Tension, Impact and Repeated Impact Tests of Mild and Hard Steels.

By

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The comparative tension, impact and repeated impact tests were carried out on mild and hard steel flat bars, with the object of detecting the obscure property of materials supposed to be the cause of unexplained fractures and the results thereof, though not very abundant in number, will be reported hereinafter, in the hope that the experiments will be followed along this line.

The flat bars were got from the Imperial Steel Works of Yawata and are of the following steel grades.

No. 1	Extra mild steel	with	0·102 %	of carbon.
No. 2	Mild steel	,,	0·19	,, ,, ,,
No. 3	Semi-mild steel	,,	0·25	,, ,, ,,
No. 4	Semi-hard steel	,,	0·30	,, ,, ,,
No. 5	Hard steel	,,	0·55	,, ,, ,,
No. 6	Extra hard steel	,,	0·65	,, ,, ,,

The carbon contents were determined in Prof. Saito's laboratory by colorimetric analysis, each being the mean of three trials.

The tension tests were performed with Wicksteed's 30 ton machine and

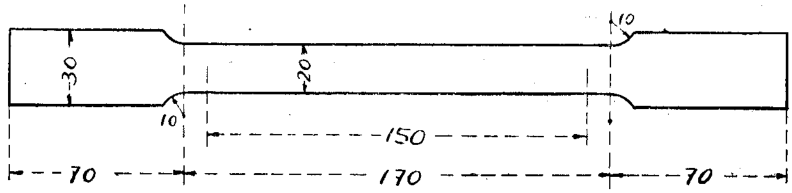

Fig. 1.

the impact tests with Charpy's machine of 75 mkg. capacity. Fig. 1. shows the test piece for tension and Fig. 2 that for impact test. The repeated impact tests were made with the author's machine specially designed for the purpose. Fig. 3. shows its general appearance. Fig. 4 to 6 are the projection drawings A short description of its principle of working is as follows:—The test piece resting on supports at the ends receives blows of a hammer on the central part. It is provided at each end with an open slit, with which it loosely engages the flattened end of the spindles, which may be called the turning spindles, devised to make intermittent reciprocating rotations through 180 degrees. Between each blow of the hammer the test piece turns upside down, being driven by the turning spindles. Blows are continued until the test piece breaks and the blow number applied being recorded by a counter is taken as the measure of the resistance of the material tested. By the contrivance above described the test piece when struck, resting freely on the supports, experiences an unconstrained deformation and shock is transmitted to the support alone, but not to other machine parts, thus securing the correctness of the result and preventing the machine parts from damages due to the shock.

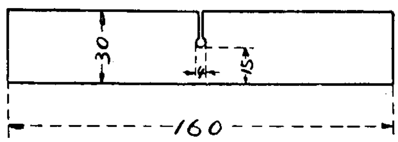

Fig. 2.

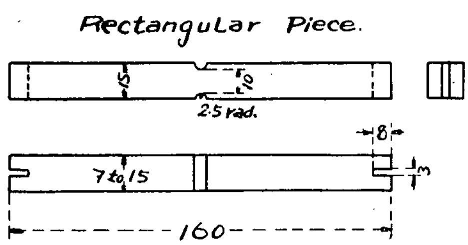

Fig. 7.

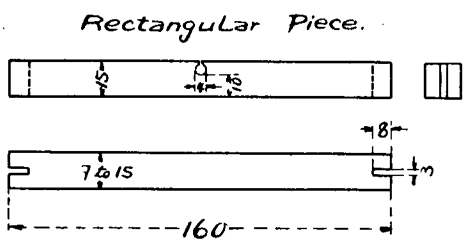

Fig. 8.

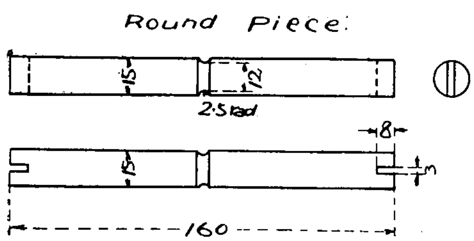

Fig. 9.

The test piece may be provided with notch at the centre to facilitate breaking. Its forms and dimensions recommended by the author are shown in Figs. 7 to 9.

In the present tests the form of Fig. 7 was taken throughout.

The test pieces for the different tests were cut out from the neighboring parts of a bar, the configuration being as shown in Fig. 10.

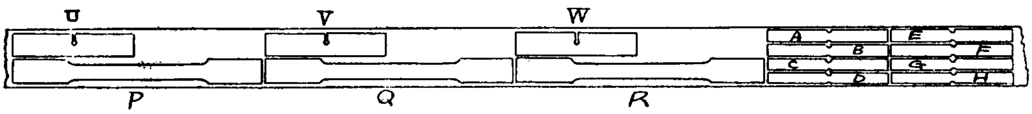

Fig. 10.

The results of the tests are recorded in Tables 1 to 3.

Table 1, TENSION TEST

Steel grade	Test piece	Thickness mm.	Yield point tons/sq. in.	Strength tons/sq. in.	Elongation %
No. 1	*P*	11·6	14·8	20·9	30·7
	Q		15·3	20·9	33·7
	R		15·3	21·1	31·8
No. 2	*P*	11·2	18·1	27·2	30·6
	Q		17·2	27·1	27·4
	R		17·0	26·9	28·3
No. 3	*P*	11·1	—	30·5	23·6
	Q		17·7	30·3	26·0
	R		17·4	30·4	25·1
No. 4	*P*	11·3	19·1	33·5	25·1
	Q		19·7	33·6	24·9
	R		19·7	33·6	25·5
No. 5	*P*	11·5	26·6	48·7	14·3
	Q		26·9	48·9	14·9
	R		27·2	50 2	10·9
No. 6	*P*	11·45	28·5	52·0	14·0
	Q		27·9	51·2	14·5
	R		28·5	51·7	15·9

Table 2, IMPACT TEST

Steel Grade	Test piece	Thickness mm.	Initial energy mkg.	Energy remaining after impact mkg.	Impact energy for breaking mkg.	Specific impact energy mkg.
No. 1	U V W	11·6	75	3·4 not broken 4·4	71·6 75+x 70·6	41·3 43·1+x 40 6
No. 2	U V W	11·2	„	25·0 37·2 35·5	50.0 37·8 39·5	29 8 22·5 23·5
No 3	U V W	11·1	„	38·7 37·8 40·9	36·3 37·2 34·1	21·7 22·3 20·5
No. 4	U V W	11·3	„	63·0 48·5 50·2	12·0 26·5 24·8	7·0 15·6 14·6
No. 5	U V W	11·5	„	64·8 63·0 62·8	10·2 12·0 12·2	5·9 7 0 7·1
No. 6	U V W	11·45	„	54·0 64·8 64·8	21·0 10·2 10·2	12·4 5·9 5·9

Table 3, REPEATED IMPACT TEST

Steel grade	Thickness mm	Energy of single blow cmkg.	Test piece	Blow number	Test piece	Blow number
No. 1	11·6	34·8	A B C D	469 473 467 405	E F G H	437 475 479 449
No. 2	11·2	33·6	A B C D	502 485 491 439	E F G H	529 451 541 503
No. 3	11·1	33·3	A B C D	526 582 566 553	E F G H	610 566 536 634
No. 4	11·3	33·9	A B C D	430 555 465 458	E F G H	503 431 486 466
No. 5	11·5	34·5	A B C D	537 500 526 506	E F G H	438 497 418 459
No. 6	11·45	34·35	A B C D	424 427 453 398	E F G H	543 557 539 489

The above results may be plotted in Fig. 11 for convenience of comparison taking the carbon content as abscissa.

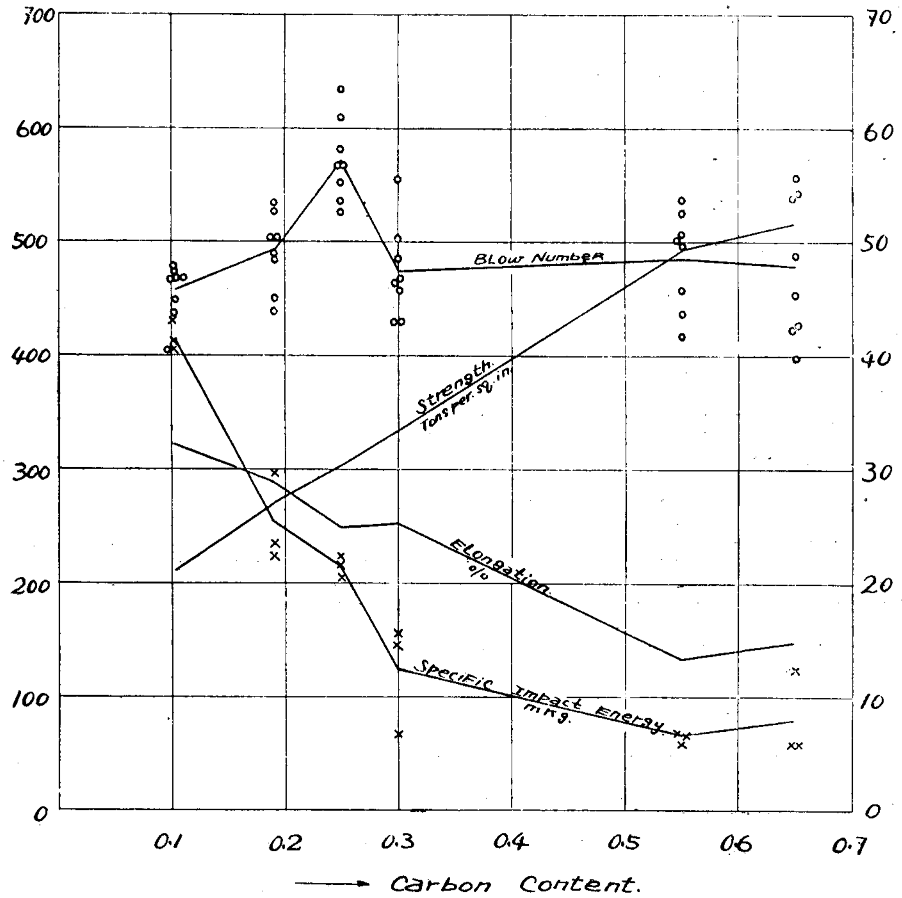

Fig. 10.

In Fig. 11 the changes of strength, elongation and specific impact energy as the carbon content increases, are as may be expected. Whilst the change of blow number is peculiar. It has a maximum point for a certain carbon content, although this point will probably shift towards the right or the left if the form and depth of the notch are altered. Thus by this test the adaptability of the steel of a certain carbon content for the machine parts subject to shock, is made evident, which is convinced neither by the tension test nor by the single blow impact test. Of course for the correct numerical determinations a more complese set of tests will be required.

In carrying out the foregoing repeated impact tests some precautions were necessary. In case of ductile materials the test piece takes the form shown in Fig. 12 before breaking asunder. For the correct working of the lifting mechanism of the hammer blow must be stopped when the angle of bend α reaches a certain value. The value of α for which the automatic stop gear acts, is adjusted by raising or lowering the hand screw (marked k in Figs. 2 to 4) in the gear. The author adjusted the screw for α equals about 5 degrees.

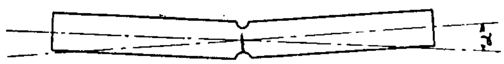

Fig. 11.

Many preliminary repeated impact tests were executed in which the author noticed that the blow number for a material always varies within a tolerably wide range, although the test pieces are cut out from the neighboring parts of a piece. In view to make the range narrower the author annealed the bottom of the notch by a short piece of wire heated to redness with a certain success. The steel wire 4 mm diameter was cut to a length equal to three times the thickness of the test piece, which being heated bright red, was applied as shown in Fig. 13 and allowed to cool naturally.

Fig. 13.

In order to obtain the comparable results for the test pieces differing in thickness, the energy of single blow was taken as proportional to thickness, at the rate of 30 cmkg energy for 10 mm thickness. This is based upon an assumption that the energy required to break a test piece is proportional to the notched cross section, provided the form and depth of the notch remain unaltered. To prove the correctness of this assumption four sets of test pieces of different thicknesses were cut out from the neighboring parts of a mild steel round bars, $3\frac{1}{2}$ inches in diameter as shown in Fig. 14 and 15 and tested for repeated impact, of which the results are given in Table 4. They are also plotted in Fig. 16.

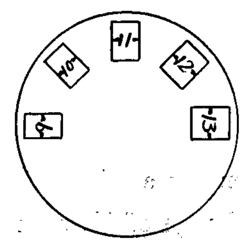

Fig. 14.

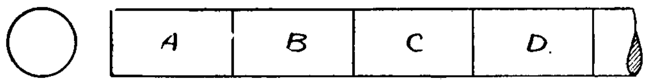

Fig. 15.

Table, 4.

Thickness mm	Energy of single blow cmkg.	Blow number			
		A	B	C	D
9	27	383	426	478	566
10	30	471	425	477	426
11	33	468	459	448	422
12	36	455	513	464	475
13	39	390	479	496	495

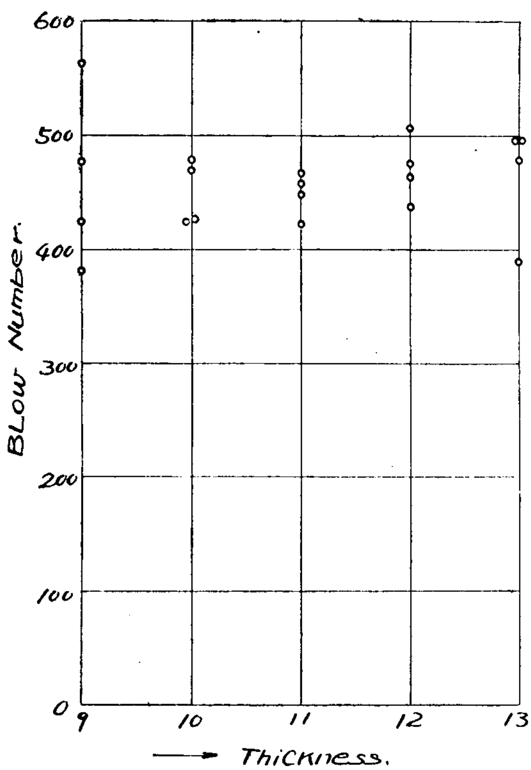

Fig. 16.

From Fig. 16 it does not appear that the blow number is a certain function of the thickness instead of being a constant. In fact the results are insufficient and more tests are required for the proof aimed at, but in the present case where the thickness varies only from 11·1 to 11·6 mm, the effect of the thickness, if any, will be negligible.

Fig. 6.

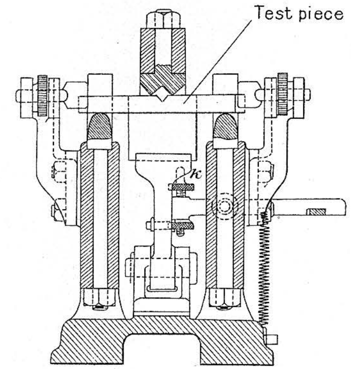

Fig. 4.

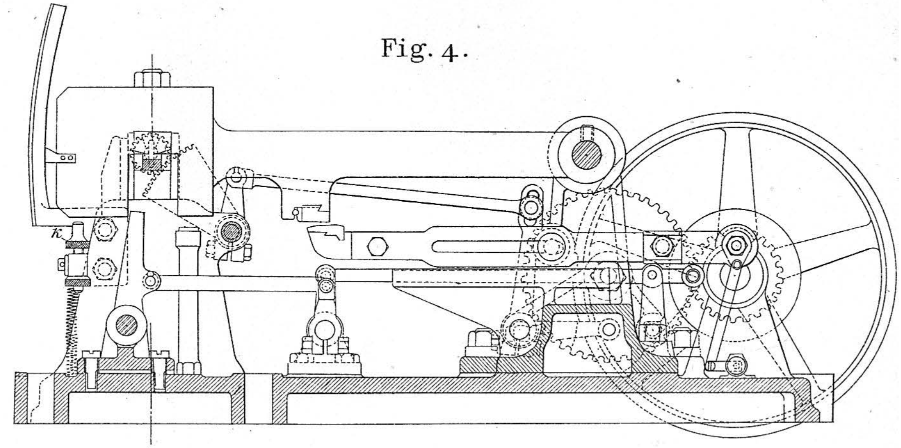

Fig. 3.

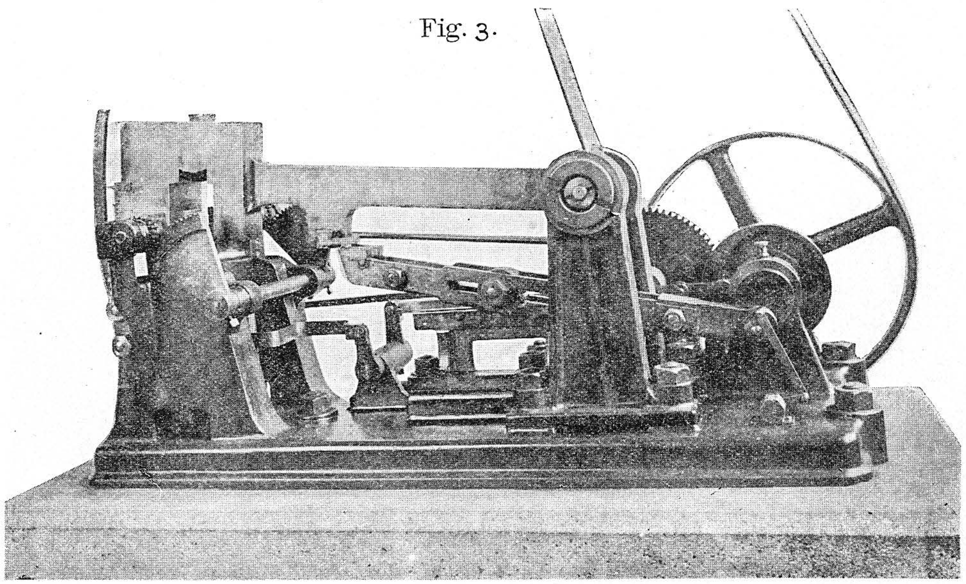

Fig. 5.