

The metals do not appear to have incorporated, small specks of a lighter color being interspersed. The remelting with the expectation of obtaining greater tensile strength by a more thorough mixing, did not produce that effect, but the contrary, as shown by comparing the mean strength of Nos. 1 and 2 with that of Nos. 3 and 4; a loss of about 3 per cent.

Specimens Nos. 5, 6, 7, and 8 are soft and ductile. The first piece of this composition had its least diameter 1 inch, and whilst being tested, the collar on one end yielded, and was drawn out of the clamp, the end assuming a cup shape. Its diameter was reduced subsequently to give the collars a greater proportionate bearing to section of rupture. Its fracture has a close fibrous appearance, with some granules about the axis. The general surface of rupture is not that of least section—at right angles to axis—but, is at an angle of about  $25^{\circ}$  to it. In this case a remelting increased the tenacity about 4.8 per cent. The color of this composition is not nearly so rich as that of Nos. 1 and 2, but is of a pale yellow, resembling common brass.

Specimens Nos. 9, 10, 11, and 12 are composed according to the formulæ given in the *Artizan*, with the spelter, tin, and iron, about in the mean proportion of the ranges given for those ingredients. The tin and iron are largely increased over the proportions required by both the other formulas, and, as might be anticipated, increased hardness results.

Their structure is granular and very close. The plane of separation is nearly at right angles to axis of piece, and somewhat jagged. In this composition a remelting produced a gain in tenacity of a little over 5 per cent.

Specimens Nos. 13, 14, 15, and 16 are of the ordinary gun metal composition, with the small portion of spelter added to insure sound castings. The remelting shows a loss of strength amounting to nearly 9 per cent.

All the materials used were new and melted in fresh crucibles.

Their values for tensile strains are about in the order they stand, the last two having very little difference between best results. No doubt a difference in quantities of spelter, tin, and iron would have increased the tenacity of Nos. 9 and 10, but the trial was not made; the results obtained showing that the metal was equal to ordinary wrought iron, whilst its greater hardness compensated for lesser tenacity.

J.

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For the *Journal of the Franklin Institute*.

*Strength Combined with Economy of Material in Constructing the Details of Steam Engines.* By R. H. THURSTON, U. S. N.

On page 47, of the *Journal* for July, I noticed a sketch of a form of piston recommended as combining strength with economy of material; but neither in that article nor elsewhere do I remember having found a rule, or a formula, by which to determine the proper thickness of metal for that most important detail of the steam engine.

In the absence of authority on the subject, I have worked out a formula, that, I think, gives ample strength and great economy of material.

Considering the action of the steam on the piston, but a moment's thought is required to prove that the piston may be made much thinner at the circumference, than at the centre.

The circular section immediately around the rod is compelled to sustain a shearing strain equal to the whole pressure exerted on the piston, while at the circumference, it might be brought to an edge, except that the arrangement of packing rings, and the strains that they are liable to cause, compel us to modify that form.

Let  $D$  = Diameter of cylinder in inches.

$d$  = " " circle on which thickness is required, in inches.

$t$  = Thickness required (in inches) of metal on circle of diam.  $d$ .

$p$  = Pressure of steam vacuum (maximum) in lbs. per sq. inch.

$$\text{Then } t = \frac{(D^2 - d^2) p}{6000 d} + \frac{D}{80}$$

In the case of a piston made with a single solid disk, after finding the thickness of section on three or four concentric circles, a curve may be struck through them, determining the form of the piston.

For the usual hollow piston,  $\frac{t}{2}$  is the proper thickness of each disk ;

or it may be slightly reduced to compensate for the extra strength given by the ribs inside it. For Mr. Nystrom's form of piston, increase the divisor as the curvature is increased.

I think the above a good formula for general use, and I find it effects a considerable saving in weight over a majority of forms usually given.

Any manufacturing engineer, having tried a similar, or any other rule for dimensions of details of engines, would confer a favor on the profession by making public the result of his trial. In a majority of these details, even recognised authorities differ so widely that none can be accepted as correct, and different manufacturers vary quite as widely in their practice.

The following formulæ were first given, as I conceived a correct form theoretically, and then corrected by comparison with similar parts of engines by our best builders, and particularly with cases that have come to my knowledge where fracture has occurred.

#### *For Piston Rods.*

Let  $D$  = Diameter of cylinder in inches.

$$d = \text{ " " rod " " } d = \sqrt[4]{\frac{D^2 l^2 p}{10000}} + \frac{1}{4}$$

$l$  = Length of stroke in feet.

$p$  = Pressure (maximum) in lbs. per sq. inch.

For screw engines divide by 4000 instead of 10000.

*For Thickness Cylinder Heads.*

Let  $D$  = Diameter of circle at which the thickness is required.

$t$  = Thickness in inches of metal in the head on circle of diameter  $D$ .

$p$  = Pressure (maximum) in lbs. per sq. inch.

$$t = \frac{D p}{3000} + \frac{1}{2}$$

I hope other engineers may be able to present other unpublished formulæ of greater value than the above.

Port Royal, S. C., September, 1863.

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FRANKLIN INSTITUTE.

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*Proceedings of the Stated Monthly Meeting, Sept. 17, 1863.*

James Dougherty, President, pro tem., in the Chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Royal Geographical Society, the Institute of Actuaries, and the Society of Arts, London; the Natural History Society, Montreal, Canada; Prof. A. Dallas Baché, Superintendent U. S. Coast Survey, and the U. S. Agricultural Bureau, Washington, D. C.; Prof. Wm. Chauvenet, St. Louis, Mo.; the Chamber of Commerce, City of New York; the Regents of the University of the State of New York, Albany, N. Y.; Robert C. Bacot, Esq., Jersey City, New Jersey; and the Union League, Philadelphia.

A Donation to the Cabinet of Minerals was received from John Hoskins, Esq., Philadelphia.

The Periodicals received in exchange for the Journal of the Institute were laid on the table.

The Treasurer's statement of the receipts and payments for the month of August was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (7) were proposed, and those (4) proposed at the last meeting were duly elected.

Mr. John W. Nystrom exhibited some French metres, and said—

I have brought to the meeting this evening some specimens of the French metre, with a view of discussing the metrical system, which is now, against great resistance, gaining ground in Europe, and is proposed to be adopted in England, and finally in America. The French metrical system was originated about 70 years ago, when MM. Delambre and Méchain measured an arc of a meridian between the parallels of Dunkirk and Barcelona, a distance of 32,808,992 English feet, from which the length of the quadrant of the earth from the equator to the