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Not to be folded or roughly handled

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*Proceedings of the Madras Government, Public Works Department,
11th December 1868.*

No. 263. Read the following Proceedings of the Government of India in the Public Works Department, (Railway,) dated Simla, 26th October 1868, No. 1,256 R:—

Mr. W. Bridges Adams' improvements in the construction of Railways, Locomotives, and Rolling-stock.

Read:—

Despatch from Secretary of State, No. 75 of 1868, and enclosures.

ORDER.—Ordered that copies be forwarded to the Local Governments and Governments of Madras, Bombay, Bengal, and Administration noted in the margin, for Punjab. information, with the intimation that Chief Commissioner, Oudh. spare copies of the pamphlet, "Railway Practice and Railway Possibilities," will be subsequently supplied.

(Signed) J. W. ALEXANDER, C. E., *Offg. Asst. Secy.,
for Secretary to the Government of India.*

From the Secretary of State for India, to the Government of India, dated 16th September 1868, No. 75.

Herewith are transmitted, for your information, copies of a letter and enclosures from Mr. W. Bridges Adams, dated 27th August 1868, relative to improvements in the construction of Railway engines and carriages, calculated to ensure safety in working over sharp curves or steep gradients.

From W. BRIDGES ADAMS, Esq., to the Secretary of State for India, dated 27th August 1868.

Finding by the Report of Mr. Juland Danvers on Indian Railways, that it is in contemplation to construct some new lines direct by the Government instead of by Companies, I beg to lay before you some important improvements of mine in the structure of engines and vehicles, contained in a pamphlet I now hand you herewith, and which have met the approval of some of the most prominent members of the Institution of Civil Engineers, as quoted therein.

This system, known as the radial system, has now been in satisfactory use for upwards of two years on the Great Northern and Chatham and Dover Lines, working over the sharp curves and steep gradients of the Metropolitan. I also call your attention to my system of permanent-way, wholly of iron, consisting only of four types or parts, making light rails as available as heavy ones, and materially cheapening structure.

The value of the radial system consists, *first*, in materially reducing resistance to traction, even on straight lines; *secondly*, in permitting the structure of curved lines following the contour of the country, and thereby avoiding expensive earth-works, and, moreover, by diminished weights of engines making less costly bridges available. It also includes the means by coupled engines of working up the steep gradients and round the sharp curves of mountain passes.

I accompany this with a paper giving the general argument on the subject dealt with, and the applicability of the system to construct light lines on the common roads of the country for the service of town localities, or heavy lines in connection with the main trunk lines of Railway.

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*Economical Railway extension in India; including the utilization of common roads, by
W. Bridges Adams.*

The Railways hitherto made in India prove that they are a profitable investment, even under very unfavorable circumstances of structure, and at a cost now acknowledged to be greatly in excess of what is at present needed. A simple analysis will give us the reason.

The mechanical datum from which to construct a Railway must be the haulage resistance per ton of load, taking into account the curves and gradients of the line. Of course gradients must cause a constantly increasing or diminishing resistance with the increase of steepness up or down. But curves do not necessarily increase the resistance at all, provided the engines and carriages be rightly constructed. If they be rigidly constructed, i. e., without lateral flexibility, they can only run with the minimum of friction when on a straight line. But really straight lines scarcely exist. The so-called straight lines will be found on examination to consist, as regards the wheel action, of a series of small waves or curves, and though at low speeds, the resistance may not be great; it increases in proportion with the speed. Atmospheric resistance is not here taken into account, as dealing with moderate paying speeds and omitting wind which may be either favorable or unfavorable.

The normal resistance of trains under favorable circumstances is under eight pounds per ton of load. But the practical resistance varies from that to forty pounds per ton, or more, according to its speed or curves, independently of gradients. The cause of the increased resistance is the grinding of the wheel-flanges against the rails, increasing in proportion to the length of wheel-base round the curves of the rails, and in case of very sharp curves, with great risk of getting off the line at a tangent.

The resistance may be wholly removed by a simple alteration of the carriages, permitting the wheels a lateral movement to right or left, so that the carriage-axes will always point truly to the centres of the curves on the line of the radii, as well as the wheels and axles of the engine, except the coupled driving axles.

And in this mode, much sharper curves can be worked, as sharp as 50 feet radius, ordinary curves being 1,350 feet radius. It is not to be supposed that such sharp curves can be worked at great speeds, but, practically, points and crossings and passing places involve commonly curves of 400 feet, unless great lengths of rail be used; but it is a very great advantage, and especially in town approaches, to enable trains to work as flexibly as horse carriages. As the strength of a machine is governed by its weakest part, so is the haulage resistance of a train increased, and the load diminished by the maximum friction at any part of the line. The engine can exert a certain power with free movement, and that power is curtailed by the increased resistance.

One great advantage of flexible trains is, the facility of thereby connecting Railways with ordinary roads, and laying down rails thereon, serving as branches and sidings to the main lines, and also serving as separate Railways when needed, and this, without interfering with ordinary traffic.

Such lines on common roads may be special light lines, or heavy lines for the hardest traffic. It is obvious, that if the excessive train resistance be reduced to its nominal condition of eight pounds per ton of load, either a much lighter engine would do the haulage, or a much larger train might be drawn.

The cost of a Railway consists, mechanically, of its earth-works, bridges, viaducts, stations, rails, sleepers, crossings, turn-tables, and other apparatus, and this cost is increased in proportion to the increase of resistance per ton of haulage.

With a given tonnage and minimum resistance, the engines, vehicles, rails and other appliances may be lighter and less costly.

By laying down rails on a common or Government road, the cost of earth-works, bridges, viaducts and stations may be dispensed with, and the rails, engines and vehicles being much lighter and cheaper, may be made to follow the curves of the road flexibly.

And such roads may thus become a part of the general Railway system, or a separate system with a different gauge, if any.

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In constructing new lines, the difference of cost in a five feet six inches, or three feet six inches gauge, would consist in earth-works and bridges. The rails must in either case be adapted to the load on the wheels, which might be the same on the narrow as on the broad, unless in articles of great bulk, such as cotton. When the load consists of dead weight in small bulk, the narrow gauge might carry as heavy a load per wheel as the broad. In very bulky goods, the broad gauge may be better than the narrow. The safe rule of structure is in all cases to make the vehicles double the width of the gauge. Thus, a three feet six inches gauge, would have vehicles seven feet in width, and the five feet six inches gauge, would have vehicles eleven feet in width. In the accompanying pamphlet "Railway Practice," a plan is shown of a radial carriage eleven feet wide and sixty feet long. The extreme wheel-base is forty feet, but in virtue of the radial arrangement, it will roll round curves as sharp as 150 feet radius, while containing all the appliances of a river steamer for eating, sleeping, reading, writing and amusements for fifty passengers, divided by sliding doors into two duplicate parts for ladies and gentlemen, and dispensing with station arrangements.

In the long journeys which will be essential to Eastern travel, and in cases when the night is pleasanter than the day, such roomy vehicles will become a necessity, and ventilation will be amply provided for by the system of sliding instead of hinging doors, which may be kept constantly open, except in time of monsoons. Large carriages are the most economical in transit, and vehicles of this size would be the most convenient for the transport of troops in numbers. It is only upon the flexible system that this can be accomplished. The vehicle is constructed in two separate halves for the convenience of construction, repairs, or shipment, Plate 4, in the description in "Railway Practice" illustrates this vehicle.

The early lines of Railway in India, were made with timber sleepers, but they wore out so rapidly with white-ants, rain and sun, that they are now considered inadmissible, and cast-iron sleepers have taken their place.

The form and structure of the cast-iron sleepers just applied, the "pot-sleeper" is, however, not favorable to durability, and it requires a very heavy rail. Moreover, it cannot be used with very hard ballast, as it breaks under the movement of the trains, and would require much greater additional weight to be durable. The rail bears over only a very small portion of the sleeper, and is fastened by wood keys, which are objectionable.

But it is practicable to use a less weight of cast-iron in a better form, so that the rail takes a two feet length of bearing instead of only six inches. A groove sleeper line, a tracing of this line in cross-section, and plan is appended (No. 1), the rail is single-headed, but it weighs only forty-eight lbs. per yard, and the rails which are double-headed, and used in very heavy chairs, are practically found not to answer, and are in England condemned by the Officers of the Board of Trade, Railway Department.

It will be observed that, the "pot system" of permanent-way as used, weighs about 280 tons per mile. It has wooden keys, fishes for the joints and screw-bolts, and is a multiple of seven types or forms to the number of 21,414 parts, per mile.

The groove sleeper system before described weighs 190 tons per mile. It has only four types or parts, and has neither wooden keys, fishes, nor screw-bolts. The number of parts per mile is 17,344, or 4,070 less than the pot system. In all large structures, simplicity of form and diminution of parts are desirable. This Railway would be equal to the transit of all the waggons and carriages of the main lines, though not to their heavy engines, and it is well adapted to lay down on sharp curves. A heavier structure of this kind can be made adapted to the heavy engines of the main lines not exceeding 250 tons of metal per mile, the rail not exceeding 60 lbs. per yard.

Radial Engines and Radial Trains.

A Radial Tank Engine on eight wheels, with four coupled driving-wheels, and 800 gallons of water in the tank, adapted to roll either end foremost round curves of ninety-nine feet radius, and weighing twenty-two tons, would draw on the level, 350 tons gross load of train equal with proper structure of vehicles to save friction, and weight to about 200 tons of paying load in goods, or 3,000 third class passengers—See Plate 5 and description "Railway Practice."

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An engine of this class, on a smaller scale, is appended in a tracing, intended for the haulage of eight large omnibuses up and down gradients of one in fifty, carrying a load of 480 passengers, half inside and half out, Nos. 2 and 3.

An economical waggon to serve for third class passengers, and occasionally for freights of bulky goods, might be arranged with folding or moveable seats, and it must be remembered that the plan of separate vehicles, not convertible to every variety of transit, involves an enormous amount of rolling-stock. If the town waggons of London were all constructed, one class for coals, another class for grain, another for sheep, and so on, the cost of transit would be much increased. The tracing appended (No. 4) shows a radial vehicle of this kind for the five feet six inches gauge, twenty-five feet long, and eleven feet wide, which will carry comfortably seated, 70 third class passengers, say, four tons. The waggon should weigh little over three tons, and with the seats removed, would take six tons of goods. Breaks are shown applied with a block to every wheel, and which are self-acting in the case of accidents, such as coupling giving way on an incline—See Plates Nos. 2 and 9 with description "Railway Practice."

Cost of a Light Local Railway on the common road.

Supposing a groove sleeper line of twenty miles single on the light system, the cost in England would be, rail sleepers and fastenings about £20,000, three locomotives £5,000, thirty omnibuses £7,500, fifty waggons £7,500, total say £40,000, add freights and laying down, which, for a three feet six inches gauge on a common road, would be very simple, the total cost would scarcely exceed £50,000, or £2,500 per mile.

The work which this line would be capable of doing would be six trains per diem, each way, with 480 passengers per train, say, 5,000 passengers per diem over twenty miles. At 1d. per mile, this would give a revenue of £52 per diem, or, in round numbers, £16,000 per annum. Deduct half for working expenses, that leaves £8,000 per annum, or about 15½ per cent. on the capital to go to renewals and profit.

It must be remembered, that a short line requires a much less proportionate amount of working stock than a long one for the work done, because the return of the vehicles is rapid. By the report of Mr. Danvers, the Madras has a proportion of one locomotive for every six miles of line, which is the amount allowed in the above estimate. The distance to be run is 240 miles per diem, averaging eighty miles per diem for each locomotive. Of course, cheap transit depends on the amount of the population. The foregoing calculation assumes a million and a half per annum. If the fare be ½d. per mile, three-fourths of a million would suffice; if 1d., 3,70,000; if 1d. per mile, 1,85,000, or about 500 per diem. The locality chosen must determine this.

Nothing is taken for goods, or for the transport of vegetables and fresh provisions from the country to the town, nor for the transit of wealthy passengers to country houses. The train is assumed to work gradients of one in fifty, and speeds up to twenty-five, and occasionally thirty miles per hour.

The five feet, six inches gauge would, of course, carry a larger number of passengers per diem, with an increased use of engines in the proportion of seventy to fifty-seven. The permanent-way would only increase in cost by the extra length of the tie-bars, but the engines and vehicles would cost more. Yet the wear and tear of the line, by reason of diminished resistance, needing less weight on the driving wheels, would almost disappear, and the maintenance of rolling-stock would be very small.

It appears, therefore, from the above calculation, that the sum of about 2½ millions, judiciously applied would construct 1,000 miles of Railway in India, either of a narrow gauge, including rolling-stock, or of the broad gauge, to work in with other lines, i. e., supposing 1,000 miles of Government or Military roads to be formed, and moderate engines to be used, this is subject to the connection of distance from the landing-place of materials.

And to adapt this line to the heaviest engines required, always supposing them to be flexible and not rigid, an addition of fifty tons of metal per mile would furnish a permanent-way capable of following the contour lines of the country, and, if need be, of using much sleeper gradients. Plate No. 7, "Railway Practice," shows a town engine adapted for hauling a heavy train up

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steep gradients, through winding mountain passes of ninety-nine feet radius; much lighter bridges might be thus used, and many viaducts dispensed with.

A permanent-way of this class could be furnished in England for about £1,500 per mile, single, and there is little doubt that the Government can make lines of their own, rolling-stock inclusive, within the estimate of £10,000 per mile, probably £7,000 to £8,000, subject of course to the correction of varying localities and bridging rivers.

The cost of the existing Indian Railways, as furnished in the Report of Mr. Danvers, has been £16,070 per mile, ninety millions, 5,600 miles. With existing knowledge, probably twenty-eight millions will double this amount of mileage.

I, therefore, submit that, as the Indian Government are going largely into the question of Railway extension, and purpose to make several lines on their own account, and not by Companies, that it would be well to select a short line on a public road in a populous district when the road may be utilised, and the system of minimised resistance by flexible, instead of rigid trains, brought into operation.

The question of the improved rolling-stock, really rolling and not sledging, is fully treated in "Railway Practice," and the opinion of several of our most noted Railway Engineers in favor of the radial system are quoted therein:—Mr. Gregory, the President, Mr. Vignoles, Mr. Berkley, Mr. Harrison, Mr. Heppell, and Mr. Hawkshaw.

Thirty-four of these engines have, since this opinion was given, for two years been working satisfactorily on the Great Northern and Chatham and Dover Lines, over the sharp curves and steep gradients of the Metropolitan.

No. 264. ORDER THEREON, 11th December 1868, No. 3,869.

RAILWAY, No. 2.

Communicated to the Consulting Engineer for Railways.

(True Extract.)

Colonel, R. E.,
Secretary to Government.

To the Consulting Engineer for Railways, with pamphlet and four plans.

Exd. G. A. Turton.

Gort. of {1868} Madras.

PUBLIC WORKS

To

THE CONSULTING ENGINEER
RAILWAYS

Dated December, 1868.

Recd

G. O., 11th December 1868, No. 263.

DECEMBER.

Nos. 263-264

Railway Engines.—Proceedings of the Government of India forwarding copies of papers relative to Mr. W. Bridges Adams' improvements in the construction of Railway Engines, &c., communicated to the Officer concerned.

Enclosure to Railway No. 1256—60 R of 1868.

No. 75, dated 16th September, 1868.

From—The Secretary of State for India,
To—The Government of India.

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The normal resistance of trains under favourable circumstances is under eight pounds per ton of load. But the practical resistance varies from that to forty pounds per ton, or more, according to its speed or curves, independently of gradients. The cause of the increased resistance is the grinding of the wheel-flanges against the rails, and in case of very sharp curves, with length of wheel-base round the curves of the rails, and in case of great risk of getting off the line at a tangent.

This resistance may be wholly removed by a simple alteration of the carriages, permitting the wheels a lateral movement to right or left, so that the carriage-axles will always point truly to the centres of the curves on the line of the radii, as well as the wheels and axles of the engine, except the coupled driving axles.

And in this mode, much sharper curves can be worked as sharp as 50 feet radius, ordinary curves being 1,350 feet radius. It is not to be supposed that such sharp curves can be worked at great speeds, but, practically, points and crossings and passing places involve commonly curves of 400 feet, unless great lengths of rail be used; but it is a very great advantage, and especially in town approaches, to enable trains to work as flexibly as horse carriages. As the strength of a machine is governed by its weakest part, so is the haulage resistance of a train increased, and the load diminished by the maximum friction at any part of the line. The engine can exert a certain power with free movement, and that power is curtailed by the increased resistance.

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Such lines on common roads may be special light lines, or heavy lines for the hardest traffic.

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But it is practicable to use a less weight of cast-iron in a better form, so that the rail takes a two feet length of bearing instead of only six inches. A groove sleeper line, a tracing of this line in cross-section, and plan is appended (No. 1), the rail is single headed

but it weighs only 48 lbs. per yard, and the rails which are double-headed, and used in very heavy chairs, are practically found not to answer, and are in England condemned by the Officers of the Board of Trade, Railway Department.

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And to adapt this line to the heaviest engines required, always supposing them to be flexible, and not rigid, an addition of 50 tons of metal per mile would furnish a permanent-way capable of following the contour lines of the country, and, if need be, of using much sleeper gradients. Plate No. 7. "Railway Practice," shows a town engine adapted for hauling a heavy train up steep gradients, through winding mountain passes of 99 feet radius; much lighter bridges might be thus used, and many viaducts dispensed with.

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The question of the improved rolling-stock, really rolling and not sledging, is fully treated in "Railway Practice," and the opinion of several of our most noted Railway Engineers in favour of the radial system are quoted therein:—Mr. Gregory, the President, Mr. Vignoles, Mr. Berkley, Mr. Harrison, Mr. Heppell, and Mr. Hawkshaw.

Thirty-four of these engines have, since this opinion was given, for two years been working satisfactorily on the Great Northern and Chatham and Dover Lines, over the sharp curves and steep gradients of the Metropolitan.

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RAILWAY.

SIMLA, OCTOBER 26, 1868.

Mr. W. Bridges Adams' improvements in the construction of Railways,
Locomotives, and Rolling-stock.

Read:—

Despatch from Secretary of State, No. 75 of 1868, and enclosures.

ORDER.—Ordered, that copies be forwarded to the Local Governments and Administration noted in the margin for information, with the intimation that spare copies of the pamphlet, "Railway Practice and Railway Possibilities," will be subsequently supplied.

Governments of Madras, Bombay, Bengal, and Punjab.
Chief Commissioner, Oudh.
C. E., Offg. Asstt. Secy.,
for Secy. to the Govt. of India.

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