times which is required to secure the public safety, as the regulations of the Company direct, and they keep sounding the whistle while approaching, without materially diminishing the speed, until it is too late to stop short of the obstruction on the line before them. I do not defend their practice, but I am sure that it will be continued while such a system is upheld.

The adoption of an interval of time between quickly following trains, coupled with injunctions to engine-drivers and guards to keep a vigilant look out, was the best expedient that could be followed for providing for the public safety, when it was first brought into use. And when an interval of five minutes was generally adopted, it was expected that the safety of the public travelling on railways was sufficiently provided for. Experience has amply shown that the expectation has not been fulfilled; the number of collisions between following trains has been very large, but fortunately a better and safer expedient than a time interval, no matter how long, can now be substituted for it.

The introduction of the electric telegraph provides ready means of keeping an interval of space between following trains. No train should be permitted to leave a station, until the station in advance has telegraphed back that the line up to that station was clear for a train to travel up to it. The electric telegraph supplies an addition to the ordinary means of out of door signals for securing the public safety. And the difference between the two systems of working by keeping a space between following trains, or by allowing them to travel at an interval of time from each other is, that when both are rigidly and faithfully carried out, a collision between following trains is impossible when an interval of space is maintained between them; but a collision may, and often does happen, when the traffic is worked by an interval of time only.

It was elicited in evidence at Egham, that the down Royal train was permitted to follow another special train past that station, when proceeding to Ascot, at an interval of four minutes; and on the return journey, although an interval of five minutes elapsed between the departure of the Royal train from Ascot and its being followed by one of the special trains, that interval had been diminished to three minutes, as the last of the two trains was permitted to run past Egham station, only eight miles from Ascot, unchecked by any danger signal. In either of these instances, if a tube had burst in the engine of the preceding train, or any casualty had suddenly delayed it, it is impossible to say that a collision would not have followed.

In my opinion, it is time that such a system of working should be done away with. If railway companies cannot be induced voluntarily to alter their system and to introduce these improvements which science has placed within their reach, then the legislature should interfere and compel them to do so. Apparently these matters are looked at entirely in a commercial point of view, and generally it is deemed more expedient to run the risk of sacrificing human lives and inflicting dreadful injuries to individuals and to accept the liabilities which such occurrences involve in the shape of heavy compensations, than to incur the certain cost of making a change in an established system, to one that may be somewhat more expensive, though it will certainly be more safe.

I have, &c.
W. YOLLAND.

The Secretary to the
Board of Trade,
Whitehall.

METROPOLITAN RAILWAY.

Board of Trade
(Railway Department),
SIR, *Whitehall, 8th July* 1864.

I AM directed by the Lords of the Committee of Privy Council for Trade to transmit to you, for the careful consideration of the Directors of the [Metropolitan] [Great Northern] Railway Company, the enclosed copy of the report made by Captain Tyler, R.E., the officer appointed by my Lords to inquire into the circumstances connected with the accident which occurred on the 9th May at the Bishop's Road Station, from the explosion of the boiler of a locomotive engine.

I am, &c.
JAMES BOOTH.

The Secretary to the
Metropolitan
Railway Company.
The Secretary to the
Great Northern
Railway Company.

SIR, *No.* 1 *Whitehall, 29th June* 1864.

IN compliance with the instructions contained in your minute of the 10th instant, I have the honour to report, for the information of the Lords of the Committee of Privy Council for Trade, the result of my inquiry into the circumstances which attended the accident that occurred on the 9th May at the Bishop's Road Station of the Metropolitan Railway, from the explosion of the boiler of a locomotive engine.

The 9·5 a.m. passenger train was about to leave Bishop's Road for Farringdon Street on the day in question, when the boiler of the engine which was attached to it, No. 138, exploded with a loud noise. The station inspector had given the signal for it to start, the guard had repeated that signal to the engine driver, the engine driver had blown his whistle, and had also, as he believes, opened his regulator, when the explosion occurred. The fireman, who was standing sideways on the tender, unscrewing the break-handle, received a blow, was twisted half round, and was thrown down on his left side,—the side that had previously been turned towards the engine. The engine driver felt himself first drawn towards the engine and afterwards thrown back from it. His cap was blown away, as he was told, into the Great Western yard; his face was covered with mud and water; he staggered back into the tender, and he lost consciousness for a short period. A breaksman who was near the engine on the station platform, was much hurt, and was sent to the hospital; and a passenger in the train due at Bishop's Road from Farringdon Street at 9·3, which was coming into the station two minutes late as the explosion occurred, was severely injured.

This train was in the act of drawing up at the opposite platform, the engine and one carriage having already passed, and the second carriage having been opposite to the engine when it exploded; but there was, fortunately, an intermediate line of rails between that on which it was travelling and that on which the engine stood. The second carriage of it, No. 29, third class, was damaged in many ways, a door and panel having been broken, as well as 14 quarter lights, 4 roof glasses, 2 steps, and 4 ventilators over the doors; and one of the partitions having been disjointed. The gas-container on the roof was also torn in three places, and the outside box completely destroyed on one side. Two other carriages were slightly damaged.

The roof of the station over the engine was blown to pieces, and portions of it were thrown into the Great Western yard, to the other side of the incoming train above referred to. The screen at the end of the roof fell upon the engine. The wall of the staircase leading to the foot-bridge over the line (on the platform side of the engine) was shattered, and the gate at the bottom of the stairs was knocked down and broken to pieces.

No. 138 was a six-wheel-coupled engine, with wheels 5 feet in diameter, and a wheel-base of 14 feet 6 inches. The cylinders were 16 inches in diameter, and the stroke was 22 inches. The weight on the leading wheels was 10 tons 8 cwt., on the driving wheels 10 tons 6 cwt., and on the trailing wheels 6 tons 9 cwt. The barrel was composed of three rings, as shown in the accompanying diagram, with which the locomotive superintendent of the company has been so good as to furnish me,—was 3 feet 9 inches in diameter by 10 feet long,—and was composed of $\frac{3}{8}$ inch plates. Its bursting pressure when new may be estimated at 850 lbs. to the square inch through the whole plate, and 566 through the rivet holes. It contained 158 tubes, each 2 inches in diameter, having a superficial area of 815 feet; and the heating surface in the fire-box was 78 feet. There were 2 safety-valves, each 4 inches in diameter, of which one had received a severe blow, which fractured its shaft; and a pressure-gauge by Johnson and Varley, which stood at 17, instead of zero, after the explosion, but which was found when tested to work correctly up to pressures of 110 and 120 lbs. to the square inch.

The engine-driver had left the Great Northern running shed at Agar Town at 4·30 a.m. on the day in question. He took two trucks of coke to Farringdon Street, and left that station with a passenger train at 5·30 for Bishop's Road. He then ran two double trips with passenger trains between Bishop's Road and Faringdon Street, and returned to the former station about 9·20. He shunted his train from the down to the up platform, took water in the tender, was coupled to the 9·50 train, and was about to start with that train, as I have above described, when the explosion occurred. The engine had been blowing off steam strongly at Agar Town in the morning, and the pressure gauge then indicated 120 lbs. to the square inch,—the maximum at which the engine was worked; but a pressure of 70 lbs. only was indicated when the engine reached Bishop's Road at 9·20, and of 110 lbs., according to the engine driver, when the engine exploded. The gauge-glass was from a half to three parts full, showing an ample supply of water in the boiler; there was no appearance of a leak; and all seemed to be in good order.

This engine was delivered to the Great Northern Company in November 1850, by Messrs. Hawthorn, of Newcastle-on-Tyne. Besides other repairs that it has received, three new plates were inserted in the bottom of the barrel, and a fresh set of tubes supplied in January 1854; a new iron tube-plate was put in, and other repairs done, in July 1854; a new set of tubes was inserted in May 1856; a patch was added on the right of the barrel in December 1859; a copper patch under the fire-hole door, and seven new stays, in August 1860; a copper patch in the fire-box, and new dome-cover, in November 1861; a second-hand set of tubes were inserted in December 1861; a quantity of copper stays in the fire-box in February 1862; a patch on the left side of the barrel near the smoke-box in January 1863, as well as a copper patch on the fire-box, and another set of second-hand tubes. A new exhaust gear was fitted up in August 1863, preparatory to the engine's being employed on the Metropolitan Railway; and the boiler was examined along the seams of rivets through certain of the tube-holes in January 1863. The tubes previously inserted in these holes had been left out, and the holes had been plugged, in order that they might serve for occasional examination.

The duty which the engine performed during the intervals which elapsed between the different periods of internal examination, were as follows:—

Period of Examination.	Intervals. Yrs.	Months.	
November 1850 to 27 January 1854.	4	2	68,277
30 May 1856	2	4	23,763
12 December 1861	5	7	107,032
16 January 1863	1	1	21,048
18 July 1863		6	8,282
9 May 1864 (explosion)		10	19,841
	14	6	248,243

Very little if any importance can be attached to the examination made as above in July 1863, because the tubes were not then taken out of the boiler. It is not safe to depend upon an examination made by merely looking through a hole in the tube-plate, as was then done, (with a light inside the boiler,) while the boiler is full of tubes. In order to discover the defects which may be expected, or which must be looked for, it is necessary that the interior should be thoroughly cleaned and the scale hammered off, and even then it is frequently difficult to discover them, when a better opportunity of close examination is thus afforded after the removal of the tubes. But it is certain that the defects which caused the explosion, as I shall presently describe, ought to have been discovered during the previous period in January 1863, when an opportunity for more thorough examination was afforded, and that the plate which ultimately failed ought not then to have been permitted to remain in the boiler.

The explosion took effect upon the upper portions of the middle and fire-box rings of the barrel, but principally upon the former; and the shape and dimensions of the different fragments are shown very distinctly in the diagram. The smoke-box ring and the fire-box were almost uninjured. The steam-pipe and three of the tubes were fractured, and of the remaining tubes some were bent upwards and spread out sideways.

The fragment marked A, with portions of the sheet-covering and a piece of the cast-iron dome cover, flew over the incoming train into the Great Western Station yard. The fragment A fell through the Great Western roof 127 yards on the south-east of the engine, and cut a piece out of the hat of a cabman, who was waiting on the edge of the arrival platform for an expected train. The dome, torn away partly at the rivet holes, but principally through the plates connected with it, was thrown in a nearly opposite direction to a distance of 404 feet. The fragment E, with a long stay attached to it, from the right of the engine (as it was standing tender first, or left of the train), was doubled down and thrown off to the right, falling between the engine and the staircase above referred to, leading to the foot-bridge over the railway. The fragment D, in front of it, and also on the right of the engine, was thrown over the engine, and fell 7 yards to the left and 34 yards in front of it. The fragment B, from the left of the engine, fell down opposite to the engine and on the left, only 10 yards from it.

It will thus be seen that the principal force of the steam was exerted on the middle ring, and it was apparent on examination of the fragments that the weakest parts of the boiler were also in that ring. The upper plate was placed outside the lower plate of that ring, and corrosion had been more or less active above the longitudinal seams of rivets on both sides. That plate was, however, far less corroded on the right side, while on the left side it had been so far eaten through as fully to account for the explosion. A groove extended for rather more than two feet above the seam of rivets, along which the metal had been reduced from the original thickness of $\frac{3}{8}''$ to the following dimensions:

	Inches.
At $9\frac{1}{2}''$, measured from the centre of the vertical joint in front of the middle ring, the thickness was - - - -	$\frac{1}{8}''$
At 14′ - - - -	$\frac{1}{16}''$ full.
At $16\frac{3}{4}''$ to 19″	Very little metal left holding.
At 20″ - - - -	$\frac{1}{16}''$ full.
At 22″ - - - -	$\frac{1}{16}''$ bare.
At 24″ - - - -	$\frac{3}{32}''$
At 26″ - - - -	$\frac{3}{32}''$

This upper plate of the middle ring, which had been for 14 years and 6 months in the boiler, must, as I have already intimated, have been in such a state at the time of the examination of January 1863, sixteen months before the explosion, that it ought then to have been condemned; and I can only suppose that its condition was overlooked when that examination was made.

This is one of three cases which I have now under report of the same description. The cylindrical portions of the boilers of locomotive engines belonging to three of the principal Railway Companies,—the Great Northern, the Midland, and the London and North-western,—all exploded during the past month of May from the same cause, namely, channeling along the upper edges of longitudinal joints. I have also had occasion to report to their Lordships upon four other cases within the last three years,—two upon the London and North-western, one upon the North-eastern, and one upon the Great Western Railway,—in all of which the barrels of locomotive boilers have been similarly eaten through until explosion occurred; and these seven cases represent a more serious amount of risk than would appear at first sight, that is daily incurred by the officers and servants of railway companies as well as by the public. Of the 6,500 locomotive engines and upwards which are in use on the passenger railways of the United Kingdom, a large proportion are affected by corrosion to an extent which is more or less dangerous. For every engine that explodes, there are a great number of others which have been much weakened from this cause, and which are kept working with a less margin of safety than ought always to be preserved between ordinary pressure and bursting pressure.

Corrosion, which is always treacherous in its action upon iron, is favoured in locomotive boilers by constant mechanical, chemical, and galvanic action. The expansion and contraction of the material from differences of pressure and temperature, and the alterations of shape (when the barrels of these boilers are not truly cylindrical) under different pressures, cause new surfaces to be exposed to the oxygen, and perhaps also to the acids in the water, near the joints and the stays, and at all those parts at which there is extra stiffness. A combination of chemical and mechanical action is thus maintained, and these are assisted by the galvanic action which is set up as the joint effect of the different materials commonly employed in the boiler, namely, copper for the fire-box, brass (frequently) for the tubes, and iron for the shell. The effect upon the interior of the shell is more or less rapid according to the quality of the water, the mileage duty performed by the engine, the quality of the material in the boiler, the manner in which it is constructed, and the pressure at which it is worked.

The durability of the barrels of locomotive boilers varies under these circumstances from 5 to 20 years, and is entirely beyond the reach of calculation when the ordinary modes of construction are employed. Internal examination can only be satisfactorily performed when the tubes are taken out, at intervals which are usually measured by years, and which extend frequently over more than seven years. The plates are not always renewed sufficiently soon on defects being first observed in them, and the boiler may or may not be so much weakened before the next period for examination arrives as to explode, as the engines above referred to have done, at its ordinary working pressure.

There are several measures which may be adopted to remedy this state of things, by the application of which the boilers may be made to last longer and to work more safely, and by which such explosions may be altogether prevented.

As regards construction,—(1.) The barrels should be made more perfectly cylindrical by the use of butt-joints and cover-strips in place of the lap-joints more commonly used. (2.) The longitudinal joints should be placed in all cases above the water line instead of below it, so as to prevent the risk of corrosion from the different actions previously referred to; and there is no necessity for having more than one longitudinal joint in each ring. (3.) The boiler should be firmly attached to the framing at one end only, the other end being allowed to slide backwards and forwards to allow for changes of temperature, as is now frequently, but by no means always done. (4.) The barrels should be strengthened at the vertical (or transverse) joints, and at intermediate intervals, either by the addition of belts, or by the use of plates rolled thicker in the middle as well as at their edges. In the analogous, though opposite, case of the internal flues of stationary boilers, a similar mode of providing against collapse has often been recommended, and has sometimes been employed with great success, by strengthening them with angle-iron or T iron rings applied at intervals. A locomotive boiler thus reinforced in a proper manner would leak when the plates had been eaten through by corrosion between the strengthening belts, but could never explode.

As regards examination and renewal, I am of opinion that a longer period than three years should not in any case be allowed to elapse without a thorough internal examination, and that no plate should be allowed to remain in a locomotive boiler to wear out another set of tubes on which distinct indications of channeling are observable. It is impossible to doubt that the weakened plates at the first lines of fracture of each of the three engines on which I am now specially reporting, must at the previous examinations of the interior of the boilers have been in a condition in which they ought then to have been renewed, or to believe that this weakness would not at once have been discovered if they had been carefully tested at any time during the previous six months by hydraulic pressure, up to—say 50 per cent. above the pressure at which they were respectively worked. The locomotive superintendents on some of the railways in this country employ the hydraulic test whenever an engine comes in for repair, while others object to it on the score of its being useless or dangerous; and it is not periodically employed on any one of the railways above referred to on which these seven explosions have occurred. It is undoubtedly simple, safe, and inexpensive, and is habitually employed on the Continent. There can be no apprehensions of danger in connexion with it, by unduly straining any of the parts, provided the bursting pressure of the boiler is a sufficient multiple of its working pressure; or in other words, provided a factor of safety—say of six for a new engine and four in an old one—be allowed and maintained. Such a test is, indeed, more necessary now than it would be if the improvements in construction to which I have above adverted were universally adopted. It is clear that improvement is needed in a system which will allow of three explosions in one month on passenger railways from such defects; and I do not hesitate to say that there is no excuse in the present state of our knowledge for the explosion of a locomotive engine boiler from this or any other cause. Stationary boilers are frequently constructed by and entrusted to manufacturers and stokers who are comparatively unscientific and irresponsible, but the officers and servants who are employed in the locomotive departments of railway companies are of a higher class; and it may fairly be expected of them that they will not allow the temptations of high pressure, which is exceedingly economical, or the want of a new plate in a boiler, to interfere with the safety of the public. There should not merely be no risk of these engines actually exploding, but no portion of them should ever be allowed to come within a margin—say of four to one, as between their bursting and their ordinary working pressures.

I have the honour to be, Sir,
Your obedient servant,
H. W. Tyler,
Capt. R.E.

The Secretary to the Board of Trade, Whitehall.

MIDLAND RAILWAY.

Board of Trade (Railway Department), Whitehall, 7th July 1864.

Sir,

I am directed by the Lords of the Committee of Privy Council of Trade to transmit to you, to be laid before the Directors of the Midland Railway Company, the enclosed copy of the report made by Captain Tyler, R.E., the officer appointed by my Lords to inquire into the circumstances connected with the explosion of the boiler of a locomotive engine which occurred on the 5th May, at the Colne Station of the Midland Railway.

My Lords trust that the report will receive the careful consideration of the Directors.

I am, &c.
(Signed) James Booth.

The Secretary of the Midland Railway Company.

Sir, *No.* 1, *Whitehall, 29th June* 1864.

In compliance with the instructions contained in your minute of the 10th ultimo, I have the honour to report, for the information of the Lords of the Committee of Privy Council for Trade, the result of my inquiry into the circumstances which attended the accident that occurred on the 5th ultimo at Colne on the Midland Railway, from the explosion of the boiler of a locomotive engine.

The engine in question, No. 356, left Leeds at 9·30 p.m. on the 4th May for Copley Hill, and returned to Leeds at 10·20. It started from Leeds again at 11·5 with a goods train for Colne, and reached that place about 2 a.m. on the 5th. It waited there for twenty minutes or half an hour for a goods train from Manchaster; and it was employed after the arrival of that train in shunting and preparing for the return journey to Leeds. It had been blowing off steam from the safety valves nearly all night, but was not doing so at this time. A train of 13 loaded and 4 empty waggons had been formed; and the engine stood in front of them, 150 yards from the passenger platform, or half-way between the platform and the engine-house. The guard was about to tell the engine driver that he was ready to start, and the driver was oiling the right, and the fireman the left side of the engine before going away, when the explosion occurred. The feed had been turned off about 10 minutes previously, because the boiler was full of water, the water reaching the top of the gauge-glass.

The engine driver was found under a waggon nearly opposite to the engine, quite dead. A part of his skull was carried away, and he received severe cuts on his right thigh and left side. The fireman was blown away nearly 100 yards, and rendered unconscious. He was not struck by any of the fragments, but was so much injured internally that he has not been able to return to his work. An old woman who was in bed in a cottage about a quarter of a mile from the spot, received a contusion on the leg from a portion which fell through the roof.

No. 356 was a six-wheel-coupled goods engine, with cylinders 16″ in diameter, and a stroke of 24 inches. The wheels were 5 feet in diameter. The barrel of the boiler was 11 feet 6 inches long, by 4 feet 3 inches in diameter, and was constructed of $\frac{7}{16}$″ plates. The heating surface was 110 square feet in the firebox, and 1000 square feet in the tubes, of which there were 184, each 2″ in (outside) diameter and Nos. 10 and 13 wire gauge at their fire-box and smoke-box ends respectively. There were two safety valves, each 4″ in diameter, provided with ferules, and placed on the dome. The boiler was supplied with a Smith's pressure gauge and was worked to a pressure of 140lbs. to the square inch above that of the atmosphere, the maximum in use on the Midland Railway. It was increased to this pressure in November 1863, from 120lbs. at which it had previously been employed. The pressure gauge was new in February last, and when tested in my presence by a mercurial column, after the explosion, up to a pressure of 180lbs. to the square inch, it worked correctly.

This engine was supplied to the Midland Railway Company by Messrs. Kitson, of Leeds, in January 1854, about the same time as nine others made to the same specification. It was retubed in December 1856, after running 66,600 miles; again in July 1860, after running 65,056 miles; again in January 1862, after running 32,648 miles; and it had run 48,335 miles in the 2 years and 4 months between January 1862 and the 5th May 1864, when it exploded, making a total distance of 212,639 miles.

The boiler had also received the following repairs:—In June 1860, the roof-stays were taken off and repaired with 48 bolts and nuts. The fire-hole plate received 66, and the tube plate 18 copper stays. Nine pieces of T iron were riveted to the boiler and shell. A new fire-hole ring was added, with 28 iron rivets. Two copper plugs were inserted in the tube-plate, and 20 in the fire-box shell. The smoke-box front and angle-iron frame were renewed, and the partition was caulked. In January 1862, the fire-hole plate was repaired with 8, and the tube plate with 1 copper stays. Three copper patches were placed over the mud-holes in the fire-box shell with 16 copper studs. Twelve iron rivets and four copper plugs were placed in the tube-plate; and four longitudual iron stays were inserted through the boiler.

The explosion took effect on the barrel of the boiler, which was constructed in three rings, and on the outer shell of the fire-box, which was continuous with the upper part of the barrel. These parts were blown away in 16 larger, and a number of smaller pieces, and the directions of the lines of fracture as well as their number is indicative of high pressure and consequently great violence. They are well shown in the accompanying diagrams, with which the locomotive engineer of the company has been so good as to supply me.

The fragment marked No. 1, containing the dome and portions of the middle and fire-box rings, flew about 300 yards to the left rear of the engine. That marked No. 2, comprising the greater part of the smoke-box ring and portions of the middle ring, flew about 500 yards in the same direction. No. 3, from the bottom of the middle ring, was blown down upon and destroyed the machinery. Nos. 4, 5, 6, and 7, from the middle and smoke-box rings, flew about 100 yards to the left. No. 8, from under the smoke-box ring, remained on the massive bracket which had been affixed to that ring, which flew against the side of