Notes on the Testing of Materials at the P. N. Russell Laboratory, with a Special Reference to Nickel Steel.

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Table I.

Determiuation of the elastic limit and the coefficient of elasticity in nsion of nickei steel "F" (mild).
Length upon which elongations were measured = 150mm. (6in.)
Diameter = 0.6085in. Area = 0·2908 square inches.

Load in 1000 lbs.	Readings in $\frac{1}{5000}$mm. Top.	Bottom.	Mean Extension[1] in $\frac{1}{10,000}$ mm.	Differences per 1,000 lbs.	
0	3·12	2·19	5·31		
2·5	4·70	4 50	9·20	1·56	
3	5·10	4·95	10·05	1·70	
4	6·00	5·91	11·91	1·86	
5	6 90	6·82	13·72	1·81	
6	7 82	7·79	15·61	1·89	
7	8·75	8·70	17·13	1·82	
8	9·66	9·64	19 30	1 87	
9	10·58	10·57	21·15	1·85	
10	11·51	11·51	23·02	1·87	
11	12 44	12·41	24·85	1·83	
12	13·41	13·37	26·78	1·93	
13	14·43	14·39	28·82	2·04	† Limit of Elasticity.
14	15·70	15·78	31·42	2 60	

† Limit of Elasticity = 12,500 lbs. or $\frac{12,500}{0·2908}$ = 43,000 lbs. per sq. in. (19·2 tons)
Coefficient of Elasticity = 27,7300,000 lbs. per sq. in.
= 12,375 tons per sq. in.

[1] Obtained by adding the figures in the preceding two columns.

Table II.

Determination of the elastic limit and coefficient of elasticity in tension of nickel steel "T" (medium).
Length upon which the elongations were measured = 150 mm (6 in.)
Diameter = 0.609 in. Area = 0·2911 square inches.

Load in 1,000 lbs.	Readings in $\frac{1}{5000}$mm. Top.	Bottom.	Mean Extension in $\frac{1}{10,000}$mm.	Differences per 1,000 lbs.	
0	0·00	7·00	7·00		
1	0·48	7·65	8·13	1·13	
2	1·30	8·70	10·00	1·87	
3	2·18	9·73	11·91	1·91	
4	3·10	10·70	13·81	1·90	
5	4 03	11·70	15·73	1·92	
6	4·85	12·62	17·47	1·74	
7	5·78	13·56	19·34	1·87	
8	6·80	14·42	21·22	1·88	
9	7·79	15·30	23·09	1·87	
10	8 78	16·20	24·98	1·89	
11	9·62	17·00	26·62	1·64	
12	10·60	17·90	28·50	1·88	
13	11·52	18·78	30·30	1·80	
14	12·50	19·70	32·20	1·90	
15	13·48	20·62	34·10	1·90	† Limit of Elasticity
16	14·48	21·78	36·26	2·16	
17	15·62	22·75	38·37	2·11	
18	16 66	23·90	40·56	2·19	
19	18·00	25·20	43·02	2·46	
20	20·00	27·25	47·25	4·23	

† Limit of Elasticity = 15,000 lbs. or $\frac{15,500}{0·2911}$ = 53,200 lbs. per sq. in. (23·75 tons)
Coefficient of Elasticity = 27,120,000 lbs. per sq. in.
= 12,110 tons per sq. in.

Table III.

Determination of the elastic limit and coefficient of elasticity in tension of nickel steel "E" (non-rusting).
Length upon which the elongations were measured = 150 mm. (6 in.)
Diameter = 0·6075" Area = 0·2899 square inches.

Load in 1000 lbs.	Readings in $\frac{1}{5000}$mm. Top.	Bottom.	Mean Extension in $\frac{1}{10,000}$mm.	Differences per 1000 lbs.	
0	0·00	5·00	5·03		
1	−0·02	5·10	5·08	0·80	
2	+0·72	6·38	7·10	2·02	
3	1·76	7·50	9·26	2·16	
4	2·82	8·48	11·30	2·04	
5	3·92	9·46	13·38	2·08	
6	5 03	10·43	15·51	2·13	
7	6·22	11·40	17·62	2·11	
8	7·34	12 39	19·73	2 11	
9	8·52	13·47	21·99	2 26	† Limit of Elasticity
10	9 89	14·88	24·77	2 78	
11	11·85	16 95	28·80	4·03	

† Limit of Elasticity = 8500 lbs. or $\frac{8500}{·2899}$ = 29,350 lbs. per sq. in. (13·1 tons)
Coefficient of Elasticity = 26,340,000 lbs. per sq. in.
= 11,760 tons per sq. in.

TABLE IV.

Determination of elastic limit and coefficient of elasticity of Vicker's axle steel No. "5" in tension.
Length upon which extensions were measured = 150 mm. (6 in.)
Diameter = 0·610" Area = 0·2922 square inches.

Loads in 1000 lbs.	Readings in $\frac{1}{5000}$mm. Top.	Bottom.	Mean Extension in $\frac{1}{10,000}$ mm.	Differences per 1000 lbs.	
1	1·39	7·52	8·91		
2	2·15	8·51	10·66	1·75	
3	2·99	9·50	12·49	1·83	
4	3·89	10·41	14·30	1·81	
5	4·77	11·31	16·08	1·78	
6	5·66	12·24	17·90	1·82	
7	6 51	13·12	19·66	1·73	
8	7·39	14·03	21·42	1·78	
9	8·29	14·97	23·26	1·84	
10	9·20	15·93	25·13	1·87	† Limit of Elasticity
11	10·09	16·09	26·99	1·87	
11·5	10·78	17·58	28·36	2·74	

† Limit of Elasticity = 9500 lbs. or $\frac{9500}{0·2922}$ = 32 500 lbs. per sq. in. (14·5 tons.)
Coefficient of Elasticity = 28,680,000 lbs. per sq. in.
= 12,805 tons per sq. in.

Table V.

Determination of the elastic limit and co-efficient of elasticity in tension of Vicker's axle steel No. "6."
Length upon which elongations were measured = 150mm. (6 in.)
Diameter = 0·610" Area = 0·2922 square inches.

Load in 1000 lbs.	Readings in $\frac{1}{5000}$ mm. Top.	Bottom.	Mean Extension in $\frac{1}{10,000}$ mm	Differences per 1000 lbs.	
2.5	2.41	7.69	10.10		
3	2.79	8.14	10.93	1.66	
4	3.60	9.11	12.71	1.78	
5	4.40	3.99	14.39	1.68	
6	5.25	10.89	16.14	1.75	
7	6.10	11.78	17.88	1.74	
8	6.97	12.66	19.63	1.75	
9	7.87	13.40	21.47	1.84	
10	8.82	14.57	23.39	1.92	† Limit of Elasticity.
11	10.10	15.90	26.00	2 61	

† Limit of Elasticity = 9.500 lbs. or $\frac{9.500}{0.2922}$ = 32,500 lbs. per sq. in. (14.5 tons)
Coefficient of Elasticity = 29,000,000 lbs. per sq. in.
= 12,950 tons per sq. in.

Table VI.

Determination of elastic limit and coefficient of elasticity in compression of nickel steel "F" (mild).
Length upon which contractions were measured = 10"
Diameter = 1" Area = 0.7854 square inches.

Load in 1000 lbs.	Readings in $\frac{1}{5000}$mm. Top.	Bottom.	Mean Compression in $\frac{1}{10,000}$mm.	Differences per 1000 lbs.	
1	0·00	4·00	4·01		
2·5	1·20	4·32	5·52	1·01	
3	1·27	4·48	5·75	0·46	
4	1 81	4·79	6·60	0·85	
5	2·35	5·21	7·46	0·86	
6	2·90	5·49	8·39	0·93	
7	3·39	5·85	9·24	0·85	
8	3·85	6·25	10·10	0·86	
9	4·30	6·69	10·99	0·89	
10	4·79	7·11	11·90	0·91	
11	5·29	7·54	12·79	0·89	
12	5·69	8·01	13·70	0.91	
13	6·11	8·45	14·56	0·86	
14	6·55	8·89	15·43	0·87	
15	6·98	9·35	16·33	0·90	
16	7·40	9·80	17·20	0·87	
17	7·80	10·30	18·10	0·90	
18	8·18	10·78	18·96	0·86	
19	8·60	11·28	19·88	0·92	
20	8·98	11·76	20·74	0·86	
21	9·37	12·25	21·62	0·88	
22	9·75	12·77	22·52	0·90	
23	10·13	13·29	23·43	0·91	
24	10·51	13·80	24.31	0·88	
25	10·88	14·25	25·20	0·89	
26	11·30	14·70	26·00	0·80	
27	11·67	15·20	26·87	0·87	
28	12·08	15·78	27·86	0·99	† Limit of Elasticity
29	12·40	16·40	28·80	0·94	
30	12·70	16·98	29·72	0·92	
31	13·15	17·57	30·72	1·00	
32	13·55	18·22	31·77	1·05	
33	14·02	18·92	32·94	1·07	
34	14·60	19·64	34·24	1·30	

† Limit of Elasticity = 27,000 lbs. or $\frac{27,000}{0·7854}$ = 34,400 lbs. per sq. in. (15·35 tons)
Coefficient of Elasticity = 28,770,000 lbs. per sq. in.
= 12,850 tons per sq. inch.

Table VII.

Determination of elastic limit and coefficient of elasticity in compression of nickel steel "F."
Length upon which contractions were measured = 2".
Diameter = 1" Area = 0·7854 square inches.

Load in 1,000 lbs.	Readings in $\frac{1}{5,000}$mm Top.	Bottom.	Mean Compression in $\frac{1}{10,000}$mm.	Differences per 2,000 lbs.	
5	0·40	4·39	4 79		
6	0·55	4·41	4·96	0·34	
8	0·69	4·59	5·23	0·32	
10	0·85	4·69	5·54	0·26	
12	1·02	4 81	5·83	0·29	
14	1·19	4·97	6·16	0·33	
16	1·34	5·12	6·46	0·30	
18	1·50	5·31	6·81	0·35	
20	1·67	5·50	7·17	0·36	
22	1·82	5·70	7·52	0·35	
24	2·01	5·90	7·91	0·39	† Limit of Elasticity
26	2·12	6·15	8·37	0·46	
28	2·48	6·42	8·90	0·53	
30	2·85	6·72	9·57	0·67	
32	3·02	6·99	10·01	0·44	
34	3·40	7·40	10·80	0·79	

† Limit of Elasticity = 23,000 lbs. or $\frac{23·000}{0·7854}$ = 30,580 lbs. per sq. in. (13·1 tons)
Coefficient of Elasticity = 28,140,000 lbs. per sq. in.
= 12,560 tons per sq. in.

Table VIII.

Determination of the elastic limit and coefficient of elasticity in compression in nickel steel "T."
Length upon which contractions were measured = 10 in.
Diameter = 1 in. Area = 0·7854.

Load in 1,000 lbs.	Readings in $\frac{1}{5000}$mm. Top.	Bottom.	Mean Compression in $\frac{1}{10,000}$mm.	Differences per 2,000 lbs.	
5	2·10	5·74	7·84		
7	3·10	6·51	9·61	1·77	
9	4·01	7·29	11·30	1·69	
11	4·96	8·09	13·05	1·75	
13	5·89	8·90	14·79	1·74	
15	6·83	9·72	16.55	1·76	
17	7·76	10·58	18·34	1·79	
19	8·61	11·45	20·06	1·72	
21	95·2	12·32	21·84	1·78	
23	10·41	13·19	23·60	1·76	† Limit of Elasticity
25	11·31	14·09	25·40	1·80	
27	12·18	15·00	27·18	1·78	
29	13·08	15·90	28·98	1·80	
31	14·00	16·80	30·80	1·82	
33	14·91	17·72	32·63	1·83	
35	15·88	18·67	34·55	1·92	
37	16·81	19·60	36·41	1·86	
39	17·79	20·55	38·34	1·93	
41	18·76	21·60	40·36	2·02	
43	19·85	22·69	42·54	2·18	
45	20·96	23·76	44·72	2·18	

† Limit of Elasticity = 23,000 lbs. or $\frac{23·000}{0·7854}$ = 29,300 lbs. per sq. in. (13·1 tons)
Coefficient of Elasticity = 28,170,000 lbs. per sq. in.
= 12,570 tons per sq. in.

Table IX.

Determination of elastic limit and coefficient of elasticity in compression of nickel steel "E."
Lengthu pon which contractions were measured = 10"
Diameter = 1" Area = 0·7854 square inches.

Load in 1000 lbs.	Readings in $\frac{1}{5000}$mm. Top.	Bottom.	Mean Compression in $\frac{1}{10,000}$mm.	Differences per 1000 lbs.	
1	0·00	0·00	0·00		
2	0·50	0·50	1·00	1·00	
3	0·98	1·00	1·98	0·98	
4	1·50	1·50	3·00	1.02	
5	2·00	2·00	4·00	1.00	
6	2·50	2·50	5·00	1.00	
7	3·00	3·00	6·00	1.00	
8	3·50	3·50	7·00	1.00	
9	3·98	4·02	8·00	1.00	
10	4·40	4·52	8·92	0.92	
11	4·86	5·00	9·86	0.94	
12	5·35	5·52	10·87	1.01	
13	5·85	6·04	11·89	1.02	
14	6·32	6·52	12·84	0.95	
15	6·80	7·02	13·82	0.98	
16	7·30	7·51	14·81	0.99	
17	7·80	8·01	15·81	1.00	
18	8·29	8·50	16·79	0.98	
19	8·80	9·00	17·80	1.01	
20	9·27	9·53	18·80	1.00	
21	9·73	10·03	19·76	0.96	
22	10·26	10·56	20·82	1.06	† Limit of Elasticity
23	10·78	11·08	21·86	1.04	
24	11·30	11·64	22·94	1.08	
25	11·81	12·16	23·97	1·03	Specimen was permanently bent

† Limit of Elasticity = 21,000 lbs. or $\frac{21,000}{0·7854}$ = 26,750 lbs. per sq. in. (11·99 tons)
Coefficient of Elasticity = 25,460,000 lbs. per sq. in.
= 11,360 tons per sq. in.

Table X.—Summary of Results obtained in Tensile Tests of Nickel Steel.

Test No.	Description.	Original dimensions. Diameter in inches.	Area in sq. ins.	Stress in Pounds. Per sq. in.	Total.	Stress in tons per sq. in.	Limit of Elasticity in tons per sq. in.	Yield point in tons per sq. in.	Ratio of Limit to Break per centum.	Contracted dimensions. Diameter in ins.	Area in sq. ins.	Contraction of Area per cent.	Elongations measured after fracture. on 6 ins.	in 8 ins.	Local Elongations, in.	General Elongation, per cent.	Coefficient of Quality.	Coefficient of Elasticity in tons per sq. in.
F	Mild ...	0·608	0·2908	73600	21400	32·88	19·2	23·05	58	0·319	0·0806	72·3	1·75	1·08	0·41	22·3	7·3	12375
T	Medium ...	0·609	0·2911	114250	33250	51·40	23·75	36·00	46	0·460	0·1662	43·0	1·30	0·80	0·30	16·6	8·5	12110
E	Non-rusting	0·607	0·2705	106100	28700	47·88	13·10	23·75	27	0·321	0·0811	70·0	2·35	1·35	0·35	33·3	15·7	11760

Note.—The yield points were raised in consequence of the elastic limit having been first determined by Martin's mirror apparatus.

Table XI.—Summary of Results obtained in Tensile Tests of Vicker's Steel.

5	Vicker's	0·610	0·2922	76200	22250	34·15	14·5	25·22	42	0·408	0·1261	56·5	1·30	0·85	0·40	15·0	5·1	12805
6	axle steel,	0·610	0·2922	77000	22500	34·40	14·5	22·48	45	0·406	0·1260	56·6	1·23	0·80	0·37	14·0	4·8	12950
													on 10 in.	on 5 in.				
2a	test pieces	1·125	0·9941	77153	76700	34·40	14·5	20·85	45	0·770	0·4656	53·16	2·10	1·46	0·82	12·8	4·4	
1a	cut from	1·125	0·9941	75940	75500	33·94	14·5	20·70	42	0·760	0·4458	55·16	2·53	1·59	0·65	18·8	6·3	
1b	the same	0·840	0·5541	76240	42250	34·03	14·5	...	42	0·565	0·2507	54·75	2·30	1·41	0·56	17·8	6·0	
2b	axle.	0·840	0·5541	76240	42250	34·03	14·5	...	42	0·567	0·2525	54·44	1·72	1·13	0·46	11·8	4·0	

Note.—The yield points in table were raised in consequence of the elastic limit having been first determined by Marten's extensometer.
In Nos. 5 and 6 the true yield point, from extensometer readings, was 18·4 tons per square inch.

TESTS OF CARNEGIE MILD STEEL.

Test Number.	Description.	Original Dimensions. Breadth.	Thickness.	Area.	Stress in Pounds. Total.	Per sq. in.	Stress in Tons, Per sq. in.	Apparent Limit of Elasticity from Auto-diagrams.	Ratio of Limit to Break.	Contracted Dimensions. Breadth.	Thickness.	Area.	Contraction of area per cent.	Elongations, measured after fracture. on 8in.	on 4in.	Local Elongations.	General Elongation, per cent,	Co-efficient of Quality.	Elongations, per cent. Bending Tests. H	C	Remarks.
1 W	Flange steel plates testod in the direction of rolling	1·25	0·5	0·625	37000	59200	26·4	14·4	0·54	0·87	0·31	0·2697	55·1	2·15	1·45	0·75	17·5	4·65		32	No sign of failure
1 C	do across	1·25	0·5	0·625	35250	56400	25·2	14·3	0·55	0·90	0·34	0·3060	51·0	2·30	1·50	0·70	20·0	5·04	30·4		do. do.
2 W	do width	1·25	0·5	0·625	35750	57200	25·5	14·2	0·56	0·89	0·32	0·2848	54·4	2·20	1·45	0·70	18·7	4 77		30·4	do. do.
2 C	do across	1·25	0·5	0·625	352·0	56400	25·2	14·7	0·58	0·85	0·29	0·2465	60·5	2·20	1·50	0·80	17·5	4·41	30		do. do.
3 W	Shell steel with plates	1·25	0·5	0·625	38500	61600	27·5	15·9	0·58	0·92	0·34	0·3174	49·2	1·85	1·30	0·75	13·7	3·76		30·8	do. do.
3 C	do across	1·25	0·5	0·625	38375	61400	27·4	15·1	0·55	0·87	0·32	0·2784	55·4	2·20	1·50	0·80	17·5	4·79			do. do.
	Cut from 24 in. girders.																				
CG 1	Web	1·25	0·47	0·5875	37600	64050	28·6	15·3	0·53	0·92	0·31	0·2852	51·4	2·20	1·4	0·60	20·0	5·72			
CG 1 f	Flange	1·25	0·48	0·6000	39000	65000	29·0	15·9	0·55	0·93	0·33	0·3115	48·1	2·40	1·50	0·69	22·5	6·52			
CG 2	Web 18 in. girder	1·24	0·445	0·5518	35750	64800	28·9	15·4	0·53	0·95	0·32	0·3056	44·6	2·15	1·40	0·65	18·7	5·40			
CG 2 f	Flange	1·24	0·48	0 5952	35750	63000	28·1	14·7	0·52	0·92	0·33	0·3036	49.0	2·10	1·42	0·72	17·0	4·76			
CG 3	Web 15 in ,,	1·24	0·40	0 4960	28600	57700	25·7	14·1	0·55	0·93	0·28	0·2614	48·3	2·12	1·40	0·68	18·0	4·63			
CG 3 f	Flange ,,	1·24	0·43	0·5332	32750	61450	27·4	13·8	0·50	0·92	0·31	0·2864	46.3	1·90	1·50	1·10	10·0	2·74			
CG 4	Web 12 in. ,,	1·24	0·38	0·4712	3150 '	66800	23 9	15·2	0·51	0·95	0·30	0·2·50	39·5	1·95	1·15	0·35	2 1·0	5·98			
CG 4 f	Flange ,,	1·24	0·423	0·5245	36000	68600	30·6	15·8	0·52	0·91	0·35	0·3192	39·1	1·70	1·10	0·50	15·0	4·59			
CA 1	Cut from angles	1·24	0·423	0·5245	36000	68600	30·6	15·8	0·52	0·91	0·35	0·3192	39·1	1·70	1·10	0·50	15·0	4·59			
CA 2	,, ,,	1·26	0·60	0·7560	43600	57700	25 7	14·0	0·55	0·86	0·39	0·3354	55·6	2·40	1·55	0·70	21 2	5·45			
	,, Cut from channels	1·26	0·60	0·7560	44000	52200	26·0	14·2	0·55	0·86	0·38	0.3268	42·2	2 00	1·60	1·20	10·0	2·60			
C 1	Web	1·26	0·38	0·4788	29750	62150	27·7	13·3	0·52	0·96	0·29	0·2784	41·9	2·15	1·35	0·55	20·0	5·54			
C 2	Flange	1·26	0·42	0·5292	30900	58400	26·1	12·7	0·49	0·83	0·28	0·2464	53·4	2·20	1·40	0·60	20 0	5·22			
L 01	Web	1·25	0·25	0·2125	19000	60800	27·1	16·6	0·61	0·90	0·175	0·1575	49·6	2·20	1·35	0·50	21·2	5·75			
L 03	Flange	1·25	0·34	0·4250	25250	59400	2 65	13 9	0·53	0·89	0·235	0·2098	56 3	2·00	1·30	0·60	17 5	4·64			

The bending tests "H" and "C" were made on strips 12in. long and 1½in. wide, planed on each side and divided into spaces of ¼in, throughout the length. After the test, the portion "xy" over ten spaces was measured, and the elongations expressed in percentages of the original length, 2½in. The strips marked "H" were first heated to a cherry red, then plunged in water about 80 degrees F., and bent to the form shewn in the sketch. The strips "C" were bent without previous treatment.

Table XII.

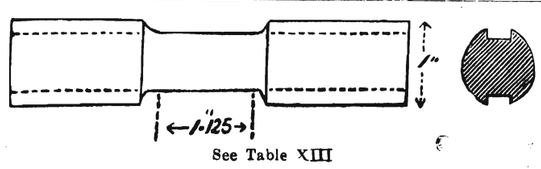
Summary of Results obtained in Compressive Tests of Nickel Steel.
Diameter of test piece 1 inch, area 0·7854.

Reference Letter.	Description.	Length of test piece in inches.	Elastic limit in tons per square inch.	Co-efficient of elasticity in tons per square in.	Compressive strength in tons per square inch.	Maximum load applied in tons per square inch.	Plastic compression with maximum load per lineal inch.
F	Mild ...	10·00	14·50	12705			
		2·00	...	...	24·2	44·5	0·11
		1·52	...	..	..	63·6	0·26
T	Medium ..	10·00	13·10	12570			
		2·00	...	...	42·0	69	0.137
		1·48	...	..	..	73	0.172
E	Non-rusting	10·00	11·99	11360			
		2·00	..	...	25·3	55·5	0·115
		1·49	..	...	25·3	70·0	0.175

Table XIII.

Torsonal Tests of Nickel Steel.

Reference Letter.	Diameter of test piece in inches.	Length of the piece in inches.	Total twisting moment in inch pounds.	Value of f in equation, $f = \frac{T}{0·196d^3}$ in pounds per sq. in.	Total angle of twist in degrees	Length of test piece after fracture in inches.	Percentage of elongation or shortening.
E	0·715	1·125	10931·3	152578	900	1·140	+ 1·3
F	0·714	1·125	6809·6	95448	405	1·120	− 0·44
T	0·714	1·125	8960·0	125591	180	1·125	0

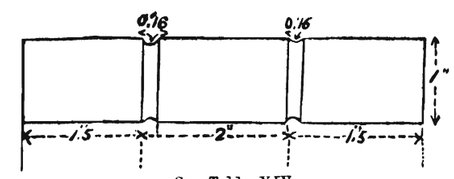


See Table XIII

Table XIV.

Shearing Test.

Reference Letter.	Diameter in inches.	Area in square ins.	Total Load in double shear in pounds.	Double shear per sq. inch in pounds.	Single shear per sq. in.
E	0·780	0·4778	99456	208096	104048
F	0·783	0·4815	71568	8624	74312
T	0·783	0·4815	95200	568	98784



See Table XIV.

Table XV.

Description of Specimen.	Original Weight, Grains.	Final Weight, Grains.	Loss in Weight.	Loss in Weight, per cent.
Nickel Steel, E (non-rusting) ...	No loss	could be	detected.	
,, ,, F (mild)	743 0	731·8	11·2	1 31
Krupp, Essen, K	755·1	736·4	18·7	2·48
,, H E (special ingot Iron ...	747·5	726·8	20·7	2·77
,, K				
Dalziell's Steel	738·5	715·9	22·6	3 06
Patent Shaft and Axle Co.	738·3	705·3	33·0	4·47
Lowmoor Boiler Plate...	734·0	694·0	37·0	5·06
Monkbridge Boiler Plate	733·2	690·2	43·0	5·86
Nickel Steel, T (medium)	754·5	705·0	49·5	6·56

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