THE WASTE OF LOCOMOTIVE POWER.

Paper read before the Institution by H. KELWAY-BAMBER, M.V.O., Member of Council, London, on 6th March, at London, 9th April, Manchester, and on 13th April, 1920, at Leeds.

Paper No. 83.

It is generally conceded that modern British locomotives of all types are rapidly approaching the maximum possible in respect of boiler and cylinder capacity, as well as of adhesive weight and tractive power, while the loads these fine machines are called upon to haul leave little margin for the contingencies of everyday working conditions. In the matter of design and performance, therefore, present-day locomotive practice, so far as up-to-date engines are concerned, is fully abreast of the times, and it is solely with the power wasted in the haulage of unnecessary and avoidable dead-weight that the Author proposes to deal in this Paper.

GROSS TRAFFIC RECEIPTS.

In the absence of ton mile statistics, which it is hoped will shortly be available, the useful work done by railway rolling stock is best indicated by gross traffic receipts, and on this basis the work done by locomotives on all the railways in the United Kingdom, treated as one system during the ten years ended December 31, 1913, is compared below :—

Year ended Dec. 31.	Total Traffic Receipts (Millions). £	No. of Locomotives.	Average Receipts per Loco. £
1903 ...	103.08	22,385	4,604
1905 ...	105.13	22,346	4,704
1907 ...	112.16	22,514	4,982
1909 ...	110.68	22,778	4,859
1911 ...	117.24	22,849	5,125
1913 ...	123.62	24,728	5,000
Increase in 10 years	20.54	2,343	396
Percentage of increase	20.00	10.4	8.6

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FIG. 1.

It will be observed that immediately before the outbreak of war the gross receipts per locomotive averaged £5,000 per annum, and that the increase in earnings per engine on a busy year's traffic, such as that of 1913, was only 9 per cent. greater than that for the year 1903, notwithstanding the increase in locomotive power which had taken place during that period.

COACHING VEHICLE RECEIPTS.

Similar statistics for coaching vehicles for the same period follow, and it will be seen that the average earnings per coaching vehicle per annum only increased by 9 per cent. during the decade.

Year ended Dec. 31.		Total Coaching Receipts (Millions). £	No. of Coaching Vehicles.	Average Receipts per Vehicle. £
1903	...	47.97	70,291	682
1905	...	48.92	70,909	659
1907	...	50.97	72,694	701
1909	...	51.20	72,942	702
1911	...	53.95	73,074	738
1913	...	56.98	76,614	743
Increase in 10 years		9.01	6,323	61
Percentage of increase		18.79	9.0	9.0

In the absence of reliable information, a similar statement cannot, unfortunately, be made for the earnings of goods vehicles in general merchandise and in coal traffic, but for the year 1913 the average earnings of wagons in coal and mineral traffic were about £37.41. If similar statistics for the earnings of locomotives, carriages and wagons during the war period had been forthcoming, with Government traffic charged for at public rates, startling results of the work done and revenue earned by the rolling-stock remaining in service would be revealed.

HIGHER WORKING COSTS.

In view of the cost of living and of the higher standard of comfort rightly demanded by and acceded to railway men and others, and to the consequent general increase in the cost of manufacture, it is probable that when more normal conditions return the cost of working railways will be found

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FIG. 2.

to be about 80 per cent. more than ruled in pre-war days. But while these increases are necessary and unavoidable, there is no reason why existing practice should not be reformed with a view to eliminating wasteful and out-of-date methods, thereby reducing the cost of working.

TRAIN MILE GROSS RECEIPTS.

The following figures show the gross receipts per total train mile (coaching and goods traffic) for all the railways of the United Kingdom, treated as one system, for the ten years 1903-1913, and it will be noted that the total increase has been very slow, amounting to only 8.5 per cent.

Gross Receipts per Train Mile from Traffic.				
Year.		Coaching. Pence.	Goods. Pence.	Total. Pence.
1903	...	49.53	81.84	62.75
1905	...	47.85	86.64	63.00
1907	...	46.58	88.56	62.75
1909	...	46.61	91.92	63.75
1911	...	47.90	95.76	65.75
1913	...	49.99	98.88	68.07
Increase	...	0.46	17.04	5.32
Percentage of increase		0.99	20.82	8.5

COACHING VEHICLE DESIGN.

A notable advance in coaching vehicle design aiming at the reduction in the dead-weight and resistance of passenger trains, and also of the first cost and maintenance charges in coaching vehicles, is that introduced by Mr. H. N. Gresley, Chief Mechanical Engineer of the Great Northern Railway, in the form of "grouped" carriages, as developed in his patent articulated bogie truck, as the outcome of which, it is understood, that the dead-weight of grouped vehicles can be reduced by some 20 per cent., the saving in weight and resistance, etc., thus effected being available either for additional accommodation, or for the reduction in train resistance, and therefore of coal consumption.

SIDINGS AND TERMINALS.

Much has recently been said about the necessity for in-

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FIG. 3.

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FIG. 4.

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FIG. 5.

creased sidings and terminal accommodation, and no doubt much remains to be done to meet rapidly increasing traffic, but what appears to the Author to be of greater immediate importance is the more effective use of existing sidings and terminals by the adoption, so far at least as coal and mineral traffic is concerned, of high capacity wagons, *i.e.*, of wagons of a capacity of from 45 to 50 tons, similar to those in use on the 3ft. 6in. gauge railways of South Africa, particulars of which are given below:—

Details.		Bogie High-Sided (Side Door Discharge).	Bogie Hopper (Self-Dis- charging).
Length over buffers	...	43ft. 0in.	42ft. 9in.
Height over all	...	9ft. 4½in.	10ft. 0in.
Width do	...	8ft. 7½in.	8ft. 4in.
Cubic capacity	...	1,680 cu. ft.	1,685 cu. ft.
Centres of bogie trucks	...	27ft. 0in.	28ft. 6in.
Wheel base of bogie trucks	...	5ft. 9in.	5ft. 9in.
Carrying capacity	Flush	41.0 tons	41.0 tons
	Piled	4.0 tons	4.0 tons
for coal	Total	45.0 tons	45.0 tons
Tare weight	...	17.00 tons	18.0 tons
Gross Weight	Wagon	62.00 tons	63.0 tons
	Axle	15.50 tons	15.75 tons
per Foot of Length..	...	1.44 tons	1.47 tons

The high-sided wagons, when discharging coal at the port of Durban, are raised bodily and overturned, their contents (45 tons of coal) being discharged instantly in the manner described and illustrated in the issue of "Engineering" dated August, 17, 1917.

COMPARATIVE ADVANTAGES OF BRITISH WAGONS.

In a paper on "Coal and Mineral Traffic on the Railways of the United Kingdom," read before the members of the Institution of Locomotive Engineers, the subject was dealt with at length, and the main conclusions, comparing the advantages of 45-ton all-steel bogie Hooper wagons with the ordinary British privately-owned 10-ton wagons on the basis of the mineral traffic dealt with by the railways of the United Kingdom during the year 1913 are reproduced below:—

Point of Comparison.					Detail.	Per cent. of Possible Improvement
(a)	Reduction in the number of vehicles to be handled					666,668 77.66
(b)	Improvement in percentage of <i>paying load</i> to gross weight hauled					56.01 45.45
						10.56 23.00
						Tons.
(c)	Reduction in <i>dead weight hauled</i>					130,000,000 36.11
(d)	Reduction of main line locomotive coal consumption					3,482,136 25.64
						Miles.
(e)	Reduction in overall wagon length for the total number of wagons loaded					204,583 107,926
						96,657 47.25
(f)	Increase in gross weight of loaded trains per foot of train (wagon) length tons					1.45 0.89
						0.56 62.92

With such possibilities, there is plenty of scope for improved efficiency in railway working in all branches, and while modifications in existing terminal arrangements in large towns and at ports of shipment must necessarily take time, and meanwhile rolling stock to suit these facilities must continue to be constructed, it is, in the Author's opinion, much more important that expenditure should be incurred in the direction of the provision of such facilities as will permit of the handling of higher capacity vehicles than in the extension and perpetuation of out-of-date, slow and costly methods of working.

RAILBORNE COAL TRAFFIC.

During the war there has been, and to a great extent it is understood there is likely to continue, a heavy railborne coal traffic between the north of England, London and southern counties. So far as existing locomotive facilities permit, coal trains composed of 80 10-ton wagons and a 20-ton brake van of an over-all length, including engine, tender and brake van, of 1,520ft., and a gross weight behind the engine of 1,300 tons, carrying 800 tons of coal for a dead-weight, including the brake van, of 500 tons for the loaded journey and 1,000 tons for the round trip, are working over the main lines between the north of England and London. At 9s. 6d. per ton, until recently the freight rate for coal, the

gross receipts for such trains work out at £380 for the loaded journey, the dead-weight hauled on the round trip being equivalent to 260,000 ton-miles.

HOW TO ECONOMISE.

For about the same gross weight, and for considerably less tractive resistance, 945 tons of coal could have been hauled in 21 bogie wagons of 45-ton capacity for an over-all train length of 985ft., the earnings for the loaded journey amounting to £449 and the dead-weight ton-mileage to 207,000; an improvement in earnings of 18 per cent. and a reduction in dead-weight ton-mileage of over 20 per cent. for the same, or less, engine power. *For the same train length of 1,520ft.* (that is of one of 80 10-ton wagons) 33 bogie vehicles of 45 tons capacity, carrying 1,485 tons of coal and weighing 2,100 tons behind the tender, could, with double-heading and the use of comparatively low-power engines, be hauled for the same siding accommodation, earning on the journey £700, or 85 per cent. more than the train of 10-ton wagons, the dead-weight for the round trip being only about one-fifth more than that of the 10-ton wagon train.

In these and similar directions are to be found the solution of the present traffic difficulties and means for the reducing "Waste of Locomotive Power."

DISCUSSION.

The Chairman: The waste of locomotive power is much to the fore at the present time, and Mr. Kelway-Bamber has mentioned that shortly he hoped there would be statistics available on ton mileage. No doubt there will be, and while I thoroughly believe in statistics, they can be most misleading to the man in the street when he tries to make comparisons between the various railway systems. They are, however, of considerable service to an operating official in dealing with his own particular railway, and much good can result if they are used intelligently. Mr. Kelway-Bamber has mentioned the 10-ton wagon as the standard British wagon; at a previous meeting of this Institution I did not agree that this should be accepted now as the standard type, and I join issue with him again on this point.

The twelve or fifteen-ton wagon is the one I consider is nearer the mark. For export coal traffic, locomotive coal where modern facilities are provided at running sheds, and

again for power houses, the twenty-ton capacity wagon on four wheels is hard to beat.

You are liable to have somewhat slower shunting in marshalling yards with such wagons, and still more so with 45-ton wagons, but the effect would be largely reduced through having fewer individual wagons to marshal for the same tonnage, so I do not attach any importance to that drawback.

The really important point in my view is that of the prompt clearance of wagons at their destination, and this should be work that requires concentrating upon, especially at the present time. It is very annoying to the operating department to provide power and a good road for a train, and then see the wagons detained for days at their destination because the people they are for do not come along with the necessary transport. It is gratifying to notice the penalties are being increased.

The clearance of coal wagons at running sheds is kept well to the fore, but it has not been so with the traders' wagons. On some railways no doubt there is much congestion in the sidings, owing to the colliery sidings not being large enough to hold the empties required for their business. Hence I repeat the clearance of wagons on receipt is the important point to concentrate upon.

I am pleased to hear what Mr. Kelway-Bamber has said of the improved facilities he has seen in the North and in London for dealing with large wagons. Many of the older collieries cannot take large wagons under their screens, nor can the docks' companies deal with them on their tipping plant. I remember some years ago pressing this matter very strongly.

Mr. Kelway-Bamber stated, I believe, that he could get £350 for the loaded journey with one engine and £700 with two, but I do not know if he referred to double-heading, and whether he meant in that case each engine would be credited with £350; perhaps he will clear up that point?

The Author : £350 per engine.

The Chairman : Mr. Kelway - Bamber referred to Mr. Gresley's twin bogie arrangement for coaches. I recollect some ran on the S.E. and C.R. for inspection, and they certainly ran very smoothly and the tare weight was considerably reduced; there is a good deal to be said for the system, in conversions especially.

I should like to refer to another subject for a moment; it has been very disheartening to the managers and engineers of the railways to have had to stop practically all progress in renewal of bridges and building up-to-date rolling stock and locomotives during the past few years and to be now faced with the urgent demand for pre-war facilities—in fact, a considerable increase on them—before they can possibly recover from the war conditions the country has passed through.

Great publicity is given to any subject of transport to-day, and the public are made to feel the railways are not doing their best—a supposition which is quite incorrect.

Boards of directors cannot attempt to raise fresh capital in these days until they know what is to be done with the railways in the future, so the best has to be done with what is at hand, and I submit that this is being done by the railway companies.

Mr. W. Vaughan (L. & S.W. Rly., Strawberry Hill): One is always interested in anything Mr. Bamber undertakes to place before this Institution. But it is difficult to deal with the remarks as made, as the Paper, being more or less an abstract one, arises out of the general contingency of our railways' obligations and future development. From a locomotive point of view, one is confined to things which concern from day to day, in a more or less mundane way, and the application may perhaps not quite follow on the lines Mr. Bamber might conceive, in the particulars as put before us.

It is most essential that there should be improved methods of dealing with the railway transport of this country, both as regards the mineral and passenger services. I recall, when a travelling inspector, having to occasionally count the number of passengers travelling in certain long-journey competitive trains. My departmental chief was intensely interested in the question of unnecessary haulage, and the comparison of the dead weight with the number of passengers carried, gave interesting statistics. Just as such questions in those days appeared somewhat vague; similarly, Mr. Bamber to-day in this may be considered so. Yet, "as thoughts once expressed belong to the world," he may get his views impressed upon the minds of the authorities, and if not developed now, they may add to the general advantage of the community in the future.

As regards the provision of accommodation for passengers, it must be conceded that the companies pandered to the public in the old competitive days, to which the traffic

superintendents had to be agreeable under the conditions prevailing. The public have rights, but, as carriers, railways have to consider theirs by giving travelling and haulage facilities without waste, which proposition similarly applies to goods and mineral traffic. In this, Mr. Bamber has a clear vision in pressing for the best utilisation of the locomotive power placed at disposal.

The question of engines standing idle has not in the past received the attention due to it, and was not the business of any other than the locomotive department, and the saying of "that's a loco. matter" was proverbial. But the obligation of all, whether connected with loco. traffic or other department, is a more fuller application to the need of facilitating the prompt use and release of engines to avoid wastage of engine hours when away from the depot.

As an example of this the results of work performed by engines of depots A, B, C, and D are tabulated as follows:—

Depôt.	Average miles per engine per day.	Average hours each engine in service.		Average miles per engine per engine hour.	Per cent. of engine hours—Coaching.	Per cent. of engine hours—Freight.	Per cent. of engine hours—Departmental.	Per cent. of engine hrs.—Coaching productive.	Per cent. of engine hrs.—Freight productive.	Per cent. of engine hours—Shunting.	Per cent. of other hours—Non-productive.	Per cent. of engine hours—Standing idle.
		Shed to	Shed.									
A	148	16 $\frac{3}{4}$	9	64	33	3	21	8	20	37	14	
B	132	17	8	56	43	1	15	5	40	24	16	
C	120	15	8	26	72	2	12	13	41	20	14	
D	124	14	8.7	36	54	10	15	10	32	37	6	

Depots A, B, and C are situated in an area where terminal and transfer facilities are less advantageous than those of D in another area better situated for avoiding standing-idle time. This indicates that developments should be sought in improving lay-outs for terminal release of engines after trips and a fuller co-ordination at transfer points between one company and another.

Mr. R. E. Thayer ("The Railway Mechanical Engineer"): I am very glad to see that a locomotive engineer

is discussing in an Institution of this nature the subject of high capacity goods wagons. From the superficial observations I have made since I have been in England it has appeared to me that great economies could be made in railway operation here if wagons of greater capacity were used, but I have been told by various railway men that under conditions existing in England it would be quite difficult to use the high capacity wagon economically. With the railroads in the United States, the high capacity wagon has been one of the greatest means by which the cost of operation of the railroads could be maintained within reasonable limits. Of course, it is not possible under the present loading gauge for English roads to go anywhere near to the same size of wagons as it has been possible in the United States, but it does seem as though much more could be accomplished in this respect than has in the past. There has been some talk by railway economists of the possibilities of the high capacity wagon in England, but it needs the technical analysis of the engineers to prove the point and show what savings can actually be made.

With more detailed statistics which we may now expect from the Ministry of Transport, it would be possible to present figures that will better prove the desirability for the high capacity wagon.

Mr. Bamber quotes £5,000 as the gross receipts per locomotive immediately before the outbreak of the war. In the United States for the year 1916, the average gross receipts per locomotive were in the vicinity of £11,500, and it should be added that this was obtained with lower freight and passenger rates than obtained in Great Britain.

Mr. H. Holcroft (S.E. & C. Rly., Ashford): The subject which Mr. Kelway-Bamber has placed before us—this matter of waste of locomotive power brought about by the use of low capacity wagons—is a subject very much to the front at the present time, and I think we are all agreed that the use of high capacity wagons is desirable. The question is: Are we ready for them? I think that the introduction of high capacity wagons is a railway problem as a whole, and not a problem that belongs to any particular department. For instance, there is the shunting problem. The heavy high capacity wagons cannot be treated in quite the same way as the small 10-ton wagons, by fly-shunting, for instance. Then again, there is the question of back-shunting on main lines to clear the goods train out of the way of a passenger train. That is another problem that wants thinking about,

for in stopping a long heavy goods train at present a great deal of time is lost owing to the fact that there are no brakes except on the engine, tender and brake van, and when the train is eventually brought to a stop a back shunt is necessary to get into the refuge siding or cross over on to the other main line out of the way. With a railway system having a lot of mixed traffic, high speed passenger trains, stopping trains and goods running at different speeds on two pairs of lines, it requires great skill on the part of a signalman in the busy sections to get the trains through. It is very much better on a four-line track because traffic can be segregated a little by dividing it into two, the faster traffic on two lines and the slower traffic on the relief lines, but, of course, it is an expensive business doubling the main lines. An alternative is to provide running loops. Between Swindon and Didcot and also between Oxford and Leamington on the Great Western Railway, there are several running loops extending alongside the main line for quite a considerable distance. The loop is entered by facing points, and it joins again with the main line by trailing points. The consequence is that heavy trains need only slow down a little to enter the loop and may continue to run along while the fast traffic overtakes them. Owing to the very much greater weight for a given length of train, I think liberal provision of that sort is wanted before using high capacity wagons so that the traffic can be handled without loss of time. Very big engines must be employed in order to move heavy loads, and as we know, big engines standing in sidings a long time use up a lot of fuel besides wasting the men's time on the footplate, and it is not economical.

I should like to know whether Mr. Kelway-Bamber intends that the present couplings should be dispensed with. It seems to me something of the kind would be necessary. It is all very well to have loose couplings on the small wagons, but I do not think they would work in with big weights. That means either an automatic coupling or close coupling of some kind. Screw couplings would necessitate a man going between the buffers to couple up. On the other hand, the "instant" couplings of the Great Western Railway might be used. It is quite possible that the subject of automatic couplings will be thought over anew, as also the introduction of continuous brakes. No one wants to institute fitting continuous brakes where there are loose couplings. To put a power brake on each 10-ton wagon and a pair of automatic couplings would mean a very big capital expenditure, but on a 40 or 45-ton wagon they represent a very

much smaller percentage of the total. The fact of having automatic brakes would increase the running speed because it is not necessary to slow up such a long distance away from signals. On the other hand, with the use of tight couplings more locomotive power would be needed. At present, a comparatively small locomotive can start a very large train because of the snatch on the couplings, the reason being that the starting effort is very much greater than the pull when the train is running. With loose couplings the starting resistance of each wagon is overcome separately instead of collectively, as with close couplings.

The Great Western Railway find the 20-ton coal wagon very economical to use. The tare weight is only eight tons—those fitted with the vacuum brake are $8\frac{1}{2}$ tons—and I think they compare very well with the 40-ton wagon so far as net weight is concerned.

There is another problem that wants considering in connection with the automatic brakes, and that is the weight of wagons empty and full. More brake power can be applied when the train is fully loaded, but when the tare weight bears a small percentage to the total, the brake power will be too much for the wagon running light. Some means of partially decreasing the brake power on empty wagons is needed.

Another difficulty in connection with the big 40-ton wagons is that of emptying them, unless they have hopper bottoms. With the 10-ton wagon the flap can be let down and a good deal of the coal will fall out or can be shovelled out. In a 40-ton wagon where the contents have to be thrown over the side or through a couple of small doors in the side, a great deal more labour is required.

Mr. V. P. Rawlings (The Consolidated Brake Co., London): With regard to Mr. Holcroft's remarks on the necessity for a brake that varies in power with the load of the vehicle, taking the tare at about one-third of the gross weight of a wagon, the original brake power may be as much as 80 per cent. With a fully-loaded wagon that will drop to about 20 per cent. or even 16 per cent., according to the condition of the brake and the maintenance of the piston stroke, so that it is very desirable especially for high capacity wagons to have a brake that allows of a varying power between empty and loaded or partially loaded conditions. In fact, it is a matter of sufficient importance in itself to form the subject of a Paper. I have had some experience in this matter, and made a good many calculations in connection

with it, and the figures show the very great advantage that would be gained by the introduction of such a brake. Of course, it introduces complications and increased cost, but I am sure the advantage gained is sufficient to make the extra cost worth while, and I think it is a matter that requires more consideration.

The Author : As usual, the discussion has been interesting and instructive.

The Chairman joins issue with me regarding a 10-ton wagon as the basis for comparison of train loads.

I am aware that large numbers of 12-ton vehicles are now being built, but at the moment the average capacity of mineral wagons in this country is certainly not in excess of 10 tons.

With the loss of wagon hours at stations the Ministry of Transport is dealing, and enhanced demurrage charges have already had a very marked effect.

In the absence of the information afforded by reliable statistics the cares and harassment of management are greatly increased, and without this effective working becomes largely a matter of chance.

With regard to the use of self-discharging wagons for coal and mineral traffic, I venture to think that in the near future the railways will deliver coal at principal stations on systems, and that distribution from these stations will be effected by motor lorries. In this way the number of vehicles required to handle the traffic will be very greatly reduced, time and labour being saved in proportion.

The Lancashire and Yorkshire and the North-Eastern Railway Companies some years ago recognised these possibilities, and to a large extent availed themselves of them, but it needed a war and its consequences to bring home to the general public the necessity for more up-to-date methods, and to overcome in some measure the opposition of vested interests and prejudices.

Mr. Vaughan gave some very useful figures on engine mileage, and his reference to co-ordination of effort between departments is one of the most important features in successful railway practice.

Mr. Holcroft spoke of the necessity for considering the high capacity wagon in relation to railway working as a whole. It is, of course, useless to propose such vehicles where suitable work is not forthcoming, and their extended use can only follow suitable traffic and terminal facilities.

Such conditions already exist for much point-to-point long-distance traffic, and it is hoped that for this work high capacity wagons will in the near future be more extensively used. Such vehicles would facilitate the introduction of automatic vacuum brakes, the equipment of which would give the engine staff more control of, and confidence in, the handling of heavy trains moving at comparatively high speed, and would vastly improve the position for the rapid handling and movement of traffic.

The vacuum power brakes have been in general use for some years past on the heavy mineral trains of India and South Africa with eminently satisfactory results. Some form of closer coupling either screw or adjustable link, such as that in use on the Great Western Railway to which Mr. Holcroft refers, will certainly be necessary.

With heavy axle loads, axle journals, bearings and lubrication will require more attention, but what is standard practice on Indian and other railways operated very largely by natives of the country should present little difficulty in Great Britain.

Until every mineral traffic gross wagon axle loads are at least 16 tons per pair of wheels on rails, through speeds of from 20-25 miles per hour per long-distance traffic, and quick return of wagons have become the general practice, a reasonable working efficiency for mineral traffic in this country will not have been attained.

The close coupling of vehicles will demand more concentrated effort on the part of the locomotive in starting trains from rest, and some experiments under actual working conditions carried out by the speaker when Chief of the Rolling Stock Department of the East Indian Railway gave the following results for wagons equipped with 37in. diameter wheels, cold-rolled journals, white-metal lined bearings, and lubricated with heavy mineral oil, viz :—

FOUR-WHEELED WAGONS.

Gross Weight of Wagon. Tons.	Resistance to motion from rest in lbs. per ton.
24	21.43
26	22.5
28	24.18
30	24.57
32	25.3