Inv-2378

INTERSTATE COMMERCE COMMISSION

WASHINGTON

REPORT OF THE DIRECTOR

BUREAU OF SAFETY

ACCIDENT ON THE

BOSTON AND MAINE RAILROAD

PORTSMOUTH, N.H.

SEPTEMBER 10, 1939

INVESTIGATION NO. 2378

SUMMARY

Inv-2378

Railroad:	Boston and Maine
Date:	September 10, 1939
Location:	Portsmouth, N. H.
Kind of accident:	Derailment
Train involved:	Passenger
Train number:	2020
Engine number:	3636
Consist:	4 cars
Speed:	5-7 miles per hour
Operation:	Timetable, train orders, and automatic block system
Track:	Single; tangent; vertical curve
Weather:	Cloudy; strong wind and intermittent rain
Time:	7:10 p. m.
Casualties:	2 killed
Cause:	Collapse of truss span of bridge as a result of pile bents supporting end of the span having been pulled out of position by the drifting of a caisson resulting in the fouling of the bents by anchor cables attached to the caisson

To the Commission:

On September 10, 1939, there was a derailment of a passenger train on the Boston and Maine Railroad at Portsmouth, N. H., which resulted in the death of two employees. The investigation of this accident was made in conjunction with a representative of the New Hampshire Public Service Commission.

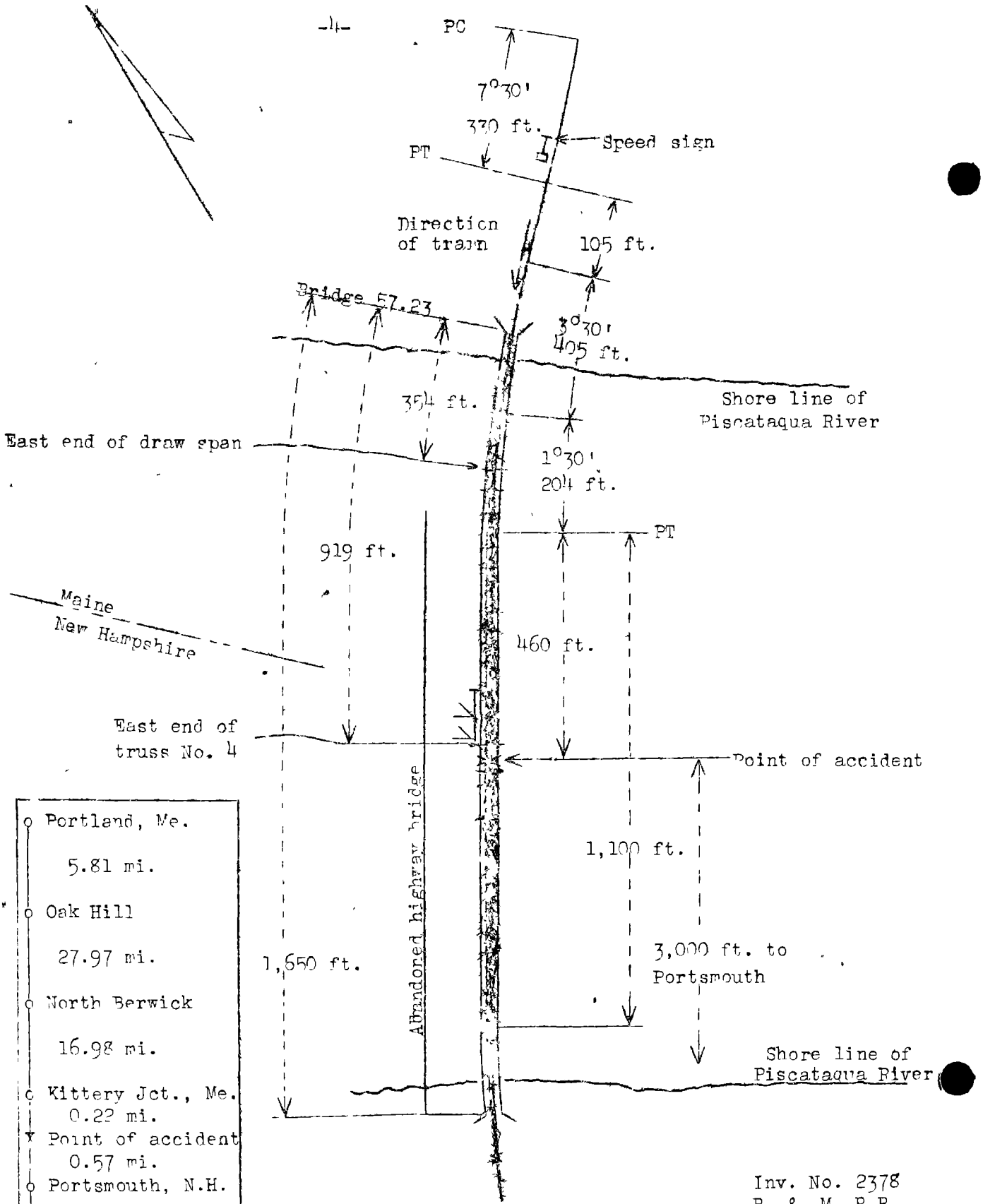
Location and Method of Operation

This accident occurred on that part of the Portland Division which extends between Beverly, Mass., and Oak Hill, Maine, a distance of 84.32 miles. In the vicinity of the point of accident this is a single-track line over which trains are operated by timetable, train orders, and an automatic block system. Kittery Junction, Maine, and Portsmouth, N. H., lie east and west, respectively, of Piscataqua River and are joined by Bridge 57.23, which spans the river and is 1,650 feet in length. The accident occurred near the center of the bridge at a point 3,000 feet east of the station at Portsmouth. Approaching the point of accident from the east there is a 7°30' curve to the right 330 feet in length, which is followed in succession by a tangent 105 feet in length, a compound curve to the left consisting of 3°30' curvature a distance of 405 feet and 1°30' curvature a distance of 204 feet, and a tangent 1,100 feet in length extending practically to the west end of the bridge; the accident occurred on this latter tangent at a point 460 feet from its east end. The grade for westbound trains is 0.72 percent descending a distance of 1,244 feet, which is followed in succession by a vertical curve 400 feet in length, on which the accident occurred, a 1.50 percent ascending grade a distance of 400 feet, and a vertical curve extending to the west end of the bridge.

The track structure consists of 85-pound rail, 33 feet in length; it is single-spiked and tieplated; the bridge is provided with 85-pound guard rails which are spiked on each tie.

The bridge is composed of one draw span, seven truss spans, and trestle construction. There are 181 pile bents and 84 stringer spans. The truss spans are numbered consecutively from the west end. The east end of the draw span is located 354 feet from the east end of the bridge. The accident occurred at truss span 4, the east end of which was located 919 feet west of the east end of the bridge.

Truss span 4 was supported on the west end by pile bents 25, 25-1/2, and 26, having a total of 36 piles, and on the east end by pile bents 27, 27-1/2, and 28, also having a total of 36 piles. Each pile was constructed of two 45-foot oak timbers, with a minimum of 18-inch butts and 12-inch tips, spliced together at their



- Portland, Me.
- 5.81 mi.
- Oak Hill
- 27.97 mi.
- North Berwick
- 16.98 mi.
- Kittery Jct., Me.
- 0.22 mi.
- Point of accident
- 0.57 mi.
- Portsmouth, N.H.
- 38.58 mi.
- Beverly, Mass.

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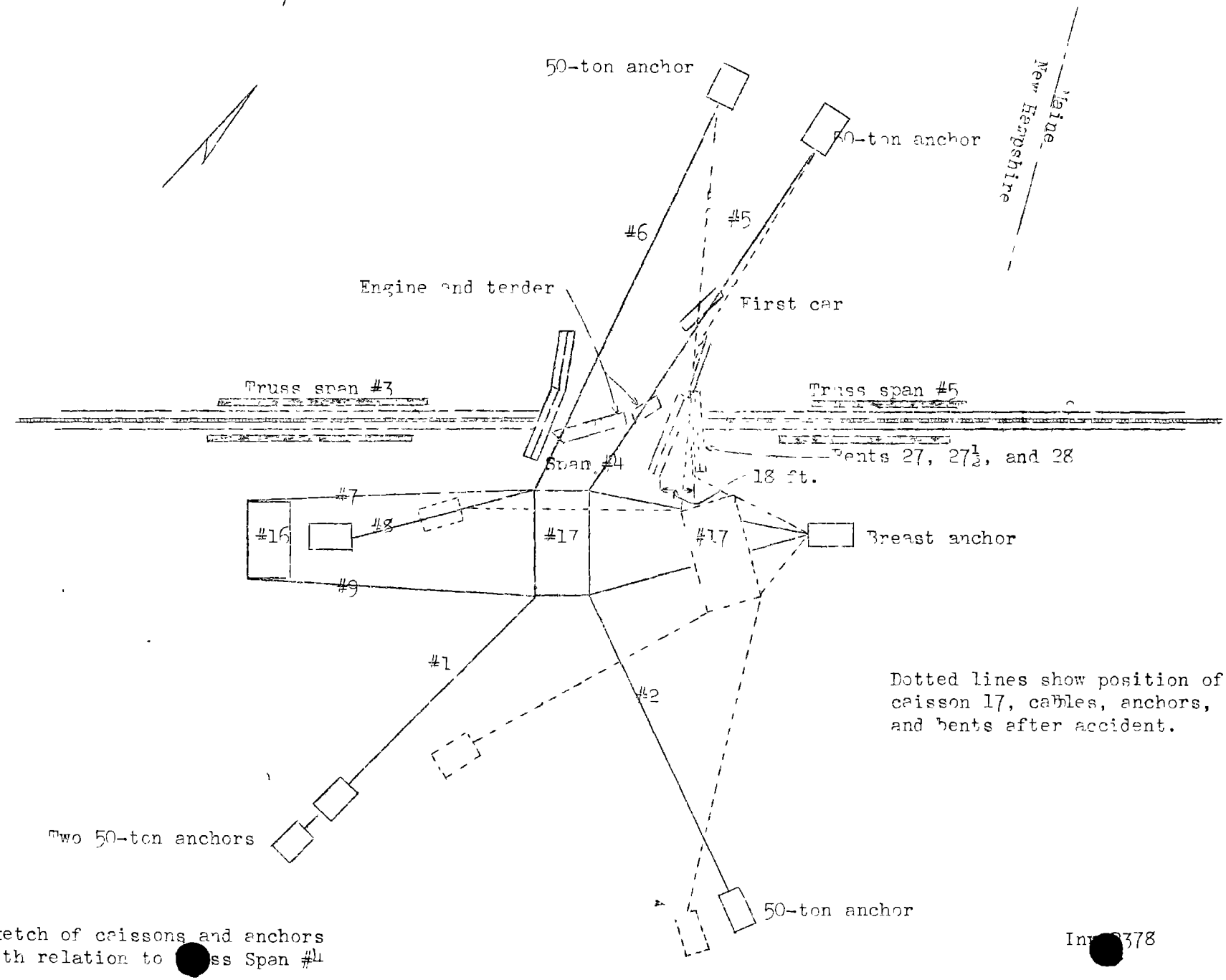
butt ends to provide a pile of sufficient length and stiffness for the depth of water encountered. The piles were driven to refusal, which was a distance of from 8 to 10 feet in the river bed. Tenons were cut in the tops of the piles, and heavy timbers, which formed girder caps, were bolted on either side. On some of the bents rider caps rested on top of the girder caps, on top of which were truss bearings of varying thickness, and bolster blocks rested on top of the bearings; the ends of the trusses rested on the bolster blocks.

The truss span involved was a Howe truss; the upstream and downstream trusses each were 84 feet in length and were of the usual construction for this type of truss. The bottom and the top chords each consisted of four longitudinal timbers 8 inches by 16 inches, laid horizontally and parallel to each other and separated by spacing blocks. The two chords were secured to each other by heavy steel rods and wooden diagonals. The entire assembly of each truss was covered by wooden housing to protect it from the weather. Large timber floor beams extended from one truss to the other; they were not fastened to the trusses, but there were steel rods under the floor beams which connected the two trusses and provided some degree of lateral stability. The track structure rested on longitudinal stringers, which in general rested on such sills and blocking as were necessary to compensate for the different elevations of the pile bents. The downstream truss was renewed in 1919 and the upstream truss in 1935. At this latter time all floor beams were renewed, and the downstream truss was inspected and adjusted; also, the bolster blocks were renewed at all four corners and the housing was renewed.

At the time of the accident the Frederick Snare Corporation was constructing a new two-level bridge south of Bridge 57.23, designed to carry trains on the lower level and highway and pedestrian traffic on the upper level. The new bridge is to be a steel structure supported on concrete piers; in the immediate vicinity of the point of accident the center line is 60 feet downstream from the center line of the railroad bridge. Caissons were being used in the construction of piers for this bridge, and the caisson for pier 17 had been placed in the desired location on August 29. This caisson, which was 30 feet wide, 72 feet long, and 76 feet high above the cutting edge, had been partly filled with concrete at the time of the accident, the total weight then being approximately 4,200 tons. It had been secured in position by means of 50-ton concrete anchors. The cables leading from the upstream corners of the caisson passed under truss span 4 to anchors upstream from Bridge 57.23, and cables from the downstream corners extended to anchors downstream. The downstream anchor nearest Portsmouth was a double anchor. The cables were of plow steel and were 1-1/4 inches in diameter. Breast anchors, one on each side of caisson 17, also were provided; these were 30-ton anchors secured by 1-1/8-inch cables. In addition, on the Portsmouth side, anchorage was provided by means of a 1-1/8-inch cable, which extended from the two west corners of caisson 17 to and



Sketch of caissons and anchors with relation to [illegible]ss Span #4

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around caisson 16, located west of caisson 17. A 2-ton weight was placed at caisson 16 to hold the cable on the bed of the river. All these cables extended upward from their various anchors and were fastened to caisson 17 by a block-and-tackle arrangement at points approximately 46 feet above the cutting edge. The river at this point is approximately 60 feet deep at mean low tide. The average tide in the vicinity of the point of accident is from 8 to 10 feet; the average rate of flow is about 5 miles per hour.

Train movements over Bridge 57.23 are governed by semi-automatic signals of the 2-arm, 2-position, lower quadrant type, and are approach lighted. Signal P578, an absolute signal, governing west-bound movements, is located 1,598 feet east of the bridge; the next westward signal is signal P576, which is located on the bridge at a point 2,838 feet west of signal P578 and 185 feet east of the point of accident. These signals function as a part of the automatic block system, and, in addition, may be placed in stop position by the operation of a lever when the drawtender desires to open the draw span.

A speed sign, located 260 feet east of the bridge, provides that enginemen will use 1-1/2 minutes in crossing the bridge.

There had been intermittent squalls of rain. There was a strong wind and the weather was cloudy at the time of the accident, which occurred at 7:10 p. m.

Description

No. 2020, a west-bound passenger train, consisted of three coaches and one combination baggage and smoking car, in the order named, hauled by engine 3666, and was in charge of Conductor Storer and Engineman Beattie. All cars were of steel under-frame construction except the third car, which was of all-steel construction. This train departed from North Berwick, Maine, 17.77 miles east of Portsmouth, at 6:46 p. m., according to the train sheet, on time, proceeded upon Bridge 57.23, and was moving at a speed of 5 to 7 miles per hour when truss span 4 collapsed under the engine.

The engine, tender, and first car dropped into the river and were submerged to a depth of about 60 feet. The engine was found on its left side with its front end close to the piles which had supported the west end of the truss span and its rear end extending diagonally upstream. The tender, also on its left side, was practically in line with the engine. The first car was in upright position, practically parallel with the river bed, and its nearest end about 100 feet upstream from the original location of the span. The upstream truss remained in place for a few hours after the accident and then disappeared into the river; it had not been located at the time of this investigation.

The employees killed were the engineman and the fireman.

Summary of Evidence

Conductor Storer stated that at North Berwick the air brakes were tested and they functioned properly. No stops were made en route. East of Kittery Junction the speed was reduced to about 25 miles per hour to comply with a slow order; the train proceeded upon the bridge at the usual slow speed, and was moving at a speed of 6 or 7 miles per hour when he felt an emergency application of the air brakes as though an air hose had burst. The accident occurred about 7:10 p. m. He stated that his crew had just made an eastbound movement on No. 2021, with the same equipment, leaving Portsmouth at 5:15 p. m., at which time it was daylight. He, together with the baggageman and the brakeman, stood on the rear platform of the rear car and he did not notice any unusual movement of the train at any time while crossing the bridge, and there was no indication of anything unusual about the condition of the bridge. He observed that caisson 17 was standing in its proper position in line with the other caissons. He did not observe the location of the caisson at the time of the accident, but several days after the accident he observed that it was east of the location in which he had seen it prior to the accident.

The statements of Baggagemaster Gee and Brakeman Claffy developed nothing additional of importance, except that Brakeman Claffy estimated the speed of his train to have been 5 miles per hour at the time of the accident.

Drawtender Hayes, on duty from 3 p. m. to 11 p. m., stated that he was at his shanty, located east of the draw span, when No. 2021 passed over the bridge, at which time he observed nothing wrong with the train and that the signals were functioning properly. He was down on the pier of the draw span when he heard No. 2020 approach, and he returned to his post. The headlight of this train was burning, and soon after it passed he heard a sound as though the brakes had become applied. He saw that the train had stopped; then someone who approached informed him that the engine and first car had gone into the river. He did not observe the position of the signals, but his lever was in normal position. When he went on duty that afternoon caisson 17 appeared to be in its normal position. At no time had he occasion to go west of the draw span. Fifteen or twenty minutes after the accident, however, he saw that the caisson had moved nearer to the Kittery shore. There was a strong wind, coming in squalls, from the southeast, and the incoming tide was running strong.

Drawtender Williams, on duty from 7 a. m. to 3 p. m., stated that at noontime he walked westward from the draw span toward caisson 17, and at that time it was on an even keel and in line with the other caissons. He did not notice any movement of the caisson during the day, and he did not see it again until the morning after the accident.

Track Supervisor Leavitt arrived at the east end of the bridge about 8 p. m. He inspected the track and equipment and found nothing wrong; there was no evidence that the train had been derailed prior to the collapse of the bridge. The water was high and the current was unusually swift. At that time caisson 17 was directly opposite bent 27, having moved eastward the length of truss span 4, and it was at a 45-degree angle to the center line of the new bridge. The track on the bridge is inspected daily except on Sundays, and he had last been over the bridge on Friday, September 8, at which time he observed nothing unusual.

Division Engineer Archibald arrived at the scene of accident about 1-1/2 hours after its occurrence, and at that time caisson 17 was still swinging a few inches with the tide and on an even keel. Bents 27, 27-1/2, and 28 were found to have been pulled eastward a maximum of 18 feet on the downstream end, and divers found two sets of cables, Nos. 5 and 6, bearing tightly against the bent and embedded to a maximum depth of three-fourths inch in the piling. After tracing cables 5 and 6 under the water it was disclosed that one set extended to the northeast corner and the other set to the northwest corner of caisson 17. The caisson had drifted nearly 80 feet eastward from its original position. After tracing cables 5 and 6 in the opposite direction it was found that cable 5 came close to the buoy over an anchor, while cable 6 led to an obstruction which was discovered to be the first car in the train. Cable 7, which had extended from caisson 17 around caisson 16, had been broken, having failed at the northwest corner of caisson 16 and having started to fail at the southwest corner. The broken ends of this cable were sharp as if the cable had failed suddenly; there were practically no marks of abrasion or chafing. From his observations and the information furnished by the divers, he concluded that when caisson 17 moved out of position upstream cables 5 and 6 pulled upon the piles supporting bents 27, 27-1/2, and 28 and pulled them from beneath the truss bearing, leaving no bearing for the corner of the downstream truss on the east end. He thought the truss would have remained in place until some load was placed upon it, and that the engineman would have been unable to detect anything wrong until the engine reached the span. The divers found a portion of the truss on the downstream side of the bridge and under it was a cable, apparently cable 8, the one leading to the breast anchor on the west side of caisson 17, although it had not yet been traced the entire distance to the anchor. The caps on all the bents under the downstream truss of span 4 were in such condition that they did not need immediate attention; the blocking was in good condition, although there was one spot under a bearing which showed some decay. The piling under water is inspected by a diver every 2 or 3 years; the housing for the trusses is removed every 2 years for detailed examination of the trusses, including the adjustment of all rods and bolts. The remaining portions of the bridge are inspected annually by the supervisor of bridges and buildings, semi-annually by the bridge inspector, and almost

daily by the foreman carpenter. The last inspection of truss span 4 was made in July, 1937, and of the piling in September, 1938. The last semi-annual inspection was made by the bridge inspector in March, 1939, and the last inspection by the supervisor of bridges and buildings was made in August, 1939; the foreman carpenter inspected the bridge on the day prior to the accident. As a result of the last pile inspection, no piles were renewed in the bents supporting truss span 4, as there was a sufficient number of good piles to support the load adequately. Subsequent to the accident an examination of the piling was made, which disclosed that there had been no material change in its condition from the time of the inspection in September, 1938.

Diver McIntyre, employed by the railroad company, stated that following the occurrence of the accident he made an underwater inspection of conditions and found that cables 5 and 6 were pressing tightly against the piles of bent 27 and were embedded to a depth of one-half the diameter of the cables; the cables were in good condition except one strand was broken in cable 6, which at that point consisted of 6 strands. Tracing the cables from caisson 17, he found that they extended along the face of the piles of bent 27 and crossed each other about the tenth pile; cable 5 extended toward its anchor, but cable 6 angled downward toward the riverbed and was found to be held under the south truck of the first car of the train, which car had fallen into the river and was standing upright on the riverbed. Examination at the ground line of bent 27 did not reveal that any of the piles had been broken, and inspection of caisson 17 did not reveal any marks or abrasions that would indicate it had scraped or secured against any object. The engine was found lying on its left side on the riverbed, with its front end about 5 feet from bent 26. No mark on the engine to indicate that it had come in contact with a cable when it dropped into the river was found, and he did not find any portion of the bridge under the engine. He entered the engine cab and found the brake valve in emergency position. The piles of bent 26 were in upright position, and although the bark had been scraped off, they did not appear to have been struck by the engine. A portion of a broken truss was found on the downstream side of the bridge near bent 26; the timber of this truss was in good condition.

C. R. Norris, an independent diver who was employed by the railroad company on September 11 to assist in the underwater inspection of conditions at the point of accident, stated that the current in the Piscataqua River was very strong, that on the incoming tide it pulls toward the east shore, and on the ebb tide it pulls toward the west shore. His inspection did not reveal anything additional except under two portions of a truss on the downstream side of the bridge near the west end of span 4 he found a cable, which was slack; it led to caisson 17, but he could not follow it westward as it was embedded in the sand. Although the bark had been scraped off the piles of bent 26 at a point about 10 or 12

feet from the bottom, he observed nothing to indicate that the engine had struck this bent as it dropped into the river.

Engineer of Structures Guppy stated that he arrived at the scene of accident on the morning following its occurrence, and after his examination and after hearing reports of the divers it appeared to him that when the caisson broke free from some of its bearings it was forced across the stream by the action of wind and tide; then the anchor cables pulled against the bents at the east end of the span and pulled them out. He found no condition of the timbers that could have caused or contributed to the accident. He stated that if the downstream truss itself had broken at some point, both ends of it would have been pulled in and the engine and truss would have dropped into the river on top of cables 5 and 6 and pinned them down, and that they would not have been against the bents if the truss and engine had fallen before caisson 17 had moved out of its position. Engineer Guppy stated that he had been more or less familiar with this bridge since 1890. The capacity of truss span 4 has been computed under his direction and it was found to be ample for the maximum loads permitted, which were P-8 passenger engines, K-8 freight engines, and Maine Central engines 701 and 702.

The total weights of these engines and their tenders are as follows:

Passenger P-3	437,800 pounds
Freight K-8	398,200 "
Maine Central engines 701 and 702	512,200 "

Engine 3666, the engine involved, was of the 4-6-2 type, a class P-2 engine, and its weight was as follows:

Drivers	157,850 pounds
Total weight of engine	249,350 "
Tender loaded	145,000 "
Total weight of engine and tender	394,350 "

Truss span 4 was designed for Cooper's E-40 rating, and engine 3666 was equivalent to an E-44 rating; the P-3 and the K-8 with booster, an E-46 rating; and the Maine Central engines an E-50 rating, an increase in load over the design load of 25 percent. It is the practice to increase the design loads on their bridges about 50 percent without any reduction in speed. In this particular case, so far as the trusses themselves were concerned, he would have approved an E-60 rating; but, on account of the piling, he would not have approved such loading for the bridge as a whole.

Consulting Engineer Moore, specializing in structural work and bridges, examined the bridge at the request of the railroad company. It appeared to him that the piling had been pulled back

at the east end and the bearing had slid out from under the downstream truss. Computations as to the stresses in the truss span and the unit stresses of the different parts indicated that the loading was well within safe limits. He said the load on it could be doubled without causing failure. Examination of truss span 3, built at the same time and of the same material as truss span 4, showed that it was in good condition; therefore, it seemed a reasonable conclusion that span 4 also had been in good condition. In his examination he found none of the timbers at the ends of span 4 in such condition from rot or other causes as to induce them to give way under the loads placed upon them, and he observed nothing improper in the construction of the bridge. In his opinion, based upon his observations and the statements of the various witnesses, the accident was caused by caisson 17 pulling the upstream anchor cables 5 and 6 against bent 27, which in turn was pulled from under the corner of the downstream truss on the east side; the bearings on the Portsmouth side indicated that the truss on that end had tipped downward. He said that the truss would not fall as a result of bent 27 being pulled from under the truss bearing, as there was considerable bearing surface on the other three corners of the truss.

Foreman Bridge Carpenter Libby stated that the last work he performed on truss span 4 was to renew some ties early last spring. He went over the bridge on the day prior to the accident and he considered it to be in good condition.

Engineer of Signals and Telegraph Muller stated that the signals in the vicinity of the point of accident were tested at 8:30 p. m. on the day of the accident and again on the next day, and all circuits and apparatus were found to be in good working order.

Watchmen Gustafsen, Merryfield, and Hart, employed by the Frederick Snare Corporation, were on duty at the time of accident, but did not witness its occurrence. Watchman Gustafsen crossed the river in his motor boat shortly after going on duty at 5 p. m. and at that time he observed that caisson 17 was in its proper position. He was in his boat near the Kittery side at the time of the accident. Watchman Merryfield, located on the Portsmouth side, stated that about 6:50 p. m. he walked out on the bridge on the old highway side, turned on four spotlights, and flashed one against caisson 17, at which time it was in position. He returned to the Portsmouth side, then heard the engine whistle as the train approached the bridge, and saw the signal on the west side of the bridge change from green to red; then he heard a crash. Watchman Hart, located on the Kittery side, stated that he saw the train, with the headlight burning, approach the bridge at a low rate of speed.

Assistant Superintendent of Construction Manning, of the Frederick Snare Corporation, stated that the 50-ton anchors

were connected with caisson 17 by two cables fastened to a U-bolt in the anchor by means of a triangular plate containing sockets for holding the ends of the cables; at a point about 30 or 40 feet from the caisson end the cables were fastened to another triangular plate, which in turn was shackled to a 3-sheave block, with six lines of cable leading from this block to another 3-sheave block at the corner of the caisson, the latter block being fastened to a plate at that point. The cable making up the six lines between the two 3-sheave blocks then led up over the top of the caisson to a connection with 3 drum-engines, the entire arrangement being such that by adjusting this cable the caisson could be kept in proper position. No difficulty had been experienced with caisson 17 and the anchors had held properly at all times. His inspection of caisson 17 subsequent to the accident showed it to be in the position previously described. The breast anchor attached to cable 8 on the west side and the downstream anchor attached to cable 1 had been dragged eastward. Examination of the broken cable which had been around caisson 16 showed that the cable had been broken at one corner as a result of sudden shock, while on the downstream corner all but two strands of the cable had been torn; this cable appeared to have been pulled or dragged. No material of any kind had been placed between the cable and the corners of the caisson, but it was his opinion that this did not have anything to do with its failure, as the material of which the cable was composed was harder than the soft iron of which the outer shell of the caisson was constructed. This cable was fastened originally to the caisson at only the downstream corner, but subsequently was tied to both corners so that it could be used in adjusting the position of the caisson. He thought it would have required from 15 to 17 minutes for caisson 17 to drift from its original position and drag its anchors to the point where subsequently it was found. He stated that cable 6 leading to the upstream anchor on the west side originally cleared the pile bents of the railroad bridge a distance of 5 or 6 feet, and that cable 5 leading to the upstream anchor on the east side cleared the east bent about 40 feet.

Vice President Cremer, of the Frederick Snare Corporation, stated that studies of the currents at different stages of the tide were made for the purpose of determing the action of water at each of the pier sites. Detailed calculations then were made as to the stresses that would be caused in the caisson itself as a result of the impact of the currents on the shell of the caisson. A detailed survey to determine the exact location of the pile bents of the railroad bridge also was made to ascertain in which direction lines could be run to upstream anchors; the other cables leading downstream and also toward each shore were so located as to balance the various forces and keep the caisson in equilibrium for different stages of the tide. On September 10, caisson 17 weighed approximately 4,200 tons and at low tide it was on the bottom with the cutting edges probably not penetrating the streambed more than a few inches, and at high tide the caisson would float. Subsequent to the accident he ordered that a hole be

cut in the caisson to ground it. On the morning of September 12 he found the caisson on the river bottom toward the Kittery shore, approximately 10 feet lower on the downstream end than on the upstream end, and skewed at an angle of about 30 degrees from normal. From his observations he concluded that the train had fallen on or jarred cables 5 and 6 in such way as to place excessive stress on cables 7 and 9, which led around caisson 16, causing the cable to break and permitting caisson 17 to move toward the eastern shore; the current carried the caisson practically parallel to the railroad bridge until it grounded on one corner and then the other end swung farther toward the Kittery shore. After the ebb of the tide, the downstream end of the caisson settled. He thought that when the engine struck cable 5, each cable being 7/8 inch, the cable was not broken because of its flexibility and at the same time the load was transmitted to the other parts of the same cable, causing a very powerful pull toward the anchor and jerking the caisson; the sudden pull broke the U-bolt on one of the 50-ton anchors of cable 1, leading to the southwest anchors, causing a sudden readjustment of all the cables and considerable added stress on cables 7 and 9, resulting in their failure. A scar or gouge from 5 to 6 feet in length was found on the tackle section of cable 5, indicating it had received a heavy blow, apparently made by metal. Cables 1, 2, 5, and 6 were of plow steel, 1-1/4 inches in diameter, and cables 3, 4, 7, 8, and 9 were 1-1/8 inches in diameter. The original plan specified only one downstream anchor toward the Portsmouth shore and there was no provision for a cable around caisson 16, however, the holding powers of the anchors could not be foreseen; the single anchor seemed to drag, which would throw excessive strain on the breast anchor of cable 8, therefore, an additional 50-ton anchor was placed on cable 1, and cables 7 and 9 were placed around caisson 16. He stated that his inspection of the railroad bridge indicated that many of the stringers, the ties, and even some of the more important structural timbers, such as the sills supporting the trusses, the blocking under the ends of the stringers and other members, were rotted. There was evidence of bad rot in one of the stringers of the span involved, and the sills under the downstream truss were in bad condition, particularly two of the three sills which had been under the Portsmouth end. At the Kittery end there was evidence of bad rot in the clamps of the bent nearest the open span; the other two seemed quite sound. The piles under the eastern end of span 4 were fairly good and he considered that the chief weakness at this point was the fact that the three bents were not connected together with braces; also there was a weakness in having only a 3-inch tenon in a pile, instead of 6 or 8 inches in thickness, to allow for deterioration; in this case the tenons had rotted to such an extent that there was very little sound timber left. He stated that the chief objection to wooden trusses is that they have no lateral stability, having no top-chord bracing and no connection between the floor beams and the trusses to hold the latter in vertical position. Most

of the trusses were out of plumb, which in turn creates objectional stresses in the truss members. It was his opinion that this bridge is not safe for an E-40 loading unless all trusses are vertical, floor beams fastened to the trusses, stringers fastened to the floor beams, the tie reasonably sound, and the piling in good condition. Of the various factors mentioned by him, assuming truss 4 to have been in good condition, he considered the most serious objection to be the two unsound sills at the Portsmouth end. He said that the rot on the downstream side at this point was bad, which might throw the truss in that direction. It was his opinion that the span gave way under the engine when it was near the Portsmouth end, probably starting with the failure of a stringer under the load; the end of this stringer was still in the bridge and he felt that if it had been carried down with the span it would have been unseated entirely and lost. This stringer was on the upstream side, and its failure could have caused the engine to rock, throwing excessive load on the chords, and resulting in demolishing the span. He stated that the movement of the caisson took place after the span collapsed. Had the caisson drifted prior to the accident, causing the upstream cables to displace the supports for the truss at its east end, the truss would have fallen into the water and probably would have been thrown against the structure by the incoming tide and wrecked. He had examined the bridge prior to the accident, and observed that there was a movement of the bridge when trains were passing over it, that it would move upstream and downstream with the tides, and that these various movements were such that his engineers could not locate a line on it.

Cable Foreman Petrie, of the Western Union Telegraph Company, stated that in March, 1939, he relocated their cable at the Portsmouth side to a point 75 feet downstream from the center line of the new bridge; it was anchored at the shore ends but not in the river. The armor on this cable, which had an outside diameter of 2-1/2 inches, was in poor condition and if the cables attached to caisson 17 had come in contact with it they would have put it out of service.

Traffic Manager Cavanaugh, of the Western Union Telegraph Company, located at Boston, stated that the following offices reported wire failures on the night of the accident: Bangor, Maine, at 7 p. m., the cable department at New York City at 7:02 p. m., and Portland, Maine, at 7:03 p. m. At 7:10 p. m. the board at Boston had an entry showing that 14 wires had failed. Subsequent to the accident temporary wires were placed around the broken span in the railroad bridge, and the telegraph wires then worked properly, indicating that the trouble had been with that part of their cable which extended between the Portsmouth and Kittery shores.

Two residents of Kittery stated that their home is located

on the shore of the river, about 300 yards north of the bridge. About 7 p. m. on the day of the accident they heard a rumbling sound and a crash, and one of them remarked that it sounded as if the bridge had gone out or else the caisson had broken loose and struck the bridge, but from their porch they could not see anything on the bridge. Possibly 5 minutes later, they heard the train approach, saw through a window that the signal on the bridge displayed a green aspect, watched the train as it proceeded upon the bridge, and then saw the headlight suddenly disappear, giving them the impression that the engine had dropped out of sight.

Observations of Commission's Inspectors

Examination of the bridge by the Commission's inspectors showed that there was no mark of derailment or of dragging equipment. The bents of the east end of truss span 4 were bent eastward, and the remaining portion of the floor beams of truss span 4 was sloping downward toward the river and was tilted sharply to the south. There were indications of weather rot on the girder cap on the east side and downstream end of the girder cap, but apparently nothing that would contribute to the cause of the accident. That portion which supported the truss was in good condition and all the tenons were engaged despite the fact that the bent had been pulled back 18 feet on the downstream end. On the west side there were signs of rot on two girder caps on the downstream side of the bent, although there was no bearing on this decayed portion of the bent, neither was there any fracture or scour marks showing that it had contributed in any way to the cause of the accident. Inspection of the downstream truss on September 28, after it had been removed from the river, failed to disclose any important weakness; although the truss had been twisted and broken, all timber where the breaks occurred was in good condition, with no indication of any weakness or unusual strain or wear at any point. All metal rods and plates were in good condition and they had been bearing evenly on the various members at the places where they were attached to the truss rods. The diagonals showed no sign of having been out of place prior to the accident and the spacing blocks were in good condition. All four main members of the bottom chord had been broken at a point about 56 feet from one end of the truss, and all main members of the top chord also had been broken off at a point a few feet short of the break in the bottom chord. The remaining section of the bottom chord members was in one piece, but the remaining section of the top chord members, which was about 30 feet in length, had been broken about the middle, these fractures being of an irregular splintering type of break.

The Commission's inspectors were informed that the Western Union cable had been relaid in an arc downstream from a point not less than 75 feet from the Portsmouth shore so as to clear the draw span pier on the Kittery shore a distance of 30 feet, thus bringing the Western Union cable under the caisson downstream cables and near their anchors.

Discussion

After the accident it was found that caisson 17, located downstream from the railroad bridge and weighing approximately 4,200 tons, had drifted eastward a distance of 88 feet, and that the cables leading from the caisson to its upstream anchors had fouled the piles of bent 27, finally pulling that bent, together with bents 27-1/2 and 28, eastward a distance of 18 feet at the downstream end; no material bending took place at the upstream end. Although occasional signs of rot were discovered at the span involved, it was not sufficient to have contributed to the cause of the accident. Examination of the downstream truss after its recovery from the water did not indicate that it failed because of structural weakness of any kind. If the caisson and the upstream cables had been in their proper positions when the engine and the span dropped into the water, the engine would have fallen on cable 5 and in all probability it would have broken or pinned down the cable. The first car was found 100 feet upstream and resting on cable 6, which extended from the caisson toward the west upstream anchor. These cables extended upward from their anchors to the caisson, being attached 46 feet above the cutting edge of the caisson, and it is believed that it would have been impossible for this car to be on top of the cable unless the caisson first had dragged its anchors and drifted eastward to the point where it was found after the accident. It is to be noted further that, under one portion of the downstream truss, one of the divers found a cable which was slack and which led in the direction of caisson 17; he could not follow it in the opposite direction as it was embedded in the streambed; it is probable that it was cable 8 leading to the west breast anchor.

Failure of Western Union wires was first reported at 7 p. m. and this failure was later traced to the cable across the Piscataqua River. It is probable that the caisson was moving at this time and was dragging its anchors as it drifted toward the Kittery shore, as the cable foreman of the Western Union Telegraph Company stated that the armor on the Western Union cable was in poor condition and any contact with another cable would have put the Western Union cable out of service. Further evidence to indicate that the caisson drifted and pulled the bents out of line prior to the arrival of the train is afforded by the statements of two nearby residents who testified that a rumbling noise followed by a crash from the direction of the bridge was heard very shortly after 7 p. m. and prior to the arrival of the train.

On the night of the accident there was a 30-mile-an-hour wind and the incoming tide was unusually swift and high, running across the stream toward the Kittery shore. The area of the side of the caisson, facing the direction from which the tide was flowing, was about 5,472 square feet; the tide exerted its force against the part that was submerged, which was the greater part of the area. Cable 6, leading to the upstream west anchor, afforded no

protection against this cross-stream current, because of the angle at which it was anchored on account of interference of the piles of the railroad bridge, and the holding power in that direction was in the downstream west anchors, the cables around caisson 16, and the west breast anchor. It is believed that the weather and the tide conditions prevailing at the time caused caisson 17 to drift, placing heavy strain on cables 7, 8, and 9, and cables 7 and 9 broke, shifting the strain to cable 1; then the connection to one of the 50-ton anchors snapped off, and caisson 17 drifted eastward, dragging the other 50-ton anchor and the breast anchor. Caisson 17 continued to drift until it became grounded after the upstream cables had caused sufficient damage to the bridge to permit truss span 4 to be unsupported at its downstream corner, and the span collapsed when the weight of the engine hauling No. 2020 was placed upon it.

Conclusion

This accident was caused by the collapse of a truss span of Bridge 57.25 as a result of the pile bents supporting the east end of the span having been pulled out of position by the drifting of a caisson, resulting in the fouling of bridge bents by anchor cables attached to the caisson.

Respectfully submitted,

S. N. MILLS,

Director.