SIR,

I have the honour to report, for the information of the Board of Trade, in compliance with your Order of the 28th February, the result of my inquiry into the causes of the accident which occurred on the 27th February to a passenger train on the Leven Viaduct, near Ulverston, on the Furness Railway.

In this case as the 4.25 a.m. down mail passenger train from Carnforth to Barrow was standing on the viaduct all the vehicles on the train, 10 in number, were overturned on to the up line during a terrific gale.

All the passengers in the train, 34 in number, were injured, but only one is reported as being in a serious condition. The two guards were also injured, one rather severely, and one Post Office sorting clerk.

The engine was a four-wheels-coupled passenger tender engine, with brake blocks on the four coupled wheels and six wheels of the tender, and fitted with a steam brake, which is applied simultaneously on the engine when the vacuum brake is applied throughout the train. The blocks in the tender wheels can also be applied by hand.

The vehicles in succession from the engine were as follows, viz.:

<table>
<thead>
<tr>
<th>Description</th>
<th>Wheels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furness Railway mail van</td>
<td>6</td>
</tr>
<tr>
<td>London and North-Western Railway meat van</td>
<td>6</td>
</tr>
<tr>
<td>&quot;&quot; &quot;&quot; third</td>
<td>6</td>
</tr>
<tr>
<td>&quot;&quot; &quot;&quot; composite</td>
<td>6</td>
</tr>
<tr>
<td>&quot;&quot; &quot;&quot; van</td>
<td>6</td>
</tr>
<tr>
<td>&quot;&quot; &quot;&quot; bogie-brake</td>
<td>8</td>
</tr>
<tr>
<td>Furness Railway third brake-van</td>
<td>4</td>
</tr>
<tr>
<td>Midland Railway brake</td>
<td>4</td>
</tr>
</tbody>
</table>

All the vehicles were fitted with the vacuum automatic brake working blocks on all wheels with the exception of the centre pair of each of the six-wheeled vehicles. All the brakes are stated to have been in good order.

The accident occurred at about 5.30 a.m. Details of damage to rolling stock are given in the Appendix.

There was no damage to the permanent way or superstructure of the viaduct.

Description.

Leven Viaduct, on which the accident occurred, is situated at the north of Morecambe Bay, across the estuary of the River Leven. It is 500 yards in length, 25 feet in width, with a double line of rails. It is formed of cast-iron piles 10½ inches in diameter, with six to each pier, viz., one vertically under each rail and two on the batter on the outsides of the viaduct under the fence rail. The spans between the piers are 30 feet, with the exception of one across the channel, which is 36 feet in length, with longitudinal girders under each rail and at the sides, all cross-braced. The rails and inside check rails are carried in double chairs on longitudinal timber beams 16 inches by 6 inches. The space between the longitudinal girders is filled in with buckled floor plates. There is a hand rail on each side consisting of iron standards and a single horizontal rod about 3 feet above the flooring. Thus the surface of the rails is 15 inches above the top edge of the outside longitudinal girder, and there is no solid parapet of any kind to act as a shelter to the train from wind.

The viaduct is quite straight, and its direction is from a few points south of east to a few points north of west, and the direction of the wind during the gale was almost broadside on, with nothing to break its force before striking the viaduct.

The average depth of water at high water, taking the mean between ordinary spring and neap tides, is about 8 feet 6 inches, and the height of the rails above this is 19 feet 6 inches. At low water the feet of the piers are dry except in the channel under the 36 feet span. At the time of the accident, 5.30 a.m., it was nearly low water.

There is a speed restriction over the viaduct of 20 miles an hour.
Mr. William Fleming states: I am the telegraph inspector of the Company for the contractors, Messrs. C. B. Saunders & Co. I arrived on the scene of the accident shortly after 8 o'clock and found the top wire down for five spans from the viaduct end to the crossing 402 yards towards Carnforth. The wires at the crossing were all up when I passed them. I think the original break occurred in the second span from the viaduct, and that the engine pulled off the cap, saddle and insulator attached to the wire from the second pole from the viaduct, and that when these struck the vacuum pipe they were torn off the wire and fell into the four-foot 15 yards from the viaduct end. The whole of the five spaces of wire are accounted for except about 90 yards next to the piece produced, which extended back from the viaduct 33 yards.

F. T. Tingley, signalman, states: I am a signalman at Carnforth. The mail train was blown over, the Company's service 1 year 3 months, the whole time as signalman at Carnforth. I was previously 12 years signalman with the Great Northern Railway. I switched in at 4.40 a.m. on the 27th. I came off duty at 1 p.m. on the 26th. The mail train was not offered to me, as the block had failed. I could not tell where the mail was at 4.40, as it arrived at the signal box at 5.23 a.m. Had signals against the train but only checked it. I had to get down to collect the Grange breakdown ticket from the driver. I offered the train at 5.23 a.m. to Plunton Junction, which was accepted same time and sent "Train entering section" 5.23. I got the breakdown ticket before I offered the train. Both engine head lights were out. The tail light was in. About 6.5 or 6.10 Plunton called up and said mail was off the road. He rang me obstruction danger signal 5.58, and I sent him it as soon as I got to know up road was blocked at 6.19 a.m. When I did not get "Train out of section" signal I enquired of Plunton if he had heard or seen anything of the mail. He said "No." I then said he was sending an engine on up road to look for it, which he did at 5.45. The "Entered section" signal was received same time and cancelled at 6.3. At 6.19 communication was broken. I left duty at 1 p.m. same day.

Mr. W. F. Pettigrew states: I am locomotive engineer and carriage and wagon superintendent of the Furness Railway. I arrived on the scene of the accident about 5.30 a.m., before the carriages were removed. I found the mail van next the engine was not lying over, it was held up by the coupling. The engine stood quite straight on the road. The rest of the vehicles were all lying right over on their side on the up line. No couplings were broken. Some buffers were locked and the last two couaches were lying on the viaduct on the up line touching the hand-rail. My general impression was that the rear van must have fallen over first, and the rest would fall like a pack of cards afterwards. The rear van was a four-wheeled vehicle about 25 feet 6 inches in length. I do not know the weight, but I know that our six-wheeled coach, which was near it, is about 9½ tons when empty. The last brake contained fish. The wire off the engine was on the viaduct lying amongst the carriages. I examined the engine and found that the pipe at the leading end had been severely chafed by the wire apparently, but was not fractured.
after leaving Cark, and three or four hundred yards before we got to the viaduct we struck some wires again. I immediately shut off steam, but as we heard no more noise I thought we had cleared them and put on steam again. We were on the viaduct when I found the vacuum had gone. I put on the big ejector and tried to get up the vacuum, but could only get about nine inches. We got about half-way over the viaduct when the train came to a stand. My mate got off and walked round to the front of the engine and found the pipe was partly off the plug. I think this was done by the wires before we got on the viaduct. He put the pipe on the plug again and says he was shunting to me to blow up, but I could not hear him. He was just returning to the engine when he saw the van next the engine go over. We could not stand without holding on to something with a good grip. As soon as we knew the train was over, the first thing we thought of was the morning up goods train coming, and to get assistance. I thought if the morning goods train gets the signal at Plumpton Junction there will be nothing to stop him, so I sent the fireman off at once to Plumpton. When the passengers began to come up I sent them to the cottage at the end of the viaduct, where there was a light to guide them. I think the accident happened about 5:30 a.m. The guards came up to us about 20 or 30 minutes after the accident. I asked Holmes how he was; he said, "Not so bad, but I have had a nasty knock." He went back to protect the train. All the lights went out when the train went over. It did not strike me after the train went over. It did not strike me after the train went over. I thought it was my duty to go on if I could. After showing the wires were down, I put in helping passengers off the viaduct and directing them to the cottage. The wind was so strong that some of the passengers had to hang on to the rails.

Harry Barber, fireman, states: I have been 22 years in the Company's service, 16 as fireman and six years as cleaner. I came on duty on the morning of the 27th at 3:30 to work until 2:10 p.m. I went off duty the previous day at 2:10 p.m. The driver works the same hours as I do. I was the fireman of the down mail on that day. The first time anything out of the ordinary happened I was between Arnside and Meatrow Fall, where the head lamp was pulled off the engine by some wires. I got down and cut the wires, which took me 15 to 20 minutes. We next got to Grange, and between Grange and Cark we went under caution ticket as the wires were down. At Cark we got "Right away" from the signalman who took the ticket from us. The rails were very greasy, and we kept the steam sander on the whole time. I had no discussion with my mate as to whether there was any danger in crossing the viaduct. The next wires we came into would be a few hundred yards on the Cark side of the viaduct. We felt the wires cutting at the wheels, but did not notice that the vacuum hose pipe had been partially displaced until we got on to the viaduct. We kept going slowly the whole time until we got to the middle of the viaduct. We did not stop until forced. I first noticed that the vacuum went off after striking the wires before we got to the viaduct. When we stopped on the viaduct I found a piece of wire pressing against the hose pipe, which had partly raised it off the plug. I put this right, and as I was going back to the engine I saw the first two coaches fall over. I could not see any further. I then took a lamp and walked across the viaduct to Plumpton Junction, and on the way I knocked up platerayer Hartley who lives at the cottage, and told him to go down to the viaduct, and on going on to Plumpton Junction I met engine No. 77, I called to him, and he stopped and took me back to Plumpton signal-box. I told the signalman at Plumpton that the two first coaches of the mail train were over on the viaduct and asked him to obstruct both roads, and the signalman sent the same engine back to Ulverston, I met him on the up road, and he ran back to Ulverston on the down road. I went back with another engine to the viaduct.

Captain Ward, the Company's harbour master at Barrow, states: On the 27th February the wind was registered by our anemometer from about 3:30 a.m. until 8 a.m. It was 100 miles an hour. Before and after that it was slightly easier. That was the mean force, but, of course, in the violent and terrific gusts, of which we had a great many, I should say it was 120 miles per hour. It was certainly the most severe storm I have ever seen in this district. The wind might be more severe at Leven than at Barrow; the passage being narrow would tend to increase the force of the wind.

T. Shaw, driver (recalled), states: I was on the viaduct when the brake first came on. I thought the driver might have had a tendency to stop us. I shut off steam and put my hand on the brake and if the big ejector was on before we got to the viaduct I must have touched it then. I was not looking at the vacuum. My object in putting on the big ejector was to get the brakes on. I am certain I was on the viaduct when I noticed the brake was on. I was running at about 18 to 20 miles an hour, when the engine struck the wires three or four hundred yards before reaching the viaduct.

H. Barber, fireman (recalled): I first found the brake on immediately we struck the wires. The vacuum went off gradually. It reduced the gauge to about 9 inches before we got on to the viaduct. I first noticed the train slowing down before we got to the viaduct when we struck the wires. We had no power to pull up or go ahead. The regulator was shut off. The train had sufficient way on to go on to the viaduct and it stopped itself. The big ejector was put on directly we struck the wires but it did not keep the brake off. The wind might have had a tendency to stop us but I think the brakes would act more. In any case I do not think we could have stopped after we struck the wires until we got on to the viaduct.

Statements made by guards Holmes and Kelly, who were unable to attend the Inquiry.

Irae Holmes, guard, states: I have been a guard with the Furness Railway Company for the last 25 years; on the 27th of February last I went on duty at 4 o'clock a.m., and took charge of the 4:45 a.m. train Carnforth to Whitehaven. The train was made up of an engine and tender, three passenger coaches and seven vans. I was in the fifth coach from the engine, Thomas Kelly the second guard.
was in the seventh coach counting from the engine. We left Carnforth at 4.34 a.m., there was a good breeze, but nothing out of the way at that time, and all went well with the train until the Arnside Viaduct was passed. At that point the telegraph wires were blown from the posts, and became entangled with the engine and carriages, and the train came to a stand. The driver and fireman, and myself and Kelly took the wires away, and the train went all right to Cark station, at Cark the block to Plumpton was not working and the train was stopped to take a break-down ticket. The train left Cark at twenty-five minutes past five as near as I can judge. The wind was then very strong but all went well until the train was on the middle of the Leven Viaduct, then the train stopped, and I noticed the vacuum gauge was at zero. Thomas Kelly came to my van and I asked for a light, as my lamp had gone out, Kelly stepped into my van, and as he did so the near side of the van arose, and the van fell over on its side on to the up line. I was pinned down under some luggage, Thomas Kelly liberated me; I got out of the van with difficulty and then saw the train was over on its side, and Kelly and my self turned off the gas from the London and North-Western coaches, I did not notice any telegraph wires or anything else wrong. I saw the driver, Shaw, and he told me he had sent his fireman on to Plumpton Junction. I then returned to the train, and while I walked alongside the whole train (but the engine and tender) was laid over on to its side. The wind was then blowing so strong I could not stand without holding on to something. I assisted Holmes to turn out the gas and I then saw the passengers were all out of the train. I did not see any telegraph wires about or anything wrong with the train. The train was at a stand-still for some minutes before it turned over; it was standing when I left my van and while I walked alongside the train to Holmes' van.

Thomas Kelly, guard, states: I have been a guard with the Company for 14 years. On the 27th February last I went on duty at 3.45 a.m., and was the second guard of the 4.25 a.m. train from Carnforth to Whitehaven. The train was made up of an engine and tender, three passenger coaches and seven vans. I was in the seventh coach counting from the engine. We left Carnforth at 4.34 a.m. There was a good breeze, but nothing out of the way at that time. All went well with the train until the Arnside viaduct was passed. Between the viaduct and Meathop Fell the telegraph wires were blown from the posts and became entangled with the engine and carriages, and the train came to a stand. The driver and fireman, myself and guard Holmes took the wires away, and the train went all right to Cark station. At Cark the block to Plumpton was not working, and the train was stopped to take a break-down ticket. The train left Cark a twenty-five minutes past five, as near as I can judge. The wind was then very strong, but all went well until the train was on the middle of the Leven Viaduct; there the train stopped. I got out of my van and walked up the six-foot to the next van. Holmes asked me for a light, and I got into his van to give him one, and almost immediately the van turned over on to its side on to the up line. Both Holmes and myself were covered with luggage, but I got out first and helped Holmes. I tried to get out of the door on the top, but the wind was so strong I could not face it. I got out at the bottom door and then saw the whole train and the telegraph wires were blown from the posts and laid over on to its side. The wind was then blowing so strong I could not stand without holding on to something. I assisted Holmes to turn out the gas and I then saw the passengers were all out of the train. I did not see any telegraph wires about or anything wrong with the train. The train was at a stand-still for some minutes before it turned over; it was standing when I left my van and while I walked alongside the train to Holmes' van.

Conclusion.

The chain of events which preceded the overturning of this train on the Leven Viaduct was as follows:—

It left Carnforth at 4.34 a.m., nine minutes late, and all went well until just after passing the viaduct over the Kent river about seven miles from Carnforth, when the engine came in contact with some fallen telegraph wires which broke and extinguished the head lamp on the engine. It took some 15 to 20 minutes to clear the wires before the train could proceed to Grange, 9 1/2 miles from Carnforth.

At Grange the driver was given a caution ticket as the wire by which the block signals were sent between signal-box and Cark was broken; this he gave up at Cark signal-box at 13 miles 15 chains.

The wire was not broken between Cark and Plumpton Junction at 17 miles 58 chains, so the train was signalled forward in the usual way from Cark to Plumpton Junction at 5.25 a.m.

After leaving Cark the driver states he proceeded cautiously as the rails were very greasy, sand being used all the time, and three or four hundred yards short of the Leven Viaduct, which commences at 16 miles 57 chains, when the engine was running about 18 to 20 miles an hour, it struck some more wires which caused sparks to fly. The driver immediately shut off steam, but noticing the sparks cease, put it on again thinking he had cleared all the wires.

Just as he had passed on to the viaduct, he noticed that the vacuum had gone, showing that the brakes were on. He applied the big ejector but could not get more than nine inches of vacuum, and when about half-way over the viaduct, the train came to a stand. The driver also noticed sparks just before reaching the viaduct, which he thought were caused by a wire being dragged along, but as this seemed no impediment to the train he continued his journey.
On the fireman getting off the engine when the train had come to a standstill, he found a wire pressing hard against the vacuum hose pipe on the front of the engine, displacing the coupling from the plug and so destroying the vacuum throughout the train. The fireman cleared the wire and replaced the coupling on the plug, and was just getting back to the engine when he noticed the two vans next the engine go over on their right sides. He could see no further down the train on account of the darkness.

The train staff then did all that was required to protect their train, the fireman, Barker, going forward to Plumpton Junction signal-box, while one of the guards, Holmes, who was not so badly injured as guard Kelly, went back to protect the rear of the train. They also did all in their power to assist the passengers, most of whom got out of the carriages without help and were directed to the platelayers' cottages at the Plumpton end of the viaduct. The guards also extinguished the gas lights in the London and North-Western vehicles to prevent danger from fire. The electric lights in the Furness vehicles went out when the carriages turned over. Signalman Miller, at Plumpton, on becoming alarmed at the non-arrival of the mail sent off a banking engine to the viaduct at 5.50 a.m. to ascertain what had happened, and as the driver soon met fireman Barker, he took him back to the signal-box and signalman Miller was then able to send messages for assistance and doctors who were at the viaduct by 6.30 a.m. The passengers were all in the cottages by that time, and their injuries were at once attended to, after which they were sent forward to their destinations.

As there were rumours of some passengers being missing, some platelayers, headed by Dr. Bowman, roped together, crawled on to the viaduct, as it was impossible to walk upright, and searched the carriages and under them, but no persons were found, and as no representations have been made as to any one being missing, it may be concluded that the rumour was unfounded. There was considerable risk in this, and the conduct of all who went on to the viaduct to assist at that time is deserving of the highest praise. The break-down gang arrived from Barrow at 7.20 a.m., and from Carnforth some time later, and the viaduct was clear and traffic resumed by 4.30 p.m.

On examination of the wires at 8 a.m. by the telegraph inspector it was found that all the wires across the viaduct itself were intact, as they run along the side of the girders and are protected, but on the eastern side of the viaduct the top wire for five spans was down from the poles. From the position of the cap and insulator of the pole 80 yards from the viaduct, which were found on the down line 28 yards from the viaduct, it is evident that these were pulled down by the engine and that the original break in the wire was beyond the pole.

The driver estimates the spot where he first struck wires as being from three to four hundred yards from the viaduct, and this is probably correct. He shut off steam, and had he immediately applied his brakes, he might have stopped the train before it got on to the viaduct, but thinking he had cleared the wires he went ahead again, and states he only noticed that his vacuum had gone just as he got on to the viaduct, and that there he applied the big ejector to try to create a vacuum and release the brakes.

Fireman Barker's evidence does not quite agree with driver Shaw's, in that he states the vacuum went down to nine inches before they got on to the viaduct, and that the big ejector was put on directly they struck the wires, but he does not think the train could have been stopped until actually on the viaduct.

This discrepancy has no actual bearing on the cause of the accident, though it would, I consider, have been prudent on the part of driver Shaw after his previous experience near the Kent viaduct, to have stopped at once on first striking the wires, and ascertained that the engine had cleared them before going on to the viaduct. I consider, even if he had stopped, cleared the wires, and then proceeded on to the viaduct, that the carriages would have been blown over by such a tremendous gale, as the wind pressure was considerably greater than that required to overturn them.

The stiffest vehicle in the train against overturning was the London and North-Western bogie brake—the sixth from the engine—and if fully loaded this would theoretically overturn with a direct side wind pressure of approximately 42 lbs. to the square foot.

The six-wheeled vehicles would theoretically all overturn with a direct side pressure of 35 lbs. per square foot, and the four-wheeled vehicles with a pressure of 32 lbs. per square foot. If not fully loaded they would overturn with 3 or 4 lbs. per square foot less pressure.

The evidence of Captain Ward, the Furness Company's harbour master at Barrow, shows that the mean hourly run of the wind as measured by the anemometer between
4.30 a.m. and 8 a.m. was 100 miles an hour, and that in the violent gusts he estimated it as high as 120 miles an hour.

The Leven viaduct is 10 miles from Barrow, and being situated across the estuary of a river is quite unsheltered, so though it by no means follows, yet it is probable that the force of the wind was as strong there as at Barrow. The direction of the wind was almost broadside on to the viaduct, being slightly against the train, as described to me on the spot by Dr. Bowman.

According to the table in the Appendix of the Report of the Committee appointed to consider the question of wind pressure on railway structures in 1881, the result of careful measurements at Bidston Observatory showed that a run of wind of even 70 miles an hour might exert a pressure of 48 lbs. per square foot. From a table, kindly supplied by the Mersey Docks and Harbour Board, of observations taken at Bidston of the greatest hourly velocity and of the greatest pressure on the square foot during gales between the years 1867 and 1895 inclusive, I find that the average pressure (24 readings) for an hourly run of wind at 70 miles an hour was 45 lbs. per square foot. Similarly, the average pressure (18 readings) at 80 miles an hour was 60 lbs. per square foot, and that at 90 miles an hour (only 4 readings) was 71 lbs. per square foot.

From the description of the viaduct it will be seen that there is no provision for giving any shelter to trains when passing over it, and the fact that the surface of the rails is 15 inches above the flooring of the viaduct gives the wind greater overturning power by allowing it free access to the undersides of the vehicles—which was not taken into account when estimating the figures given above.

No doubt these very strong gales are rare, yet when they do occur a very serious disaster can be caused by the overturning of a train on an exposed viaduct such as the one in question. Had this mail train been on the up line it would most certainly have fallen over the viaduct into the river bed below with terribly results.

The requirements of the Board of Trade regarding viaducts and bridges now lay down that substantial parapets of not less than 4 ft. 6 ins. in height above rail level must be provided in all cases, unless the main girders between which the permanent way is laid are sufficiently high, but this was not in force when the viaduct in question was originally opened for traffic in 1857.

I think the Company should consider the advisability of adding substantial parapets to this viaduct, or if this would affect its stability by the amount of wind pressure brought to bear on it, then some means should be devised for warning the signalmen on either side of the viaduct when the wind is of sufficient force to be likely to cause danger to trains passing over it.

I have, &c.,

E. DRUITT,

Major, R.E.

APPENDIX.

DAMAGE TO ROLLING STOCK.

Furness Railway Mail Van, No. 1.—Paint slightly scratched.
Furness Railway Third-class, No. 69.—One corner pillar, four bottom quarter panels, five door panels, three light glasses, one door pillar and one top stepboard broken.
Furness Railway Passenger Van, No. 42.—One lookout, one door pillar, one bottom side, four bottom quarter panels and moulding, five bottom hinges, three light glasses, two axle-boxes and one top step broken.
Furness and North-Western Meat Van, No. 53,996.—One or two bolt heads broken; all paint scratched.
Furness and North-Western Fish Van, No. 1,120.—Four door pillars broken; one corner pillar damaged; three bottom panels and one stepboard broken.
Furness and North-Western Third-class, No. 1,890.—Ten window lights, one corner pillar, six bottom quarter pillars, five bottom hinges, one stepboard, two commode handles, one end panel and two quarter lights broken.
London and North-Western Composite, No. 156.—One corner pillar, one door pillar, three bottom quarter panels, two door handles, six door panels, lap plate, seven lights, seven hinges and one door stop broken.
London and North-Western Brake, No. 456.—Lookout damaged; four bottom quarter panels, two door pillars, four door panels, lap plate and stepboard broken.
London and North-Western Passenger Bogie Brake Van, No. 68.—One door, two long bottom quarter panels, one lookout, eight door hinges, two door pillars, one stepboard, one axle box and three axle box lids broken.
Midland Railway Passenger Brake, No. 550.—One lookout, two pillars, ten hinges, two luggage door handles, six commode handles, two light glasses and two stepboards broken; one corner pillar and six door pillars damaged.

Printed copies of the above Report were sent to the Company on the 18th April.