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Ministry of Transport.

# Railway Accidents.

Report by

## Colonel Sir JOHN W. PRINGLE, C.B.

On the Derailment of a Passenger Train, which occurred on the 3rd November, 1924, near Lytham, on the London, Midland and Scottish Railway, as the result of the failure of an engine tyre.

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# LONDON, MIDLAND AND SCOTTISH RAILWAY.

Ministry of Transport,
7, Whitehall Gardens, London, S.W. 1.
19th February, 1925.

SIR,

I have the honour to report, for the information of the Minister of Transport, in compliance with the Order of the 4th November, the result of my Inquiry into the cause of the derailment of a passenger train, which took place on the 3rd November, at 5.46 p.m., at Warton signal box, near Lytham, on the London, Midland and Scottish Railway.

The 4.40 p.m. down express train, ex Liverpool (Exchange) to Manchester and Blackpool, after leaving Kirkham Station and passing Moss Side Station, was travelling at its usual speed towards Lytham, where it was booked to stop, when the leading pair of engine wheels struck the rails of a siding crossing in the vicinity of mile post 12¼, with the result that 90 yards of the down line track was torn up and destroyed, and the whole of the train derailed.

The train was heavily loaded, and I much regret to report that, mainly as a consequence of the over-turning of the two leading coaches, 12 passengers were killed and two subsequently died of injuries received. Ten others suffered more or less seriously from wounds and the effects of shock. The driver of the train also was killed, and the fireman and guard were injured. The signal box was struck by the derailed engine and demolished. The signalman on duty at the time received injuries to his head, arms and legs, and was fortunate to have escaped with his life.

The train was drawn by engine No. 1105 (type 4—4—0) with six-wheeled tender (see Fig. 1, Plate II attached). At the time of the accident it had attached to it the undermentioned vehicles :—

| *No.* | *Description.* | *Weight.* T. | cwt. | qr. | | *Built.* |
|---|---|---|---|---|---|---|
| 701 | 8-wheeled non-corridor Composite coach ... | 23 | 3 | 3 | ... | 1899 |
| 12890 | 8-wheeled non-corridor Third class van ... | 25 | 3 | 0 | ... | 1910 |
| 11491 | 8-wheeled non-corridor Composite coach ... | 25 | 16 | 1 | ... | 1907 |
| 12888 | 8-wheeled non-corridor Third class van ... | 25 | 3 | 0 | ... | 1910 |
| | | 99 | 6 | 0 | | |

All vehicles were gas-lighted.

The train was fitted throughout with the vacuum continuous brake (working pressure 19 inches to 20 inches) applicable from the engine footplate, and from either of the two brake compartments ; all wheels, except those of the engine bogie, being fitted with brake blocks. Those on the wheels of the tender could also be operated by hand from the footplate, and hand brake gear was also available in the case of the third class vans. The percentage of vacuum brake power to total weight was 52·4 in the case of the passenger vehicles, and 48 in that of the engine. The continuous brake was tested before the train left Liverpool, and again at Midge Hall 23 miles from Liverpool, where three coaches were slipped, and is stated to have been in good order.

After the accident (see Fig. 2, Plate I attached) the drawbar at the leading end of No. 701 was found broken inside the headstock, and the two front vehicles (701 and 12890) with bogies displaced, but intermediate coupling intact, were found lying on their right sides on the rails of the up line. The engine and tender came to rest in rear of the two first coaches on the down side slope of the railway embankment. They were reversed in position, facing north instead of south, with the drawbar between them twisted but unbroken. The engine lay on its proper right-hand side, the tender being slightly tilted in the same direction. The engine bogie had been wrenched away from its fastening to the cast iron cylinder frame, and was found in two portions north of the position occupied by the overturned engine. The drawbar at the leading end of coach No. 11491 had broken inside the headstock, and the two rear coaches were found derailed and standing in rear (to the north) of the overturned engine—No. 11491 in an upright position, across the down track and foul of the up

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line, and No. 12888 outside the down track and tilted over towards the position occupied by the demolished signal box. A list of damage to rolling stock is given in Appendix I.

*Description.*

Warton signal box, the scene of this disaster, is situated between Moss Side and Lytham Stations, about $12\frac{5}{8}$ miles from Preston and $8\frac{3}{4}$ miles from Blackpool Central Station.

The railway in the vicinity has a general north (Moss Side) and south (Lytham) direction. The formation is on low embankment and the down line is the easterly of the pair of roads. Plate I attached shews (Fig. 1) a line diagram of the railways in the vicinity, and a scale plan (Fig. 2) of the section of railway immediately concerned. On the latter is also shewn the position occupied by the vehicles, etc., after the accident, and of the marks found on the permanent way, and the direction of movement of the tyre of an engine wheel. Fig. 3 gives a longitudinal section of the railway shewing gradients and curvature, between Kirkham and Lytham stations.

The distances from Warton signal box to the undermentioned posts are approximately as follows :—

| | | | |
|---|---|---|---|
| Lytham Goods Junction signal box ... ... | | 1550 yards | south |
| Moss Side signal box ... ... ... ... | 1 m. | 432 ,, | north |
| Wrea Green signal box ... ... ... ... | 2 m. | 1078 ,, | ,, |
| Kirkham North Junction signal box ... ... | 3 m. | 1567 ,, | ,, |

It will be seen from the drawing that the train was approaching Warton signal box on a right-hand curve on falling gradients of 1 in 660 and 1 in 157. Also that, with one exception (gradient rising 1 in 990), the rails fall continuously from mileage $9\frac{1}{3}$ to the scene of the derailment.

The permanent way on this section of railway was laid in 1918. It consists of 86-lb. rails in 45-foot lengths, supported on cast iron chairs, each weighing 56 lbs. There are 17 sleepers, measuring 9 feet by 10 inches by 5 inches, to the rail length. The chairs are fastened to the sleepers by two spikes and two trenails, alternately placed in opposite corners. Ash ballast is laid to a stated depth of 6 inches below the sleepers, and up to the level of the upper surface of the sleepers. The super-elevation on the curve varies from $2\frac{3}{4}$ inches to 3 inches, and the rails since the line was relaid in 1918 have been from $\frac{1}{32}$ inch to $\frac{1}{16}$ inch tight to gauge.

*Report.*

1. This case of derailment, with its disastrous results in the way of loss of life, emphasises the great need that exists for some practical method of detecting concealed defects in steel used in the manufacture of tyres of engine wheels.

2. Excessive speed has been suggested in correspondence as one of the causes of this accident. There is no evidence in support of this suggestion. In Appendix II is a statement shewing the booked timings and average speed of the train in question. It will be seen that only on one short section of route traversed, *i.e.*, between Ormskirk and Burscough Junction, does the timing of the train necessitate an average speed of more than 50 miles an hour. Also, that the average speed throughout the journey to Blackpool is 35·6 miles an hour, and between Kirkham and Lytham Stations 39 miles an hour. It was, moreover, proved by guard Bullock that the train was running approximately to scheduled time. There appears no reason to expect that the maximum speed when the train was approaching Warton signal box was more than about 50 miles an hour. The permanent way and track in the vicinity are certainly of sufficient strength to justify this or higher speed.

3. Little, if any light is thrown on the circumstances attending this derailment by the evidence of the railwaymen in charge of the train and engine. Of the two men on the footplate, only fireman Livingstone was able to relate his experience, as driver Crookes succumbed shortly after the accident to the injuries he received. Livingstone rode on the right-hand side of the footplate, and was not aware of any unusual movement of the engine, which was "running nicely," until the violent smash of the derailment took place. He was only able to recollect that after passing the down distant signal for Warton, he was looking out on the right for the distant signal for Lytham Goods Junction, when he noticed sparks flying at the leading end of the

engine. He was on the point of drawing driver Crookes' attention to these sparks when the crash took place. He remembered nothing more until he recovered consciousness, and found himself surrounded with steam, with his leg pinned under a telegraph pole. He could not say whether steam was shut off, or whether the continuous brake was applied. It all happened in a few seconds of time. Livingstone had had experience of engine 1105 prior to the 3rd November, but had not ridden on it since it came out of the Works after overhaul.

Goods-guard Bullock was in charge of the train, and stated that he saw the continuous brake tested at the rear of the train by the rear guard before leaving Liverpool. It travelled in the usual manner to Kirkham, after slipping three coaches at Midge Hall for Burnley. There was nothing unusual in the movement of the train, and he had many times worked round the curves approaching Warton signal box at a higher speed than on this particular evening. He was sitting in the guard's seat in the last vehicle, and noticed nothing wrong until his van was derailed on the Lytham side of the bridge near Warton signal box. He was thrown violently on to the floor and for a time was in a semi-conscious condition. The continuous brake was not, he said, usually applied on the curve in question, and he did not feel any effect from such an application before his van was derailed.

Mr. Housley, Assistant Superintendent of Motive Power, Western Division, stated that he examined engine 1105 at 9.35 p.m. on November 3rd. The driver's vacuum brake handle was fully applied; the regulator handle was closed; and the reversing wheel was $1\frac{1}{2}$ notches in forward gear. A driver approaching Lytham, where he was due to stop, would have his regulator slightly open, and his reversing wheel in the position described. The steam sanders had not been applied. He drew the conclusion that the driver had not had sufficient warning of anything wrong to call for reversal of gear, and that he only had time to close the regulator and apply his brake.

4. The foregoing evidence, combined with the destructive effect of the derailment on the permanent way and rolling stock, proves, in my opinion, that the enginemen, whilst travelling over the curve approaching Warton, were not aware by reason of any unusual movement on the footplate, that any of the engine wheels were off the rails; and that nothing was done therefore to stop the train, or check its speed, until after the engine struck the rail crossing the down track to the Gas Works siding.

5. After the accident one of the engine wheels was found to be without a tyre, and a careful examination of the down line track shewed unmistakable marks of derailed wheels for some distance on the Preston side of Main Dyke Bridge.

The first mark A discovered, 352 yards from the bridge, was a scrape about 7 inches in length on the head of the near hand rail between two sleepers. This mark was clearly visible when I made my examination of the track on the 6th November. It was wider throughout (maximum $\frac{5}{16}$ inch), and at its commencement more deeply incised, than the score on a rail head such as is generally made when a flange rides over the rail. The second mark B, 11 yards further south, was on the 13th sleeper in advance of A. The indentation on the timber, which differed somewhat from that ordinarily made by a derailed wheel in being somewhat under-cut, was across the top of the sleeper about 8 inches from its near side extremity. There was no corresponding mark of a derailed right hand wheel on this sleeper in the four-foot way. The next mark C was an abrasion in the four-foot way across the fifth sleeper (14 feet from B), situated about 8 inches from the off-hand rail. Proceeding further southward, a mark similar to the last was found in the four-foot on nearly all the sleepers up to the rail crossing the down line near Main Dyke Bridge about 326 yards from A. These abrasions were situated at distances varying from $3\frac{1}{2}$ inches to 8 inches from the inside edge of the chairs under the off-hand rail. The marks, evidently made by a wheel flange, were sometimes deep abrasions, 2 inches wide by $\frac{3}{8}$ inch deep, and at other times merely faint scores on the timber and hardly perceptible. Whenever the marks were as close as $3\frac{1}{2}$ inches to $4\frac{1}{2}$ inches to the edge of the chairs, there were also slight bruises on the trenails, and cuts on the spike heads; whilst in some cases flakes of cast iron had been knocked off the chairs at the trenail and spike holes. This marking of trenails, spikes and chairs was obviously occasioned by the outside edge of the tyre of the same derailed wheel. Corresponding with these tyre marks on the chairs, spikes, etc., under the off-hand rail, slight bruise marks on the trenail and spike heads were occasionally to be seen on the outside of the chairs under the near-hand rail. These markings were not so frequent as those on the sleepers in the four-foot way, and the blows causing them were evidently lighter in character.

They were clearly made by a wheel without a tyre travelling outside the rail, otherwise some at least of the chairs would have been found broken.

Mr. Sutton, Permanent Way Inspector, stated that after the accident he found some slight out of line (¼ inch to ½ inch) of the rails on the curve, sometimes to one side and sometimes to the other. This was due to a slight movement of the sleepers and had to be put right. The only new material necessary in this length of 326 yards of track was four spikes which had been broken in the chairs under the off-hand rail about 167 yards from A.

The opinion of Mr. Townshend, Divisional Engineer, and of Mr. Morris, District Engineer, was that all these marks on sleepers, trenails, spikes and chairs, except A and B, were made by the leading pair of wheels of the engine bogie, the left hand wheel having lost a tyre. This opinion, with which I concur, is supported also by Mr. George Hughes, Chief Mechanical and Electrical Engineer, and his technical advisers.

The rail crossing the down line to the Gas Works siding was struck by the derailed right hand bogie wheel, and was found displaced. Ten chairs carrying this crossing rail were broken. The near side cast iron girder of Main Dyke Bridge, which is about 6 inches outside the near hand rail of the down line, was struck a heavy blow, and a small portion of the girder flange fractured, without displacement in position of the girder itself. On the bridge the near-hand rail of the down track was entirely displaced, and the longitudinal timber on which it rested was split. All the chairs under the off-hand rail were also broken. Beyond the bridge the track was entirely destroyed, some of the rails being bent into a semi-circle.

6. The bogie, as the result of the front wheels coming into contact with the crossing rail and bridge girder, was wrenched away from its housing to the underside of the cylinders ; the bolts securing the upper table of the bogie to the cylinder frame held, but the iron castings broke. The engine then became fully derailed to the outside of the curve, and came in contact with the signal box, which collapsed.

The tyre of the left-hand leading engine bogie wheel was found in a field east of the railway, about 50 yards from the down track, and 120 yards measured along the line, from the mark A. From marks found between the hedge and boundary fence of the railway, and on the turf in the field, the path taken by the tyre, after it left the wheel centre, has been plotted on Plate I, Fig. 2, and is shewn thereon by a chain dotted line.

The tyre was found to be broken at one place (see Plate II, Fig. 2) at a point intermediate between two stud screw holes. A space of about 3 inches separated the two surfaces of the fracture. A flattening was found on the outside of the periphery of the flange of the broken tyre, which is a maximum at the point of fracture, and tapers off contrary to the direction of rotation, finally disappearing about 6½ inches from the fracture. The length of this flat roughly corresponds with the length of the scrape on the rail head at the mark A. All five stud screws shewed signs of shearing.

The fractured surfaces of the tyre (see Plate III) shew the existence of a large defect in the centre of the tread of the tyre, which is outlined ABC and has an area of something over 1 sq. inch, due to the existence of a blow hole cavity in the metal.

The right-hand leading wheel of the engine bogie was also found after the accident to have its tyre fractured, the opening between the fractured surfaces being ¼ inch. In this case also the fracture was midway between two studs, but in a different relative position from that of the fracture in the tyre of the left-hand wheel. It is clear that the fracture of the tyre of the right-hand wheel was caused by the wheel coming into violent contact with some obstruction after it was derailed—possibly the crossing rail.

7. A careful examination of the permanent way was made at a later date between Warton and Moss Side Station, but no other marks were found on the rails, chairs or sleepers. At my request an accurate survey was also made by the Engineer of a length of 700 yards of the down track north of Main Dyke bridge, which shews there is some irregularity in the curvature. The longitudinal section (Plate I, Fig. 3) indicates the existence of two points of reverse curvature in the alignment about miles 9⅔ and 11⅓, where no tangent intervenes between right and left-hand curves of radii of 40–57 chains and 52–150 chains respectively. I found some slight tightness ($\frac{1}{16}$ inch) to gauge in the vicinity of the marks mentioned. Although the irregularity of the curvature and the existence of the above-mentioned points of reverse would be sufficient, in my opinion, to account for some degree of rough riding and oscillation

on the falling gradient approaching Lytham, complaints of which have been received from passengers who travel habitually on the line, I do not consider that the alignment or permanent way were in any way accountable for this derailment.

8. I think there can be no doubt regarding the circumstances which led up to the final derailment of this train. The inherent weakness, due to the cavity in the tread of the tyre of the left-hand leading engine bogie wheel, when the thickness of the steel had been sufficiently reduced by wear and turning, was the primary cause of the disaster. The tyre possibly broke some distance before the wheel reached the mark A. Under rolling effect, of longer or shorter duration, dependent upon the time the five set screws in the rim of the wheel took to shear or work loose, the tyre opened out until it became loose enough to slip on the wheel centre, and be pushed out of its vertical plane on the wheel by the pressure of the flange against the rail. The upper portion of the lip of the tyre would thereby be forced outwards from its groove in the rim of the wheel. The rotating wheel centre would then ride over the flange of the inclined tyre, and the tyre become free of the wheel. It is quite likely that the mark A on the rail head, and the corresponding flattening on the periphery of the flange of the tyre were caused by this over-riding of the tyre by the wheel centre. The mark B was, I think, made by the tyre, after escaping from the wheel, bumping on the sleeper, the under-cutting of the timber being caused by the inclined plane to the vertical at which the tyre was moving when it left the wheel. The mark B could not have been made by the rim of the derailed tyreless wheel, otherwise there would most certainly have been a mark on the same sleeper in the four-foot way, made by the flange of the right-hand wheel. I gather from the above described marks on the sleepers, chairs, spikes, and trenails, which were found southward of B, that the bulk of the total weight carried by the engine bogie (about 12 tons), after the leading wheels were derailed, was transferred to the rear axle, and that any weight, clearly variable from time to time in amount, which came upon the front axle was carried by the tyred right-hand wheel—the left-hand tyreless wheel being practically in a floating condition. The engine must have travelled round the curve in this condition for a distance of about 300 yards, at a speed of perhaps 50 miles an hour. The marks in the four-foot way, made by the derailed right-hand bogie wheel, clearly shew the tendency of the front of the engine to move outwards on the curve, and that the rounding effect was being produced by the flanges of the engine driving wheels acting on the engine frame. It is remarkable that the movement of the engine round the curve, with its two leading wheels off the rails, should have been so little different from what was normal that it failed to attract the attention of the men on the footplate. But as already observed, the evidence shews that this was the case. It appears that the obstruction caused by the rail crossing the down road, and the proximity of the cast iron bridge girder to the near hand rail, were the immediate cause of the complete derailment of the train and the final disaster.

It was found by experiment, using a similar engine bogie, but utilising the actual side check springs, washers and bushes of the bogie of engine 1105, that with the centre casting loaded with 12 tons 13 cwts, 1-ton pressure was required to overcome the initial compression ($\frac{7}{8}$ inch) of the spring, and a further pressure of 3·7 tons to obtain $1\frac{3}{4}$ inches of side play of the bogie.

II.—Engine No. 1105 (see Fig. 1, Plate II) was built in 1891, and is stated to have been thoroughly maintained. It was last in Horwich Works for general repairs on September 2nd, 1924, and was turned out of the shops after repair on October 24th, 1924. It had therefore been out of the works only ten days before the accident. A list of repair work executed will be found in Appendix III. Details of the steel bogie wheel, with dimensions and method of fastening, will be found on Plate II, Figs. 3 and 4. It will be noted that the tyre, originally 3 inches in thickness, measured at the time of the accident $2\frac{7}{16}$ inches.

Mr. Shawcross was in charge of the Manufacturing Department at Horwich when the tyre was made, and was able, by means of the stamped marks (LYR—HS. S.628, 3.20.W) on the tyre, to trace its history. It was one of 34 tyres made from castings from heat No. S.628 on the 27th February, 1920. The tyres at Horwich are all manufactured to British Standard Specification for Locomotive Tyres (1921) Class "C," and the charge of this particular heat was calculated accordingly. For details of the charge, original tests, etc., see Appendix IV. Out of the 34 tyres cast, three were used for tup tests before the steel could finally be approved.

The tyre in question, after being shrunk on a wheel centre in the usual manner, was put into service in May, 1920, and had been running ever since, subject to shop repairs and overhaul. The wheel ran 100,355 miles up to 2nd September, 1924 (see Appendix III). The tyre, after being turned up in October, 1924, was thoroughly inspected, went through the usual bumping test, and no flaw was detected. Any actual surface crack would have been observed in the shop during turning. Subsequent to October the wheel ran 712 miles, making a total up to the date of the accident 101,067 miles.

Mr. Hughes stated that prior to April, 1923, the single ingot system of casting steel for tyres was in force at Horwich. Separate ingot moulds, generally of the beehive shape, were grouped in batches of four or five round a central feeder, and metal poured from the feeder into all the moulds. After casting, the group of ingots was allowed to stand for three hours. The central feeder was then removed, the ingot moulds stripped, and the ingot loaded up whilst still hot. The discard in the single ingot system is punched out of the centre, and provided the ingot remains in an upright position, the contraction cavities are removed. But if disturbed before the metal is entirely consolidated eccentrical blow holes may be formed which will not be removed when the centre is punched out. Since April, 1923, the vertical long (dodecagon) ingot system has been used, whereby ingots 6 or 7 feet in height are cast, from which blooms are sliced off without encroaching upon the discard space at the top of the ingot where the piping concentrates. These ingots are allowed to stand for four hours to ensure solidification, and are cut up cold.

Since the accident the remaining 30 tyres manufactured from the same heat, which were in service, have been withdrawn, and the whole number has been broken up under the tup without any of them disclosing any sign of flaw or other defect.

III.—Chemical analyses and metallurgical examinations.—Results of analysis and examination made at Horwich by the Railway Company, and at Teddington by the National Physical Laboratory, on separate pieces of steel cut from A and B sides of the fracture (See Fig. 2, Plate 2) are given in Appendix V. The existence of phosphorus to a slightly greater extent than is desirable is indicated in the chemical analyses. Sulphur prints taken shew no segregation. Etchings prove that microstructure and heat treatment have been satisfactory. Microscopic examination of the immediate region of the defect shewed the existence of minute cavities extending from the main cavity. These indicate that the defect, at one time larger in extent, was folded into the material during manufacture without complete welding, and that the strength of the metal was thereby considerably reduced. The contention of the Company that the existence of the defect could not have been discovered during manufacture of the tyre, and that the existence of a defect of this size was sufficient in itself to account for the failure of the tyre, is supported by the conclusion of the National Physical Laboratory.

IV.—Tyre Failures.—The number of broken tyres of all classes, reported by Railways in the United Kingdom during the undermentioned years, has been as follows :—

| | | | |
|---|---|---|---|
| 1880 ... ... ... | 1,238 | 1905 ... ... ... | 160 |
| 1885 ... ... ... | 920 | 1910 ... ... ... | 100 |
| 1890 ... ... ... | 577 | 1915 ... ... ... | 80 |
| 1895 ... ... ... | 454 | 1920 ... ... ... | 57 |
| 1900 ... ... ... | 234 | | |

For the years 1921 to 1924 the returns of broken tyres for Great Britain have been :—

| | 1921. | 1922. | 1923. | 1924. |
|---|---|---|---|---|
| Engine wheels ... ... | 14 | 14 | 18 | 16 |
| Tender wheels ... ... | 3 | 2 | 1 | 3 |
| Coach wheels ... ... | 2 | 3 | 5 | 3 |
| Wagon and van wheels ... | 60 | 36 | 46 | 41 |
| Totals ... ... | 79 | 55 | 70 | 63 |

The average yearly number of steam locomotives in actual service in Great Britain is now about 17,000. The yearly average number of engine tyre failures (including tender) may be said therefore to approximate 1 per 1,000 locomotives in service at any time. From the point of view of engine miles worked, the average incidence of failure is about 1 per 27 million.

It is comparatively rare for an engine or tender tyre, even when it breaks, to leave the wheel. Out of 29 cases which occurred in 1923 and 1924 the whole tyre remained on the wheel after failure in 22 instances, whilst in 7 either the whole or part of the broken tyre left the wheel.

I cannot trace, since 1893, a case of accident due to tyre failure, which occasioned loss of life or injury to any passenger.

The above figures illustrate, I think, the great improvements that have been effected in the manufacture, design and material of wheel tyres, the infrequency with which tyre failures now occur, and the comparative rarity of a case of serious accident arising therefrom.

2. There are, however, two directions in which further consideration and research is required. These are :—

(*a*) The allowance which should be made for shrinkage of locomotive tyres, the desirable manner of measuring such allowance, the most effective method of fastening tyres to wheel centres, and the degree of permissible wear. Practice in all these respects varies on different railways, and standardisation in what may be determined to be the best direction is desirable.

(*b*) The establishment of a practical means of detecting the existence of flaws in steel used in the manufacture of locomotive tyres, axles, etc. It has recently been stated in a lecture by Mr. V. E. Pullin, of the Research Department at Woolwich, that some new X-ray apparatus has been made which has enabled them to penetrate a mass of steel 4 inches in thickness. If an apparatus of the kind can be designed for use in what may be called every-day workshop examination of tyres, etc., defects of the nature which led to this accident could possibly be detected.

V.—Origin of fire in train.—Mr. C. Mason, Divisional Wagon and Carriage Superintendent, gave evidence that all of the four coaches in the train were lighted by gas, each coach carrying two cylinders with gas pressure up to 120 lbs. In the leading vehicle (No. 701) the cylinders were found undamaged and the low pressure pipe broken, which would permit of gas escaping in small quantities. In the second coach (No. 12890) the high pressure connection pipe was broken. This would permit of gas escaping rapidly, and would no doubt account for the smell of gas observed by some witnesses. In the third coach (No. 11491) one of the cylinders was dislodged and ripped open, so that all the gas was immediately discharged into the atmosphere. On the last vehicle the gas fittings were all intact, and the pilot lights remained burning for several days after the accident. The outside woodwork, as well as the interior of one compartment of this coach, was burned, and the outside of compartments on each side was also charred, though the fire did not penetrate into the interior. Mr. Mason had no doubt that the fire in this coach was started by the contents of the signalman's grate, which fell with the signal box, and set alight the debris, the conflagration afterwards setting fire to the side of the coach.

This circumstance was clearly proved by the evidence of Mr. J. H. Ranft, Gas Engineer of the Lytham-St. Anne's Corporation, and by the report upon the fire made by Mr. R. E. Whittaker, Chief Fire Brigade officer.

Mr. Ranft saw the accident take place from his office about 600 yards away. He described how he saw the lights of the first coach, and then those of the second, go out and the train divide. He immediately sent his foreman to collect all the men he could, and procure all necessary equipment, tools, etc., and take them down to the scene. He then telephoned the news of the accident to Lytham Railway Station, and to the Cottage Hospital, asking that all beds might be prepared, and for ambulances, doctors, and police. From his office window he saw a fire behind one of the coaches, and telephoned for the Fire Brigade. When he first arrived at the scene of the accident, there was no sign of fire in any of the coaches, but there was fire by the side of the two last coaches in the debris of the signal box. Carriage No. 12888, which was tilted over the burning debris, was subsequently set alight.

Mr. Whittaker arrived on the scene at 6.20 p.m. He reported that he found a large fire at the side of the railway where the signal box had been demolished, which had set alight to two compartments of a passenger carriage. The fire was quickly extinguished by the Fire Brigade, and in fifteen minutes all danger was removed.

It is fortunate, in view of the escape of gas which took place from the two overturned carriages, that these coaches did not take fire. Otherwise rescue of those passengers who were not killed would have been seriously menaced. Mr. Mason stated that none of the gas cylinders were housed in the frames, nor did they contain internally fitted check valves. All passenger stock, however, constructed subsequent to 1913 has cylinders provided with check valves, and in addition the cylinders are housed in the frames and protected by plating.

VI.—Availability of salvage tools, and effectiveness of rescue work.—No salvage tools or ambulance equipment were carried in the two brake compartments on the train. Until recently it was the practice of the Lancashire and Yorkshire section of the London, Midland and Scottish Railway to fit only corridor express trains with such equipment. Some tools for rescue purposes were available from a permanent way hut close by, and it was fortunate that great assistance in the way of tools, ropes, ladder, etc., was afforded by Mr. Ranft and his gang of fifteen to twenty men, who were probably the first helpers to arrive on the scene equipped with serviceable implements.

Evidence was given (Ticket collector Teale) that before 6.30 p.m. all of the injured had been rescued from the carriages. All the passengers in the last two coaches were extricated before the sides of the coaches caught fire. Soon after 6.5 p.m. railway ambulance men arrived from Lytham Station. Altogether, 13 men trained in ambulance duties were available, and in addition, St. John's Brigades from Kirkham and Blackpool, together with fifteen doctors, were quickly in attendance.

Mr. Royle, Divisional Superintendent, explained that delay in the arrival of a break-down gang with a crane of adequate capacity was due in the first place to interruption of telegraph and telephone connections between Warton and Moss Side. This was caused by the destruction of Warton signal box. The first telephone message received had therefore to be transmitted, after it reached Lytham Station signal box, through three signal boxes to Blackpool Central Station, and thence by road to Talbot Road (Blackpool), before information could reach the Control Office at Manchester. Further delay was caused by the bursting of a tube on the Preston steam crane when it arrived at Kirkham South Station at 8.5 p.m., which rendered the crane useless. The Liverpool steam crane was then ordered out and arrived at Kirkham at 10 p.m. This break-down train had to be re-marshalled to get the crane in front, and it eventually arrived at the north end of the scene of the accident at 10.50 p.m. The Newton Heath steam crane was also ordered out at 8.26 p.m., and arrived at the south end at 11.58 p.m. The two rear coaches had to be lifted out of the way before the Liverpool crane could deal with the two overturned front coaches. Mr. Royle did not think that, in view of the interruption of communication—the break-down gangs had in each case to be called out after the order for despatch had been received—and of the mishap to the Preston steam crane, any time was wasted. There was difficulty in getting reliable information as to the extent of the accident. The first message he himself received made no mention of coaches being overturned.

## *Conclusion.*

It may be of service to recapitulate shortly conclusions from the report, and points to which attention is directed :

(i) This accident was brought about by the failure of the tyre of the left-hand leading bogie wheel of the engine, caused by the existence of a large defect in the tread. The tyre left the wheel, with the result that the leading bogie axle became derailed. After travelling for 300 yards, without the enginemen becoming aware of the position, the derailed wheels came in contact with the rails of the crossing and the girder of a bridge, so that the whole train left the rails.

It is unfortunate that the enginemen were unable to detect the derailment of the leading axle, otherwise the speed of the train could, and would no doubt, have been reduced so considerably before the engine reached the crossing rail and bridge, that serious loss of life would in all probability have been avoided.

The quality of the steel used, and the tests carried out after manufacture of the tyres from the particular heat concerned, were in accord with best standard practice. The single ingot (beehive) group system of casting steel, which was in vogue at Horwich in 1920, has been replaced since 1923 by the more modern and preferable long ingot process, whereby the cavities caused by piping are removed by a sufficient discard from the top of the ingot.

The existence of the cavity could not with present day appliances have been detected during manufacture, or subsequent turning, as there was no evidence of the extension of the cavity to, or of hair cracks in, the surface.

The size of the defect was sufficient in itself, when wear of the tyre ($\frac{9}{16}$ inch) is taken into account, to cause failure at any moment. There is no reason to suppose that excessive speed, or the condition of the permanent way, was the cause of the fracture.

It is satisfactory, I think, to know that the Company have withdrawn from service the 30 remaining tyres, manufactured from the same heat of steel, that all have been broken up, and that no defect or flaw was found in any of them.

Statistics of tyre breakages are given in the report, and other information, indicating the continued improvement which has taken place, and the rarity of a case of this description leading to serious results.

(ii) The fire which took place in one coach originated in the contents of the grate in the signal box, which fell when the building was demolished by the engine, and set alight to the debris.

The rescue work of the passengers, the assistance in the way of ambulance and medical attendance, and the clearance of the disabled stock, appears, having regard to the interruption of communication, to have been effected without undue delay.

The action taken by Mr. Ranft, in supplying manual assistance, tools, etc., and in telephoning news of the accident, is worthy of commendation.

(iii) The circumstances of the case, however, again illustrate, in my opinion, the danger inherent in the use of gas as an illuminant for railway carriages.

I drew the attention of the Company also at the Inquiry to the desirability of providing rescue tools (including ladders) and ambulance equipment on non-corridor, as well as corridor, stock used with fast or express passenger services.

It is further for consideration, whether the complaints of rough riding between Kirkham and Lytham cannot be disposed of by improving the irregularities in curvature, and providing lengths of tangent at the points of reverse shewn on the longitudinal section.

(iv) I call the attention of Railway Companies generally to the desirability of—

(*a*) Standardising the shrinkage allowance, the manner of measuring the allowance, and the method of fastening, locomotive tyres.

(*b*) Devising, with the aid of Research Departments, some practical means whereby flaws in metal used for tyre, axle, etc., manufacture can be detected.

I have the honour to be, Sir,

Your obedient Servant,

J. W. PRINGLE,

*Colonel.*

The Secretary,

Ministry of Transport.

## APPENDIX I.

### (1) Particulars of Damage to Coaching Stock.

*Bogie Composite No.* 701.

Both ends knocked in.
Sides badly damaged.
Two headstocks, one solebar and two timber bolster beds damaged.
Both bogies torn from under and badly damaged.
One drawbar broken, leading end, new brake.
Drawgear and brakework badly bent.

*Bogie Third Van* 12890.

Both ends of coach and one side badly damaged.
Both solebars (steel) and headstock bent.
Both bogies torn from under and badly damaged.
Horizontal vacuum cylinder, and vacuum main train pipe and connection broken.
Drawgear and one bogie centre casting pin bent.

*Bogie Third Van* 12888.

One compartment destroyed by fire.
Four quarter lights broken.
One bottom panel and fascia panel burned.
One bottom footboard broken.
One bogie frame knocked out of square.
One centre casting out of position.
One drawbar broken.
One bogie bolster bed bent.
Six retaining ring bolts broken.
Three axleguards bent.
Three axleboxes and one bearing spring eye bolt broken.
One spiral spring missing.
One bogie frame slightly bent.
One bolster bed and bolster springs out of position.
One truss bar, one truss fulcrum, two leg irons, vacuum main train pipe, steam main train pipe, and hand-brake pull rod bent.

*Bogie Compo* 11491.

One corner, two door pillars, two door hinge pillars broken.
Four waist and three bottom panels broken.
Two top footboards and four fascia panels damaged.
Two headstocks bent.
Two buffers and one buffer casting broken.
Two bogie frames, two straddle rods, two bolster beds, two truss bars, and three axleguards bent.
Two auxiliary springs missing.
Two axleboxes broken.
Vacuum and steam main train pipes bent.
Two bogie longitudinal frame bars bent.
Two bearing springs and one gas cylinder displaced.
Two gas cylinder bands broken.
Gas fittings twisted.

### (2) Damage to Engine No. 1105.

*Engine.*

| | |
|---|---|
| Bogie ... ... ... | Broken away from cylinders and badly damaged. |
| Leading axle ... ... | Both tyres broken. |
| Trailing axle ... ... | Badly bent. |
| Bogie slide ... ... | Became detached and smashed. |
| Cylinders ... ... | Broken at bottom through bogie breaking away. |
| Piston and crosshead | Strained. |
| Wheels and axles ... | Strained. |
| Splashers and cab ... | Badly twisted. |
| Smoke box ... ... | Bent. |
| Boiler clothing ... | Damaged. |
| Brake beams and rods | Badly bent. |

*Tender.*

| | |
|---|---|
| R.H. footstep ... | Broken. |
| Frame ... ... | Slightly bent at front R.H. side. |
| R.H. panel plate ... | Slightly bent. |
| Pickup casting ... | Broken. |

## APPENDIX II.

TIMING AND SPEED OF THE 4.40 P.M. LIVERPOOL TO MANCHESTER.

| Distance. M. ch. | | Station | | Timing. p.m. | | Speed. m.p.h. |
|---|---|---|---|---|---|---|
| — | ... | Liverpool (Exchange) ... ... | depart | 4.40 | ... | — |
| 4 66 | ... | Aintree ... ... ... ... | pass | 4.47 | ... | 41.3 |
| 7 26 | ... | Ormskirk ... ... ... ... | pass | 4.57 | ... | 43.9 |
| 2 47 | ... | Burscough Junction ... ... | arrive | 5.0 | ... | 51.8 |
| | | | depart | 5. 1 | ... | |
| 8 23 | ... | Midge Hall ... ... ... | pass | 5.12* | ... | 45.2 |
| 1 60 | ... | Moss Lane Junction ... ... | pass. | 5.15 | ... | 35.0 |
| 3 78 | ... | Preston ... ... ... ... | pass | 5.22 | ... | 34.1 |
| 7 67 | ... | Kirkham ... ... ... ... | arrive | 5.37 | ... | 31.4 |
| | | | depart | 5.38 | | |
| 5 68 | ... | Lytham ... ... ... ... | arrive | 5.47 | ... | 39.0 |
| | | | depart | 5.48 | ... | |
| 1 19 | ... | Ansdell ... ... ... ... | arrive | 5.51 | ... | 24.8 |
| | | | depart | 5.52 | | |
| 1 53 | ... | St. Annes ... ... ... | arrive | 5.56 | ... | 24.9 |
| | | | depart | 5.57 | | |
| 3 29 | ... | Waterloo Road ... ... ... | arrive | 6. 4 | ... | 28.8 |
| | | | depart | 6. 6 | | |
| 1 14 | ... | Blackpool (Central) ... ... | arrive | 6.10 | ... | 17.6 |
| 49 70 | | Average throughout speed ... ... | | | | 35.6 |
| | | Average speed Liverpool to Lytham ... | | | | 38.8 |

* Three coaches slipped at Midge Hall.

## APPENDIX III.

1.—*Repairs carried out to Engine 1105 at Horwich, between September 2nd and October 24th,* 1924

All engine wheels turned up—skimming about $\frac{3}{16}$ inch.
All tender wheels turned up.
Motion stripped and overhauled.
All engine axleboxes refitted to horns and journals.
Two new axleboxes supplied to driving axle.
Bogie axlebox refitted to horns and journals.
Connecting rods and valve gear taken down and repaired.
New brasses fitted to all tender axleboxes.
Cylinders rebored.
Tender tank repaired.
Springs taken down and overhauled.
Bogie stripped and refitted.
Pistons and piston valve taken out and refitted.
Engine weighed.

2.—*Mileage worked by Tyre.*

| | | | |
|---|---|---|---|
| Under engine No. 1228 ... ... | 22,351 miles | | May, 1920–September, 1924. |
| Under engine No. 1104 ... ... | 31,238 ,, | | |
| Under engine No. 1414 ... ... | 34,666 ,, | | |
| Under engine No. 1112 ... ... | 12,100 ,, | | |
| Under engine No. 1105 ... ... | 712 ,, | | After October 24th, 1924. |
| Total ... ... ... | 101,067 ,, | | |

## APPENDIX IV.

Heat S.628, cast in No. 1 Furnace.
Charged February 26th, 1920, at 8.45 p.m.
Tap February 27th, 1920, at 7.15 a.m.

| | | |
|---|---|---|
| Charge ... ... ... | 220 cwts. | Carnforth No. 1 |
| | 220 cwts. | Scrap. |
| | 5–2–14 | Fe. Mang. |
| | 2–2– 7 | Fe. Silicon. |
| Total ... ... ... | 448–0–21 | cwts. = 22 tons 8 cwts. 0 qrs. 21 lbs. |

Total yield = 21 tons 8 cwts. Loss 4·5

| | C. | Si. | S. | Ph. | Mn. | |
|---|---|---|---|---|---|---|
| Final analysis ... | 0·63 | 0·33 | 0·04 | 0·05 | 0·87 | per cent. |

Tyres cast in the heat—

| | |
|---|---|
| 15 "A" tyres, Coal Eng. | 3 ft. 11 7/8 in. inside diam. |
| 10 "E" tyres, R.P.T. | 5 ft. 1 7/8 in. inside diam. |
| 9 "F" tyres, Bogie | 2 ft. 6 3/8 in. inside diam. |
| | 3 ft. 0 3/8 in. outside diam. |
| Total 34 | |

2 ingots, 15 cwts. to 20.

Result of Test (after first heat treatment)—

First tyre tested broke at tup, second gave insufficient (4 inches) deflection.

The remaining 32 tyres were therefore annealed with the following results:—

Tup—Six blows at tup gave 4½ inches deflection.

Specification demands 4¼ inches deflection.

Tests—Class C.—

55·5 tons tensile. Specification, 50–55.

19 per cent. elongation. Specification, 13–11 per cent.

Shrinkage allowance, 1/750 of the diameter.

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## APPENDIX V.

### Chemical Analyses and Metallurgical Tests, etc., of Pieces of the Broken Tyre.

1.—By the L.M. and S. Railway Company (B. side of fracture)—

Chemical analysis—(average of three).

| | | |
|---|---|---|
| Carbon ... ... | ·703 per cent. | B.S.S. calls for not more than ·05 per cent. of sulphur or of phosphorus. |
| Silicon ... ... | ·323 ,, ,, | |
| Sulphur ... ... | ·039 ,, ,, | |
| Phosphorus ... | ·054 ,, ,, | |
| Manganese ... | ·816 ,, ,, | |

Tests—average of 5, on test pieces 2 inches in length and with an area of ·25 sq. inches.

Tensile breaking stress tons per sq. inch, 49·57 B.S. Specification C Class. 50–55 tons.

Elongation per cent., 21·5 B.S. Specification C Class. 13–11 min. elongation.

*Report.*

Micro-photographs indicate structures are fairly homogenous, but slightly coarse.

Sulphur print shews section is practically free from non-metallic inclusions.

Examination shewed no evidence of skin flaws on the surface of the tyre above the flaw.

2.—By National Physical Laboratory (A. side of fracture).

Chemical Analysis.

| | | |
|---|---|---|
| Carbon ... ... | ·652 per cent. | Average composition near fracture is not abnormal, but phosphorus content is higher than is regarded as desirable for locomotive tyres. |
| Silicon ... ... | ·309 ,, ,, | |
| Sulphur ... ... | ·049 ,, ,, | |
| Phosphorus ... | ·057 ,, ,, | |
| Manganese ... | ·870 ,, ,, | |

*Report.*

Fracture reveals presence of large defect (Plate III shews extent of defect as outlined in black).

Sulphur prints taken on radial sections ⅞ inch and 12 inches from fracture shew no segregation. Etching by means of a cupric chloride reagent suggests that in the ingot from which the tyre was made the cavity was larger in extent, but had been reduced during the rolling of the tyre.

Microscopic examination of specimens cut both in circumferential and radial directions reveals presence of numerous non-metallic inclusions, which, though not in themselves sufficient to cause the fracture of the tyre, would materially assist the spreading of a fracture after its commencement.

Examination of polished surface, etched with a 1 per cent. solution of nitric acid in alcohol, shews that the micro-structure of the steel and the heat treatment to which it had been subjected have been satisfactory.

Examination in the immediate region of the defect shews that there are many minute cavities and inclusions extending from the main cavity. From the arrangement of these it would appear that the walls of the cavity formerly larger in size were folded into the material during the manufacture of the tyre, without complete welding. The strength of the material in the region of the cavity has therefore been considerably reduced. No evidence has been found that the cavity at any point reached the outside of the tyre, so that its presence during manufacture would not be readily observed.

*Conclusion.*

Chemical analysis and micro-structure do not reveal any causes which would account for the failure of the tyre. The fracture has occurred in the region of a defect due to a cavity in the original steel ingot, which occupies a considerable proportion of the cross section. The defect has probably been considerably reduced in size by rolling, but the folded surfaces still constitute lines of weakness. Defects of this character are usually situated in the centre of the ingot and are generally removed by cropping or by piercing of the tyre blank. The unusual position of the cavity has probably been responsible for the failure to detect it during manufacture.

The presence of a defect of this size is sufficient to account for the failure.

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# Derailment at Lytham (L.M & S. Ry.)

3rd Nov. 1924.

**Plate I**

*To accompany Sir John Pringle's Report dated 19th Feb. 1925.*

Fig. 2

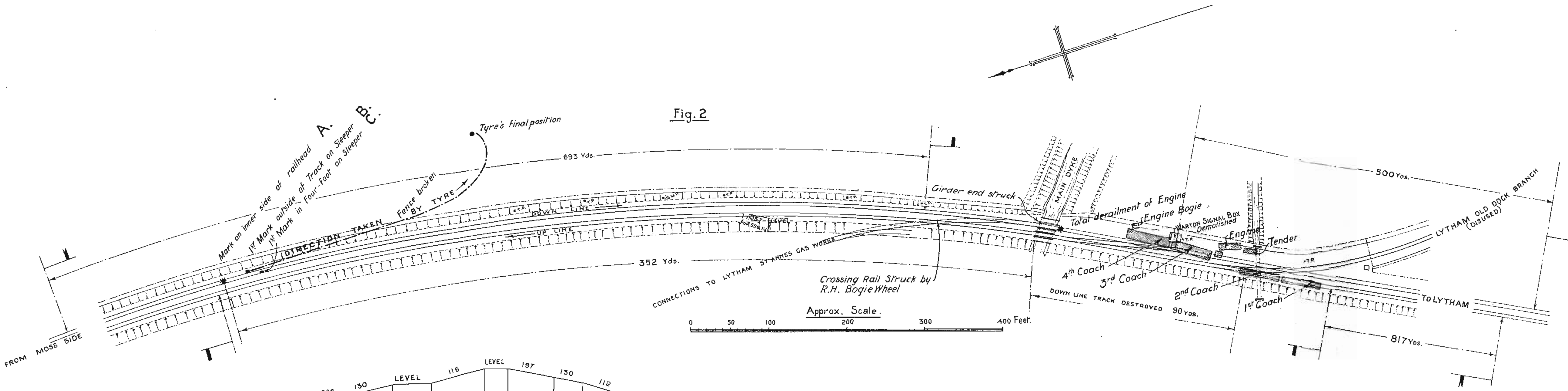



Fig. 3

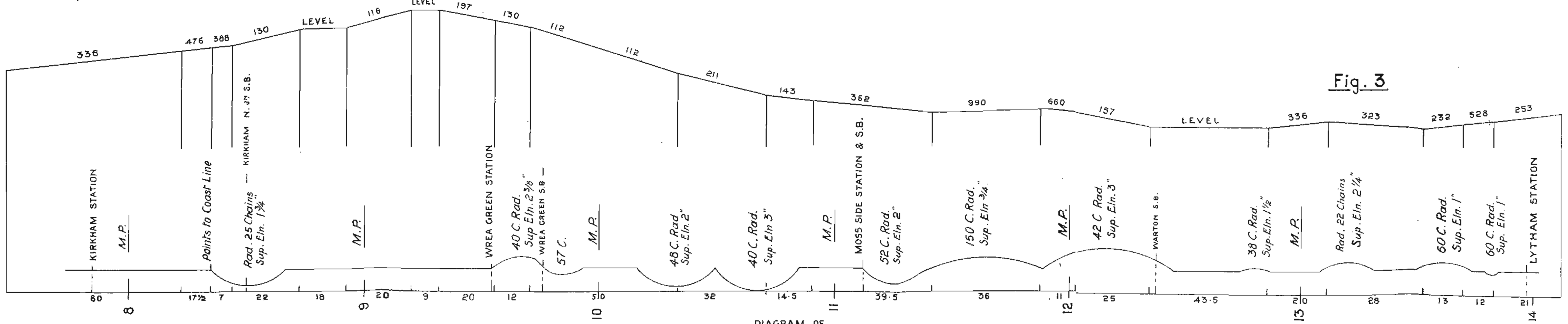
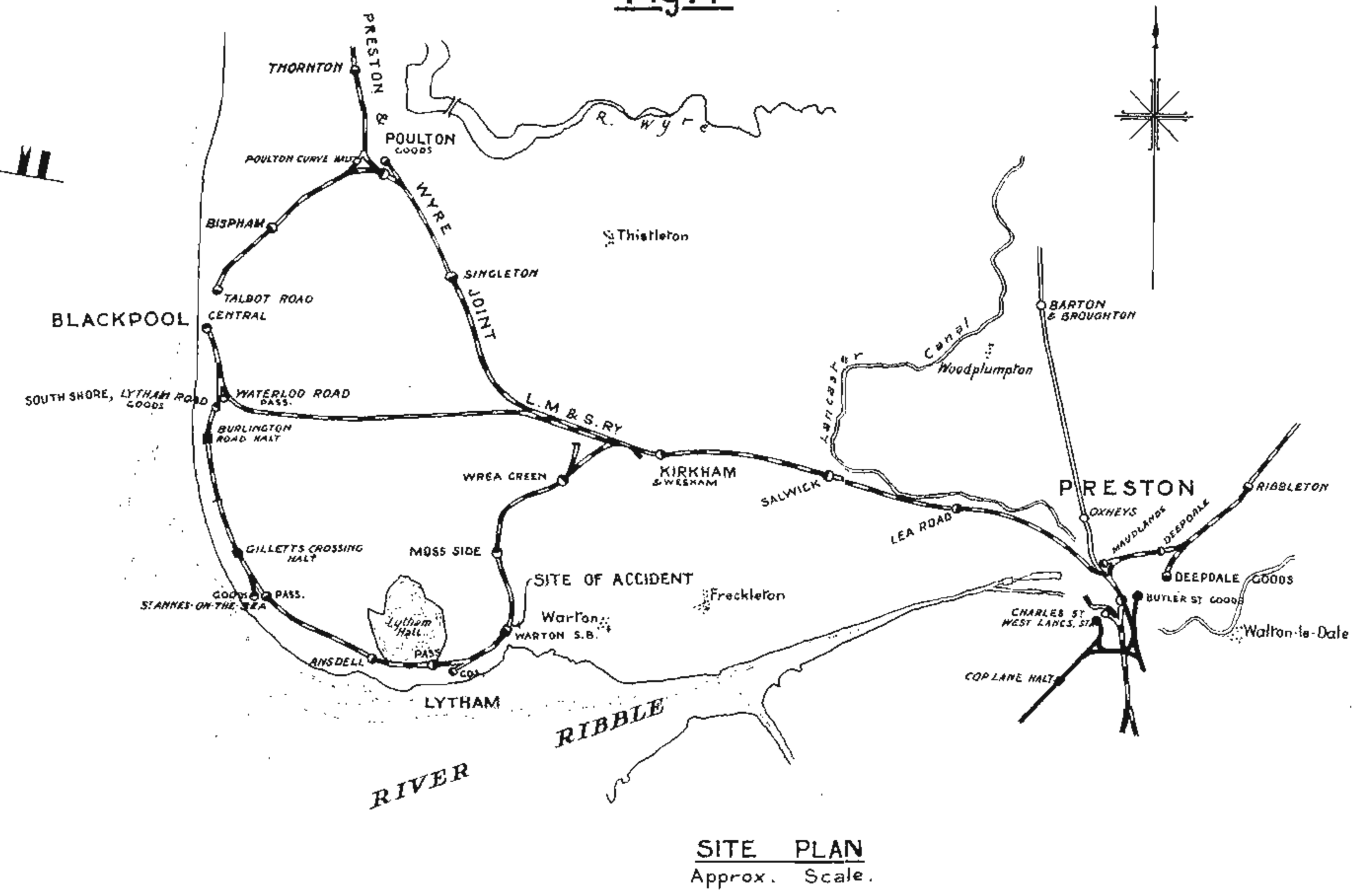



Diagram of Gradients & Curves from Kirkham to Lytham

Scale: 3 inches to 1 mile.

Fig. 1




Site Plan

Approx. Scale.

0 1 2 3 4 5 6 Miles

KEAAL HASP GEZT. 25987A. 169/1834. 750. 3/25.

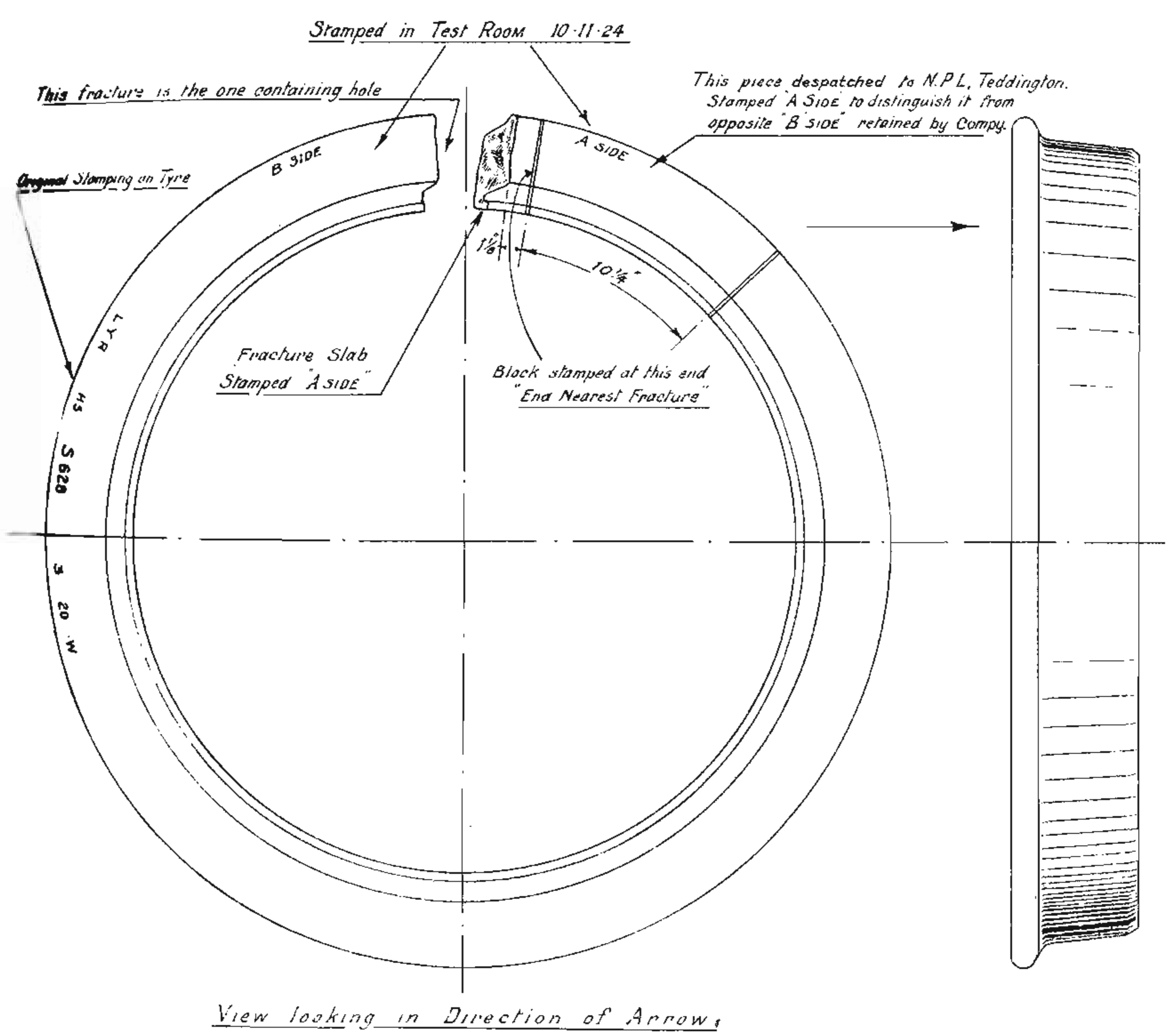
*Plate II*

To accompany Sir John Pringle's Report dated 19th Feb. 1925.

# Derailment at Lytham (L.M & S. Ry.)

## 3rd Nov. 1924.

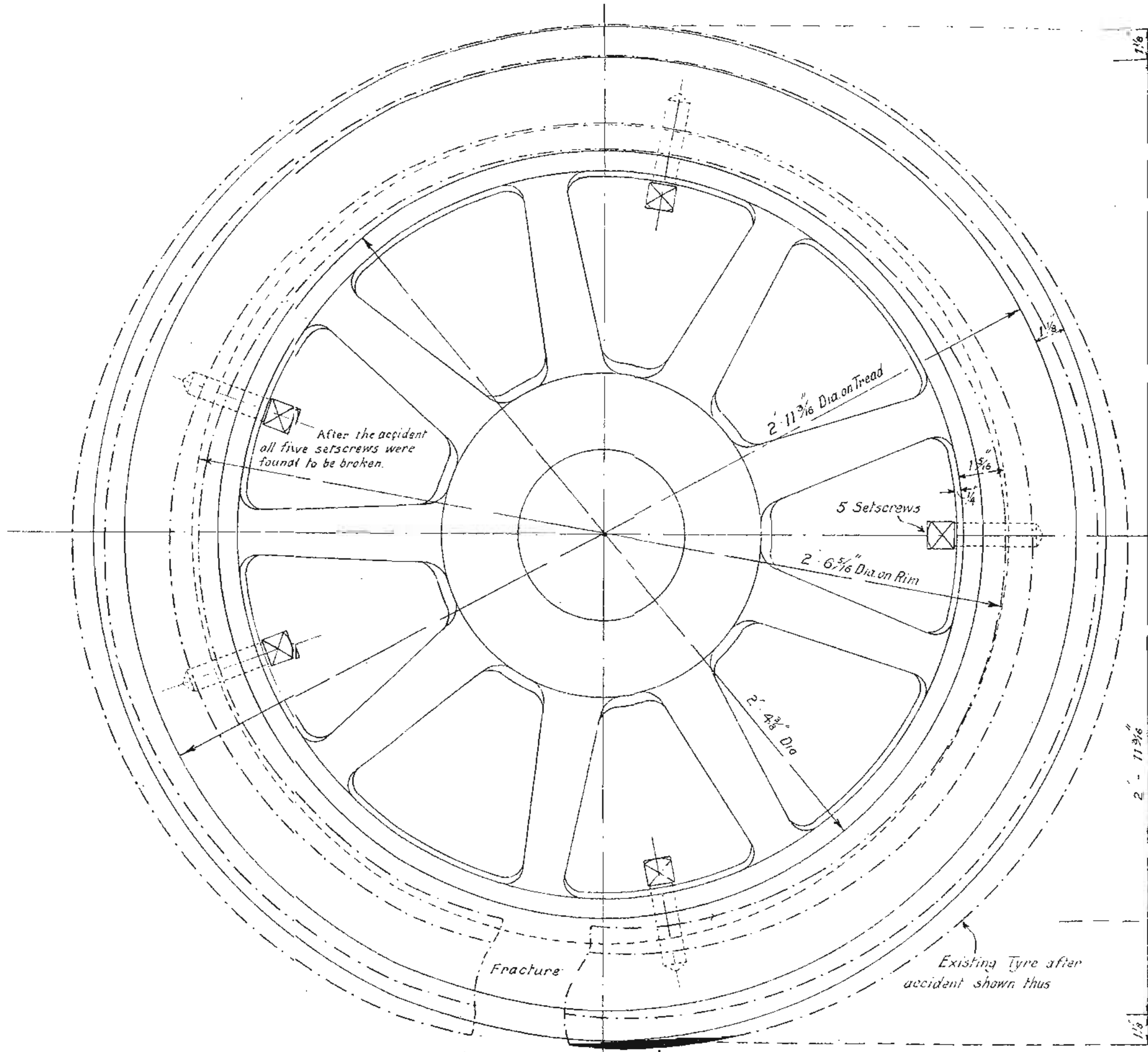
Fig. 2.




View looking in Direction of Arrow.

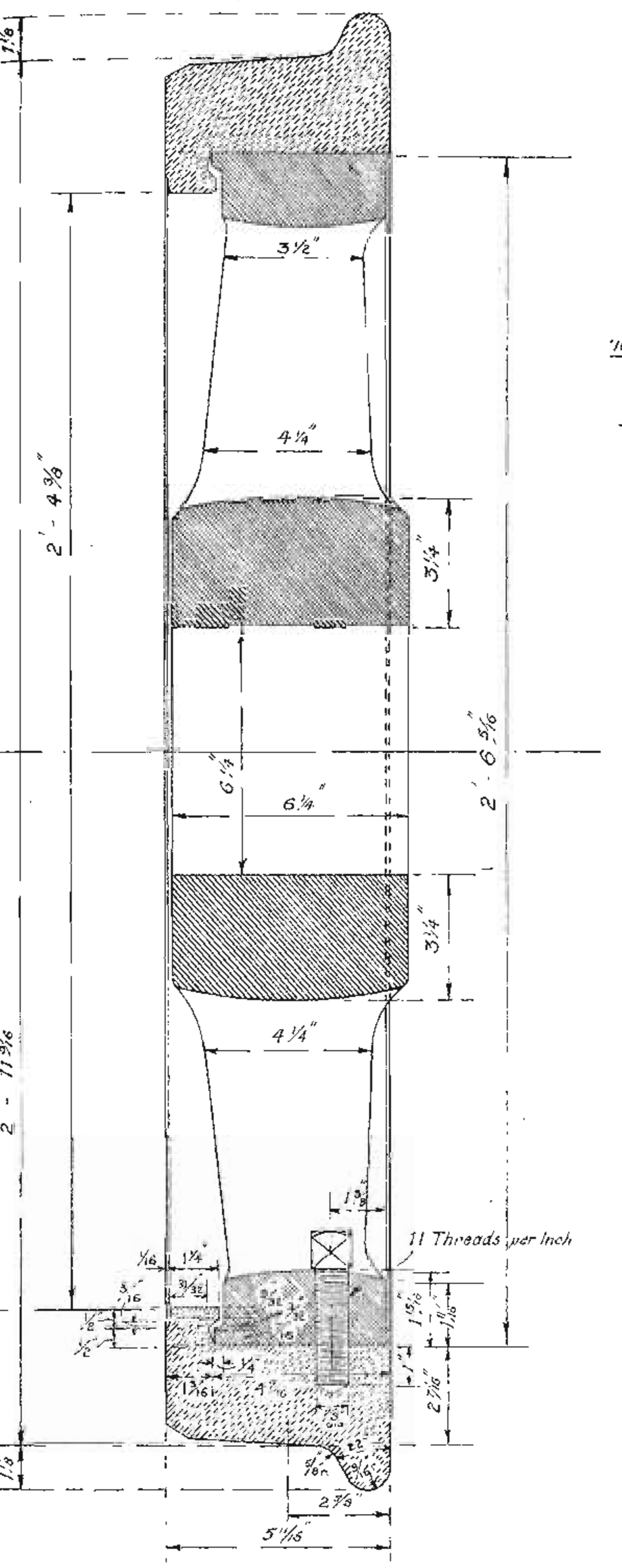
Sketch of Broken Tyre 5628 3.20.W.

Fig. 3.




Flange flattened for 6½")

Fig. 4.

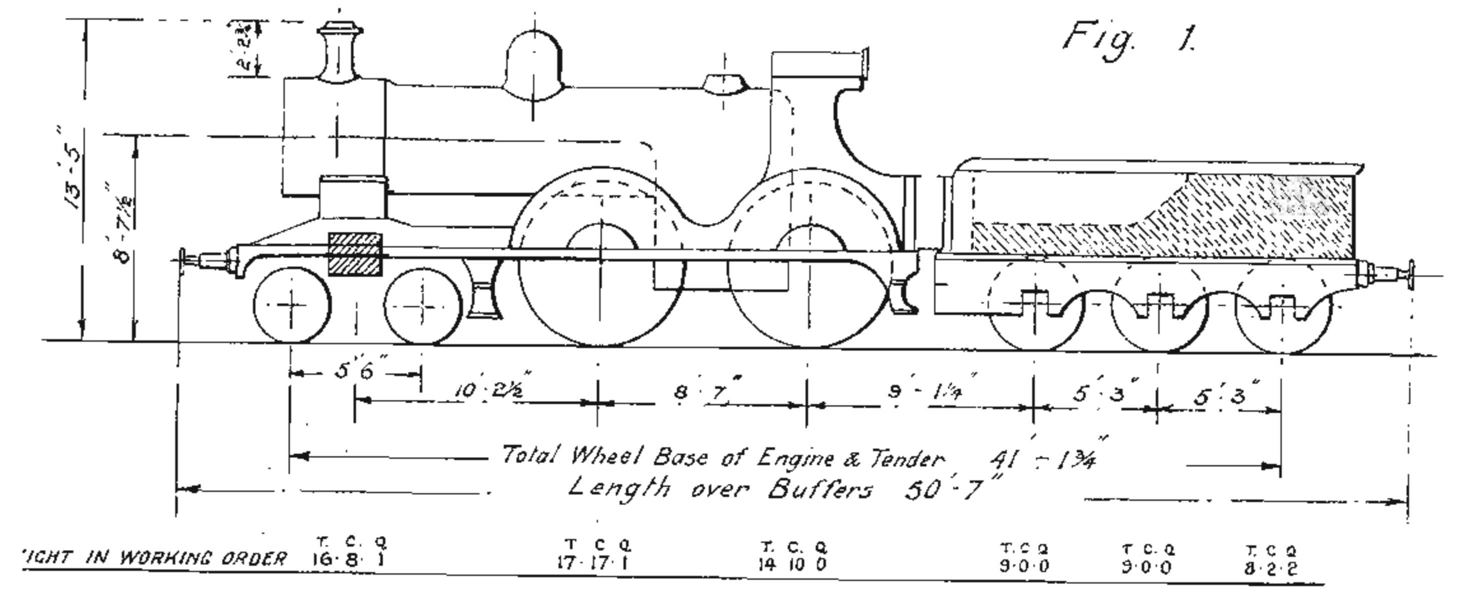



Scale: ¼ Full Size

8 Wheeled Bogie Passenger Engine (Schmidt Superheater)

No 1105.

Fig. 1.




Boiler Pressure 180 lbs per sq. in.

Heating Surface (Fire Side)

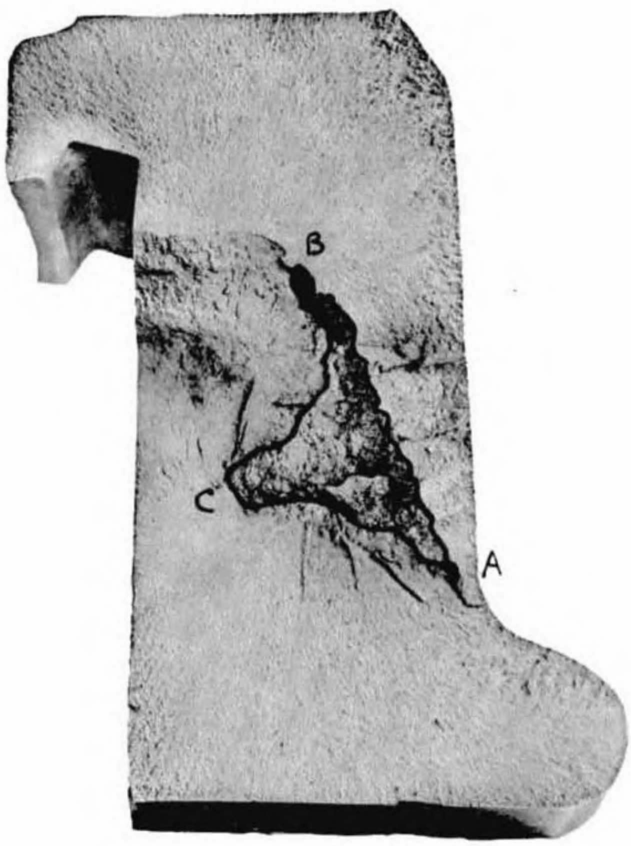
| | |
|---|---|
| Tubes (Large & Small) | 693·000 sq. feet |
| Firebox | 108·189 " " |
| Total | 801·189 " " |

Grate Area = 18·75 sq. feet

Cylinders 20" dia. × 26" stroke

Water Capacity 1800 Gallons

Quantity of Coal 3 Tons




DERAILMENT AT LYTHAM (L.M. & S. RLY.)

3RD NOV., 1924.