

*(Students' Paper, No. 324.)*

**"On Forms of Tensile Test-Pieces."**<sup>1</sup>

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SCIENTIFIC testing is now so extensively practised by engineers that further investigation of the subject might almost seem to be unnecessary. But it is a common thing, on comparing the results of two experimenters, using the same material but different dimensions of test-piece, to find that, though the yield-point and maximum load are the same in each, one sample will stretch over 40 per cent. whilst another extends only 25 per cent. The reason for this is, that in testing round bars when the maximum load is reached, the bar begins to draw down in the form of a cone and to extend very rapidly over a short piece, generally the 2 inches nearest to the point of fracture; hence, in a short test-piece, this drawing down influences the extension on perhaps the entire distance between the datum points, whereas in a long bar it would extend over a comparatively small percentage of the total length. In other words, short or thick test-pieces give a higher percentage of ultimate elongation than long or thin bars.

It is nearly ten years since a Paper on "The Adoption of Standard Forms of Test-Pieces for Bars and Plates," by Mr. W. Hackney,<sup>2</sup> was read at the Institution; and the discussion and correspondence to which it gave rise contained many valuable suggestions and recommendations as to the way in which future experiments on this subject should be carried out. Several speakers then pointed out the necessity for further tests to verify the law of similarity, as enunciated by Mr. Barba;<sup>3</sup> but so far the Author has seen no record of such tests having been made. This induced him, during his course of study in the Engineering Department of University College, London, to make a series of experiments on the salient points brought out in the discussion referred to.

<sup>1</sup> This Paper was read and discussed at a Students' meeting on the 1st December, 1893, and has been awarded a Miller Scholarship, Session 1893-94.

<sup>2</sup> Minutes of Proceedings Inst. C.E., vol. lxxvi. p. 70.

<sup>3</sup> Mémoires de la Société des Ingénieurs Civils, 1880, Part I., p. 682.

Before proceeding with a description of the tests made and the material used, it will be well briefly to mention the results which Mr. Barba obtained, and the laws he deduced therefrom.

First, he took three bars of very soft steel of the same ratio  $\frac{\text{length}}{\text{diameter}}$ , each bar being of different dimensions, viz. :—

(a)	200	millimetres	long	by	20	millimetres	diameter.
(b)	100	"	"		10	"	"
(c)	50	"	"		5	"	"

These he found to give approximately the same stretch, viz., 31 per cent. He then experimented on mild steel, taking eight bars varying in length between 50 and 225 millimetres, and in diameter between 6.9 and 31.05 millimetres, the ratio  $\frac{\text{length}}{\text{diameter}}$  being 7.24 in each. These gave an extension varying between 32.8 per cent. and 34 per cent. in the smallest and largest bars respectively. Finally, he experimented on hard steel, taking seven bars of the same dimensions as those of the first seven mild steel specimens; these gave an extension varying between 18 per cent. and 20 per cent. From these results he deduced the following law: "In cylindrical test-pieces of the same material and similar in form the percentages of ultimate stretching are identical." Next, three sets of test-pieces of equal length (100 millimetres), ranging from 5 to 20 millimetres in diameter, were cut from a bar of extra soft steel and of half-hard steel respectively, and were tested with results from which Mr. Barba framed the law, "That in test-pieces of the same length but varying diameter, or of the same diameter but varying in length, the extension per cent. diminishes as the ratio  $\frac{\text{length}}{\text{diameter}}$  increases." This law indirectly comprehends the one previously quoted, and is generally known as Barba's law of similarity; it was to investigate this law that the experiments described in this Paper were undertaken.

The Author's tests were made with hard and mild Bessemer steel, the material used being rolled at the Phoenix Works, Rotherham. Both qualities are constantly being rolled for commercial purposes, and were chosen in preference to any specially prepared or extra soft steel, in the hope that the results might prove of interest to commercial and scientific testers alike. The process of manufacture was the same for each material: an ingot 6 feet 6 inches high by 13½ inches square at the bottom, tapering to 11½ inches square at the top, was rolled down at one heat into

3-inch square billets, and cut up whilst hot into short lengths; these billets were then taken to smaller mills, reheated and rolled down to  $1\frac{1}{2}$ -inch diameter bars, which were cut into lengths of about 12 feet by the hot saw. After cooling, the bars were carefully annealed in the same furnace as that generally used for crank-axles, forgings, &c.

A chemical analysis was made from a sample taken from each bar with the following results :—

—	Hard Steel.	Mild Steel.
Carbon . . . . .	0·260	0·140
Silicon . . . . .	0·028	0·005
Sulphur . . . . .	0·067	0·070
Phosphorus . . . . .	0·045	0·058
Manganese . . . . .	1·190	0·510
Iron (by difference) . . .	98·410	99·217
	100·000	100·000

It will be seen that there is nearly  $2\frac{1}{4}$  times the amount of carbon and manganese together in the hard steel than there is in the milder quality, these being the chief factors of hardness. Various purely empirical formulas have been drawn up to express the relation of the tenacity of steel to the amount of carbon and manganese it contains, and Mr. Deshayes, of Terre Noire, has given the following equations for T the tenacity in tons per square inch and the elongation per cent. in 4 inches, in terms of carbon, manganese, phosphorus, and silicon :—<sup>1</sup>

$$T = 19\cdot5 + 11\cdot4 C + 30 C^2 + 11\cdot4 Mn + 9\cdot5 Ph$$

$$\text{Elongation} = 42 - 36 C - 5\cdot5 Mn - 6 Si$$

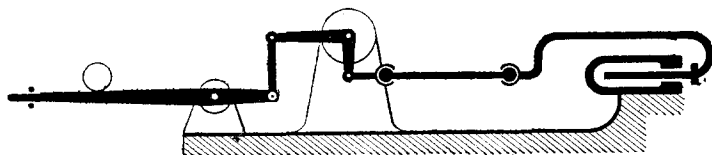
These formulas give T = 38·5 for hard steel, and 28·0 for mild steel, the actual tenacity being 34 and 25 tons per square inch respectively. The calculated elongation is 28·03 per cent. for hard steel, and 34·16 per cent. for mild steel, the actual figures being 28·6 per cent. and 32·7 per cent. respectively; but Mr. Deshayes does not stipulate any diameter, so the Author has taken the mean of all the 4-inch specimens tested. The sulphur is rather high in the mild steel (0·07 per cent.), and it is interesting to know that this particular cast was made during the great strike in Durham, when manufacturers were unable to obtain an equally good quality of coke and iron as those used under ordinary circumstances.

<sup>1</sup> Minutes of Proceedings Inst. C.E., vol. lxxvi. p. 136.

Sufficient material was obtained for three test-pieces of each form experimented upon, but it was decided to take the mean of two tests first, and, if any serious discrepancy arose, to break a third bar. This was only necessary in six cases out of one hundred and thirty tests with the round bars, and it is satisfactory to note the uniformity that good Bessemer steel possesses. The whole of the test-pieces were cut from the original bar in the lathe and turned to gauges specially made for the various diameters experimented upon, this being done to endeavour to obtain an exact ratio of  $\frac{\text{length}}{\text{diameter}}$  without altering the length in a given pair of bars. A slight curve of  $\frac{1}{2}$ -inch radius was left at each end of a test-piece, and the ends screwed for a length of an inch or an inch and a half.

Mr. Barba's tests were confined to ascertaining the effect of increasing ratios of  $\frac{\text{length}}{\text{diameter}}$  on the total extension per cent. of a test-piece. The Author is indebted to Dr. Kennedy, M. Inst. C.E.,

Fig. 1.



for the suggestion that he should note the behaviour of corresponding intermediate lengths in test-pieces of different total lengths; for instance, how far the 2 inches, including fracture in a test-piece 10 inches long, compares with the 2 inches of fracture in an 8-inch bar, and with a 2-inch specimen of the same diameter, and similarly for other intermediate lengths, 4, 6, 8 inches. Before testing, each bar was marked up in inch lengths by means of gauges corrected to  $\frac{1}{1000}$  inch by vernier-callipers; after fracture the two ends were joined and held securely between lathe centres, while the extensions on each inch and the final diameter were being measured.

The testing machine in the engineering laboratory at University College, London, is generally well known;<sup>1</sup> Fig. 1 shows in skeleton the arrangement for tensile tests, from which it will be seen that it is adapted to give a horizontal pull, and has a compound lever system involving the use of a bent lever between

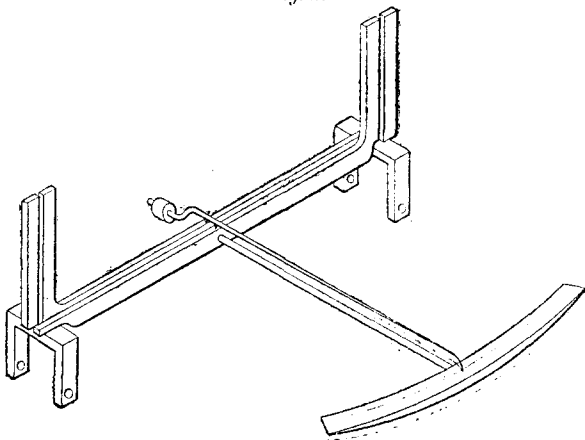
<sup>1</sup> Minutes of Proceedings Inst. C.E., vol. lxxxviii. pp. 10 *et seq.*

the steelyard and the specimen, the total leverage being 100 to 1. The load is applied by the ram and measured by the position of the poise on the steelyard.

Most of the bars were tested by running out the weight, and pumping at the same time, care being taken to keep the steelyard floating until the breakdown point was reached. In all bars of 10 inches and upwards in length readings were taken by means of an extensometer for each increment of stress of 2,000 lbs. per square inch (in the case of bars of more than 10 inches in length the extensions were measured on the middle 10 inches of the bar). The extensometer used was designed by Mr. A. G. Ashcroft, Assoc. M. Inst. C.E.,<sup>1</sup> and has the form shown in *Fig. 2*. The ratio of magnification of this apparatus is 100 to 1.

In the long bars for which readings were taken the stress

*Fig. 2.*



was applied by increments of 2,000 lbs. per square inch, and the corresponding extensions were measured in 10,000ths of an inch. At stresses of 10,000 lbs., 20,000 lbs., 30,000 lbs. &c. per square inch, the load was released in order to see if any permanent set was visible, and this process was repeated up to the limit of elasticity; the extensometer was then removed, and further readings were taken by means of a finely-pointed pair of dividers placed in the 10-inch length centre dots. When the maximum load was reached, and the bar began to draw down as described, the weight was run back and the steelyard was kept floating, to suit the gradually decreasing load on the bar, until the point of fracture; the final load divided by the final area gives the actual breaking-load per

<sup>1</sup> Minutes of Proceedings Inst. C.E., vol. cxvii. p. 322.

square inch of the fractured area. The stress per square inch of original area to which this load corresponds was then calculated; this is invariably less than the maximum load, so that the two quantities must not be confused. In ordinary practice the actual final load is an unknown quantity; its ratio to the maximum load varies with the material, being least in the softest material.

The amount of work done in breaking the bars has been calculated for each bar from Dr. Kennedy's formula

$w x \left( \frac{r + 2}{3} \right)$ , where  $w$  is the maximum stress in tons per square inch,  $x$  the final extension in inches, and  $r$  the ratio  $\frac{\text{limit of elasticity}}{\text{maximum load}}$

The accuracy of this formula has been repeatedly tested by measuring the area of the curve of extensions up to the breaking point, and in all cases it has been found to hold good within 2 or 3 per cent. By dividing the total work done by the original length of the test-piece there is obtained the number of inch-tons required per cubic inch to fracture the bar, and since the chief features of the tensile test are amalgamated in this one expression, it will be seen that this quantity forms of itself a convenient criterion of the test-piece under experiment. The extensions per cent. have been calculated for each inch of the bar both including and excluding the 2 inches of fracture; the latter method seems to give a better criterion of the uniformity of the bar. There seems little doubt that the local contraction in a short length of the bar depends very much on the local conditions of strength and hardness.<sup>1</sup> Professor Unwin quotes an instance of this, in which a very small patch of dark coloured slaggy material, occupying about  $\frac{1}{16}$  of the area of the section of the bar, completely altered the contraction at that place, and Professor Bauschinger,<sup>2</sup> of Munich, has a large collection of test-pieces showing the same effect. If then the stretch of that short portion of the bar in which the local contraction takes place be discarded from the ultimate stretch of the whole bar, there is obtained the most accurate measure of the capability of the bar of taking a large set just beyond the elastic limit. Professor Unwin recommends the deduction of a length equal to two diameters, but unless the test-piece be 1 inch in diameter it would be necessary to mark up the bars in very small lengths; and the Author ventures to suggest that the extension on a constant length of 2 inches, irrespective of the diameter of the bar, would form a more convenient quantity for deducting from the total extension.

<sup>1</sup> Minutes of Proceedings Inst. C.E., vol. lxxvi. p. 92.

<sup>2</sup> *Ibid*, p. 93.

## TESTS OF HARD STEEL.

These tests were made on diameters of  $\frac{1}{2}$  inch,  $\frac{3}{4}$  inch,  $\frac{7}{8}$  inch and 1 inch, and in each of these four series bars were cut to lengths of 2, 4, 6, 8, 10 and 30 diameters between the datum points. The results are given separately in Tables I to IV, Appendix, and the whole are summarized in Table V. The corresponding curves are given in *Fig. 3*. In these Tables the ratio  $\frac{L}{D}$  indicates the number of diameters in the total length between the datum points.

In the curves the abscissas are extensions per cent. plotted to the successive values of  $\frac{L}{D}$  as ordinates.

As will be seen, the curves in *Fig. 3* lie very close together, the  $\frac{1}{2}$ -inch bar having on the whole the greatest extension, especially in the long bars of thirty diameters. The extensions per cent. on the intermediate lengths along the bar decrease gradually as the value of the ratio  $\frac{L}{D}$  increases.

In Table III, the specimens where  $\frac{L}{D} = 4$ , have an exceptionally small extension on the  $1\frac{1}{2}$  inch of the bar neglecting fracture; in these bars the mean total extension was 0.95 inch, of which 0.79 inch has gone in the 2 inches of fracture; the reduction of area is near 4 per cent. higher than the mean of this series, and altogether this is a good example of how the local contraction of area affects the extension in test-pieces.

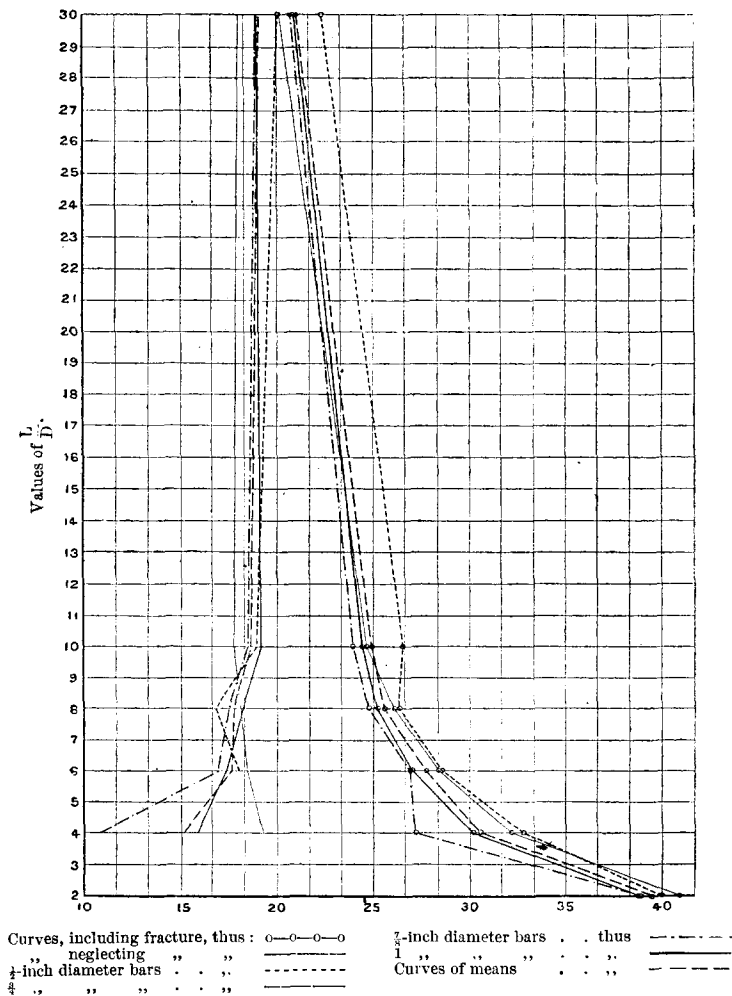
The curves corresponding with the last two columns of Table V, Appendix, being the curves of total extensions per cent. including and excluding fracture for each of the four diameters tested, were found to approach closely to one another. If Barba's law of similarity be taken literally, these curves should all coincide.

In the curves neglecting fracture the extensions per cent. have for convenience of comparison been plotted to the values of  $\frac{L}{D}$  given by the total length including fracture, though these are not the exact positions of the points on the curve; it will be noticed that the mean curve rises gradually, the maximum extension being reached when  $\frac{L}{D}$  is greatest; thus showing that the effect of the local contraction is magnified in the short test-pieces.

In testing a bar 30 inches long, the Author found that the extensions measured on intermediate lengths were considerably higher than those measured on corresponding total lengths of

bars of the same diameter, being as much as 10 per cent. higher when the ratio  $\frac{L}{D} = 2$ , and gradually decreasing to 3 per cent.

Fig. 3.



## HARD STEEL, EXTENSIONS PER CENT.

higher when the ratio  $\frac{L}{D} = 10$ . Mr. Barba carried out a similar set of experiments to these, on one long bar 500 millimetres and ten shorter bars from 50 to 500 millimetres in length; on plotting the





more complete series of bars having the same length but varying in diameter; the results obtained from these experiments are given in Table VI, Appendix. This last series of tests shows conclusively that—

(i.) The total extension per cent. decreases as the ratio  $\frac{L}{D}$  increases, when the length is kept constant and the diameter varies.

(ii.) For a given intermediate length, the extension per cent. decreases as  $\frac{L}{D}$  increases.

(iii.) For a given value of  $\frac{l}{D}$  the extension per cent. increases as  $\frac{L}{D}$  increases, between the limits of 2 and 12 diameters, on which these tests have been carried out.  $\frac{l}{D}$  = number of diameters in any intermediate length of the bar.

#### TESTS OF MILD STEEL.

These tests were conducted in a similar manner to those with hard steel. The results are given in Tables VII to XI, Appendix, and the corresponding curves are shown in *Fig. 4*. These experiments confirm those previously made in hard steel. The slight irregularity in the  $\frac{7}{8}$ -inch bar with ratio  $\frac{L}{D} = 6$  is attributed by the Author to an error in marking off the specimen before testing. The results of the  $\frac{3}{4}$ -inch bars, though very regular in themselves, differ from those of the other three dimensions, the maximum load being slightly higher with a lower reduction of area, while the extensions were 4 to 5 per cent. lower. This fact led the Author to make a fresh analysis from the broken pieces, which agreed so closely with the original that there could be no doubt the specimens were from the same cast. The percentage of sulphur was however higher, and this was possibly due to these particular bars having come more in contact with the flames of the annealing furnace.

Accepting the tests on the  $\frac{3}{4}$ -inch bars, which give uniformly harder results, it will be seen that Barba's law of similarity holds good within 3 per cent., and for the shorter bars up to those where the ratio  $\frac{L}{D} = 10$  the maximum difference is 2.12 per cent.

On plotting the extensions on the intermediate lengths of a 30-inch bar in comparison with those on the corresponding total length of shorter bars, the curves of the actual extensions were found to approach more closely than in the case of the similar

tests in hard steel; but the curve for the short bars had a tendency to become a straight line. It would seem then that, given the results of two bars of the same material and same diameter but different length, by plotting the actual extensions to the original length of the test-pieces, a very close approximation could be obtained as to the probable extension on a bar of any other length. For instance, taking an extreme case, given the extensions on bars 2 inches and 4 inches long, the error on 30 inches is  $4\frac{1}{2}$  per cent. for the mild steel, and only  $2\frac{1}{2}$  per cent. for the hard steel; but on 10 inches the error is 0.3 per cent. on each, becoming still less as smaller lengths are chosen.

An analysis of Tables V and XI, Appendix, shows that, taking the average of all the total extensions for a given value of  $\frac{L}{D}$ , the mean difference between

$\frac{L}{D} = 2$  and  $\frac{L}{D} = 4$  is 9 per cent. in hard and 10 per cent. in mild steel.

$\frac{L}{D} = 4$  and  $\frac{L}{D} = 6$  is 3        "        "        2.5        "        "

$\frac{L}{D} = 6$  and  $\frac{L}{D} = 8$  is 2        "        "        3        "        "

$\frac{L}{D} = 8$  and  $\frac{L}{D} = 10$  is 0.7        "        "        1        "        "

$\frac{L}{D} = 10$  and  $\frac{L}{D} = 30$  is 4        "        "        6        "        "

this last being a much wider range. It appears, then, that the difference between the percentages of extension on eight and ten diameters is so small that tests carried out on these ratios may practically be considered comparable. No doubt the difference between two higher ratios of  $\frac{L}{D}$  such as twenty-two and twenty-four diameters would be still smaller, but in ordinary testing it would rarely happen that such a ratio could be obtained, whereas eight or ten diameters is by no means so difficult to get.

To sum up the results of the foregoing tests it seems that, when ductile materials are subjected to tensile stress:

- (i.) The total extension per cent. decreases as the ratio  $\frac{L}{D}$  increases, whether length or diameter is varied. (ii.) The extension per cent. decreases as  $\frac{l}{D}$  increases, whether length or diameter is varied. (iii.) For a given value of  $\frac{l}{D}$  the extension per cent.

increases as  $\frac{L}{D}$  increases until a maximum is reached in bars of about ten diameters in length, falling off again in the higher ratio of  $\frac{\text{length}}{\text{diameter}}$ . (iv.) Bars of similar form give similar percentages of extension. (v.) The total extension on a bar of given length is less than the extension including fracture on a corresponding intermediate length of a longer bar of the same diameter, the difference becoming greater as the value of  $\frac{L}{D}$  in the longer bar increases, until  $\frac{L}{D} = 10$  or thereabouts. (vi.) Bars of large diameter afford a better criterion of the average ductility of the material under test than those of smaller diameter. (vii.) Bars of eight or ten diameters in length give the most useful results for the purposes of general comparison.

#### TESTS OF FLAT BARS.

A series of tests were made on twenty-four bars of the same length, but varying in ratio of  $\frac{\text{width}}{\text{thickness}}$ ; and on twenty-four bars of similar dimensions, but varying in the form of the ends. The material used in these tests was very hard Bessemer steel, having a chemical composition of—

	Per cent.
Carbon . . . . .	0·440
Silicon . . . . .	0·052
Sulphur . . . . .	0·052
Phosphorus . . . . .	0·053
Manganese . . . . .	1·020
Iron . . . . .	98·383
	<hr/> 100·000 <hr/>

The treatment was the same as for the round bars, except that the final rolled section was 4 inches by  $\frac{3}{8}$  inch; the test-pieces were cut in the shaping machine to the required lengths and widths, the thickness of the test-pieces being that of the rolled bar. Mr. Barba tested eight bars in which the ratio  $\frac{\text{width}}{\text{thickness}}$  rose from 1 to 8, and found that as this ratio increased the percentage of extension became greater until a maximum was reached at the ratio  $\frac{W}{T} = 6$ , from which point the extensions fell off.

Table XII, Appendix, gives the results of twenty-four experi-

ments made with a view of ascertaining how far Barba's results in mild steel were applicable to the hard steel described.

Working with the same ratios of  $\frac{\text{width}}{\text{thickness}}$ , and with approximately the same cross-sections, the Author found that the extension per cent. increased steadily up to the ratio  $\frac{W}{T} = 5$ . The

results for the next ratio cannot be regarded as indicative of the average quality of the material, owing to the presence of two exceptionally hard bars; but the mean extension of the next three bars being 18.3 per cent., and of the last set 20.1 per cent., seems to show that after a ratio of 5 or 6 has been reached in hard steel, there is still a tendency to increase in the extension.

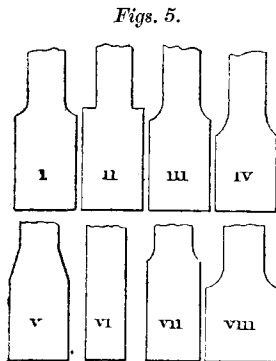
The actual initial ratio of  $\frac{W}{T}$  for each bar is shown in the fourth column of Table XII; the final ratio of  $\frac{W}{T}$  after fracture was calculated for each bar, and is given in the tenth column. A comparison of the two shows that the final ratio is slightly the higher, showing that the material has drawn down more in the thickness than in the width. In the course of the discussion on Mr. Hackney's Paper,<sup>1</sup> Mr. Wrightson pointed out that in testing iron the reverse was the case, and attributed this "to the fact that the rolls in rolling the iron compressed it more in the thickness, and that the side action of the rolls did not compress the particles so thoroughly, the consequence of which would be that the internal strains of the iron, when under test, would not cause the same amount of compression in the direction of its thickness as in the direction of its breadth." The Author ventures to express the opinion, based on a large number of tests of various qualities of wrought iron and steel, that this unevenness should rather be attributed to the laminated structure of wrought-iron which is caused by the "piling" process in the earlier stages of its manufacture. In steel, however, the structure of the material is so different, and the composition so much more uniform, that there is but little difference between the proportions of the final section and those of the original test-piece.

*Tests of Flat Strips having different forms of End.*—In 1884 Dr. Kennedy made a series of tests of very soft basic steel, to investigate the effect of various forms of ends; he experimented on the eight types shown in *Figs. 5*. No. 1 is the standard form used for plate tests in the German official testing establishments;

<sup>1</sup> Minutes of Proceedings Inst. C.E., vol. lxxvi. p. 119.

No. 2 had square shoulders; No. 6 had no enlargement at the ends; No. 5 had a straight taper; the others being forms with various radii not quadrants of circles. Nos. 7 and 8 had the same radius,

but No. 8 was given much wider ends. He made twenty-four experiments with these eight forms, three of each, but there were no discrepancies which could be directly traced to the form of ends. All broke in or towards the middle; but in testing form No. 2 against form No. 7 in common wrought-iron plate there was not only a great difference in the elongation and reduction of area per cent., but also in the strength. To investigate the effect of these various forms of ends on hard steel, the Author made the tests summarized in Table XIII. A glance at the Table will show



Scale, half full size.

that there is no appreciable difference between forms Nos. 1, 3, 4, 5, 7, and 8, though No. 4 has slightly less extension per cent. But No. 2 gave strikingly conclusive evidence of the effect of square shoulders; each of the four bars broke sharp off at the shoulders, outside the gauge mark, with a slightly rounded outline. The maximum load was only 30 tons per square inch, or 25 per cent. below the average of the other twenty-one bars, the extension being as low as 2 per cent. on the 10 inches, and the reduction of area only  $5\frac{1}{2}$  per cent. The fracture was very crystalline in all the bars of this form of rail. The parallel strips also gave very uneven results so far as elongation and reduction of area are concerned. The first two broke near one end with a regular crystalline fracture, but the maximum load was not affected. It would seem, then, that this form of test-piece should be avoided for hard material on account of the influence of the wedges.

In conclusion, the Author advocates the use of some standard proportions of test-pieces, in order that the results of different experimenters may be more directly comparable. He also wishes to tender his thanks to Prof. T. Hudson Beare, of University College, for the facilities kindly afforded to him for carrying out the experiments.

The Paper is accompanied by numerous diagrams, from some of which the *Figs.* in the text have been prepared.

## APPENDIX.

TABLE I.—HARD STEEL.  $\frac{1}{2}$ -INCH DIAMETER BARS.

Number of Tests Made.	Test Number.	Dimensions.				Resistance.			Reduction of Area.	Work Done.		Extensions per Cent.	
		Length.	Diameter.	Ratio $\frac{L}{D}$ .	Area.	Limit of Elasticity.	Maximum Load.	Ratio $\frac{L}{E.}$ Max. Load		Total.	Per Cubic Inch.	(i) Including Fracture—Total.	(ii) Neglecting $\frac{2}{2}$ inches of Fracture—Total.
		Ins.	Inch.		Square Inch.	Tons per Sq. Inch.	Tons per Sq. Inch.		Per cent.	Inch-Tons.	Inch-Tons.		
2	53	1·0	0·500	2·0	0·196	22·33	35·42	0·631	55·37	11·930	11·930	40·00	..
2	17	2·0	0·500	4·0	0·196	22·46	34·35	0·654	57·87	19·895	9·948	32·75	..
2	18	3·0	0·500	6·0	0·196	21·68	33·88	0·641	56·35	25·470	8·489	28·50	18·00
2	19	4·0	0·500	8·0	0·196	22·21	33·60	0·661	59·45	31·420	7·855	26·37	16·75
2	20	5·0	0·500	10·0	0·196	21·82	34·17	0·638	56·00	39·940	7·988	26·60	19·00
2	21	6·0	0·500	12·0	0·196	21·84	33·62	0·649	59·00	44·930	7·489	25·25	19·12
2	22	15·0	0·500	30·0	0·196	21·43	33·12	0·647	54·90	97·890	6·526	22·33	20·05

TABLE II.—HARD STEEL.  $\frac{3}{4}$ -INCH DIAMETER BARS.

Number of Tests Made.	Test Number.	Dimensions.				Resistance.			Reduction of Area.	Work Done.		Extensions per Cent.	
		Length.	Diameter.	Ratio $\frac{L}{D}$ .	Area.	Limit of Elasticity.	Maximum Load.	Ratio $\frac{L}{E.}$ Max. Load		Total.	Per Cubic Inch.	(i) Including Fracture—Total.	(ii) Neglecting $\frac{2}{2}$ inches of Fracture—Total.
		Ins.	Inch.		Square Inch.	Tons per Sq. Inch.	Tons per Sq. Inch.		Per cent.	Inch-Tons.	Inch-Tons.		
3	55	1·5	0·750	2·000	0·4417	24·82	36·14	0·687	58·27	19·86	13·24	40·89	..
2	56	3·0	0·750	4·000	0·4417	23·82	34·06	0·700	58·77	29·73	9·91	32·34	19·00
3	57	4·5	0·750	6·000	0·4417	23·78	34·25	0·714	58·92	39·59	8·66	28·37	18·53
3	58	6·0	0·748	8·021	0·4393	22·74	34·95	0·651	57·74	48·63	8·10	26·11	18·17
2	59	7·5	0·750	10·000	0·4417	22·95	33·45	0·686	60·46	55·39	7·39	24·66	17·80
3	60	22·5	0·750	30·000	0·4417	22·32	33·63	0·664	57·50	135·30	6·01	20·13	18·13

TABLE III.—HARD STEEL.  $\frac{3}{8}$ -INCH DIAMETER BARS.

Number of Tests Made.	Test Number.	Dimensions.				Resistance.			Reduction of Area.	Work Done.		Extensions per Cent.	
		Length.	Diameter.	Ratio $\frac{L}{D}$ .	Area.	Limit of Elasticity.	Maximum Load.	Ratio $\frac{L}{L \text{ of E. Max. Load}}$ .		Total.	Per Cubic Inch.	(i) Including Fracture—Total.	(ii) Neglecting $\frac{1}{2}$ Inches of Fracture—Total.
		Ins.	Inch.		Square Inch.	Tons per Sq. Inch.	Tons per Sq. Inch.		Per cent.	Inch-Tons.	Inch-Tons.		
3	23	1.75	0.875	2.00	0.601	24.55	37.98	0.648	58.23	22.92	13.100	38.86	..
2	24	3.50	0.875	4.00	0.601	24.52	37.63	0.652	61.76	31.78	9.082	27.28	10.65
2	25	5.25	0.873	6.01	0.598	23.67	34.32	0.689	57.78	43.52	8.290	26.95	16.75
2	26	7.00	0.875	8.00	0.601	22.83	34.57	0.660	58.59	53.16	7.590	24.79	17.50
2	27	8.75	0.874	10.01	0.600	24.59	34.68	0.709	57.31	65.78	7.520	24.00	18.50
2	28	26.25	0.875	30.00	0.601	22.32	33.85	0.659	55.12	160.55	6.117	20.63	18.85

TABLE IV.—HARD STEEL. 1-INCH DIAMETER BARS.

Number of Tests Made.	Test Number.	Dimensions.				Resistance.			Reduction of Area.	Work Done.		Extensions per Cent.	
		Length.	Diameter.	Ratio $\frac{L}{D}$ .	Area.	Limit of Elasticity.	Maximum Load.	Ratio $\frac{L}{L \text{ of E. Max. Load}}$ .		Total.	Per Cubic Inch.	(i) Including Fracture—Total.	(ii) Neglecting $\frac{1}{2}$ Inches of Fracture—Total.
		Ins.	Inch.		Square Inch.	Tons per Sq. Inch.	Tons per Sq. Inch.		Per cent.	Inch-Tons.	Inch-Tons.		
2	29	2.0	0.997	2.006	0.7810	23.38	36.05	0.649	55.96	24.65	12.330	38.75	..
2	30	4.0	0.996	4.016	0.7792	22.53	34.79	0.648	57.84	37.14	9.284	30.25	15.75
2	31	6.0	1.000	6.000	0.7854	22.06	34.37	0.642	57.38	49.01	8.170	27.00	17.37
2	32	8.0	1.000	8.000	0.7854	22.52	34.27	0.657	57.35	61.07	7.755	25.16	18.29
3	33	10.0	1.000	10.000	0.7854	21.42	33.94	0.631	56.43	73.00	7.300	24.50	19.21
3	34	30.0	1.000	30.000	0.7854	21.73	33.18	0.655	59.11	183.50	6.120	20.83	18.85



TABLE V.—HARD STEEL.

Number of Tests Made.	Dimensions.				Resistance.			Reduction of Area.	Work Done.		Extensions per Cent.	
	Length.	Diameter.	Ratio $\frac{L}{D}$ .	Area.	Limit of Elasticity.	Maximum Load.	Ratio $\frac{L}{L \text{ of E. Max. Load}}$ .		Total.	Per Cubic Inch.	(i) Including Fracture—Total.	(ii) Neglecting 2 Inches of Fracture—Total.
	Ins.	Inch.		Square Inch.	Tons per Sq. Inch.	Tons per Sq. Inch.		Per cent.	Inch-Tons.	Inch-Tons.		
2	1	1 $\frac{1}{4}$ 1 $\frac{1}{2}$ 1 $\frac{3}{4}$ 2	2	0·1960	22·33	35·42	0·631	55·37	11·93	11·93	40·00	..
3	1 $\frac{1}{2}$			0·4417	24·82	36·14	0·687	58·27	19·86	13·24	40·89	..
3	1 $\frac{3}{4}$			0·6010	24·55	37·98	0·648	58·23	22·92	13·10	38·86	..
2	2			0·7810	23·38	36·05	0·649	55·96	24·65	12·33	38·75	..
Mean	..	..	..	..	23·77	36·90	0·654	56·96	..	12·65	39·62	..
2	2	1 $\frac{1}{2}$ 1 $\frac{3}{4}$ 2 4	4	0·1960	22·46	34·35	0·654	57·87	19·89	9·95	32·75	..
2	3			0·4417	23·82	34·06	0·700	58·77	29·73	9·91	32·34	19·00
2	3 $\frac{1}{2}$			0·6010	24·52	37·63	0·652	61·76	31·78	9·08	27·28	10·65
2	4			0·7800	22·53	34·79	0·648	57·84	37·14	9·28	30·25	15·75
Mean	..	..	..	..	23·33	35·21	0·663	59·06	..	9·55	30·65	15·13
2	3	1 $\frac{1}{2}$ 1 $\frac{3}{4}$ 2 6	6	0·196	21·68	33·88	0·641	56·35	25·47	8·49	28·50	18·00
3	4 $\frac{1}{2}$			0·441	23·78	34·25	0·714	58·92	39·59	8·66	28·37	18·53
2	5 $\frac{1}{4}$			0·601	23·67	34·32	0·689	57·78	43·52	8·29	26·95	16·73
2	6			0·782	22·06	34·37	0·642	57·38	49·01	8·17	27·00	17·37
Mean	..	..	..	..	22·90	34·20	0·671	57·61	..	8·40	27·71	17·66
2	4	1 $\frac{1}{2}$ 1 $\frac{3}{4}$ 2 8	8	0·1960	22·21	33·60	0·661	59·45	31·42	7·85	26·37	16·75
3	6			0·4400	22·74	34·95	0·651	57·74	48·63	8·10	26·11	18·17
2	7			0·6010	22·83	34·57	0·660	58·59	53·16	7·59	24·79	17·50
2	8			0·7854	22·52	34·27	0·657	57·35	61·07	7·75	25·16	18·29
Mean	..	..	..	..	22·57	34·35	0·657	58·28	..	7·82	25·61	17·66
2	5	1 $\frac{1}{2}$ 1 $\frac{3}{4}$ 2 10	10	0·1960	21·82	34·17	0·638	56·00	39·94	7·99	26·60	19·00
2	7 $\frac{1}{2}$			0·4417	22·95	33·45	0·686	60·46	55·39	7·39	24·66	17·80
2	8 $\frac{3}{4}$			0·6010	24·59	34·68	0·709	57·31	65·78	7·52	24·00	18·50
3	10			0·7850	21·42	33·94	0·631	56·43	73·00	7·30	24·50	19·21
Mean	..	..	..	..	22·69	34·06	0·666	57·55	..	7·55	24·94	18·63
2	15	1 $\frac{1}{2}$ 1 $\frac{3}{4}$ 2 30	30	0·1960	21·43	33·12	0·647	54·90	97·89	6·53	22·33	20·05
3	22 $\frac{1}{4}$			0·4417	22·32	33·63	0·664	57·50	135·30	6·01	20·13	18·13
2	26 $\frac{1}{4}$			0·6010	22·32	33·85	0·659	55·12	160·55	6·12	20·63	18·85
3	30			0·7854	21·73	33·18	0·655	59·11	183·50	6·12	20·83	18·85
Mean	..	..	..	..	21·95	33·44	0·656	56·66	..	6·19	20·98	18·97

TABLE VI.—HARD STEEL.—SUMMARY OF TESTS MADE ON BARS OF CONSTANT LENGTH AND VARYING DIAMETER.

Number of Tests Made.	Test Number.	Dimensions.				Resistance.			Reduction of Area.	Work Done.		Extensions per Cent.	
		Length.	Diameter.	Ratio L. D.	Area.	Limit of Elasticity.	Maximum Load.	Ratio L. of E. Max. Load.		Total.	Per Cubic Inch.	(i) Including Fracture—Total.	(ii) Neglecting 2 inches of Fracture—Total.
		Ins.	Inch.		Square Inch.	Tons per Sq. Inch.	Tons per Sq. Inch.		Per cent.	Inch-Tons.	Inch-Tons.		
2	29	2·0	0·997	2·006	0·7810	23·38	36·05	0·649	55·96	24·65	12·83	38·75	..
2	68	2·0	0·876	2·283	0·6020	23·81	36·02	0·661	55·06	22·54	11·27	35·25	..
2	67	2·0	0·750	2·667	0·4417	24·72	36·27	0·682	53·63	21·72	10·86	33·50	..
2	17	2·0	0·500	4·000	0·1960	22·46	34·35	0·654	57·87	19·90	9·95	32·75	..
2	69	3·0	1·000	3·000	0·7854	23·69	36·18	0·655	55·78	32·18	10·73	33·50	18·5
2	70	3·0	0·876	3·425	0·6020	23·51	35·26	0·667	56·69	30·40	10·13	32·67	17·5
2	56	3·0	0·750	4·000	0·4417	23·82	34·06	0·700	58·77	29·73	9·91	32·34	19·0
2	18	3·0	0·500	6·000	0·1960	21·68	33·88	0·641	56·35	25·47	8·49	28·50	18·0
2	30	4·0	0·996	4·016	0·7792	22·53	34·79	0·648	57·84	37·14	9·28	30·25	15·75
2	72	4·0	0·876	4·566	0·6020	23·06	35·87	0·643	57·74	37·26	9·31	29·50	15·75
2	71	4·0	0·751	5·326	0·4428	25·25	35·61	0·709	58·57	36·49	9·12	28·38	16·25
2	19	4·0	0·500	8·000	0·1960	22·21	33·60	0·661	59·45	31·42	7·85	26·37	16·75
2	31	6·0	1·000	6·000	0·7854	22·06	34·37	0·642	57·38	49·01	8·17	27·00	17·37
2	74	6·0	0·875	6·86	0·6010	23·83	35·88	0·665	57·85	49·55	8·26	25·92	17·37
2	73	6·0	0·749	8·01	0·4406	25·11	35·23	0·713	57·57	48·27	8·04	25·42	17·75
2	21	6·0	0·500	12·00	0·1960	21·84	33·62	0·649	59·00	44·93	7·49	25·25	19·12

TABLE VII.—MILD STEEL.  $\frac{1}{2}$ -INCH DIAMETER BARS.

Number of Tests Made.	Test Number.	Dimensions.				Resistance.			Reduction of Area.	Work Done.		Extensions per Cent.	
		Length.	Diameter.	Ratio L D	Area.	Limit of Elasticity.	Maximum Load.	Ratio L <sub>e</sub> of E. Max. Load		Total.	Per Cubic Inch.	(i) Including Fracture— Total.	(ii) Neglecting 2 inches of Fracture—Total.
2	54	1.0	0.500	2	Square Inches. 0.196	Tons per Sq. Inch. 20.34	Tons per Sq. Inch. 28.39	0.716	63.74	12.21	12.21	47.50	..
2	35	2.0	0.500	4	0.196	18.68	25.73	0.726	61.97	17.54	8.77	37.50	..
2	36	3.0	0.500	6	0.196	18.93	25.35	0.747	62.01	22.87	7.62	32.83	21.00
2	37	4.0	0.500	8	0.196	18.27	25.10	0.728	62.87	26.87	6.72	30.13	21.25
2	38	5.0	0.500	10	0.196	18.15	25.19	0.721	63.49	31.98	6.49	28.00	20.00
3	40	15.0	0.500	30	0.196	16.66	25.30	0.659	62.07	69.29	4.62	20.71	17.81

TABLE VIII.—MILD STEEL.  $\frac{3}{4}$ -INCH DIAMETER BARS.

Number of Tests Made.	Test Number.	Dimensions.				Resistance.			Reduction of Area.	Work Done.		Extensions per Cent.	
		Length.	Diameter.	Ratio L D	Area.	Limit of Elasticity.	Maximum Load.	Ratio L <sub>e</sub> of E. Max. Load		Total.	Per Cubic Inch.	(i) Including Fracture— Total.	(ii) Neglecting 2 inches of Fracture—Total.
2	61	1.5	0.750	2.000	0.4417	Square Inch. 19.35	Tons per Sq. Inch. 27.28	0.710	52.91	14.90	9.94	40.33	..
2	62	3.0	0.748	4.010	0.4393	20.24	27.08	0.747	59.77	21.71	7.24	29.00	13.00
2	63	4.5	0.750	6.000	0.4417	20.47	27.07	0.756	53.16	32.99	7.33	29.44	19.00
3	64	6.0	0.750	8.080	0.4417	21.78	27.21	0.801	55.07	40.19	6.37	26.44	18.83
2	65	7.5	0.750	10.000	0.4417	20.22	26.97	0.750	53.23	47.60	6.35	25.67	19.70
2	66	22.5	0.750	30.000	0.4417	17.86	26.78	0.667	55.08	108.25	4.77	20.20	18.24

TABLE IX.—MILD STEEL.  $\frac{7}{8}$ -INCH DIAMETER BARS.

Number of Tests Made.	Test Number.	Dimensions.				Resistance.			Reduction of Area.	Work Done.		Extensions per Cent.	
		Length.	Diameter.	Ratio $\frac{L}{D}$ .	Area.	Limit of Elasticity.	Maximum Load.	Ratio $\frac{L}{L. of E. Max. Load}$ .		Total.	Per Cubic Inch.	(i) Including Fracture—Total.	(ii) Neglecting $\frac{2}{8}$ inches of Fracture—Total.
		Inch.	Inch.		Square Inch.	Tons per Sq. Inch.	Tons per Sq. Inch.		Per cent.	Inch-Tons.	Inch-Tons.		
2	41	1.75	0.875	2	0.6010	18.22	25.92	0.704	62.49	18.57	10.61	45.43	..
2	42	3.50	0.875	4	0.6010	18.74	25.36	0.739	62.75	29.38	8.39	36.29	20.60
2	43	5.25	0.875	5.993	0.6028	19.61	25.15	0.779	62.31	41.83	7.97	34.19	24.58
2	44	7.00	0.875	8	0.6010	19.02	25.39	0.749	63.37	49.07	7.01	30.14	22.00
2	45	8.75	0.875	10	0.6010	18.19	25.18	0.722	63.58	59.33	6.78	29.66	22.95
2	46	26.25	0.875	30	0.6010	16.96	25.00	0.678	62.13	140.20	5.34	23.88	21.78

TABLE X.—MILD STEEL. 1-INCH DIAMETER BARS.

Number of Tests Made.	Test Number.	Dimensions.				Resistance.			Reduction of Area.	Work Done.		Extensions per Cent.	
		Length.	Diameter.	Ratio $\frac{L}{D}$ .	Area.	Limit of Elasticity.	Maximum Load.	Ratio $\frac{L}{L. of E. Max. Load}$ .		Total.	Per Cubic Inch.	(i) Including Fracture—Total.	(ii) Neglecting $\frac{2}{8}$ inches of Fracture—Total.
		Inch.	Inch.		Square Inch.	Tons per Sq. Inch.	Tons per Sq. Inch.		Per cent.	Inch-Tons.	Inch-Tons.		
2	47	2	1.000	2	0.7854	19.77	25.54	0.774	62.70	21.50	10.75	45.50	..
2	48	4	1.000	4	0.7854	20.05	25.24	0.795	62.97	33.26	8.31	35.38	18.00
2	49	6	1.000	6	0.7854	20.29	25.21	0.805	64.14	45.37	7.57	32.09	21.63
2	50	8	1.000	8	0.7854	18.60	25.20	0.738	63.00	53.93	6.75	29.44	22.08
1	51	10	1.000	10	0.7854	16.07	25.89	0.621	56.44	63.78	6.38	28.20	22.50
3	52	30	1.000	30	0.7854	16.66	25.89	0.644	58.27	150.37	5.01	21.97	19.70

TABLE XI.—MILD STEEL.

Number of Tests in Mean.	Dimensions.				Resistance.			Reduction of Area.	Work Done.		Extensions per Cent.	
	Length.	Diameter.	Ratio $\frac{L}{D}$ .	Area.	Limit of Elasticity.	Maximum Load.	Ratio $\frac{L}{D}$ of E. Max. Load.		Total.	Per Cubic Inch.	(1) Including Fracture—Total.	(2) Neglecting 2 inches of Fracture—Total.
2	1	1	2	Square Inch.	Tons per Sq. Inch.	Tons per Sq. Inch.		Per cent.	Inch-Tons.	Inch-Tons.		
2	1½	1		0.1960	20.34	28.39	0.716	63.74	12.21	12.21	47.50	..
2	1½	1		0.4417	19.35	27.28	0.710	52.91	14.90	9.95	40.33	..
2	2	1		0.6010	18.22	25.92	0.704	62.49	18.57	10.61	45.43	..
2	2	1		0.7854	19.77	25.54	0.774	62.70	21.50	10.75	45.50	..
Mean	..	..	..	..	19.42	26.78	0.726	60.46	..	10.88	44.69	..
2	2	1	4	0.1960	18.68	25.73	0.726	61.97	17.54	8.77	37.50	..
2	3	1		0.4405	20.24	27.08	0.747	59.77	21.71	7.24	29.00	13.0
2	3½	1		0.6010	18.74	25.36	0.739	62.75	29.38	8.39	36.29	20.6
2	4	1		0.7854	20.05	25.24	0.795	62.97	33.26	8.31	35.38	18.0
Mean	..	..	..	..	19.43	25.85	0.752	61.86	..	8.18	34.54	17.2
2	3	1	6	0.1960	18.93	25.35	0.747	62.01	22.87	7.62	32.83	21.00
2	4½	1		0.4411	20.47	27.07	0.756	53.16	32.99	7.33	29.44	19.00
2	5½	1		0.6019	19.61	25.15	0.779	62.31	41.83	7.97	34.19	24.58
2	6	1		0.7854	20.29	25.21	0.805	64.14	45.37	7.57	32.09	21.63
Mean	..	..	..	..	19.82	25.69	0.772	60.40	..	7.62	32.14	21.55
2	4	1	8	0.1960	18.27	25.10	0.728	62.87	26.87	6.72	30.13	21.25
3	6	1		0.4417	21.78	27.21	0.801	55.07	40.19	6.37	26.44	18.83
2	7	1		0.6010	19.02	25.39	0.749	63.37	49.07	7.01	30.14	22.00
2	8	1		0.7854	18.60	25.20	0.738	63.00	53.93	6.75	29.44	22.08
Mean	..	..	..	..	19.42	25.72	0.754	61.08	..	6.71	29.04	21.04
2	5	1	10	0.1960	18.15	25.19	0.721	63.49	31.98	6.49	28.00	20.00
2	7½	1		0.4417	20.22	26.97	0.750	53.23	47.60	6.35	25.67	19.70
2	8¾	1		0.6010	18.19	25.18	0.722	63.58	59.33	6.78	29.66	22.95
1	10	1		0.7854	16.07	25.89	0.621	56.44	63.78	6.38	28.20	22.50
Mean	..	..	..	..	18.16	25.81	0.703	59.18	..	6.50	27.88	21.29
3	15	1	30	0.1960	16.66	25.30	0.659	62.07	69.29	4.62	20.71	17.81
2	22½	1		0.4417	17.86	26.78	0.667	55.08	108.25	4.77	20.20	18.24
2	26½	1		0.6000	16.96	25.00	0.678	62.13	140.20	5.34	23.88	21.78
3	30	1		0.7854	16.66	25.89	0.644	58.27	150.37	5.01	21.97	19.70
Mean	..	..	..	..	17.04	25.74	0.662	59.39	..	4.94	21.69	19.38

TABLE XII.—SUMMARY OF TESTS OF HARD STEEL STRIPS

Number of Tests Made.	Test Number.	Dimensions.				Resistance.			Reduction of Area.	Final Ratio $\frac{\text{Width}}{\text{Thickness}}$	Work Done per Cubic Inch.	Extensions per Cent.—			
		Thickness.	Width.	Ratio $\frac{W}{T}$ .	Area.	Limit of Elasticity.	Maximum Load.	L. of E. Ratio Max. Load.				10 inches.	9 inches.	8 inches.	7 inches.
		Inch.	Inch.		Sq. Inch.	Tons Sq. In.	Tons Sq. In.		Per cent.		Inch-Tons.				
3	9	0.376	0.376	1.010	0.1414	25.71	40.90	0.629	39.84	1.021	5.31	14.83	15.40	15.87	16.48
3	10	0.381	0.751	2.004	0.2861	24.96	42.20	0.591	37.82	2.069	5.65	15.57	16.37	16.87	17.23
3	11	0.381	1.125	2.990	0.4285	23.37	41.37	0.565	35.97	3.104	5.97	16.87	17.53	18.49	19.25
3	12	0.373	1.503	4.012	0.5606	24.06	41.18	0.584	30.29	4.055	6.34	17.87	18.70	19.37	20.00
3	13	0.375	1.888	5.025	0.7080	24.08	41.59	0.611	32.91	5.259	6.73	18.60	19.29	19.83	20.52
3	14	0.372	2.243	6.014	0.8344	24.19	41.43	0.583	23.85	6.189	5.22	14.63	15.43	15.97	17.00
3	15	0.377	2.630	6.972	0.9912	24.29	41.66	0.583	28.31	7.110	6.58	18.33	19.40	20.33	21.15
3	16	0.373	3.004	8.050	1.1205	24.42	40.99	0.596	31.26	8.271	7.11	20.10	21.32	22.33	23.72

TABLE XIII.—SUMMARY OF TESTS OF HARD

Number of Tests Made.	Form.	Dimensions.				Resistance.			Reduction of Area.	Work Done.	Extensions per Cent.—				
		Length.	Thickness.	Width.	Area.	Limit of Elasticity.	Maximum Load.	L. of E. Ratio Max. Load.			Per Cubic Inch.	10 inches.	9 inches.	8 inches.	7 inches.
		Inches.	Inches.	Inches.	Square Inches.	Tons Sq. In.	Tons Sq. In.	Tons Sq. In.	Per cent.	Inch-Tons.					
2	I	10	0.377	1.500	0.5635	24.07	41.44	0.581	36.31	6.330	17.75	18.55	18.91	19.70	
4	II	10	0.377	1.494	0.5632	24.10	30.96	0.779	5.43	0.566	..	..	..	..	
3	III	10	0.372	1.500	0.5580	23.64	39.67	0.596	38.33	6.470	18.83	19.63	20.63	21.67	
3	IV	10	0.380	1.500	0.5700	24.14	40.82	0.591	36.11	6.130	17.40	18.03	18.79	19.53	
3	V	10	0.375	1.500	0.5625	23.41	40.26	0.582	38.06	6.380	18.80	19.67	20.42	21.20	
3	VI	10	0.378	1.510	0.5708	24.18	40.94	0.591	14.78	3.790	10.73	10.90	10.79	10.90	
3	VII	10	0.381	1.500	0.5715	23.14	40.16	0.576	34.79	6.470	18.77	19.56	19.88	19.73	
3	VIII	10	0.378	1.500	0.5670	22.85	39.72	0.575	40.21	6.340	18.50	19.02	19.67	20.33	

VARYING IN RATIO OF  $\frac{\text{WIDTH}}{\text{THICKNESS}}$  LENGTH, 10 INCHES.

(i) Including Fracture.						Extensions per Cent.—(ii) Neglecting 2 inches of Fracture.								
6 inches.	5 inches.	4 inches.	3 inches.	2 inches.	1 inch.	8 inches.	7 inches.	6 inches.	5 inches.	4 inches.	3 inches.	2 inches.	1 inch.	
17·22	18·20	19·33	21·33	24·33	26·67	12·46	12·81	13·04	13·33	13·67	14·11	14·18	15·33	
17·67	18·33	19·83	21·87	25·83	31·67	13·00	13·67	13·90	13·80	13·75	13·33	13·83	14·00	
20·28	21·50	23·17	25·67	29·33	39·00	13·73	14·17	14·83	15·20	15·75	16·33	17·00	18·33	
21·00	22·07	23·92	26·44	29·17	36·00	15·03	15·73	16·11	16·27	16·92	17·33	18·67	19·00	
21·50	22·33	24·83	27·06	31·33	40·67	15·42	15·80	15·99	16·20	16·58	16·78	18·33	19·00	
17·59	18·60	19·75	22·22	24·67	30·67	12·12	12·83	13·11	13·80	14·08	14·54	14·83	17·33	
22·44	24·20	26·08	28·67	33·67	40·67	14·50	15·33	15·89	16·13	16·80	17·89	18·50	18·67	
25·28	26·93	29·08	32·11	37·00	47·00	15·86	16·90	17·44	18·40	19·75	20·22	21·17	22·33	

## STEEL STRIPS VARYING IN FORM OF ENDS.

(i) Including Fracture.						Extensions per Cent.—(ii) Neglecting 2 inches of Fracture.								
6 inches.	5 inches.	4 inches.	3 inches.	2 inches.	1 inch.	8 inches.	7 inches.	6 inches.	5 inches.	4 inches.	3 inches.	2 inches.	1 inch.	
20·58	21·70	23·25	26·50	31·50	37·50	14·30	14·85	14·91	15·00	15·12	15·15	15·00	16·50	
..	..	..	..	..	..	2·04	1·98	01·98	2·05	1·88	1·93	2·00	2·00	
22·50	23·93	24·92	28·78	33·67	42·33	15·12	15·70	16·28	16·87	16·92	17·43	17·83	19·00	
20·56	21·90	23·50	26·33	31·00	40·00	13·99	14·33	14·72	14·93	15·33	15·78	16·00	17·00	
22·22	23·60	25·42	28·44	33·17	42·30	15·21	15·80	16·20	16·40	16·75	17·22	17·67	19·00	
10·95	11·13	11·58	11·89	12·33	12·67	10·32	10·53	10·30	10·33	10·25	10·33	10·83	11·00	
20·33	21·53	23·25	25·56	29·17	37·00	16·15	16·83	16·77	16·60	15·92	16·44	17·33	18·33	
21·44	22·80	24·92	27·33	31·67	42·67	15·20	15·47	15·67	15·80	16·33	16·89	18·17	18·67	