INTERSTATE COMMERCE COMMISSION

WASHINGTON

REPORT NO. 3489

DENVER & RIO GRANDE WESTERN RAILROAD

IN RE ACCIDENT

AT LOUVIERS, COLO., ON

OCTOBER 19, 1952

Report No. 3489

SUMMARY

Date:	October 19, 1952
Railroad:	Denver & Rio Grande Western
Location:	Louviers, Colo.
Kind of accident:	Boiler explosion
Train involved:	Freight
Train number:	67-S
Locomotive number:	3703
Consist:	Locomotive, 31 loaded and 64 empty cars, and caboose
Speed:	15 m. p. h.
Operation:	Freight movement
Track:	Practically level and tangent
Time:	11:10 a. m.
Casualties:	4 killed
Cause:	Overheated crown sheet resulting from low water

INTERSTATE COMMERCE COMMISSION

REPORT NO. 3489

IN THE MATTER OF MAKING ACCIDENT INVESTIGATION
REPORTS UNDER THE LOCOMOTIVE INSPECTION ACT
OF FEBRUARY 17, 1911, AS AMENDED

DENVER & RIO GRANDE WESTERN RAILROAD

December 2, 1952

Accident (boiler explosion) at Louviers, Colo., on October 19, 1952, caused by overheated crown sheet due to low water.

REPORT OF THE COMMISSION[1]

PATTERSON, Commissioner:

On October 19, 1952, about 11:10 a.m., at Louviers, Colo., the boiler of Denver & Rio Grande Western Railroad locomotive 3703 exploded while the locomotive was hauling a freight train at an estimated speed of 15 miles per hour. The engineer, fireman, brakeman, and a trespasser were killed.

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[1]Under authority of section 17 (2) of the Interstate Commerce Act the above-entitled proceeding was referred by the Commission to Commissioner Patterson for consideration and disposition.

DESCRIPTION OF ACCIDENT

Denver & Rio Grande Western Railroad locomotive 3703, hauling southbound freight train No. 67-S, departed from Burnham yards in Denver, Colo., at 10:25 a.m., October 19, 1952, and proceeded without any known unusual incident to a point approaching Louviers, Colo., a distance of 19.5 miles, where, at about 11:10 a.m., the boiler of the locomotive exploded while the train was moving at an estimated speed of 15 miles per hour.

The train consisted of 31 loaded and 64 empty cars and a caboose, 4241 adjusted tons. The tonnage rating of the locomotive in this district was 5300 tons. The engineer, fireman, and brakeman were on duty in the cab of the locomotive at the time and a fourth unauthorized occupant of the cab, designated as a trespasser. The accident occurred on practically level tangent track.

The force of the explosion tore the boiler from the running gear and hurled it and the attached cab forward and slightly to the right. The boiler half turned in the air and alighted on its top nearly parallel with the track and just outside the right rail and plowed forward 35 feet, splintering or breaking off the ends of 10 ties. The boiler came to rest approximately 260 feet from the point of explosion, buried 3 to 4 feet in cinders and dirt; it was headed in reverse direction to the train movement, with firebox 9 feet and smokebox 4 feet from west rail, and leaning 35° from the track axis.

Parts of the locomotive were scattered in various directions. Pieces of grates were blown over 75 feet from point of explosion; 200-pound sections of center and side bars over 100 feet; ashpan supports as far as 350 feet; hot pieces of arch brick were thrown as far as 450 feet to the sides and rear and started fires in adjoining stubble fields, which burned over several acres. The front end door and both halves of fire door were blown off. Air and water pipes, pieces of jacket and ashpan, sand boxes, part of headlight case, pieces of reverse gear and arch support, and other wreckage were scattered from scene of explosion to the resting place of boiler. Both right-of-way fences were blown down, and some telephone wires were broken. The cab was crushed against the boiler back head. One air pump and the feedwater heater bundle were torn from the front end ring, and safety valves, saturated steam turret, and overhead boiler checks were torn from the boiler.

The force of the explosion broke the heavy hinged casting forming the articulated connection between the front and rear

engines of the locomotive and broke both rear sections of main frames over the trailing axle. The front engine and engine truck became separated from the rear engine and continued forward for nearly 1800 feet on a .79 percent ascending grade before coming to a stop. The front two-thirds of the train remained attached to the tender, trailing truck, and rear engine and moved forward to a point more than 200 feet beyond the boiler before coming to rest. All locomotive and car wheels remained on the rails. Where the front end of the tender stood on a track fill, small gullies were washed into each side of the embankment by streams of water from the broken connections in inspirator piping and at front end of left tank hose.

The rear steam pipes were pulled out of expansion joints at rear valve chambers. The rear exhaust pipes were broken, the left pipe remaining on running gear and the right on the boiler. All front live and exhaust steam pipes remained on boiler. When blown from its frame fastenings the boiler sheared 6 1-1/16 inch bolts at each rear expansion pad; 3 1-1/4 inch bolts at each front expansion pad; 26 1-1/4 inch bolts at saddle over rear cylinders and broke 3 1-1/2 inch bolts at left end of strap securing boiler to oscillating table on front frame between No. 1 and 2 driving wheels.

There were slight depressions in both rails showing exact location of rear driving and trailing truck wheels at instant of explosion; three bent lengths of rail were subsequently renewed.

The four occupants of the locomotive cab were killed.

DESCRIPTION OF LOCOMOTIVE

Locomotive 3703 was a simple articulated 4-6-6-4 type, company's classification L-105, with tractive effort of 105,000 pounds. It was built by Baldwin Locomotive Works in April, 1938. All cylinders were 23 inches in diameter with 32-inch stroke; driving wheels 70 inches in diameter with full tires; total weight on driving wheels in working order 437,939 pounds, and weight of locomotive 641,900 pounds. The rectangular tender with cast steel water bottom frame had a capacity of 20,000 gallons of water and 26 tons of coal and weighed 394,000 pounds when loaded. The locomotive was equipped with Baldwin power reverse gear, American multiple front end throttle, Standard modified Type B stoker, Economy vertical firedoor, vestibule cab, Walschaert valve gear, Elesco tangential steam drier, Franklin Type E-2 radial buffer, locomotive valve pilot, and Elesco feedwater pump and heater.

The boiler was a straight-top four-course type with wide radial-stayed firebox, builder's No. 62142. The inside diameter of first course was 92-3/4 inches, and fourth course 100-1/8 inches. The barrel sheets were of silicon manganese steel, 7/8 inch thick in first two courses, 29/32 inch in third, and 15/16 inch in fourth. The boiler carried 255 pounds working pressure, and had 61 2-1/4 inch and 238 3-1/2 inch flues with beads fusion welded to back flue sheet. A new first course had been applied on February 20, 1946. It was stoker fired and equipped with Type E superheater; Hulson grates; three Nicholson thermic syphons; a brick arch supported by the two rear syphons and a Gaines wall.

The firebox was 108-1/4 inches wide, 224 inches long at inside of mud ring and the combustion chamber was 96 inches long. The firebox was of five-piece construction, with the side sheets welded to the crown sheet and inside throat sheet. The door sheet flange was riveted to crown and side sheets. Door, side, and throat sheets were riveted to the mud ring. The one-piece combustion chamber was welded to flanges of combustion chamber syphon, back flue sheet and other firebox sheets. All firebox sheets were 3/8 inch thick except flue sheet and throat sheet which were 1/2 inch thick.

All firebox sheets were original. Numerous patches with fusion welded butt joints had been applied. Crown sheet had a patch in right front corner just outside of syphon, 8 stay rows wide and 12 long; one in left front corner outside of syphon, 8 rows wide and 18 long; and another outside of left syphon, 4 rows wide and 17 long; also a small patch back of each firebox syphon. Each side sheet had two diamond-shaped patches; those in left side were adjacent end to end, one 7 stay rows high by 15 long, the other 5 rows by 5 rows. Those in right sheet were similar, one 8 rows high and 16 long, while the smaller one included only 4 staybolts. The inside throat sheet had four patches; a large one across center, 8 stay rows high and 14 long, including diaphragm for both firebox syphons, braced by 44 staybolts. The upper part of left throat sheet knuckle had a patch 4 rows wide by 7 high; the upper right knuckle had one 5 rows wide by 9 high, and above that another patch 1 row wide by 7 long. There was a patch in roof of combustion chamber back of its syphon 5 rows wide by 5 long. All original firebox welds were fusion butt welds reinforced on water side; those made later were welded from fire side only.

There were two Nicholson thermic syphons in the firebox and one syphon in combustion chamber. Syphon water space was 3 inches, necks were 6-1/4 inches inside diameter, and sheets 3/8 inch

thick. All seams between syphons and crown sheet were welded and reinforced. There were numerous patches in the syphons; the front syphon had a patch in upper part of barrel, 6 stay rows long and included 1 row of staybolts on right side and 2 rows on left. The neck had been renewed from within 2 inches of diaphragm to the stayed portion, including 3 stays on right side and 7 on left.

The right firebox syphon had a two-piece barrel patch, the lower one 11 rows long and the upper one 5 long, each including one row of staybolts on inner face and two rows at outer. There were also two patches in front flange above neck, the lower one being 4 rows long, the next adjacent above it 3 rows long, and each had one row of staybolts at inside and two at outside. The neck had been renewed from 8 inches above diaphragm to include 5 staybolts on outer and 8 at inner wall.

The left firebox syphon had a patch in front half of top inside flange 2 rows wide by 26 long. A patch in lower part of barrel was 10 rows long and had 2 rows of stays on inner and 1 row at outer wall. The neck had been renewed from 12 inches above diaphragm and included 6 stays at inner and 10 in outer wall.

The crown sheet, including the top of combustion chamber, was supported by 28 longitudinal and 79 transverse rows of driven-head stays. The first 8 longitudinal rows at each side of center were rigid, except the front 4 transverse rows of expansion stays, and were originally 1-inch body, 1-1/8 inch straight thread in wrapper sheet, and 1-3/16 inch tapered thread in crown sheet. The 9th longitudinal row on each side consisted of expansion stays with tapered threads in crown sheet. The outer 5 longitudinal rows on each side of crown sheet were flexible stays with 1-inch straight threads. Stays in syphon flanges were 1/16 inch larger than adjacent ones. Due to several renewals since the firebox was built, many stays were 1/16 to 1/8 inch larger than original application. Side sheets were supported by rigid staybolts, except in breaking zones at front and back ends, where flexible stays were used. All stays in the firebox sheets were spaced approximately 4 by 4 inches.

Company drawings showed the top of combustion chamber to have been level, while the firebox crown sheet sloped downward 6-1/4 inches from the crown sheet-combustion chamber seam to the door sheet.

EXAMINATION OF BOILER AFTER EXPLOSION

Approximately 90 square feet of the crown sheet had been overheated. The line of demarcation was clearly defined. It extended back from the flue sheet between 11th and 12th longitudinal rows of stays on each side of center line to 37th transverse row of stays, thence inward toward front end of firebox syphons, curving around them in about 34th row and then curving back between the syphons to 40th transverse row. The sheets above this line were a distinct blue color. No overheating was observed on flanges of syphons. The upper part of rear flue sheet showed distinct signs of overheating to approximately 1 inch below top of second full row of superheater flues, or about 8 inches below the top of combustion-chamber crown sheet.

The initial failure of the crown sheet occurred in the 34th transverse row of stays back of flue sheet, or just ahead of firebox syphons. In that area the sheet pulled from the stays, sagged downward and thinned to 3/32 inch in several places while tearing transversely along that row from center of sheet to beyond each syphon. Then the tear followed the 35th transverse row on each side and outward to the 10th row from center. From this point the right tear followed an irregular diagonal path downward and forward through right side sheet, throat sheet knuckle, and into right side of combustion chamber below center line, ending near the 21st stay back of flue sheet and 16th stay to right of center. The left end of tear also progressed downward and forward in a similar fashion, ending near the 21st stay back of flue sheet and 20th stay to left of center.

The portion of crown sheet between the front ends of firebox syphons tore back from the initial rupture in 34th transverse row through the inner flange of each syphon to the 43rd transverse row, then folded downward and bent back sharply. A large area of crown sheet, partly from firebox and partly from combustion chamber and just ahead of the initial rupture, pulled from its stays and folded downward against the combustion chamber syphon, the folds running from the ends of the tears in sides of combustion chamber upward and inward to the top flanges of combustion chamber syphon in 18th row of stays back of flue sheet, or approximately at longitudinal center of the syphon. This large sheet also tore across back end and forward along both sides of top syphon flanges, with an irregular tear extending outward 20 inches from back end of syphon toward the left and nearly closed off the entire cross-sectional area of combustion chamber. There were two small tears in this sheet near fold on right side, and an 18-inch tear extending forward from

its edge in the 12th longitudinal row of stays to left of center. At the right and left sides the tears and pulled sheet extended well down below the overheated area.

The crown sheet pulled from a total of 580 stays. Three crown stays on right side in the overheated area were fractured and broke when the sheet dropped. The inside walls at top front corners of both firebox syphons and both walls of combustion chamber syphon at top back corners were pulled from a total of 59 staybolts when the crown sheet folded down. There was one broken and one fractured staybolt in the right syphon. The mud ring was bulged outward at center approximately 4 inches on each side.

The greatest heating and stretching of crown sheet appeared to have been in the area about 7 rows in width between back end of combustion chamber syphon and front ends of firebox syphons. Here several stay holes were enlarged to 1 inch greater diameter than the corresponding stays, without tearing the sheet. Ends of stays in the overheated area were blue in color and approximately 15 percent were cupped to a maximum depth of 1/4 inch, but heads were sheared from most of these stays. In the overheated area the threads on stays and in sheets appeared to have been in good condition before the explosion. Heads of undamaged stays in the firebox were well driven, of proper thickness, and in good condition. Staybolt heads in severe cutting areas, as on sides of rear syphons, were protected by a semi-circular bead of weld.

There was other distortion of firebox sheets, probably caused by impact when the boiler struck the ground. The combustion chamber-crown sheet was pushed downward considerably in the area to the right of top center line, the greatest deflection being about 4 inches located 6 rows to right of center. In that vicinity the top flue-sheet flange was bent downward, and flues in right top corner were distorted elliptical shape. The third large flue to right of center in top row pulled entirely out of the sheet, and others in that area were loosened and pulled to a varying degree. In the entire back flue sheet a total of 124 large and 17 small flues were loosened at welds around the beads, the majority being on the right side. At the front flue sheet 13 flues in two lower rows showed signs of loosening. There was a longitudinal crack in combustion-chamber crown sheet extending forward from syphon approximately 20 inches, nearly to flue sheet. The wrapper sheet appeared to be flattened on right side above combustion chamber. On October 23 when the boiler was leveled at the steam dome to check the location of water glasses and gage cocks, it was found that the

left back corner of mud ring was 4 inches lower than right back corner, and that the slope of right side of mud ring was 5-3/4 inches, left side 4-7/8 inches. Prints showed 6-inch slope upward toward the rear. There was a light, irregular deposit of scale on parts of sheets and stays which reached 1/32 inch in thickness.

APPURTENANCES AS FOUND

Wreckage of the locomotive was immediately protected after the accident to prevent tampering with or removal of any appurtenances. As far as is known, none of the appurtenances were changed in any way, except that both tender water valves were closed soon after the accident to prevent loss of all the water in the tender cistern, and left tank hose was removed to allow movement of the tender to clear the line.

Safety valves: The boiler was equipped with three 4-inch Consolidated open-type safety valves, direct connected to the boiler at rear of the main steam dome. When the boiler fell the left safety valve nipple was pulled out of the sheet and the center and right nipples were broken. The outer cases of two of these valves were distorted and one had a small section broken off. The nipples were renewed, and all three safety valves were applied to D&RGW locomotive 3700, of the same class as 3703. Company records showed that safety valves were set to open at 255 pounds, 258 pounds, and 260 pounds. On the first test the first valve opened at 250 pounds, partly closed at 247-1/2 pounds, and seated at 245 pounds. On the second test this valve opened at 250 pounds and closed at 247 pounds. The fire was forced, and the steam pressure in the boiler could not be raised beyond 256 pounds. During this test the second and third valves did not open. After the adjusting screw on the first valve was tightened, the second valve started to blow at 260 pounds, opened fully at 263 pounds, and closed at 240 pounds. The case of this valve had been distorted. After the adjusting screw on the second valve was tightened, the third valve which had a piece broken from the outer case opened at 275 pounds and then closed gradually at 260 pounds.

Steam gage: The boiler was equipped with one Ashcroft 6-3/4 inch illuminated double-dial steam gage, graduated to 400 pounds, located to company standard 67 inches above the cab deck and 12 inches to the left of center of the back head. The gage was broken from the bracket and only fragments were found. The steam gage siphon valve was broken off flush with the back head

top knuckle. Opening into the boiler was 1/4 inch in diameter, clean, and unobstructed. The siphon valve and pipe were not found.

Water level indicating devices: A carrier's standard water column, with tubular type water glass and five Prime double-seated gage cocks attached, was mounted on the boiler back head 16 inches to the right of center and a tubular type water glass was mounted on the left side of the back head 16-3/4 inches to the left of center. The water-glass guards were Okadee two panel-long vision type with 11-1/4 inch clear readings, and were fitted with 1-1/2 inch escape pipes. This equipment was applied in accordance with the carrier's specifications.

The column was made of steel tubing, 27 inches long, with ends tapped for 3-1/4 inch brass fittings. The steam pipe connection fitting entered the roof sheet 10-1/2 inches ahead of the back head knuckle and 11 inches to the right of center and had an opening into the boiler 1-3/4 inches in diameter. The bottom connection fitting entered the back head 16 inches to the right of center and 4-3/8 inches below marker plate on back head indicating the highest part of the crown sheet; the fitting extended horizontally into the water space 2-1/4 inches and had an opening 3/4 inch in diameter.

The top and bottom water-column fittings were broken off flush with the boiler. Both openings into the boiler were found clean and unobstructed. The 1-1/2 inch O. D. copper steam pipe connecting the column and top fitting was broken off at both ends and was bent and crushed, but it apparently was open and unobstructed prior to the explosion. The column was somewhat damaged; the top brass fitting was pulled out at the threads and the fitting was broken, but the interior of column and all openings into it were found clean. The column drain valve was a carrier's 3/4-inch double-seated type; it was broken from the column, but was found in good condition and in closed position against the working seat. The drain pipe was not found.

A carrier's brass "gage marker" was attached to left side of the water column which read: "Water must show here on level track when approaching 3% grade", with an arrow pointing to water level even with the 2nd gage cock, also "Water must show here going up 3% grade", with an arrow pointing to water level even with the 4th gage cock.

The top and bottom valves of right water glass were broken off flush with the water column; both openings into the column were 1/2 inch in diameter and were found clean. Both water-glass

valves were found wide open, stems badly bent, and all openings clean. The 11/16 inch O. D. copper pipe connecting the top water-glass fitting to the top water-glass valve was broken and crushed, but apparently was open before the accident. The broken ends of the water glass and the rubber gaskets were found in the packing nuts and were apparently in good condition prior to the explosion.

The drain pipe valve, broken from the bottom fitting, was found closed and in good condition; the drain pipe was not found. The lowest reading of the right water glass, which corresponded with bottom gage cock, was 4-5/8 inches above the reference on the marker plate on back head which indicated the height of the highest part of the crown sheet.

The left water-glass top valve fitting entered the roof sheet 18 inches ahead of the back head top knuckle and 5-1/2 inches to the left of center and had opening into the boiler 5/8 inch in diameter. The bottom fitting entered the back head 16-3/4 inches to the left of center and 1-1/2 inches below the marker plate on the back head; had opening into the boiler 5/8 inch in diameter and extended horizontally into the water space 5-5/8 inches. Both fittings were broken off flush with the boiler; both openings were clean and unobstructed. The 11/16 inch O. D. copper steam pipe was broken off at top of water glass, but remained attached to the top valve; the pipe was badly bent and crushed, but was clean and open at the ends and apparently in good condition before the explosion. Both water-glass valves were found wide open. Top valve was broken off at the bonnet and the stem on bottom valve was badly bent. The valves had 1/2-inch openings and were found clean and unobstructed. The end of water glass and gasket were missing at top packing nut. The broken end of the water glass and gasket were found in bottom packing nut and apparently had been in good condition before the explosion. The 3/8-inch water-glass drain pipe, with valve closed, was found in good condition. The lowest reading of the left water glass was 4 inches above the reference on the marker plate on back head.

Gage cocks: Five Prime double-seated type gage cocks were spaced 3 inches apart vertically and had openings into the water column 3/8 inch in diameter which were found clean. All gage cocks were broken off flush with the water column and all stems were bent at nearly right angles. The gage cock dripper pipes were bent but otherwise in good condition. All gage cocks were found in closed position and openings were clean and unobstructed. Bottom gage cock was located 4-5/8 inches above reference on the marker plate on back head.

Although the boiler was badly distorted, it was moved to the D&RGW Burnham back shop and leveled by the top of the steam dome. As the crown sheet was badly damaged, the top of the back flue sheet flange, which had been butt-welded to the crown sheet, was used to determine the highest part of the crown sheet. Level readings taken at this time indicated that the highest part of the crown sheet was 3/4 inch lower than reference on the marker plate on the boiler back head. The 5/8-inch variation between lowest readings of right and left water glasses could have been due to distortion of the firebox.

Injector: The locomotive was equipped with a Hancock K-NL inspirator mounted on the rear end of the main frame under the right side of the cab. The right tank hose and short inspirator feed pipe were intact. The overflow valve was found intact and closed. The operating rod had been carried away with the cab. The inspirator main steam pipe and regulating steam pipe were torn off at the top of the inspirator, and the delivery pipe fitting was broken at the inspirator. The regulating valve was broken off at the inspirator and pulled off of its steam pipe. This valve and its extension rod to the cab were not found. The telltale valve remained attached to the inspirator, but the warning pipe was torn off and found on the boiler. All inspirator pipes, except the feed pipe, were damaged but were apparently open and in good condition before the accident. A Hancock Type K-NL vertical operating valve was mounted on the right side of mud ring ahead of the cab. It remained on the boiler connected to the main steam supply pipe from the saturated steam turret and to the two steam pipes supplying the injector. The operating valve was not damaged except the handle was bent when the operating rigging was torn off during the explosion. This valve was found in closed position after the accident, but the inspirator steam valve at the turret and the main turret shut-off valve were found wide open. All inspirator pipes were found to conform with manufacturer's recommendations as to size and material.

The inspirator and its operating valve were tested on locomotive 3700. It started and delivered water to the boiler at 110 and 125 pounds pressure with 16 inches of 108° F. water in the cistern. The warning feature operated properly. Then the tender was filled to two-thirds capacity which was the probable amount of water at the time of the accident, and the inspirator was tested as follows: On the first test of 1 minute duration, starting from 195-pound boiler pressure with all valves wide open, the boiler water level was raised 1-1/16 inches and the pressure dropped to 182-1/2 pounds. On the second test of 1 minute duration, starting from 220-pound boiler pressure, the boiler water level was raised 1-1/8 inches and the pressure dropped to 215 pounds. On the third test of 1 minute duration,

starting from 242-pound boiler pressure, the boiler water level was raised 1-1/4 inches and the pressure dropped to 230 pounds. On the fourth test of 1 minute duration, starting from 240-pound boiler pressure, the boiler water level was raised 1-1/4 inches and the pressure dropped to 222-1/2 pounds.

After these tests the tubes were removed from the inspirator and found to be 12,000 gallon rated capacity, which was the largest size possible in this type of inspirator. All tubes were in good condition other than a slight roughness beyond the throat of the forcer tube, which apparently did not interfere with proper operation. The delivery line check was built integral with the inspirator, and the valve was found to be free and had 1-1/8 inch lift.

Feedwater pump: The locomotive was equipped with an Elesco type CF-2 feedwater pump with cylinders 9-1/2 x 6-1/2 x 10 inches. This pump was located on a bracket at left side of boiler. The steam supply throttle valve was located under the superheated steam turret at the left side of smokebox and controlled from the cab by a long extension rod. After the accident, this valve was found one turn open, while fully open position of the valve was four turns. The main shut-off valve in the superheated turret and also the shut-off valve in the steam line at the pump were found wide open. The steam supply pipe and its valves were removed and found to be in good condition and unobstructed. The water pump feed pipe and delivery pipes were torn off at the time of the explosion, but were tested and found open and unobstructed. Indications were that the pump was being properly lubricated by the mechanical lubricator.

This feedwater pump was tested on locomotive 3700. On the first test of 2 minutes duration, starting from 200-pound boiler pressure with pump throttle valve open one turn, the boiler water level was raised slightly over 7/8 inch and the pressure dropped to 180 pounds. On the second test of 2 minutes duration, starting from 230-pound boiler pressure and with throttle valve open one turn, the boiler water level was raised 15/16 inch and the pressure dropped to 215 pounds. On the third test of 2 minutes duration, starting from 245-pound boiler pressure and throttle valve open one turn the boiler water level was raised 13/16 inch and the pressure dropped to 230 pounds. On the fourth test of 2 minutes duration, starting from 240-pound boiler pressure with throttle valve wide open, the boiler water level was raised 1-3/4 inches and the pressure dropped to 217-1/2 pounds.

Feedwater pump gage: The Ashcroft 5-inch feedwater pump gage was found on left side of boiler back head in cab, still connected to a section of pipe. This pipe was found open. The gage was tested on a deadweight tester and was accurate at pressures up to 300 pounds, but 5 pounds low at 350 and 400 pounds.

Feedwater heater: The locomotive was equipped with an Elesco K-60 closed-type heater located on brackets at the top of the smokebox front end ring. It was torn off and all water and steam pipe joints were broken at the time of the explosion. The outer housing was broken, a section was missing, and some of the tubes were bent. A 200-pound cold water test was placed on the heater bundle without developing any leakage. The tube headers were then removed and the interior of the tubes was found unobstructed, allowing a free water passage from the feedwater pump to the boiler.

Main turret: The main turret was mounted, with two flange connections, on top center line of the boiler in front of cab and supplied with saturated steam through two 2-3/4 inch inside diameter dry pipes from the main steam dome. The main turret was broken from the boiler at flange studs, and all valves and connections were broken off or pulled out of the threads. The main turret valve was found in full open position with the stem badly bent. All openings and the interior of the main turret were found clean and unobstructed.

Boiler checks: A Hancock 3-inch double combination stop and vertical check valve was mounted on top of the first boiler shell course. The two boiler checks were examined and found in good condition, body passages unobstructed and openings clean. The lift of the right check valve was 5/8 inch and lift of the left valve was 1/2 inch. Both stop valves were found in fully open position of 13/16 inch. Both stop valve stems were badly bent and the 3-inch delivery pipes were broken off at the flange connections. Company prints showed the lift of the right check valve as 5/8 inch and the left valve 3/8 inch.

Delivery pipes: The 3-inch delivery pipes between the feedwater pump and boiler check and between the injector and the boiler check were found distorted but otherwise in good condition, open and unobstructed.

Blow-off cocks: The boiler was equipped with two 2-inch Wilson blow-off cocks. One was located near the right front mud ring corner and was not operative from the cab, as it was used for blow-down or fill-up purposes only. The other, located at left back corner of mud ring, was operated from cab by means of an extension rod and handle. Both cocks were found attached to

boiler and in good condition with valves open, but the cab extension rod and operating lever were torn off of the left cock, and the right lever appeared to have been struck by some object.

Specialties: The boiler was equipped with an Elesco tangential steam drier in the steam dome with a 2-inch electro-pneumatic discharge valve, Type C-2, mounted on left side of boiler. The discharge was piped to a separator on top of the boiler, where steam was vented upward while water and sludge were piped down and discharged at side of rail below left front mud ring corner. The external piping and muffler were torn off, but the discharge valve was found intact on the boiler. It was removed and applied to D&RGW 3700 for test. The manual shut-off valve was found in wide open position, but under pressures up to 275 pounds there was no leakage from discharge valve. When the test button in cab was pressed and released, the valve opened and closed properly.

The locomotive was equipped with locomotive valve pilot which was inoperative at time of explosion due to wheel having been removed for repairs.

The boiler was not equipped with low water alarm or fusible plugs.

Feedwater tank, tank valves, hose and strainer boxes: The feedwater tank was a rectangular cast steel water bottom type. Tank valves were closed by the conductor and some unknown person after the accident. At the time of this investigation the tank contained 21 inches of water. The tank was drained and the interior was found clean with all swash plates in good condition. The cylindrical type strainers, 10-1/2 inches in diameter and 18 inches long with 1/4-inch holes spaced 1/2 inch apart, in the right and left tank wells at front end of the cast steel bottom, were found in good condition and clean, except a small amount of straw at bottom of left tank well which did not restrict the flow of water. The right tank valve, a Crane 3-1/2 inch, and the left tank valve, a Crane 4-inch type, were located below the tank wells and were provided with extension handles to the outer edge of the tank, near the cab gangways. The tank valves were dismantled and found to be clean and in good condition. The right and left tank hose in the order named were 4 and 4-1/2 inches in diameter and were found clean and in good condition. Tank hose strainer boxes were not equipped with strainers, but were found clean and unobstructed.

Boiler and tender water condition: There was no water in the boiler after the accident. No mention of poor water conditions was made by engineers on 20 daily inspection and repair reports covering D&RGW 3703 at different terminals since October 3, when

the boiler was last washed. The water in the boiler was changed twice at Burnham enginehouse between its last arrival at 7:30 p.m. October 17 and the morning of October 19 when it was dispatched. The boiler was first blown down through both blow-off cocks to allow repairs to the front end multiple throttle. When it was filled and heated from a direct steaming system, it was found that the main steam dome gasket was leaking. The boiler was again blown down, gasket annealed, and boiler refilled.

A sample of the water remaining in 3703 tender cistern showed 2.2 hardness and 11.5 dissolved solids.

INSPECTION AND REPAIR REPORTS

The last annual inspection was made at Salt Lake City, Utah, on November 8, 1951. The last monthly inspection, a quarterly, was made at Pueblo, Colorado, on October 3, 1952, at which time the boiler was last washed.

The daily inspection and repair reports from all terminals which handled D&RGW 3703 in the 90 days preceding the accident were examined. Items pertaining to appurtenances involved in this accident are listed below.

From Pueblo, Colo., in 45 daily reports since July 28, 1952:

Sept. 11, reported by inspector:
"Water pump will not pick up water."
Repaired by machinist.
Approved by foreman.

Sept. 15, reported by engineer:
"Feedwater pump does not work."
Repaired by machinist.
Approved by foreman.

Sept. 16, reported by engineer:
"Gauge to water pump don't work. Clean both water glasses, can't see water."
Repaired by machinist with notation, "No gauge in stock."
Approved by foreman.

Sept. 21, reported by engineer:
"Air pumps and water pump not getting enough oil."

Heading on sheet shows condition of air compressors "Good" and condition of water pump "Good".
Repaired by machinist.
Approved by foreman.

Oct. 13, reported by engineer:
"Weld bolt on injector so can put injector on."
Repaired by machinist.
Approved by foreman.

From Burnham enginehouse, Denver, Colo., in 15 daily reports since August 15, 1952:

August 15, reported by inspector:
"Drain valve to front water pump cyl. leaking."
Repaired by machinist.
Approved by foreman.

August 24, reported by inspector:
"Gauge cock union leaks. No tag on water pump handle."
Repaired by machinist.
Approved by foreman.

August 29, reported by inspector:
"Test out water pump & injector. No water in tank."
Work done by machinist.
Approved by foreman.

August 31, reported by engineer:
"Water pump don't supply boiler when working eng. hard."
This item signed off, "No out of line condition found" by foreman.

Sept. 5, reported by inspector:
"Pck. nut to R. top water glass cock leaking."
Repaired by inspector.
Approved by foreman.

From Grand Junction, Colo., no pertinent items found in 2 daily reports.

From La Veta, Colo., no pertinent items found in 18 daily reports.

From Salida, Colo., no pertinent items found in 17 daily reports.

From Minturn, Colo., in 13 daily reports since July 28, 1952:

August 9, reported by engineer:
"Lubricator pipe broken at water pump."
Repaired by machinist.
Approved by leadman.

August 12, reported by machinist:
"Titen caps on water pump discharge valves."
Repaired by machinist.
Approved by foreman.

SUMMARY OF EVIDENCE

The engineer who operated D&RGW locomotive 3703 on a freight train from Pueblo, Colo. to Denver, Colo., on its last complete trip, arriving at Burnham enginehouse at 7:30 p.m. October 17, stated he had used this locomotive several times in the previous month and that it did not steam very well; however, on the last trip it steamed freely. He had tonnage rating, but never had to use the inspirator, as the feedwater pump kept one-half to three-fourths glass of water in boiler at all times. He had tested the inspirator before starting the trip and found it operated satisfactorily. All water level indicating devices were in good condition, were well illuminated, and gave uniform readings. There was no smoke or steam in the cab. The throttle stuck open at the top of the hill at Palmer Lake; he finally worked it nearly shut, but it leaked some. He stated he would not have objected if called to operate the locomotive again after repairs were made to the throttle.

The fireman on 3703 on October 17 stated he was nervous on that date because when he last fired 3703 on September 7 it did not steam well. On that date the feedwater pump supplied the boiler easily, as it again did on October 17. On the latter trip the boiler steamed freely, and he noted that a safety valve started to open once just as the steam gage hand neared the red mark on the dial; he opened the water pump valve wider to prevent this. The feedwater pump gage fluctuated normally with each stroke. He had to work the pump to capacity only once, even when making good time with the full tonnage. The water glasses were clean, well illuminated, and showed uniform readings. He tested all appurtenances before

leaving Pueblo and found them functioning properly. He used the blow-off cock several times. He never noticed any discharge from the tangential drier. There were no leaks in the firebox and the boiler did not foam.

Three enginehouse foremen, the firebuilder, a machinist, a hostler, and a hostler helper testified with respect to work performed on locomotive 3703 and stated that the locomotive and devices functioned normally at time of departure. The conductor and rear brakeman stated that members of the engine crew appeared normal and in good spirits prior to the accident.

CAUSE OF ACCIDENT

It is found that this accident was caused by an overheated crown sheet due to low water.

Dated at Washington, D. C., this 2nd day of December, 1952.

By the Commission, Commissioner Patterson.

SEAL

GEORGE W. LAIRD,

Acting Secretary.