Tabular Statement of the Duration of Iron Railroad Bars.

<table>
<thead>
<tr>
<th>Number of cases or examples</th>
<th>Weight of rail (in pounds) per yard</th>
<th>Depth of rail, in inches</th>
<th>Bearing surface presented by sleepers for each linear foot of track, in superficial feet</th>
<th>Greatest weight rolling on 4 wheels, in tons</th>
<th>Greatest weight on a foot length of track, in tons</th>
<th>Velocity of trains in miles per hour</th>
<th>Motive power employed</th>
<th>Gross traffic over a single track of rails before renewal, in tons</th>
<th>Weight of rails per mile for a single track, in tons</th>
<th>Cost of rails per mile estimated at 60 dollars per ton</th>
<th>Number of tons carried over one mile of road for each dollar's worth of iron consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>56</td>
<td>2.5</td>
<td>-75</td>
<td>16</td>
<td>27</td>
<td>16</td>
<td>Locomotive</td>
<td>1,822,800</td>
<td>88</td>
<td>4400</td>
<td>414</td>
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<tr>
<td>2</td>
<td>63</td>
<td>3.75</td>
<td>2.25</td>
<td>16</td>
<td>27</td>
<td>16</td>
<td>&quot;</td>
<td>12,000,000</td>
<td>99</td>
<td>4950</td>
<td>2424</td>
</tr>
<tr>
<td>3</td>
<td>56</td>
<td>2.5</td>
<td>1.75</td>
<td>7</td>
<td>1.2</td>
<td>12</td>
<td>Gravity,</td>
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<td>919</td>
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<td>4</td>
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<td>2.5</td>
<td>1.1</td>
<td>7</td>
<td>1.2</td>
<td>3</td>
<td>Horses,</td>
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<td>88</td>
<td>4400</td>
<td>2227</td>
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<tr>
<td>5</td>
<td>90</td>
<td>3.4</td>
<td>1.7</td>
<td>14</td>
<td>2</td>
<td>8</td>
<td>Stationary,</td>
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<td>142</td>
<td>7100</td>
<td>1125</td>
</tr>
<tr>
<td>6</td>
<td>55</td>
<td>5</td>
<td>1.1</td>
<td>8.5</td>
<td>2.2</td>
<td>3</td>
<td>Horses,</td>
<td>1,628,840</td>
<td>86</td>
<td>4300</td>
<td>378</td>
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<tr>
<td>7</td>
<td>56</td>
<td>2.37</td>
<td>2.1</td>
<td>4.8</td>
<td>1.5</td>
<td>6</td>
<td>Stationary,</td>
<td>7,840,000</td>
<td>89</td>
<td>4400</td>
<td>1781</td>
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<tr>
<td>8</td>
<td>75</td>
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<td>1.5</td>
<td>11</td>
<td>2.4</td>
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<td>Locomotive,</td>
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<td>5650</td>
<td>940</td>
</tr>
<tr>
<td>9</td>
<td>40</td>
<td>3.87</td>
<td>2.5</td>
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<td>8.5</td>
<td>3</td>
<td>Horses,</td>
<td>15,000,000</td>
<td>63</td>
<td>3150</td>
<td>4126</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>4.5</td>
<td>2.5</td>
<td>16</td>
<td>2.8</td>
<td>30</td>
<td>Locomotive,</td>
<td>10,000,000</td>
<td>78</td>
<td>3900</td>
<td>2564</td>
</tr>
<tr>
<td>11</td>
<td>72</td>
<td>5</td>
<td>2.7</td>
<td>16</td>
<td>2.8</td>
<td>30</td>
<td>&quot;</td>
<td>41,000,000</td>
<td>113</td>
<td>5650</td>
<td>7256</td>
</tr>
<tr>
<td>12</td>
<td>72</td>
<td>5</td>
<td>2.7</td>
<td>16</td>
<td>2.8</td>
<td>30</td>
<td>&quot;</td>
<td>22,400,000</td>
<td>113</td>
<td>5650</td>
<td>3964</td>
</tr>
<tr>
<td>13</td>
<td>46</td>
<td>4.25</td>
<td>2.2</td>
<td>10</td>
<td>2.1</td>
<td>10</td>
<td>&quot;</td>
<td>1,318,000</td>
<td>72</td>
<td>3600</td>
<td>363</td>
</tr>
</tbody>
</table>

For the Journal of the Franklin Institute.


The following experiments on various screw propellers, were made in 1845, by M. Bourgeois, Engineer de Vaisseau, at the government manufactory of Indret, in France; where he was furnished with the requisite manual force, a boat and a considerable number of experimental screws of different forms and dimensions. This was about the time that experiments were being made with the "Rattler," "Archimedes," "Napoleon," and other screw vessels; it was in the very infancy of screw navigation, and before sufficient experimental data, on a large scale, had been obtained to indicate the proper proportions of a screw and the laws governing its mode of action. The necessity for a correct theory of the screw was pressing, for the above mentioned experiments on a large scale were neither sufficiently varied nor sufficiently accurate to furnish it; nor has this want been satisfied to the present time by any systematic experiments on the scale of actual practice, accurate enough and varied enough to resolve the various problems of the screw: and it is only by digesting together the many unconnected and occasional experi-
ments which have been made at different times, under different circum-
stances, by different persons and on different vessels, that we can now
make an incomplete theory of the screw, and give an approximately cor-
rect answer to specific questions regarding it in function of form or di-
mensions. The power at the command of Bourgois was not of the kind
that entitled him to furnish data for the formation of a complete theory
of the screw; it consisted of the varying manual force of men impossible

to be measured; he was therefore obliged to address himself entirely to the
problem of slip, and this he solved very satisfactorily and with much
sagacity of manner, if we consider the means at his disposal, and the scale
on which he experimented; and to this day, I regard his experiments as
among the most complete and systematic that have been made, losing
nothing of their value by the lapse of time. His original report has ne-
ever, to my knowledge, been published or referred to in English, and pos-
sessing a copy in French, I have carefully reviewed and examined the
voluminous tables of detail embraced in it, and have extracted from them
such data only as were consistent with each other and with the nature of
things, rejecting a considerable mass of what was contradictory and evi-
dently erroneous. The data so selected, and which I am persuaded from
its close agreement with each other, and from the comparable manner in
which it was obtained, is very accurate, I have made the ground of the
present paper; the conclusions drawn, the accompanying remarks, and the
arrangement are my own. I have drawn on the report for the original
experimental data only. Owing to the want of knowledge of the power
exerted with the different screws, this data is strikingly deficient when we
attempt to ascertain either the relative economical efficiencies of the dif-
ferent screws as a whole, or to analyze the distribution of that power with
a view to determine the value of the friction of the screw surface on the
water. These important questions must therefore be left unanswered,
and the sole problem resolved by the experiments, is, as before mention-
ed, the slips of the screw as affected by form and dimensions. The re-
results, therefore, hereafter given, do not, it must be distinctly understood,
indicate the relative economical efficiencies of the screws, but only their
relative slips.

Objections may certainly be made to these experiments on account
of the small scale on which they were conducted; but such objec-
tions, if closely examined, will be found more specious than real.
And the very smallness of the scale, allowed the experiments to be so of-
ten repeated and varied, and with such a degree of exactness in the de-
termination of all the elements of time and dimensions, as would be
hopeless on a grand scale; where the number must necessarily be limit-
ed, the determination of the elements inexact, the labor immense, and
all the difficulties and liabilities to error great. Experiments on a grand
scale would be vitiated by many accidental circumstances impossible to
guard against, and whose effect could neither be calculated nor eliminated
from the general result. In confirmation of this, it is only necessary to
refer to the experiments on the "Rattler," "Dwarf," and many other screw
vessels.

Manner of Experimenting.—A convenient place was first selected on
the river, where the bank was straight and the water nearly on a level
with it, and a base was marked out by two javelins or staves placed 328 feet
apart, and ranging with other staves at right angles to this base.

The experiments were conducted here until a rise in the river overflowed
its banks, when a second similar base was marked out, but only 219.76
feet long. In order to be certain that the experiments made on the two
bases were comparable, a screw, which had always given consistent re-
results on the first base, was experimented with on the second base; the
mean slip obtained on the first base was 38.7 per centum, on the second
base 39.4 per centum; we are therefore warranted in assuming the results
on both bases, as comparable, and this assumption is further confirmed by
the according results of a great number of other experiments. One ob-
server in the boat counted the number of revolutions of the crank shaft
from the instant of departure to the instant of arrival, while another ob-
server took the time elapsed between the same departure and arrival.

Every care was taken to insure extreme accuracy; the base was run
over forward and back, and the mean results taken to give the slip of that
trial; this double course was again run, and the mean results obtained
gave the slips; again, a number of double courses were so run with each
screw, and not content with this, but to avoid error from inexactness in the
form of the screw surface, each screw, after being first experimented with,
was reversed on the shaft, and the number of trials repeated with the other
face of the blades; the means of all the trials with both faces were taken
to give the true slip of the screw. In the part of the river chosen for the
two bases, the current was always very feeble. The screw shaft was
g美ed to make 9.88 revolutions for each revolution of the crank shaft,
which latter was turned by four sailors; there was a double set of gear-
ing, the driving wheels of each set containing 44 and the pinions 14
teeth.

Of the Experimental Boat.—This boat was of iron and had the fol-
lowing dimensions, viz.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length between perpendiculars</td>
<td>26.26 feet</td>
</tr>
<tr>
<td>Extreme breadth, (outside of iron,)</td>
<td>5.09 &quot;</td>
</tr>
<tr>
<td>Depth of hold</td>
<td>2.87 &quot;</td>
</tr>
<tr>
<td>Draft of water, at which all the experiments were made, {</td>
<td></td>
</tr>
<tr>
<td>forward</td>
<td>1:35 &quot;</td>
</tr>
<tr>
<td>mean</td>
<td>1:575 &quot;</td>
</tr>
<tr>
<td>aft</td>
<td>1:80 &quot;</td>
</tr>
<tr>
<td>Greatest immersed transverse section at above draft,</td>
<td>6.458 sq. ft.</td>
</tr>
</tbody>
</table>

A number of experiments, carefully made with a dynamometer to
ascertain the resistance of this boat, gave 13.23 pounds avoirdupois, at
a speed of 3.281 feet per second, or 2.237 statute miles per hour. A great
number of experiments, employing the various screws, were also made
to determine whether an increase in the speed of the boat affected the
slip of the screw; or, in other words, if the slip of the screw was influ-
enced by its rotary speed. This rotary speed was greatly varied, in some
cases 70 per centum, but no greater variations of slip were observed than
the slight discrepancies inevitable to all observations of this kind; some-
times an increased speed gave a slightly increased slip, sometimes a
slightly decreased slip. There results from this, that within the limits of
speed employed, viz., 4 statute miles and under per hour, the resistance
of the boat was in the ratio of the square of its speed, requiring the power
to propel it to be in the ratio of the cube of its speed. It was found, by
experiments with two screws, that the fouling of the immersed surface of
the boat by the collection of slime, &c., during 15 days of repose, in-
creased the resistance sufficiently to cause an increase in the slip of one
screw from 35·6 to 38·6 per centum, and in the slip of the other screw,
from 37·4 to 39·4 per centum. Before experimenting, therefore, care
was always taken to clean the bottom of the boat. It was also found,
that a slight rocking of the boat materially increased its resistance, and,
consequently, the slip of the screw; for instance, a screw that gave a slip
of 31·4 per centum with the boat steady, gave a slip of 33·4 per centum
when it was slightly rocked.

Material of the Screws.—The screws of the first and fifth series were
made of wrought copper beaten very thin. Those of the second, third,
and fourth series, were made of tinned wrought iron and bound with two
circles of iron wire around the periphery; the screws of these latter se-
ries were not full threaded, that is to say, the blades did not descend to
and unite with the hub, but the interior part, or portion adjacent to the
hub, was cut out in a manner that may be imagined by passing through the
screw a cylinder of the diameter of the cut out part, and having an axis
coinciding with the axis of the screw; the blades were attached to the
hub by copper arms of sufficient size for stiffness; these arms must, neces-
sarily, by their direct resistance, have somewhat increased the slip, but
they could not influence the relative value of the slips of screws of the
same series. The screws with curved generatrices and directrices were
made of zinc beaten to the required form on a wooden die. The screws
of the first and fifth series, I shall call “full threaded screws;” those of
the second, third, and fourth series, I shall call “part threaded screws.”

Definitions.—Before proceeding further, it will be proper to give a few
definitions of the terms herein employed in relation to the screw; which
when considered abstractly from solidity, that is to say, mathematically,
and formed by lines and superficies only, is termed a helicoid.

Let any right line whatever be taken and called the axis of the heli-
coid. And let any other line, curved or straight, of definite length, be
taken, lying at any inclination to the axis and with one extremity touch-
ing the axis; this line is termed the generatrix of the helicoid.

Now let the generatrix be kept at the same inclination to the axis, and
let its outer end be moved with a rotary speed around the axis, while
its inner end is moved simultaneously along the axis, it will generate a
twisted surface, termed a helicoid. The length of the generatrix is the
radius of the helicoid.

The outer extremity of the generatrix, during the generation of the
helicoid, will describe a line curved in projection and in elevation: this
line is termed the helix of the helicoid. The helix is the directrix of the
helicoid.

When the generatrix has an uniform rotary speed around the axis and
an uniform rectilineal speed along the axis, the distance it moves along
the axis during the time it is making one revolution around the axis, is
termed the pitch of the helicoid, and the helicoid so generated, is termed
a regular helicoid. If the rotary and rectilineal speeds of the generatrix,
or either of them, be not uniform, there will be generated a helicoid of
irregular pitch, that is, the generatrix will momentarily describe helicoids of different pitches, each pitch being what would have resulted had the corresponding momentary speeds been kept uniform for one revolution around the axis.

If, now, we suppose the generatrix to move along the axis with an uniform speed, while it moves around the axis with an uniformly decreasing speed, or vice versa, it will generate an irregular helicoid, having an uniformly increasing pitch, or an expanding pitch, as it is commonly termed.

If the helix of a regular helicoid be projected on a plane, that is to say, if the circumference and pitch be made the sides of a right angled triangle, the helix, which will be the hypothenuse, will be a straight line, and such a helix is termed a straight directrix. But, if the helix of a helicoid of expanding pitch be similarly projected, it will, instead of being a straight line, be a curved line, and such a helix is termed a curved directrix.

Whether the helicoid have a straight or curved generatrix, depends, simply, whether a straight or curved line was taken for it. If a curved line be used, the helicoid will be concave on one face, and convex on the other.

If the mathematical right line, constituting the axis of the helicoid, be replaced by a cylinder, and a straight generatrix be used with the inner end kept tangent to the cylinder, an oblique helicoid will be generated, having an acute angle for one face, and an obtuse angle for the other. Such a generatrix is termed an oblique generatrix.

When the mathematical helicoid is formed of matter, it is termed a screw; the right line axis is replaced by a hub, and the superficies is replaced by a thread. When the thread is divided into two or more parts and placed around the hub, these parts are termed blades. One convolution of the thread is formed by exactly one revolution of the generatrix around the axis, and if viewed projected on a plane at right angles to the axis, would appear a disk: in such a case the whole pitch is said to be used. If any less portion of the thread than one convolution be used, a fraction of the pitch is said to be used.

Kinds of Screw.—The screws experimented with, were of the following kinds, viz.

1st. Full threaded screws with straight generatrices and directrices, formed of exactly one convolution of the thread, but having it divided into several blades.

2d. Part threaded screws with straight generatrices and directrices, formed of exactly one convolution of the thread, but having it divided into several blades.

3d. Full threaded screws with straight generatrices and directrices, formed of fractions of the pitch, and having the thread divided into several blades.

4th. Full threaded screw composed of a fraction of the pitch, with an oblique generatrix and a curved directrix.

5th. Full threaded screws with curved directrices, composed of the whole and of fractions of the pitch, with straight generatrices.

Objects of the Experiments.—With the above kinds of screw, it was
sought to determine the variation of slip in fraction of the form of the screw, as follows, viz.

1st. The influence exerted on the slip by cutting out the inner portion of the blades.

2d. The influence exerted on the slip by employing less than one convolution of the thread, or by fractioning the pitch.

3d. The influence exerted on the slip by employing an oblique generatrix.

4th. The influence exerted on the slip by employing a curved directrix, or expanding pitch.

5th. The influence exerted on the slip by the division of the same propelling surface, into a more or less number of blades.

Subordinately to these, it was essayed to determine the influence exerted on the slip by surrounding the periphery of the screw with a drum of very thin metal, fastened to and turning with the blades.

Also, the influence exerted on the slip of the screw by placing the blades checkerwise, that is, by moving back the distance of the length of the blades and in a line parallel with the axis, half the blades of the screw; by which means the length of the hub will be doubled, and the screw will present the appearance of two similar screws on the same axis placed one immediately after the other, with the blades of the last intersecting the spaces between the blades of the first.

In function of the dimensions of the screw, it was essayed to determine the influence exerted on the slip:—first by the pitch, and second by the diameter.

Experimental Data.—Bourgois, in his voluminous tables, has entered all the detail of the experiments; such as the time elapsing between departure and arrival, number of revolutions made by the screw, speed of the screw, speed of the vessel, &c.; but it is obvious, that as the speed of the screw did not affect its slip, it is unnecessary here to occupy ourselves with such unimportant detail, whose only value consists in the fact of its furnishing the means of arriving at the final results we are in quest of. I shall, therefore, in the following tables, only include in addition to the dimensions of the screws, their mean slips, and their minimum and maximum slips; and the number of double courses ran with each screw, counting once forward and once back over the base as a double course.

In comparing the experimental data, the screws are of course supposed to preserve, when propelling in water, the same form they possess when in repose: nevertheless, they are subjected, when propelling to a strong force, directly to the alteration of their form. For it is a well known fact, which, beside, is fully established by these experiments, that the propelling efficiency of the blade rapidly diminishes as we pass from its anterior to its posterior edge; that is to say, considerably increasing the length of the blade, but slightly diminishes its slip. Now the slip of the screw, which is the difference between its longitudinal speed and the speed of the boat, measures simply the difference between the resistance of the vessel and the resistance of the water pressed by the screw; hence it follows, that when by lengthwise addition of surface to a screw its slip is but slightly decreased, additional surface experiences only a slight resistance from the water it presses corresponding to the slight decrease
of slip. The strain, then, of the water pressed by the screw instead of being equally distributed over the surface of the blade is principally at the front or anterior part, diminishing very rapidly as we approach the posterior part. Now, if the metal of the blades is made very thin, as in the screws of these experiments, and has not perfect stiffness, it is plain they will yield or spring back; and the anterior part having more strain upon it than the posterior part, will spring back more; consequently the angle made by the blades with the axis when propelling, will not be the angle when in repose, but a greater angle, giving the screw, when propelling, a greater pitch than it has when in repose. Were there no slip at all, and did the screw thread its way through the water as in a solid nut, it is plain that then every part of the blade, considered lengthwise, would experience an equal resistance from the water pressed: but in proportion as slip exists, so does the pressure at the anterior part increase disproportionately over that at the posterior part; for the greater the speed with which the water is set in motion (i.e. the greater the slip), by the anterior part, the less pressure will evidently be impressed upon it by the posterior part following with the same speed as the anterior part. Hence we find, that the screws giving greater slips should have more alteration of form, that is, more increase of the pitch, when propelling than when in repose, than the screws giving lesser slips.

With regard to screws of different diameters; when the blades are made of metal so thin as to spring, it is clear, that the screws of least diameter will have the least alteration of pitch, because there is less strain upon them; therefore, in such screws the pitch will not increase when propelling so much as in screws of greater diameter over the pitch they have when in repose.

This alteration of the pitch of the screws when propelling from what they had when in repose, and which must have become permanent after the screw had been used a considerable number of times, owing to the excessive thinness of the blades, was quite overlooked by Bourgois, who was not a practical mechanician, and he proceeded to erect upon all the experimental data obtained, a number of empirical formulas involving the higher mathematics, for the calculation of the slips of screws of variously modified forms and dimensions. These formulas with the value of their elements controlled by assumed coefficients, will therefore apply only to cases where the blades spring the same as in his experiments, and where all the other accidents were likewise the same, and as they are not only false in themselves, but quite useless practically, it is unnecessary here, either to discuss or reproduce them. The results of Bourgois' experiments are certainly somewhat vitiated by the change of shape undergone by his screws when propelling from what they had when in repose, which latter forms, of course, the elements of comparison, but the vitiation is not so great in the data I have selected as to prevent these results from being, in my opinion, very valuable. Some of the screws are strictly comparable, and if in all cases the exact amount of influence exerted on the slip by different modifications of the form and dimensions of the screws is not determined, still a very close approximation is given, and the direction in which the changes operate clearly indicated.

In some of the experimental screws, the pitches are evidently erro-
neously given, and these screws I omit in the general tables, first and second, which include only those screws whose results are comparable. But as experiments were made with some of these omitted screws, which were strictly comparable with each other, such as reducing the number of blades one by one, cutting out the inner part of the blades, and shortening the length of the blades, I have discussed their results separately.

(To be Continued.)


The President and Directors of the Chesapeake and Delaware Canal Company, in making their thirty-fifth annual report to this general meeting of Stock and Loanholders, have pleasure in stating, that the business, during the past year, has been conducted with regularity, and without accident or serious interruption to the constantly increasing trade.

The tow-paths, drains, and bridges have all been extensively repaired and improved, and the works generally are now in better condition for the transit of boats and vessels, than they have been at any time since the opening of the Canal.

From the statements of the Treasurer, herewith presented, it will be perceived that the revenue from tolls, for the year ending May 31, 1854, amounts to the sum of $246,695.02. The contingent and incidental expenses, which include all items for repairs, interest on loans, officers' salaries, wages, and contingent charges, for the same period, amount to $200,131.46. Leaving a surplus of (net profits arising from tolls,) $46,563.56.

This surplus, under the provisions of the Charter, might be divided among the Stockholders, being the actual profits of the Company, above interest and expenses, arising from tolls; but in view of the present financial wants of the Company, growing out of the enlargement of its locks, it is recommended that no dividend be now declared, but that this amount may be carried to the credit of a dividend fund, that it may be kept, so as to be distributed among the Stockholders at some future day, when the Company may find it more convenient to do so than at present.

It is proper, in this connexion, to state, that to the clear income from tolls, as already stated, there may be added the further sum of $15,429.06, of revenue derived from interest, dividends, rents, &c. The total clear revenue would then stand as follows:

<table>
<thead>
<tr>
<th>Revenue from tolls</th>
<th>Other sources</th>
<th>Total revenue, clear of interest and expenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>$46,563.56</td>
<td>15,429.06</td>
<td>$61,992.62</td>
</tr>
</tbody>
</table>

At the last general meeting of the Stock and Loanholders, the necessity for additional and larger locks was communicated to the meeting.

By a resolution then adopted, the Board was authorized to undertake the necessary measures for the accomplishment of that purpose. The Board immediately proceeded to the execution of this important work.