengths from the crossing and I never left up on whistle. The bus just kept coming across the tracks and I hit it. Train was on the westbound main line. Also the headlights were working on train because I checked them immediately after the accident."

The train was approximately 1,384 feet from the crossing when the engineer first saw the school bus approaching the grade crossing from behind some trees 320 feet west of the crossing. The train was traveling 82 feet per second (56 m.p.h.) and the bus was slowing down to stop. According to the bus driver and the engineer, the bus slowed down, stopped, and then started up again to cross the tracks. During all of this period of time, the train was approaching the crossing at 82 feet per second. When the engineer realized that the bus driver was not going to make a second stop, he then made an emergency application of the train's brakes. Although the locomotive engineer estimated that the train was three car lengths (about 150 feet) from the crossing at this time, the front of the bus would already have cleared the track on the opposite side at that time. The point of application is thus not clear.

2. BRAKING CAPABILITY OF TRAIN

The most rapid deceleration capability which could be credited to the train would be based on the assumption that the brakes were applied at the crossing while the train was moving at 56 m.p.h. (82 feet per second). The locomotive came to a halt 2,150 feet later. The average deceleration is found from the equation $v^{2/} = 2 \times a \times S$ where the velocity, v, is 82 feet per second and the distance, S, is 2,150 feet. This yields a deceleration rate of 1.56 feet per second which is .0485g.

The maximum theoretical achievable deceleration of a train which depends on static friction or "adhesion" of wheel against rail varies from over .2g at low speed to about .13g at 65 m.p.h. for normal rails. These figures correspond to "adhesion" factors of over 20% and 13% respectively. The proportion of theoretical braking achieved is therefore .0485 divided by .13 x 100%, which is 37% as reported on page 40. This deceleration period includes a time interval of eight or more seconds of gradual application before the reaching of a full brake application.

3. ACOUSTICAL CAPABILITIES IN RELATION TO SPEED OF BUS CROSSING GRADE CROSSING

The bus driver stated that he stopped 20 feet from the closest rail of the eastbound tracks. The distance from the outside rail of the eastbound tracks to a point 2 feet before the inside rail of the westbound tracks (allowing a 2-foot overhang for the locomotive unit) was 48 feet.[1/] Therefore, the bus could have traveled 68 feet (48 feet plus 20 feet) before reaching the first possible point of collision. The bus would have required approximately 9 seconds to traverse this distance (7.3 feet per second at an average of 5 m.p.h.). If the school bus door had been kept open as the bus moved forward from its stopped position, the train horn should have been heard about 3 seconds after the bus started.[2/] The bus would have traveled approximately 10 feet[3/] during that time. After hearing the train horn, the driver would have had 7 seconds and 58 feet in which to react, apply the brakes and stop the bus before reaching a point of impact with the train. Allowing five-eighths of a second for reaction time (average person) and 3 seconds' braking time for 10 feet, the driver should have been able to stop the bus in 3 and 5/8 seconds and a total of 14.5 feet ($\frac{5}{8} \times \frac{7.1}{1} =$ $4.5 + 10 = 14.5$ feet). The bus would have traveled a total of 24.5 feet (10 feet = 14.5 feet), leaving a margin of safety of 33.5 feet. (Refer to Recommendation No. 1)

1/ Measurement taken from a Union Pacific Railroad Company survey map, dated October 2, 1967.

2/ R. C. Coffeen and Associates, Consultant Engineers in Acoustics and Audio Report, dated February 1968. (See page 16 of text)

3/ Measured during a test using a 1963 International Harvester bus chassis with a 54-passenger Carpenter Body, owned by Mr. Francis H. Trice of Denton, Maryland, on April 8, 1968. Bus was timed over a measured course on a level, gravel road.

4. ESTIMATED TIME SCHOOL BUS WAS STOPPED AT GRADE CROSSING

A calculation based on known facts and reasonable assumptions can indicate the approximate length of time the bus could have been stopped at the signs. The engineer and brakeman stated that they first saw the school bus when the locomotive was in the vicinity of the viaduct. The school bus came into view from behind a clump of trees. The farthermost point of the viaduct is 1,584 feet from the grade crossing. The locomotive traveling at 56 m.p.h. (82 feet per second) would cover the 1,584 feet from point of first vision to point of impact in 19.3 seconds.

There are two tree lines blocking the view of the county road from the viaduct. The taller is 320 feet west of the crossing and the lower, composed of trees and bushes, is 170 feet west of the crossing. For this computation, the closer view obstruction is used. During the 19.3 seconds that the school bus was in view of the engineer, the locomotive traveled 1,584 feet and struck the bus. During the same time, the bus traveled 170 feet, decelerated, stopped at the stop sign, shifted gears, the loading door was allegedly opened and closed, a visual search of the area was made in both directions, the bus started up, traveled 88 feet across the tracks, and was struck by the locomotive. The search could have been begun before stopping.

A computation presented elsewhere in the Appendix indicates that the bus traveled 88 feet from the point where it was stopped at the stop sign, to the point where it was struck, at an average speed of 7.3 feet per second. This movement would have required 12 seconds. Inasmuch as the period under consideration is 19.3 seconds, that leaves 7.3 seconds to traverse 170 feet, stop, shift gears, make a visual search for approaching trains, and open and close the door. Assuming speed of the bus at 30 m.p.h. as a reasonable speed, as it approached the crossing it is assumed that the bus first traveled 100 feet at 30 m.p.h., then decelerated and stopped in the last 70 feet. At 30 m.p.h. (44 feet per second), the bus would have traveled the 100 feet in 2.3 seconds. During the last 70 feet of deceleration and stopping, the average speed would have been approximately 15 m.p.h. (22 feet per second) and the time required would then have been aboat 3.2 seconds. The total time for approach and stopping under this assumption would have been 5.5 seconds. That left a calculated time of 1.8 seconds as time stopped at the signs.

These assumptions are each on the side which produces the longer stopping time. Had the bus been traveling slower than 30 m.p.h., or had the tree line been the farther one, there would have been even less time for stopping.

Based on available evidence, and with other reasonable assumptions, it is probable that the stopping time at the signs did not exceed 2 to 3 seconds, in which time all the actions of searching both ways, shifting into low gear, and allegedly opening and closing the door would have had to be completed. The stopping time was short in relation to these tasks. It is to be noted that the gearshift lever and the door-operating handle must be operated with the same hand, and that the actions could therefore not be done simultaneously.

CAUSAL FACTOR OUTLINE

A. Collision occurred between train and school bus

- School bus moved into collision
  - Bus route required passage over unprotected crossing
    - Crossing not protected or closed
      - Low vehicle traffic did not justify protection
    - Alternate safer route not selected
      - No route safety analysis requirement
      - No standards for route selection
  - Driver did not assure absence of train
    - Bus stop at crossing was momentary
  - Driver did not see train
    - Sun effects reduced vision
      - Incoming sunlight toward driver's eyes at normal time of arrival
        - Alternate safer route not selected
      - Glare not completely controlled
        - Glare reducing visor ineffective (possibility)
          - Reflections present from hood top
          - Diffuse glare from probable windshield dirt
    - Vision limited at crossing (possibility)
      - Stop sign height blocked view near required stopping point
      - "2 tracks" sign blocked view near required stopping point

x y z

x y z

Attention distracted from visual search for trains (possibility)

Narrow roadway within crossing

Drop off in roadway edge within crossing

Holes in roadway within crossing

Change in road alignment within crossing

Limited attention-getting effect of locomotive head-light

Lack of contrast to bright daylight

No requirement for daytime brilliance, or contrast

Driver did not hear train in time for response

Horn was not audible at time bus stopped, whether door opened or closed

Train at a distance too great for horn power

No audibility or sound output requirement for train horns

Horn was not audible at any time after door was closed and before bus could have been stopped short of crossing

Door was closed before starting

Engine and transmission noise tended to obscure exterior sounds

Train moved into collision

Speed of train when bus seen to start was too high to avoid collision if not braked immediately,

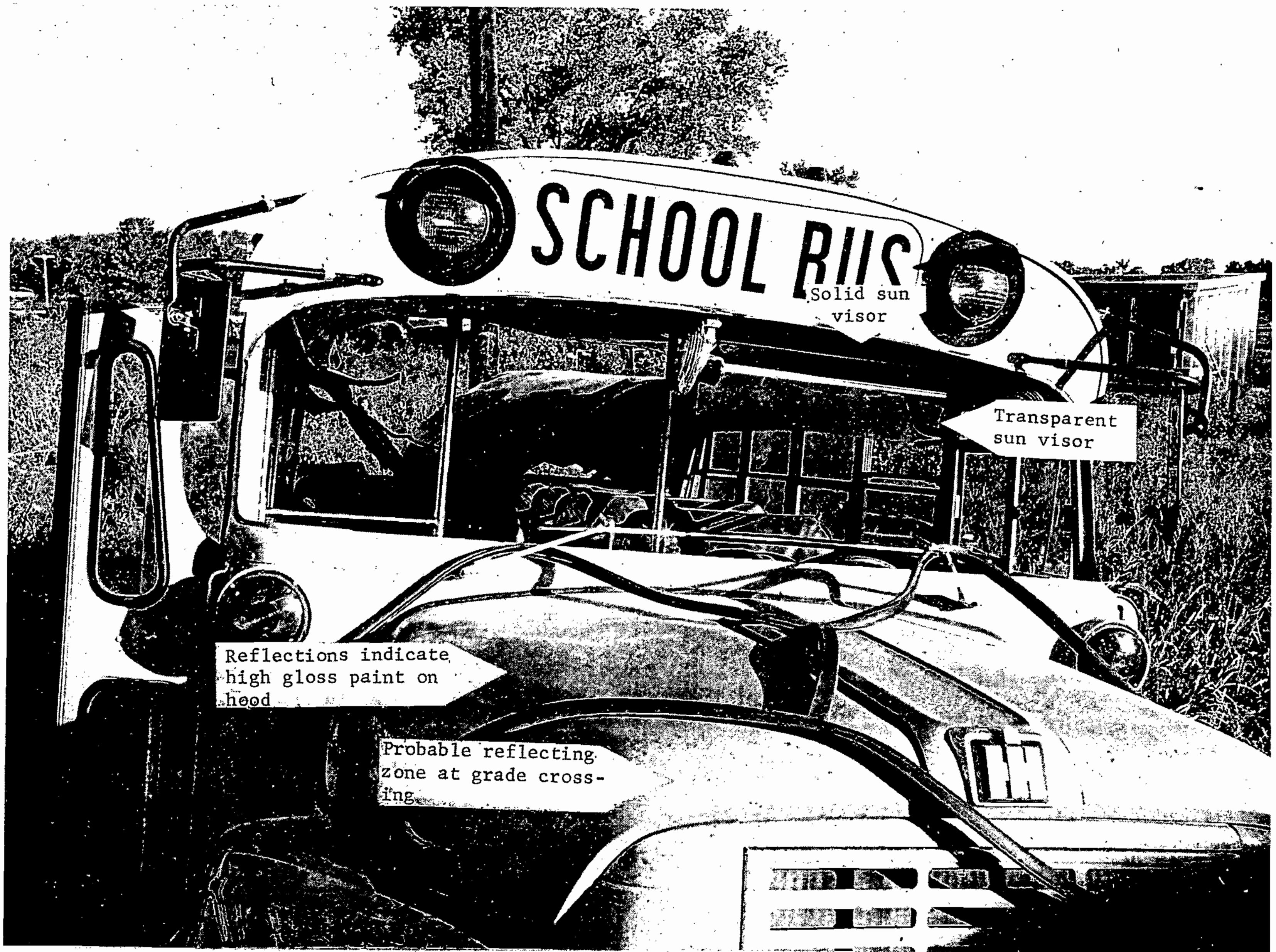
Engineer did not apply brakes immediately when bus seen to start

If brakes immediately applied, questionable whether collision would have been avoided

Slow rate of application and limited retardation capability of brakes

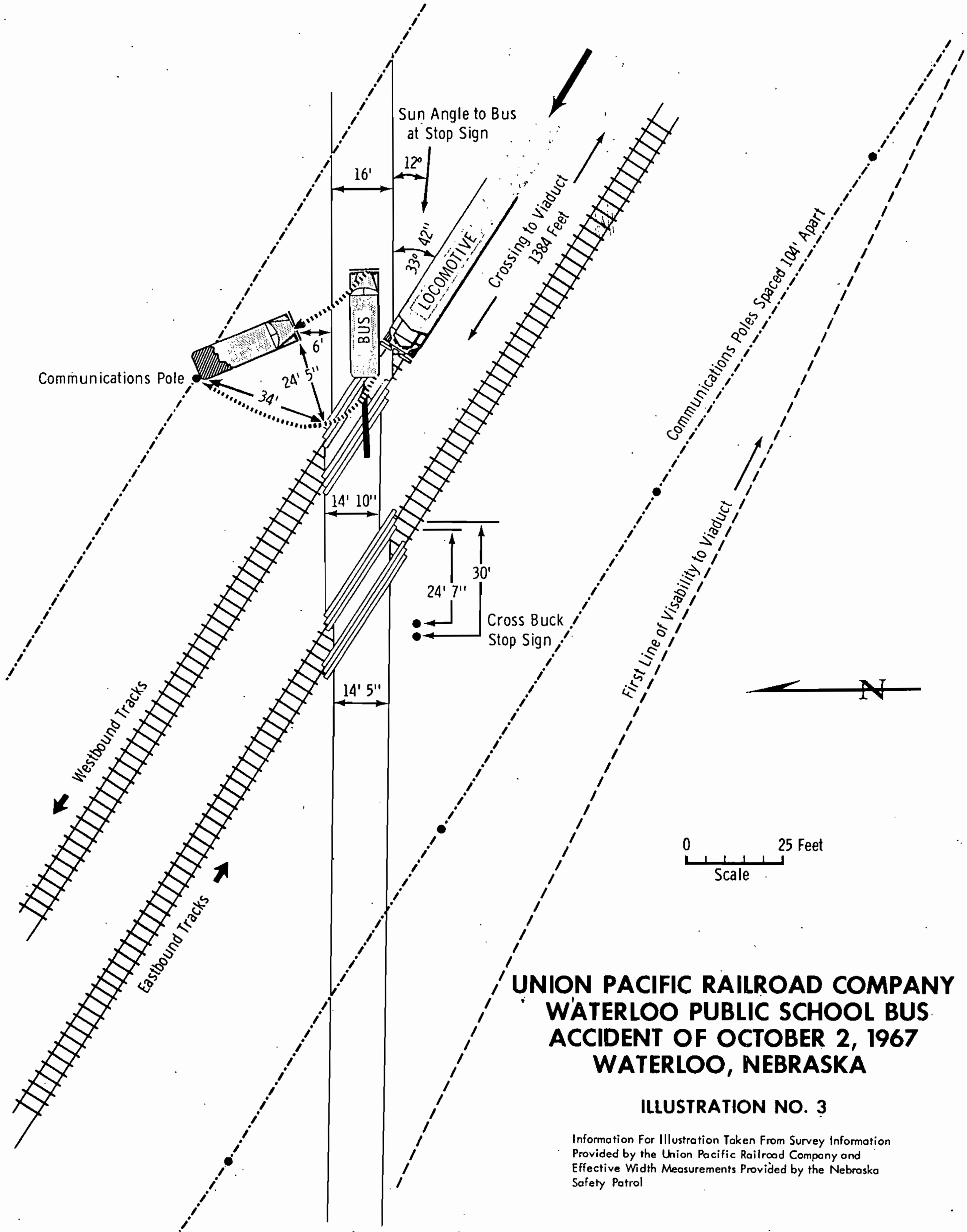
B. Collision to bus produced severe damage and fatal injury

- Impact on bus produced severe deceleration
  - High relative speed between locomotive and bus
  - Irregular frontal configuration of locomotive engaged bus structure
    - Footboard engaged right rear bus wheel
    - Hand rails, receptacle boxes, battery box, engaged bus structure
- Rear of bus body disintegrated
  - Individual structural elements separated
    - Strength of joints and fasteners exceeded
      - Maximum-strength element-joining methods not employed
        - Full strength not needed for purposes other than collision resistance
      - High localized forces developed on bus structure
        - Irregularities of locomotive frontal configuration contacted bus structure in detail
        - Stronger locomotive parts did not yield under mutual impact
        - High relative speed between locomotive and bus
- Bodily injury was undoubtedly produced by such mechanisms as direct impact with objects and crushing between objects. (Details not available because not observed in investigation.)



1. FRONT OF SCHOOL BUS AFTER THE ACCIDENT. PHOTOGRAPH ILLUSTRATES THE GLOSSY HOOD OF THE BUS, THE POSITION OF THE TWO SUN VISORS. AND THE OPEN WINDOWS ON THE LEFT SIDE OF THE BUS.

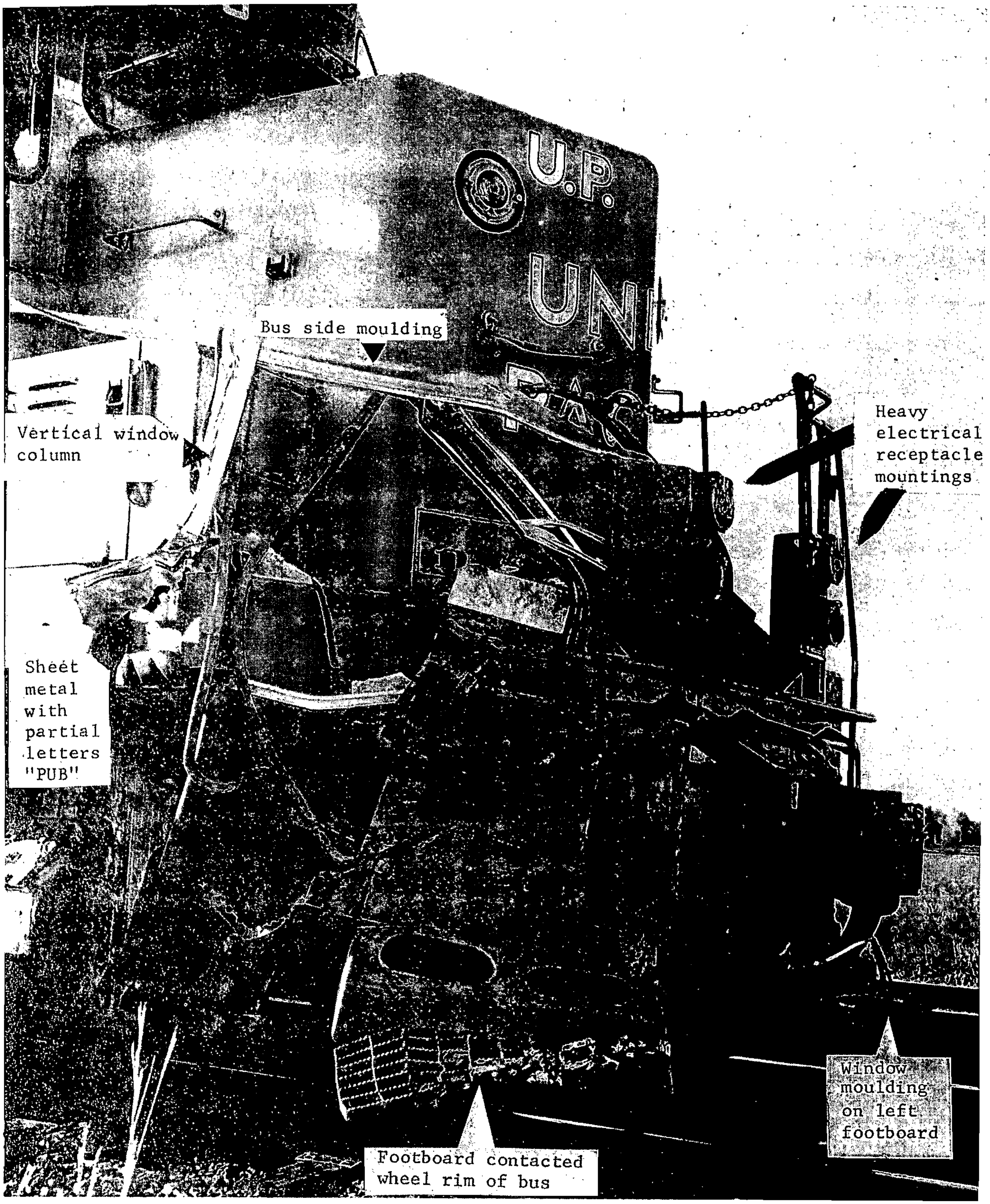
2. VIEW OF THE RAILROAD CROSSING, THE WARNING SIGNS, THE TRACKS, AND THE COMMUNICATION POLES, SEEN WHEN LOOKING IN THE DIRECTION OF THE VIADUCT.



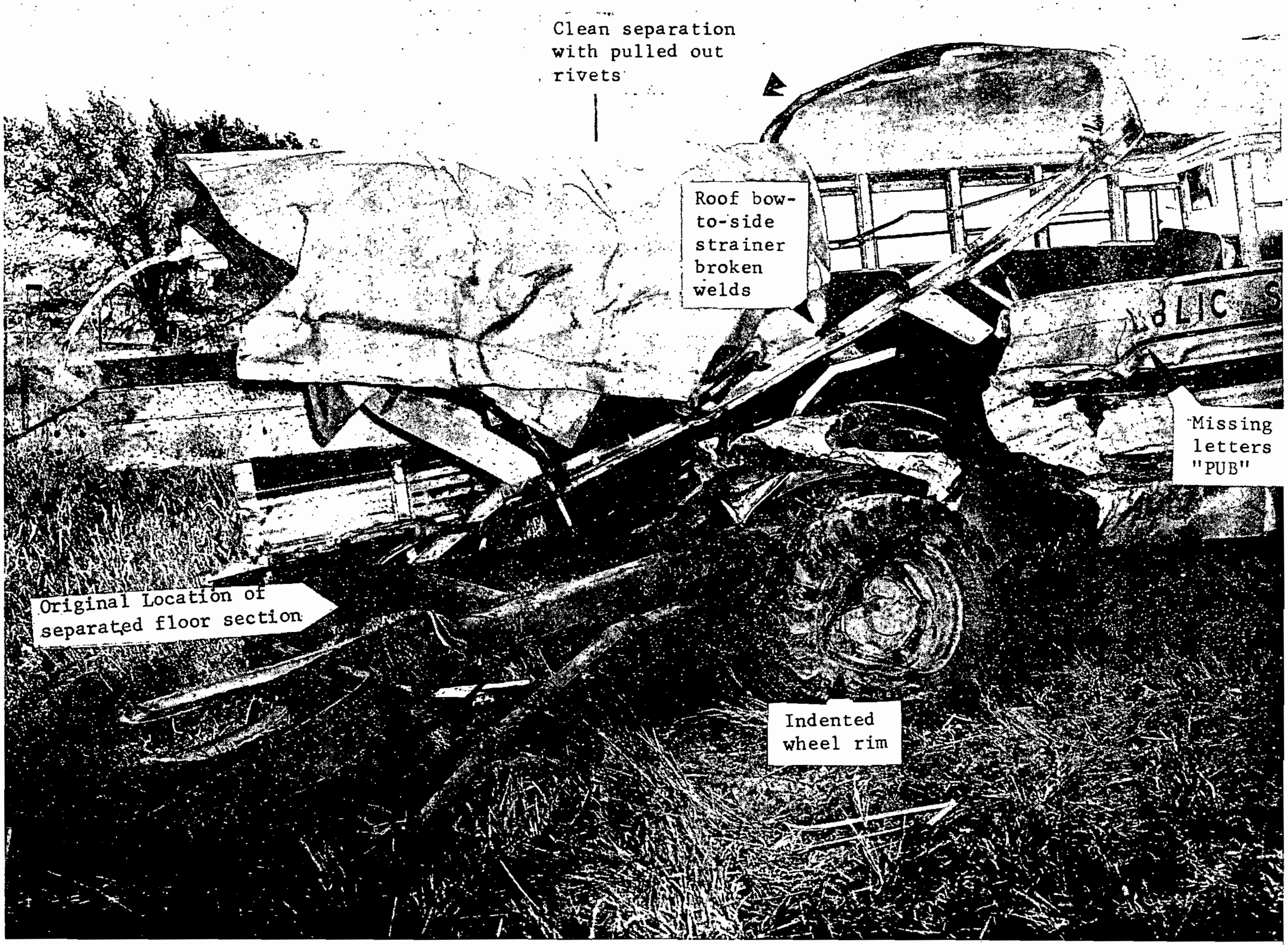
UNION PACIFIC RAILROAD COMPANY
WATERLOO PUBLIC SCHOOL BUS
ACCIDENT OF OCTOBER 2, 1967
WATERLOO, NEBRASKA

ILLUSTRATION NO. 3

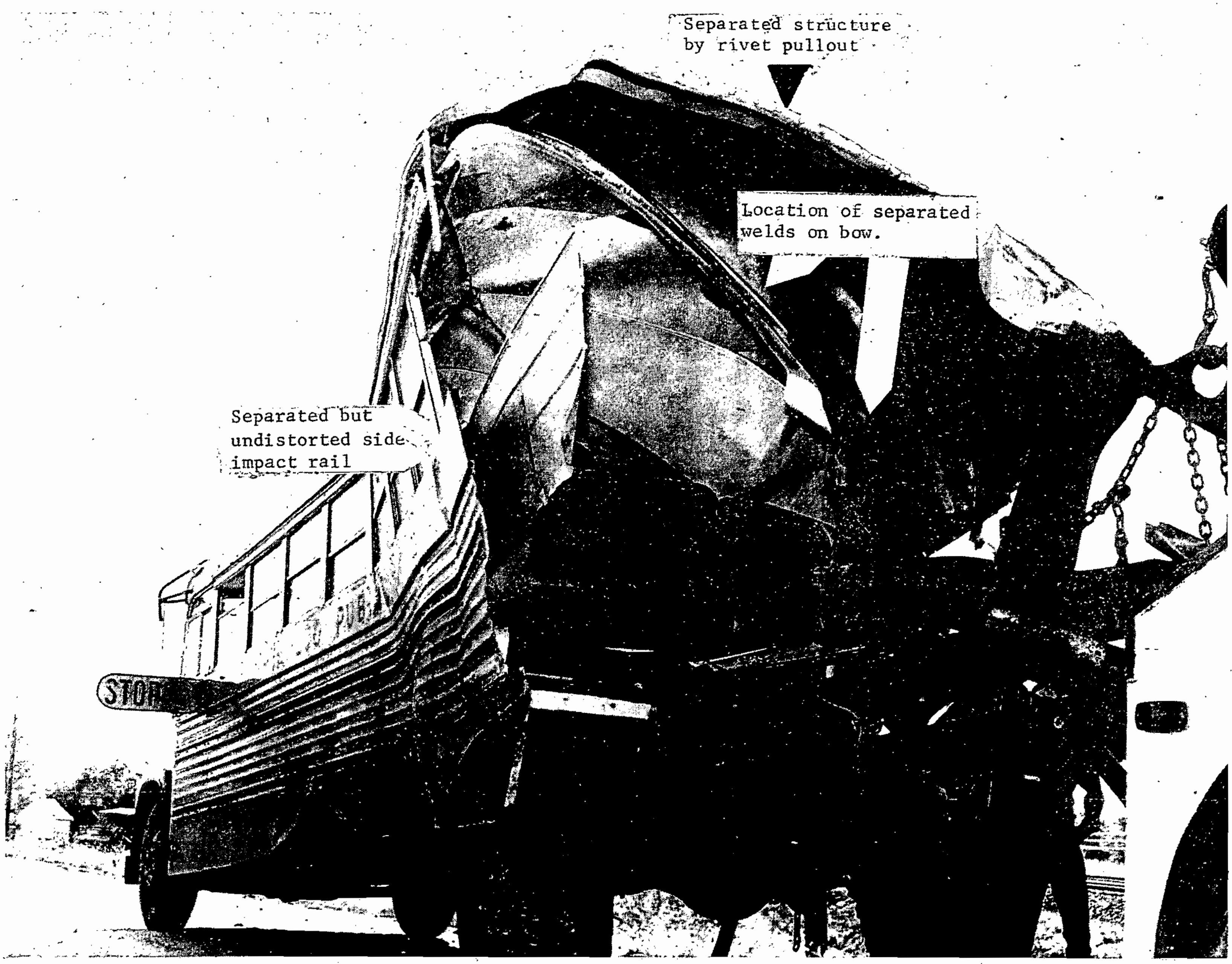
Information For Illustration Taken From Survey Information Provided by the Union Pacific Railroad Company and Effective Width Measurements Provided by the Nebraska Safety Patrol



4. FRONT END OF LOCOMOTIVE, U.P. #708, TAKEN SHORTLY AFTER ACCIDENT



5. RIGHT REAR OF THE SCHOOL BUS AFTER THE ACCIDENT AND AFTER THE BUS WAS MOVED FROM CONTACT WITH THE COMMUNICATION POLE.



6. REAR END OF THE SCHOOL BUS AFTER THE ACCIDENT AND AFTER THE BUS HAD BEEN MOVED FROM CONTACT WITH THE COMMUNICATIONS POLE. PHOTOGRAPH SHOWS THE DISINTEGRATION OF THE REAR OF THE BUS.

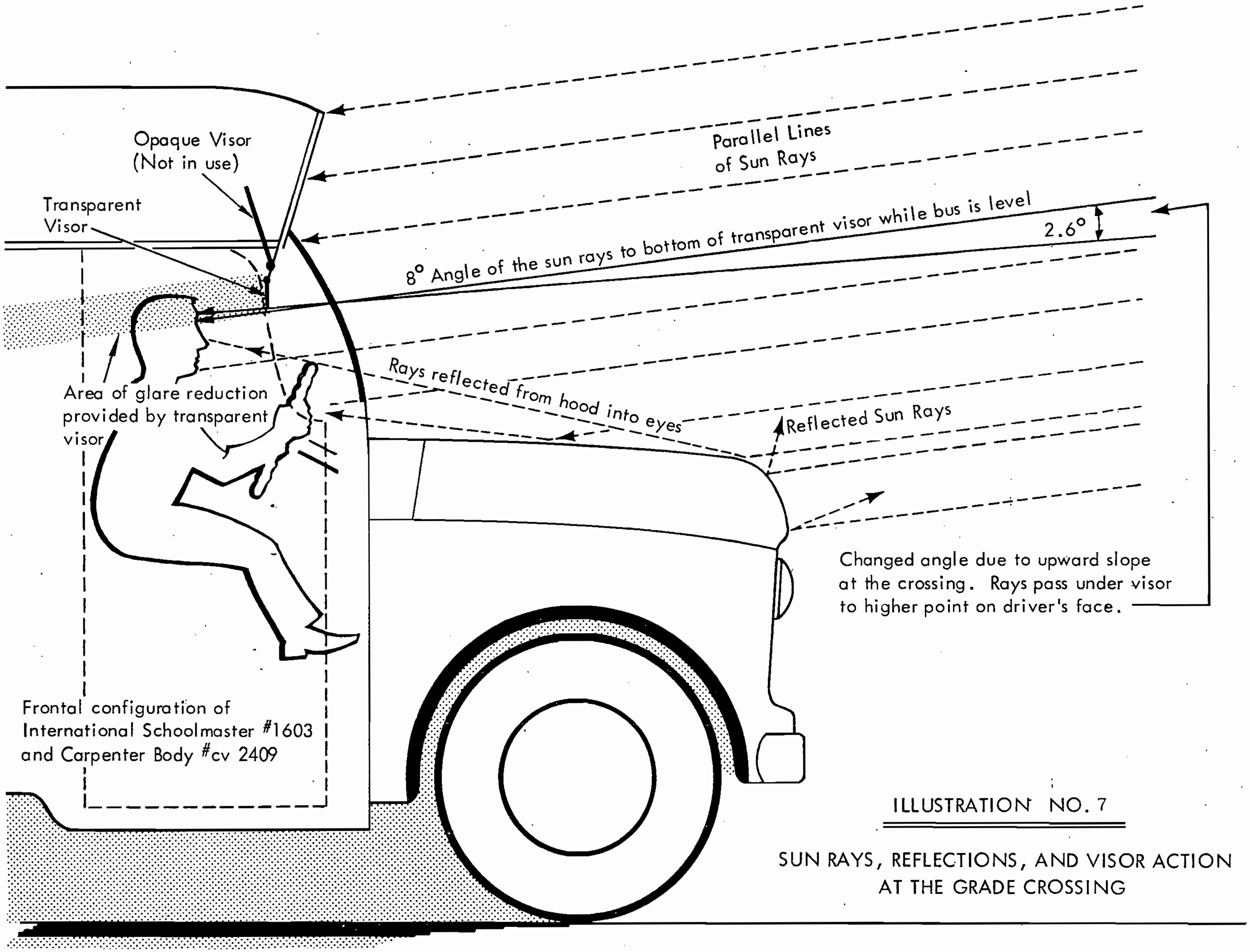


ILLUSTRATION NO. 7

SUN RAYS, REFLECTIONS, AND VISOR ACTION
AT THE GRADE CROSSING