two adjacent posts or stiffeners, \( n \) = number of panels, \( w \) the whole weight of the structure, then the proportion between the thickness of the vertical plates in the middle and at the ends, will be nearly as \( v, \frac{n v + w}{2} \); as this proportion may readily be as great as 1 : 5, it follows that a very great saving may be effected by proportioning the thickness of the sheets in each panel to the strains, an arrangement that appears to have been overlooked or neglected in the construction of tubular bridges.

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For the Journal of the Franklin Institute.

Experiments on Screw Propellers in H. B. M. Steamer Minx. By B. F. Isherwood, Chief Eng., U. S. N.

In 1847 and 1848, there were made by order of the British Admiralty, experiments on a number of screws applied to H. B. M. Steamer Minx, and I find in Bourne’s Treatise on the Screw Propeller, a table of these experiments, for the first time published. This table appears to me, in the condition in which it is given, to be of but little value to the practical engineer, and liable, without careful discrimination, to mislead him. It is accompanied by no account of the manner in which the experiments were conducted, no classification is attempted, nor are there any deductions drawn. I have, therefore, selected from those experiments in which the results are consistent with each other and with the nature of things—rejecting anomalies—such of the observed elements as were not contradictory, and from them have made my own calculations and drawn my own conclusions.

The Minx was a vessel of the following dimensions, viz:

| Description                                      | Value          |
|--------------------------------------------------|----------------|
| Length of hull between perpendiculars             | 131 feet       |
| Beam, extreme                                     | 23 1 inch      |
| Draft, mean                                       | 5 2 1 inch     |
| Immersed amidship section at 5 feet 2 1 inches draft | 82 square feet |
| Displacement at 5 feet 2 1 inches draft in tons of 2240 lbs, 203. |                |

The machinery consisted of two vertical, oscillating, condensing engines, geared so as to give the screws four revolutions for each double stroke of engines’ pistons.

| Description                                      | Value          |
|--------------------------------------------------|----------------|
| Diameter of the cylinders                         | 34 inches      |
| Stroke of pistons                                 | 2 feet 9 “      |
| Space displacement of both pistons per stroke     | 34 678 cubic feet |

The trials were made in the Thames river, at a measured geographical mile of 6082 3 feet; the vessel being kept throughout at nearly the same draft of water.

The mean gross steam pressure in the engines’ cylinders was ascertained by an indicator, and the dynamometer was applied to obtain the thrust of the screws. Now, the dynamometer measures simply the power applied to the propulsion of the vessel; that is, it measures that part of the total engine power which is expended in giving motion to the hull; and as it is evident that with the same vessel, under the same circumstances, greater speed can be obtained only by the application of greater
power to the hull, and greater in proportion to the cubes of the speeds, it follows that the dynamometer powers should be sensibly in the proportion of the cubes of the speeds within moderate limits: but the results, as given, show not only no fixed relation of the dynamometer power to the speed, but frequently a much less speed, accompanied by a much greater power; the dynamometer results must, therefore, be entirely rejected as erroneous.

The given number of revolutions made by the screw per minute, can doubtless be depended on as exact; and the steam pressure in the cylinders, as given by the indicator, can probably be depended on, not as strictly accurate, but as a pretty close approximation to the truth, as I find by testing, that in general the revolutions of the same screw in equal times, are nearly in the ratio of the square roots of the piston pressures, which should be the case.

The element most liable to error, and of the greatest importance, because its third power enters in the comparisons, is the speed of the vessel; an element obviously the most difficult to determine with exactness.

As the speed of the vessel for the purpose of comparison must be the speed in smooth water, uninfluenced by wind, current, steering, or unequal fouling of the bottom, and as these causes vary on every trial, and as it is impossible to ascertain their effects accurately, there must always be some error in the element of speed—an error which can only be reduced to an insensible amount by taking the mean of a large number of trials; the greater the number the less will be the error. In the experiments with the Minx, the number of trials made with each screw appears to have been too few, and it would have been more satisfactory had the final results been the mean of a greater number of observations.

The distance run of one geographical mile was too short, as the slight error of only a few seconds in the times of passing the stakes at each end of the course, if made in the same direction, would wholly vitiate the result; for instance, the true speed of the vessel being supposed 8 miles per hour, there would be required 7½ minutes to run one mile; now, if an error of only 5 seconds be made in the time at each stake, being called that much too late at commencing, and that much too soon at stopping, making an error of 10 seconds in all, then the mile, instead of being run in 7½ minutes, would appear to be run in 7½ minutes, and the vessel’s speed, which was really 8 miles per hour, would be given as 8.37 miles per hour; and as the cubes of the speeds are the measures of the effects, this discrepancy would become enormously exaggerated in the final result.

No drawings or descriptions being given of the screws tried, it is impossible to know their exact configuration; they were probably of uniform length from the hub nearly to the periphery, and the helicoidal area was made equal, or nearly so, in the several screws, by “cutting off the corners,” as it is termed in Bourne’s Table of the Experiments. It is not stated whether the areas of the screws, as given in this table, are the projected areas on a plane at right angles to the axis, or the helicoidal areas; they cannot, however, be the former, as they are too large, even on the supposition that the length was uniform from hub to periphery. The screws experimented with were all two-bladed, and of the same dia-
Experiments on Screw Propellers in H. B. M. Steamer Minx.

meter, viz: 4 feet 6 inches. They consisted of four series: 1st, Screws of uniform pitch. 2d, Screws of expanding pitch fore and aft, but of uniform pitch radially. 3d, Screws of expanding pitch radially, but of uniform pitch fore and aft. 4th, Screws of expanding pitch both fore and aft and radially. Each series will be considered separately.

Screws of Uniform Pitch.—The screws of uniform pitch were three in number, and had pitches of 5 feet 10 inches, 5 feet 6 inches, and 5 feet, which screws I shall call respectively $A$, $B$, and $C$. The screw, $A$, was modified by successively reducing its length by a plane at right angles to the axis, and experiments were made to ascertain the effect of each reduction.

With screw, $A$, (before modification,) six trials were made. Of these, the first two, made on the 4th and 5th June, 1847, I reject, as the results are too greatly inconsistent with the general results of the experiments, and too widely differing from the results of the last four trials, which closely agree with each other and with the general results; I therefore accept them. The mean of these four trials gives a slip of 37.3 per cent., from which the extremes do not differ 1 per cent.

The first modification of screw, $A$, was made by reducing its length from 1 foot to 10 inches, and its helicoidal surface from 7.1 square feet to 5.97 square feet. The mean of three trials with this modification gave a slip of 39.6 per cent., from which the extremes differ by only $\frac{1}{8}$ parts of 1 per cent. This reduction in the length of the screw caused an increase in the slip of $2.3 \times \frac{39.6 - 37.3 \times 100}{37.3} = 6.2$ per centum relatively; or, in general, decreasing the surface one-sixth increased the slip one-sixteenth.

The second modification of screw, $A$, was made in the same direction and in the same manner as the first one, by cutting off 2 inches more, which reduced the length of the screw from 1 foot to 8 inches, and the helicoidal surface from 7.1 square feet to 4.93 square feet. With this modification, two trials were made, of which I reject the first, made 9th July, 1847, as the result is obviously erroneous; I accept the last trial, which gives a slip of 41.7 per centum. This reduction in the length of the screw caused an increased slip over that of screw, $A$, of $\frac{41.7 - 37.3 \times 100}{37.3} = 4.4$ per centum absolutely, or $\frac{41.7 - 37.3 \times 100}{37.3} = 11.8$ per centum relatively; or, in general, decreasing the surface one-third increased the slip two-seventeenths.

A further experiment was made August 17th, 1847, in the same direction and manner, by reducing the length of the screw to 6 inches. Only one trial was made, and the result is so manifestly erroneous that I reject it.

With screw, $B$, two trials were made, of which I reject the last, made July 1st, 1848, as its result is greatly inconsistent with the general results. I accept the first trial, which gave a slip of 34.8 per centum.

With screw, $C$, three trials were made; the mean result gave a slip of 31.6 per centum, from which the extremes do not differ 1 per centum.
The following table exhibits in detail the data and results of the Screws of Uniform Pitch:

| Designation of Screw | Vessel's draft of water in ft. and in. | SCREW. | ENGINES. |
|----------------------|-----------------------------------------|--------|----------|
|                      | Date of Trial. | Forwards | Aft. | Means | Horse power act. | Length in ft. and in. | Heli-coidal area square feet | Number of revolutions per minute | Gross horse power | Per cent. of engine vol. |
| A                    | Sept. 4th, 1847 | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 12 7-1 | 2197 | 257-8 | 1012 | 51-18 | ... | 7-322 |
|                      | July 17, 1848   | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 12 7-1 | 2197 | 257-8 | 1012 | 51-18 | ... | 7-322 |
|                      | July 12, 1848   | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 12 7-1 | 2197 | 257-8 | 1012 | 51-18 | ... | 7-322 |
|                      | Means           | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 12 7-1 | 2197 | 257-8 | 1012 | 51-18 | ... | 7-322 |
| B                    | Sept. 16, 1847  | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 12 7-1 | 2197 | 257-8 | 1012 | 51-18 | ... | 7-322 |
|                      | July 1st, 1848  | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 12 7-1 | 2197 | 257-8 | 1012 | 51-18 | ... | 7-322 |
|                      | Means           | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 12 7-1 | 2197 | 257-8 | 1012 | 51-18 | ... | 7-322 |
| C                    | Sept. 17, 1847  | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 12 7-1 | 2197 | 257-8 | 1012 | 51-18 | ... | 7-322 |
|                      | July 1, 1848    | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 12 7-1 | 2197 | 257-8 | 1012 | 51-18 | ... | 7-322 |
|                      | Means           | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 1 6-5 10 5 2-5 | 12 7-1 | 2197 | 257-8 | 1012 | 51-18 | ... | 7-322 |

If, now, we compare the pitches of screws, $\alpha$, $\beta$, and $\gamma$, (which are similar screws in all respects save pitch, having equal diameters, helicoidal areas, length and number of blades,) with their slips respectively, we shall find that the slips are sensibly in the direct ratio of the pitches, as appears from the following:

| Screw $\alpha$, | Pitches. | Slips. |
|----------------|----------|--------|
| 5-833, or 1-167 | 37-3, or 1-180 |
| 5-500, or 1-100 | 34-8, or 1-101 |
| 5-000, or 1-000 | 31-6, or 1-000 |

That this should be the truth, is manifest from the consideration that the rotary velocity of similar screws with unequal pitches to advance equal distances in equal times, is in the direct ratio of the pitches; and as the moment of pressure is as the rotary velocity, it follows that the resistances of equal screw surfaces will be as their rotary velocities, i.e., as their pitches inversely, the lesser pitch having the greater resistance.

There remains to determine the relative economical efficiencies of the screws of uniform pitch. For this purpose, the horse powers developed by the engines will be taken as the expressions for the powers, and the cubes of the vessel’s speed for the measures of the effects. The effects being divided by the powers, the quotients will represent the relative economical efficiencies.
Experiments on Screw Propellers in H. B. M. Steamer Minx.

| Powers | Speeds | Effects |
|--------|--------|---------|
| Screw A. 197.42 or 1.0000 — 8.325 or 1.0000 and 1.0000^2 = 1.0000 and 1.0000 = 1.0000. | 1st Modification. |
| Screw A. 183.56 or 0.9298 — 8.110 or 0.9741 and 0.9741^2 = 0.9244 and 0.9298 = 0.9942. | 2nd Modification. |
| Screw A. 178.30 or 0.9032 — 7.972 or 0.9576 and 0.9576^2 = 0.8781 and 0.9244 = 1.0700. |
| Screw B. 207.48 or 1.0498 — 8.576 or 1.0227 and 1.0227^2 = 1.0182. |
| Screw C. 205.56 or 1.0412 — 8.576 or 1.0301 and 1.0301^2 = 1.0498. |

From the above we perceive that with similar screws, omitting the modifications of screw A, there resulted an increased efficiency from each decrease of the pitch. This increased efficiency could only have arisen from the decreased slip of the screws with lesser pitches, and as the helicoidal areas of the screws were the same, the frictions of the screw surfaces on the water must have been nearly equal, but a little greater with the screws of lesser pitch, on account of their greater helical speed. Now, as slip is a measure of the loss of useful effect, that loss should be in the direct ratio of the slip, as will appear from the following considerations:

As pressure and resistance are equal and in opposite directions, a pressure equal to the resistance of the vessel is always experienced by the water on which the screw acts propulsively; but the amount of power expended is proportional to the resistances moved and the distances through which they are moved in the same time. Now, supposing the screw to slip or recede one-fourth of its pitch per revolution by the yielding of the water on which it acts; that is to say, that per revolution it moves the vessel through but three-fourths of the pitch, instead of through the whole pitch, as it would do were there no slip; and, as pressure and resistance are equal and in opposite directions, there is the same pressure exerted by the screw upon the receding water as there is exerted by it on the advancing vessel; but in the supposed case of slip, the water acted on or pressed by the screw is moved a distance that can be represented by 3 in the same time that the vessel is moved a distance that can be represented by 1 in the same time that the vessel is moved a distance that can be represented by 3, the whole distance moved being represented by 4, equal to the pitch of the screw. Calling the pressure on the engine piston 1, the total power developed by the engine can be represented by $1 \times 4 = 4$, of which $1 \times 1 = 1$ represents the amount expended on the slip, or one-fourth of the total power for a slip of one-fourth; while $1 \times 3 = 3$ represents the amount of power expended in overcoming the resistances of the vessel, or three-fourths of the total power developed. It is thus plain that the loss of useful effect caused by slip, is as the slip. It must be distinctly understood that the loss of useful effect caused by a slip of 25 per cent. is 25 per cent. of the gross or total power developed by the engines, and not 25 per cent. of what remains of the total power, after
deducting those fractions of it required for working the engines alone, and overcoming the friction of the load; for it is evident that at each revolution, 25 per centum of the power required for working the engines alone, 25 per centum of the power required for overcoming the friction of the load, 25 per centum of the power required for overcoming the friction of the screw surface on the water, and 25 per centum of the power required for propelling the simple hull, making a total of 25 per centum of the whole power developed by the engine, is lost by slip; for, by consequence of the slip, each of these fractions or divisions of the total power has to be exerted 25 per centum longer to produce the same result; that is, to cause the vessel to go the length of the pitch instead of the length of three-fourths of the pitch, than would be required were there no slip; and although, to make a revolution in the same time with slip, requires less piston pressure than to make the same revolution without slip, yet the useful effect will also be proportionably less, as the vessel will be driven in the same time through a less distance by the amount of slip.

To obtain the same useful effect, that is, to drive the vessel through equal distances in equal times, the engines in the case of slip must be worked at a proportionally higher speed, which again requires a proportionally higher piston pressure, so that to drive the vessel equal distances in equal times, with and without slip, the piston pressures will have to be the same, but the speed of the engine, and consequently the power exerted, must be greater in the direct proportion of the slip.

On the above reasoning, we should find the relative efficiency of the different screws with equal surfaces to be sensibly in the proportion of the slips. Applying this, the following appears to be the correspondence:

Screw c has 3.2 per centum less slip than screw n, and 3.1 per centum more efficiency.
Screw b has 2.5 per centum less than screw c, and 5.0 per centum less efficiency.
Screw a has 1.8 per centum less than screw b, and 5.0 per centum more efficiency.

In the case of the same screw with reduced surfaces, this law will be modified, from the fact that the reduced surface has decreased the amount of friction of the screw on the water; therefore, the relative efficiency of the same screw with decreased surfaces will be in a higher ratio than the ratio of the slips. Applying this, we have the following:

1st Modification.
Screw a has 2.3 per centum more slip than screw n, and 6.1 of 1 per cent. less efficiency.

2d Modification.
Screw a has 4.4 per centum more slip than screw n, and 2.9 per centum less efficiency.

1st Modification.
Screw a has 4.8 per centum more slip than screw n, and 2.4 per centum less efficiency.

2d Modification.
Screw a has 6.9 per centum more slip than screw n, and 4.7 per centum less efficiency.

1st Modification.
Screw a has 8.0 per centum more slip than screw c, and 5.6 per centum less efficiency.

2d Modification.
Screw a has 10.1 per centum more slip than screw c, and 8.0 per centum less efficiency.

To be Continued.
Comparison between English and American Railway Management.*

At a time when a parliamentary committee is sitting on railway policy, it appears opportune to bring before shareholders whatever evidence is calculated to assist in arriving at correct conclusions. The position of railway administration in England at the present moment is this: it is assumed by railway directors to be perfect; its perfection is very much doubted by shareholders and the public. The former have an idea that every care is not taken for economy, the latter that every care is not taken for public safety. The directors claim implicit confidence in their management, on account of the purity of their motives; the shareholders think that every respect may be paid to motives, but that a salutary investigation may be made into the details of management. We have always upheld this principle, and acting upon it we shall take advantage of an important public document just issued in the United States, to institute a comparison between English and American management. The extravagance of one line may be defended or palliated by the greater extravagance of another line; but the experience of a remote system may be accepted as impartial evidence, and it may better guide us in arriving at results. Here a certain set of engineers have given the same general character to the railway system and management; the school of Stephenson has become the school of England, and there has been little disposition to authorize anything which did not bear the stamp of legitimacy, as authoritatively imposed by the arbiters of railway expenditure. In the United States it has been different; there has not been that blind following of the high and mighty in engineering, and as there has not been a body of open-mouthed and open-pursed shareholders to draw upon, unlimited economy, and it may be said necessity, has in many cases been allowed to have some voice. Hence we may expect to get some evidence, which, though not arising from identical circumstances, may throw light on the case, or even, as being of a negative character, may determine the course of the investigation.

The documents before us are included in the report of Mr. McAlpine, the State Engineer of New York, in pursuance of a recent law that passed in 1850, and although the operation of the system of returns is not yet complete, a large mass of valuable statistical information is brought together, and the deductions are very carefully drawn. When we state that the length of railways embraced in these returns is between 1800 and 2000 miles, it will be seen the extent is ample for comparison. The circumstances, too, of New York State admit of a better comparison than those of other parts of America. The country is not throughout so thickly peopled as England; but there is a metropolitan population in New York City of 600,000, and there are many populous towns. There are districts approaching Scotland and Wales in population, and there are large seats of manufacture, and in some places an enormous transit trade. Thus there is a great variety of character in the traffic conditions, in some cases approaching those of our wealthy and thriving districts, in others going as low as the poorest parts of the Highlands or Welsh

* From Herapath's Journal, Nos. 732 and 733.
mountains. Some might reject the comparison for these latter circumstances, but they are indeed those which claim most attention. In these islands a total population of 30,000,000 have 7000 miles of railway; in New York a population of 3,000,000 have 2000 miles of railway. This is a proposition not lightly to be set aside without investigation. In Ireland 6,000,000 of people have one-third of the length of railway possessed by half the population in New York, or one-sixth of the supply. The case of Scotland is generally better, the same population as New York having half the length of railway.

The passenger traffic on 1900 miles of railway in 1852 was 7,440,653, and the number of miles run, 343,338,545, which gave an average mileage per passenger of 46 miles. In 1851, the average distance travelled by each passenger was 47 miles; so that from discrepancies in the returns some of the figures must be received with caution; but this may be taken as a fair average. This rate is far above the European standard, as the average rate in England and Belgium is only about one-half of the above. The American returns include little of what is known as short or omnibus traffic; while from the great extent of the country and the widely scattered population, for which railways afford the most convenient transit, the distance of the journeys is greater than here. The returns likewise include a large proportion of through emigrant traffic to the far West. The average suggests some interesting reflections; first, that the American traffic is not to such a great proportion as ours intermediate; and, second, that a railway system can be carried out where the average mileage of each passenger is 46 miles, as must be the case in some thinly peopled colonies and countries requiring great length of railway. This illustration will be found useful in reference to the Canadian railways, the traffic of which is little understood here.

The average speed of the passenger trains is given as 26½ miles per hour, but this seems to be the speed without stoppages. At any rate, it is not a very high speed, but it is found suitable for a large proportion of the traffic. In this country, the question has been little considered how far low speeds and cheap fares can be made to work profitably, except so far as the Irish lines are concerned, though there the tendency is towards increasing the speed. In New York the emigrant traffic to Canada and the West is carried at very low rates, and it is contemplated to do the same on the Great Canadian trunk.

The average number of passengers in a train is returned at 77.6, the number of trains per day being generally much less than in this country. The great endeavor in the United States is to give the public low fares, and the Companies a low rate of expenditure, and every thing is directed upon these two principles, which are made to work together. By running few trains, at reasonable speeds, and by attending to the construction of the carriages, much economy is obtained. The American carriage being, as is well known, on a larger scale than here, and allowing of internal communication, admit of being worked cheaper with respect to the staff on the line and in the stations, and is effectively more convenient to the public than the English railway carriage. This is a subject well worthy of inquiry, as much of the economy of American railways depends upon it, but at present we can only briefly refer to it. The effect is to reduce
the expenses of fixed stations, and to allow of passengers being worked from places where, on the English system, a station could not be maintained. Instead of a staff distributed over twenty stations, as here, the staff in America travels with the trains, and the stations, buildings, and equipments are consequently of a minor character. On the other hand, whenever it is desirable to set down or take up a large or small number of passengers at a given spot not usually worked to as a station, nothing is necessary but to stop the train, like an old stage coach, and the requisite station staff is forthcoming. There are many places where there is a market traffic once a week, for which a fixed station staff would be required on such occasions, and with the privilege of keeping their hands in their own pockets, and dipping into the pockets of the shareholders the greater part of the week, and which must in England be neglected or worked at a loss. Of course, a staff proportional to the trains will, nevertheless, be at times in excess of the traffic, but by no means correspondent to a fixed station staff.

The element of cost, we have frequently had occasion to point out, is the foundation of traffic working, upon which depends the relation of returns to expenditure, and to a great degree the realization of a dividend. It is true enough, that where there is an enormous traffic it may be able to meet an enormous outlay for construction; but on the other hand, a moderate outlay is safer to receive a return. We have shown that the length of line in New York State is far above our standard, and we may observe that it brings a very handsome return, and this in a thinly populated country. The whole cost, however, of 1819 miles is $84,034,456. For the reduction of the various sums from American to English values, we shall take the dollar at 50d.; that is, the cent at one halfpenny, which is sufficient to meet the requirements of the case, and which will give us as the whole cost 17,500,000l. The average cost per mile of a single line of rails is $36,701, or 7500l. Upon the question of comparative cost, we shall not now dwell, only so far as it influences the question of fare.

It is obvious that lines costing 7500l. per mile can carry much cheaper than lines that cost five or eight times as much, unless the latter are qualified to carry a greater traffic. A double line effects this, but still there is the difference between 15,000l., the American standard for a double line, and the much larger cost of most of our English lines. We take the cost of a double line at double the single track, which we believe is about fair in the United States. If then a double line in the United States would cost 15,000l., it can carry at one-third the fare of a line costing 45,000l., and pay as good a profit, and it is this question of fare which, as a further step in the progress, influences traffic.

The working of a limestone quarry is as good an example for working out traffic sums as can be found. Taking the cost of the limestone at five shillings per ton, and the price which the farmer or other consumer can afford to pay, or that which is limited by competition, to be ten shillings, then five shillings remaining for cost of conveyance, the distance to which the lime can be carried will be limited by the rate of conveyance. If the rate be sixpence per mile, then the stone can be carried only 10 miles; if threepence, 20 miles; but if one-penny, then 60 miles. To the carriers
it may seem indifferent whether they carry the stone ten miles or sixty,
seeing that they receive in either case five shillings; but if they truly look
at their interests, it will suggest itself that the lowest fare which is remu-
nerative to them is the one which will bring the greatest return. With a
distance run of ten miles, the area of consumption and distribution will
be over a circle of ten miles radius, or 20 miles diameter; but with a dis-
tance run of 60 miles or 120 miles diameter, the area would be vastly
increased. Practically, of course, the whole theoretical area is not obtain-
ed, because there are natural or other bounds to traffic. Thus, in the case
cited, a neighboring stone quarry will constitute a bound at five miles’
distance, though in other directions the radius may extend to 60 miles.
The object, therefore, practically, is so to adjust the rate of conveyance
as to secure the maximum amount of income and of profit. We need
scarcely say that traffic managers in this country are seldom guided by
such considerations. At one time they put on prohibitory high rates on
articles which will not bear them; at other times they engage in foolish
competition with other companies, and put unremunerative rates on arti-
cles which can bear any amount of charge, and do not feel the benefit of
the reduction.

With regard to passengers, applying the above principle is equally
applicable, though the form is varied. Traffic managers can understand
that coal and limestone are influenced in their consumption by the rate of
charges, inasmuch as they proceed from a place; but they do not seem
to understand the converse, how when the traffic goes to a place, the
same law operates. Let us take the case of Birmingham or Cheltenham.
The consumption of Birmingham goods is general throughout the coun-
try, and the tradesman will resort to Birmingham if he can do so with
advantage to himself. This depends upon the rate of fare added to his
other expenses, and being part of the margin of profit or loss on his ope-
rations. If ten shillings be the amount which he can afford to spend on
traveling to Birmingham, he will travel so far as ten shillings will carry
him, and this depends on the railway companies; beyond that sum he
will not travel at all. Pleasure traffic is not of the same precise nature,
but is dependent on the same general law, and the area of the Chelten-
ham traffic is as much dependent on the rate of railway fare as its yearly
fluctuation is on the state of the country.

It will be seen that from certain districts a railway will receive no i,
come at all, nor can it receive any unless its rate of fare will make it
remunerative or practicable to the traveler. The hardwareman or iron-
monger will visit Birmingham, Sheffield, or Wolverhampton, and the
clothman will visit Leeds or Bradford, if his transactions will bear it, and
not without; and we need scarcely say that as matters stand, the trades-
man in the north of this island, or in the provinces of the sister island,
does not think of visiting the places named for purposes of business.

The development of passenger traffic affects goods traffic in most arti-
cles, and the two work together, so that moderate passenger fares are of
more importance than moderate goods rates. Coal, it is true, may be sent
to market in hundreds of thousands of tons with little personal supervi-
sion; but all kinds of merchandise and parcels traffic require much per-
sonal intercourse, and this, notwithstanding cheap rates of postage and
English and American Railway Management.

telegraph communications. Looking at all these circumstances, we cannot but feel that railway traffic in this country is far from bearing its full results, and has not reached a complete development.

The traffic of the United States rests, it will be seen, on a sound basis, so far as the cost of line is concerned, for it is not difficult to get a traffic for a line costing 7500l. a mile, even though the per centage of working should prove very high. Upon such a cost we may expect low fares, and indeed we find them.

On a very few lines in New York, and those short ones only, do we find a first class fare of 1½d. This is the maximum, and seems to be an enormous rate. The ordinary first class fare is our parliamentary one of one penny per mile. What do our chairmen and shareholders, who exclaim against parliamentary trains, and call out for high fares, think of that? Let them imagine, if they can, the practicability of working a railway at such fares, paying 6 to 7 per cent. on debenture debt, and higher dividends. Incredible as they may think it, it will be done in these countries as well as by our brethren beyond the Atlantic, and although engineers pronounce it impossible to make cheap lines, there will be plenty of them before many years are over.

Second class fares, properly speaking, are not found on most of the lines, the first class fares being so moderate that a uniform rate can be charged, and there is no necessity to talk of turning decent coated men out of second or third class carriages, adopting dirty tricks to prevent the public from traveling according to their means, or for turning mechanics and their wives into hog-pens. The lower class fares are chiefly for emigrants and negroes, and they go down low enough in all conscience. A great quantity of traffic is carried at 0'50d., 0'48d., 0'40d., and even at 0'37d. Here are rates for the consideration of traffic committees, though perhaps gentlemen who hold their hundred thousand pound stock in one line may not believe that there are persons among their fellow countrymen to whom a few shillings are as great an object as their guinea attendance fee is to them.

Let it not be imagined that the American lines are only short lines, having no scope for through traffic. They have short lines, it is true, upon which generally the highest rates are charged; but they have lengths of line in comparison with which our London and North-Western route falls into the shade. The New York and Erie Railway, in its main line, from Piermont to Dunkirk, is 446 miles long, or nearly as far as from London to Perth. The lowest fare from London to Perth, 452 miles, is 30s., and this is likewise the lowest fare to Edinburgh and Glasgow, 405 miles. The third class fare on the New York and Erie Railway is 15s., or half that amount. The first class fare is 37s., or little more than that amount, so that wealthy and working classes are equally well treated. The first class London and North-Western to Perth is 79s. 6d., and the express 87s. The New York and Erie ordinary rate, including stoppages, is 21 miles; what the London and North-Western is for third class passengers to Perth, we cannot make out; that for first and second class passengers seems to be about 22 miles per hour. The New York and Erie express rate is 27 miles, including stoppages, and the fare only first class fare. The London and North-Western rates to Perth are 26 miles and 30 miles
per hour, the fare as above given; therefore, we have not much to boast of in the way of accommodation. It is not to be wondered at if the average mileage of a New York passenger is twice that of an English passenger.

A peculiarity on some of the American lines is, that they charge higher rates for intermediate, or, as they call them, way passengers. This is on account of the greater average mileage.

On Improved India Rubber Springs for Railway Engines, Carriages, &c.
By Mr. William C. Craig, of Newport.*

In order to explain the difficulties which have been contended with and surmounted by the use of these springs, the condition of the roads upon which they have produced such satisfactory results has to be noticed, and the causes which first led to the introduction of india rubber as a substitute for steel, in bearing springs, buffers, and draw springs.

The Western Valleys Lines of the Monmouthshire Railway and Canal Company (upon which the writer is locomotive superintendent), consist of twenty-five miles of tramway, exclusive of branches, and worked by heavy coupled engines of the most improved construction. The tramplate is laid by means of chairs upon transverse sleepers, about 3 feet apart, and an intermediate sleeper at the joints. This plate, although heavy (about 73 lbs. per yard), is of very weak section, and there is, consequently, considerable deflexion in it, a tendency to rise at the joints, and for the sleepers to work loose: the effect of this is, to cause a much greater expenditure of power necessary to overcome a series of rising and falling gradients, than would be the case upon an edge rail; and an undulatory motion of the engine is caused, which is extremely destructive to the steel springs hitherto in use on this line. The curves are unusually sharp, (some being under five chains radius, and the majority under twenty chains,) which is productive of a prejudicial effect on the wheels, buffers, and other parts of the engines, carriages, and wagons. The gradients are very heavy, (some being 1 in 54,) producing a much greater strain on the draw-bars and couplings than is to be met with upon ordinary railways.

Upon such a road, the inconveniences attending the use of steel springs were both numerous and formidable. In addition to the continual repairs which were required by the springs themselves, the injury done to the permanent way, arising from the unequal action of the spring, and the violent concessions they were subject to, when they were totally disabled (as was frequently the case), was large in amount, and of continual occurrence, and of a character that involved considerable expense in repairs. Some idea of the damage thus occasioned may be formed, from the fact of the wheels tyres requiring to be replaced at least every eight months, having become worn by that time into a series of flats, more nearly resembling an irregular polygon in outline than the circumference of a circle.

The engine tyres used on the tramways are steeled on the wearing surface. With regard to the springs themselves, it may be proper to mention here, that the item of expenditure for steel springs (including wages for

* From the London Repertory of Patent Inventions, July, 1853.