PAGES

MISSING

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OF CANADA

OFFICIAL PROCEEDINGS

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PROCEEDINGS OF THE CENTRAL RAILWAY AND ENGINEERING CLUB OF CANADA.

TORONTO, February 5th, 1914.

This meeting was held in conjunction with the Engineering Society of the University of Toronto, in Convocation Hall, Toronto University. The regular business was therefore not transacted.

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THE APPLICATION OF STEEL TUBING TO MECHANICAL CONSTRUCTION

The proportion of iron and steel tubing used in locomotive construction is so large that experience with the various materials of which this tubing is made in locomotive practice, forms by itself a good criterion of the value of such materials for general machine construction. Hence we might first consider locomotive tubes and the relation which has been found between the properties of the materials and the mileage record of the engine.

SERVICE AND LABORATORY TESTS

We have, as you are aware, three classes of tubing for boiler work; lap-weld charcoal-iron, lap-weld steel, and seamless steel. The first of these has been able to hold its own until recently in spite of comparatively inferior physical properties, probably due to the impression that charcoal iron was better able to resist corrosive conditions and was easier to weld than most grades of steel. The numerous laboratory tests which have been made in researches on this subject, particularly during the last ten years, have not shown the difference expected under natural conditions of corrosion; however, these tests were not considered entirely satisfactory by practical men. Service tests were started by a number of the leading railroads, about the same time as these laboratory investigations and there is now available plenty of data from both sources. Most of these practical service tests were made by applying charcoal-iron and steel tubes, side by side, in the same boiler. When conditions developed which made it necessary to remove the tubes, they were cleaned and inspected, the corrosion being judged usually by the number of tubes of each set which had to be discarded, and the relative depth of pitting. Table I contains several recent examples of such investigations, typical of tests which have been run on many roads.

TUBES FOR CORROSIVE CONDITIONS

When it comes to a choice of tubes to withstand corrosive conditions we usually recommend "National" lap-weld steel tubes, which have the advantage of a patented process of roll-knobbling that the steel receives in being worked down from the bloom to the plate. By this kneading operation the metal receives considerably more mechanical work laterally, is made uniformly dense and other conditions being equal is more resistant to corrosion.

ADVANCE IN MODERN STEEL TUBES

The increased use of steel tubes in latter years, is probably due to a recognition of the physical superiority of the material, together with a better understanding of the causes of corrosion. A special grade of open hearth steel has been developed which is now used in the manufacture of both lap-weld and seamless tubes. Particular attention is given to the welding quality of this steel, and its power to withstand manipulation in setting and reworking. There is now practically no loss in installing modern steel tubes, either lap-weld or seamless, and as they will withstand without cracking so much more expansion than the old charcoal-iron, it is not a matter of much consequences if the flue-sheet hole happens to be worn a little large. The sectional expander may be used in setting, without fear of splitting the tube, and a good shoulder obtained behind the sheet and a strong bead in front, thus holding the tube firmly in the flue-sheet. The sectional expander or if preferred the roller expander, may be used until the tube is too thin for further service on this class of steel tubing, without injury to the metal. The steel being stiffer than the iron, requires less attention on account of leaking while in service, which means of course considerably less cost for maintenance. The steel beads are stronger than charcoal-iron and much better able to resist the various stresses incident to modern service. In order to be sure that each lap-weld tube is up to the required standard, a machine was designed to turn a flange on the crop ends cut from each tube. This testing operation as carried out every day in the mills is illustrated in motion pictures at this meeting.

WEARING QUALITY IN THE FLUE SHEET

With respect to durability in the flue sheet, there is abundant evidence on record to show that the mileage with modern "National" steel tubes is considerably greater under the same conditions than with charcoal iron. In Table II, we give a few comparative figures from various railroads indicated by letter. One of the most remarkable examples of unbroken service is that illustrated by the Lehigh Valley Railroad Passenger Engine No 2479, which in June, 1913, completed 245,675 miles in 28 months, pulling an average 450 ton train, on one set of lap-welded steel tubes. (Details regarding this engine can no doubt be obtained by addressing the Superintendent of Motive Power.) This brief summary will suffice to explain why the leading American tube interest has discontinued the manufacture of charcoal-iron tubes.

SAFE ENDING

With a little attention and some experience, the welding on of safe ends, steel to steel, should cause no particular difficulty. Much less is heard of difficulty in this connection to-day and there is certainly less possibility for trouble when the practice is to use steel exclusively, as is now the case in a number of shops, rather than to switch from iron to steel alternately; for the same reason the manufacture of one grade of steel for all tubes has also helped to bring about a more favorable condition.

In safe ending in the usual way it is best to heat the body tube to a bright orange color (about 1750° F) for expanding, and allow it to cool to at least a blue heat before reheating for welding. Precaution should be taken not to overheat the metal near the weld, which is more liable to occur if there is much difference in gage between the body tube and safe end.

ELECTRIC BUTT WELDING

The recent application of electric butt welding to safe ending is worthy of careful consideration. It has an important advantage in that the metal away from the weld cannot readily become overheated. It appears to be easy to control, is economical and should give a continuous, fine grained structure through the weld. Some tests recently made in our laboratory show an electric butt weld to have ninety per cent. of the strength of the metal.

About ninety per cent, of the locomotives in America are now equipped with steel safe ends. Some still adhere to the use of charcoal-iron body tubes carrying steel safe ends. The reason for this apparent inconsistency is not plain.

Seamless Tubes in Machine Design

An increasing amount of seamless tubing is being used for mechanical purposes. The variety of shapes and physical properties which can be obtained in tubular sections gives this product special advantages for many purposes. A large proportion of the tonnage of mechanical seamless tubing made in America goes into automobile parts, bushings, roller and ball bearing, hollow axles, gas containers, working barrels, drill pipe, etc., etc. We have compiled a list showing 300 separate uses.

A number of typical examples of the application of seamless tubing to machine design are illustrated at the end of this paper, these showing bending, expanding, swaging, tapering, deforming, closing of ends, upsetting, and various combinations of these operations.

Table III gives in brief form the physical properties of the standard steels used in the manufacture of Shelby Seamless Steel Tubing, with standard heat treatment. The low carbon grade is particularly adapted to case-hardening, and is frequently used in tubular forms for this purpose.

American vs. German Practice

The manufacture of tubes and pipe in the United States differs from the German practice, principally in that the welding process has further developed and predominates in United States; whereas in Germany the manufacture of seamless tubes has been so simplified and cheapened as to generally fill the uses to which welded pipe is more generally applied in this country. In Germany this is accomplished by the use of small cast rounds ingots which are fabricated directly into tubes without the intermediate blooming mill and bar mill rolling operations. Of course the finished product is comparatively inferior in quality and cannot be compared with the tubes made from the rolled round or cupped plate, but may be sufficiently sound for many purposes. In Germany, as here, solid rolled rounds made of selected steel are used for the better class of tubing, and in special cases the solid round is drilled through cold and then rolled down over mandrils in the usual manner. There is naturally a wide difference in price in German seamless tubes, depending on the purchasers' specification, which determines the process by which the tubes are to be made and how rigid an inspection shall be given.

Significance of Inspection

Investigation has shown that so far as the quality of the steel itself is concerned, our methods of manufacture give as good a quality of metal for seamless tubes as the best quality made in Germany. The fabrication of the steel puts a great strain on the metal and more or less loss is expected, principally on account of cracks and light surface defects. Most of these are quite insignificant in depth and do not effect the strength of the tube perceptibly but, as they tend to spoil the appearance of the highly finished surface, a rigid inspection is employed to cull out tubes showing such defects. The surface defects caused in the first operations of manufacture are removed, as far as practicable, with pneumatic chisels before the blank is worked any further. At present in the United States, practically all seamless steel tubing is made from solid rounds rolled from the blooms, the principal exception being seamless containers which are made by the plate and cup process.

If any difference in quality or finish is noticed between American and German seamless tubes it is probably due to the system of inspection which depends on the specifications and the use for which the tubes are made. For instance it would be waste to put more than fifty cents per ton on inspection of a lot of tubes for one purpose, whereas the same lot might require several dollars per ton to fit it for other conditions. Hence it is most important in ordering seamless tubes to specify clearly for what they are to be used and, as far as possible, adhere to standard specifications.

In looking at the relative advance in the iron and steel industry in America and Germany it would be well to consider what industrial research has had to do with efficiency.

The details of the industry in each of these countries have been worked out so far in a way best suited to their respective conditions. The problems in America have been handled, for the most part, by men who have depended more on practical than high technical training with the object of achieving immediate results to satisfy the pressing demands of the times.

Our general public have a confused or imperfect idea of the significance of the industrial research to the ultimate development of our industries.

In Germany, on the contrary, industrial research has become a highly specialized branch of their industries and receives the popular recognition and support so necessary to the largest success.

It seems safe to predict, with the dispelling of public indifference to this kind of research and the training of men along sound scientific lines who will combine in their work energy and audacity with a strong sense of initiative, even Germany must soon yield to America in the worth and volume of achievments in this field.

VALUE OF STANDARD SPECIFICATION

In closing it might be of interest to say a word briefly on the question of specification for steel tubes. Several years ago there were in use in America twenty or thirty specifications for locomotive boiler tubes, all differing slightly but sufficiently to require special attention to each individual order going through the mill. This of course increased the cost to the manufacturer and consumer, with no corresponding benefit in the quality of product.

The author endeavored to arouse interest in this matter in a paper before the American Society for Testing Materials, June 27th, 1911, after which a committee was appointed, consisting the majority of railroad engineers through whose work the first Standard American Tube Specification was adopted in 1912. In the following year this committee, in conjunction with another of the American Master Mechanics' Association, who had been laboring along the same line adopted a combined specification for tubes in June, 1913, which is reprinted on another page for reference. (See page —)

Whatever your personal views may be on the question of specifications this one should receive your careful study and consideration before deciding to write any other. It was only adopted after years of discussion and investigation on every item by engineers representing large manufacturers and users of tubes, and their recommendations were accepted without change by two of the largest engineering societies of the country. The National Tube Company also have a number of specifications for special products, such as steel shipping containers for compressed gases and liquids, trolley poles, signal pipe, etc. Whenever standard specifications are agreed upon, it has been our practice to accept these as our standard of manufacture.

The motion pictures showing welded pipe manufacture, and lantern slides showing the principles of the manufacture of products from seamless tubes, a few of which are reproduced, give a fairly complete view of the industry as a whole.

Standard specifications for Lap-welded and Seamless Steel Boiler Tubes, Safe Ends and Arch Tubes (including superheater tubes) as revised jointly, 1913, by the American Railway Master Mechanics Association and the American Society for Testing Materials.

I. MANUFACTURE

1. *Process.* The steel shall be made by the open-hearth process.

II. Chemical Properties and Tests

2. *Chemical Composition.* The steel shall conform to the following requirements as to chemical composition:

Carbon	0.08—0.18 per cent
Manganese	0.30—0.50 per cent.
Phosphorus	not over 0.04 per cent.
Sulphur	not over 0.045 per cent.

3. *Chemical Analyses.* (a) Analyses of two tubes in each lot of 250 or less may be made by the purchaser, which shall conform to the requirements specified in Section 2. Drillings for analyses shall be taken from several points around each tube.

(b) If the analyses of only one tube does not conform to the requirements specified, analyses of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

III. Physical Properties and Tests

4. *Flange Tests.* (a) A test specimen not less than 4 inches in length shall have a flange turned over at right angles to the body of the tubes without showing cracks or flaws. This flange as measured from the outside of the tube shall be $\frac{3}{8}$ inch wide for tubes $2\frac{1}{2}$ inches or less outside diameter, and $\frac{1}{2}$ inch wide for tubes larger than $2\frac{1}{2}$ inches outside diameter.

(b) In making the flange test, the flaring tool and die block as shown should be used.

5. *Flattening Tests.* A test specimen 4 inches in length shall stand hammering flat until the inside walls are in contact, without cracking at the edges or elsewhere. For lap-welded tubes, care should be taken that the weld is not located at the point of maximum bending.

6. *Crush Tests.* A test specimen $2\frac{1}{2}$ inches in length shall stand crushing longitudinally until the outside folds of metal are in contact, without showing cracks or flaws.

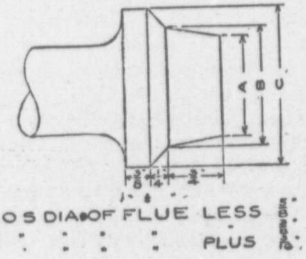
7. *Hydraulic Tests.* Tubes under 5 inches in diameter shall stand an internal hydraulic pressure of 1,000 pounds per square inch, and tubes 5 inches in diameter or over an internal hydraulic pressure of 800 pounds per square inch.

8. *Test Specimens.* (a) Test specimens shall consist of sections cut from tubes selected by the inspector representing the purchaser from the lot offered for shipment. They shall be smooth on the ends and free from burrs.

(b) All specimens shall be tested cold.

9. *Number of Tests.* One flange, one flattening and one crush test shall be made from each of two tubes in each lot of 250 or less. Each tube shall be subjected to the hydraulic test.

FLARING TOOL.



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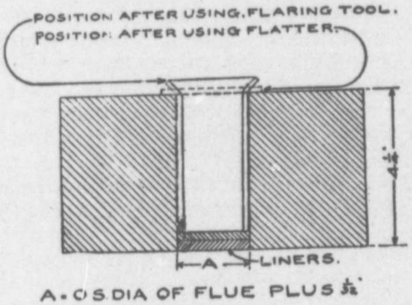


10. *Retests.* If the results of the physical tests of only one tube from any lot do not conform to the requirements specified in Sections 4, 5 or 6, retests of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

IV. Standard Weights

11. *Standard Weights.* The standard weights for tubes of various outside diameters and thicknesses are as follows:

WEIGHT IN POUNDS PER FOOT OF LENGTH

THICKNESS		OUTSIDE DIAMETER IN INCHES												
In.	Nearest B. W. G.	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	3	* $3\frac{1}{2}$	* 4	* $4\frac{1}{2}$	* 5	* $5\frac{1}{4}$	* $5\frac{3}{8}$	* $5\frac{1}{2}$	* 6
0.095	13	1.68	1.93	2.19	2.44	....	....	....	....	....	....	....	....	....
0.110	12	1.93	2.22	2.51	2.81	3.40	....	....	....	....	....	....	....	....
0.125	11	2.17	2.50	2.84	3.17	3.84	4.51	....	....	....	....	....	....	....
0.135	10	2.33	2.69	3.05	3.41	4.13	4.85	5.57	....	....	....	....	....	....
0.150	9	2.56	2.96	3.36	3.76	4.57	5.37	6.17	6.97	7.77	8.17	8.37	8.57	9.37
0.165	8	....	....	....	4.11	5.00	5.88	6.76	7.64	8.52	8.96	9.18	9.40	10.28
0.180	7	....	....	....	4.46	5.42	6.38	7.34	8.30	9.27	9.75	9.99	10.23	11.19

*NOTE. It is regular practice of National Tube Company to furnish for locomotive purposes sizes larger than 3" O.D. in Seamless only.

12. *Permissible Variations.* The weight of the tubes shall not vary more than 5 per cent. from that specified in Section 11.

V. WORKMANSHIP AND FINISH

13. *Workmanship.* The finished tubes shall be circular within 0.02 inch, and the mean outside diameter shall not vary more than 0.015 inch from the size ordered. The thickness at any point shall not vary more than 10 per cent. from that specified. The length shall not be less, but may be 0.125 inch more than that ordered.

14. *Finish.* The finished tubes shall be free from injurious defects and shall have a workmanlike finish. They shall be free from kinks, bends and buckles.

VI. MARKING

15. *Marking.* The name of the manufacturer and "Tested at 1,000 pounds" for tubes under 5 inches in diameter, or "Tested at 800 pounds," for tubes 5 inches in diameter or over, shall be legibly stenciled in white on each tube.

VII. INSPECTION AND REJECTION

16. *Inspection.* The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tubes ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tubes are

being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and are to be so conducted as not to interfere unnecessarily with the operation of the works.

17. *Rejection.* (a) Tubes when inserted in the boiler shall stand expanding and beading without showing cracks or flaws, or opening at the weld. Tubes which fail in this manner will be rejected and the manufacturer shall be notified.

(b) Unless otherwise specified, any rejection based on tests made in accordance with Section 3, shall be reported within five working days from the receipt of samples.

18. *Rehearing.* Samples tested in accordance with Section 3, which represents rejected tubes, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TABLE No. 1.

SERVICE CORROSION COMPARISONS

Railroad	Material Installed	Water Conditions	Length of Service	No. Discarded		Cause of Rejection	Remarks
				Steel	Iron		
A	Charcoal-iron and lap-weld steel tubes tubes in opposite sides of same engine.	Not stated	14 months	14 out of 176	49 out of 176	Pitting	
B	Tests made on three engines using half-sets of lap-weld steel and charcoal-iron tubes on each engine.	Bad	Three years (3 re-settings) Test continued	None	None	. . .	Steel tubes are in as good condition as iron. Tubes still in service.
C	Charcoal-iron and lap-weld steel	Very bad	60,000 miles	25	75	Pitting	Engines in which iron and steel tubes were used, were in same service under same conditions.
D	Tests made on one engine, using lap-weld steel tubes on right side and charcoal-iron on left side.	Bad	11 months (Test continued)	3	6	Pitting	Tubes removed and examined after 11 months. All put back in boiler except 9 which were discarded.
H	Ingot iron and lap-weld steel tubes.	Bad	Iron—15,000 miles Steel—30,000 miles	3%	All Scrapped	Pitting	
I	Swedish iron and lap-weld steel in opposite sides of same engine.	Very bad	14 months (When examined)	None	All scrapped (One at end of 8 months)	Pitting	They report that 18 to 24 months' service is obtained from steel; best service from charcoal-iron was 12 to 14 months.
E	See "Remarks."	Extremely Bad	—See Remarks"—				Now using lap-weld steel tubes on this division and obtain 25% more mileage and have less pitting than with charcoal-iron.

TABLE No. II.

MILEAGE—FLUE SHEET PRACTICE

Railroad	Mileage		Water conditions	Remarks
	Steel	Iron		
A	101,000 (One engine)	50,000—60,000 Was considered good	Not stated	Test made on one engine equipped with lap-weld steel tubes under same conditions as the charcoal-iron previously used.
C	95,000 (Average)	46,000 (Average)	Bad	Engines equipped with lap-weld steel tubes tested in comparison with engines equipped with charcoal-iron tubes under same conditions.
B	80,500 (Average)	40,000 (Average)	Probably most severe in country	Tests made on engines equipped with lap-weld steel tubes under same conditions as the charcoal-iron previously used.
F	70,000 to 75,000 100,000 to 125,000*	Freight 20,000 to 25,000 Passenger 40,000 to 50,000	Not stated	About three years ago the use of charcoal-iron iron tubes on this railroad was abandoned in favor of steel tubes after comparative tests on these two materials.
G	78,000 (One engine)	40,000—50,000 (Average)	Not stated	Tests made on engine equipped with lap-weld steel tubes under same conditions as the charcoal-iron previously used. Tubes still good and in service.
H	Test on engine equipped with Swedish iron on one side and Shelby seamless tubes on the other side of same engine.		Not stated	After 13 months engine was shopped. Nearly all beads on Swedish iron tubes were in bad condition; those on Shelby seamless tubes were apparently as good as ever.

*One engine on this road in fast passenger service equipped with lap-weld steel tubes made 245,675 miles before tubes were removed. This exceptional case is probably the largest tube-mileage ever made in America. Full data as to this run is given on page 2.

TABLE No. III.

on page 2.

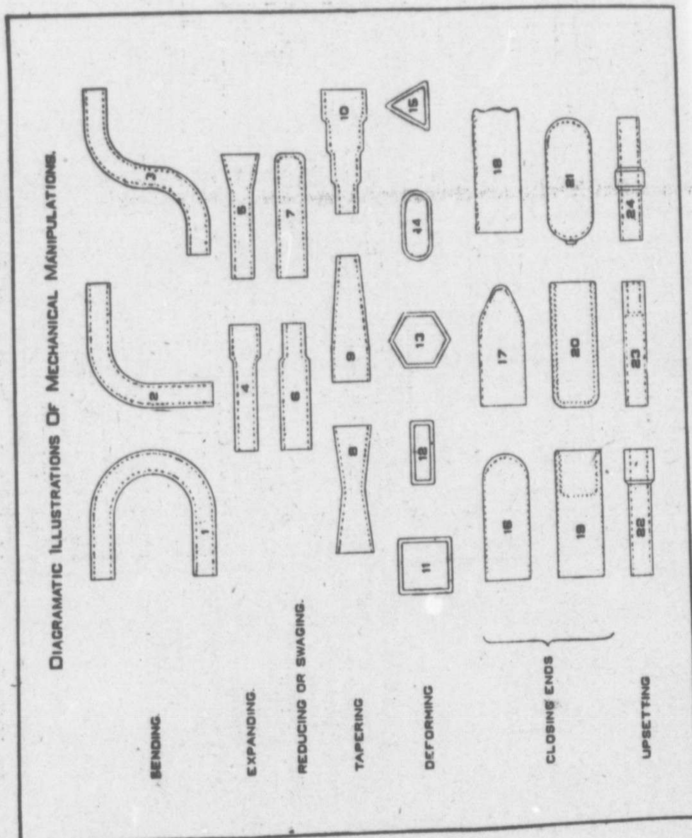
TABLE No. III.

PROCESS OF MANUFACTURE

- WELDED
  - BUTT
  - LAP
  - MATERIAL USED: WROT IRON, BESSEMER AND OPEN HEARTH STEELS OF EASILY WELDABLE QUALITY
- SEAMLESS
  - ROTARY PIERCING.
  - PUNCHING.
  - HOLLOW CAST BILLETS.
  - PLATE CUPPING PROCESS.
  - MATERIAL USED: ALL GRADES OF OPEN HEARTH STEEL OF LOW MEDIUM AND HIGH CARBON. ALSO VARIOUS GRADES OF DIFFERENT ALLOY STEELS. IRON CANNOT BE USED, AND BESSEMER STEEL WITH ONLY INDIFFERENT SUCCESS.

Torpedo Tubes
Submarine Air Flasks

GRADES		CHEMICAL ANALYSIS S	P	MN	C	NI	ELASTIC LIMIT IN LBS PER SQ. IN.	ULTIMATE STRENGTH IN LBS PER SQ. IN.	% ELONGATION IN 2 IN.	% ELONGATION IN 8 IN.	% CONTRACTION	HEAT TREATMENT
BESS.	AVERAGE	.045	.100	.30	.07		37000	57000		22	50	FINISHED HOT
O.H.	AVERAGE	.035	.030	.38	.10		32000	52000		25	55	FINISHED HOT
PUDDLED IRON	AVERAGE	.030	.200	TR	TR		27000	45000		15	30	FINISHED HOT
.17 CARBON	AVERAGE	.035	.030	.50	.17		40000	57000		30	50	FINISHED HOT
.17 CARBON COLD DRAWN	MAX.	.040	.030	.60	.19		70000	80000	18	7	30	NOT ANNEALED
	MIN.	.015	.010	.40	.14		55000	65000	12	3	20	
							65000	75000	25	16	45	FINISH ANNEALED
							50000	60000	18	10	35	
							48000	65000	60	28	60	MEDIUM ANNEALED
							35000	52000	50	22	50	
							35000	55000	65	33	62	SOFT ANNEALED
							27000	47000	55	28	52	
.35 CARBON COLD DRAWN	MAX.	.040	.030	.60	.40		90000	100000	15		18	NOT ANNEALED
	MIN.	.015	.010	.40	.30		75000	85000	10		12	
							85000	95000	30	18	32	FINISH ANNEALED
							70000	80000	20	12	25	
							65000	80000	45	30	42	MEDIUM ANNEALED
							50000	65000	35	20	35	
3½% NICKEL COLD DRAWN	MAX.	.040	.030	.60	.30	400	100000	110000	18		32	NOT ANNEALED
	MIN.	.015	.010	.40	.20	300	85000	95000	10		22	
							90000	105000	25		35	FINISH ANNEALED
							75000	85000	15		25	
							60000	85000	50	28	50	MEDIUM ANNEALED
							45000	70000	40	20	45	
Cr 1.8%	MAX	.040	.030	.60	.40		120000	165,000	30		55	900°C-water.
20% V.	MIN	.015	4 .010	.40	.30		100,000	125,000	15		40	600°C-Air.


DIAGRAMATIC ILLUSTRATIONS OF MECHANICAL MANIPULATIONS.
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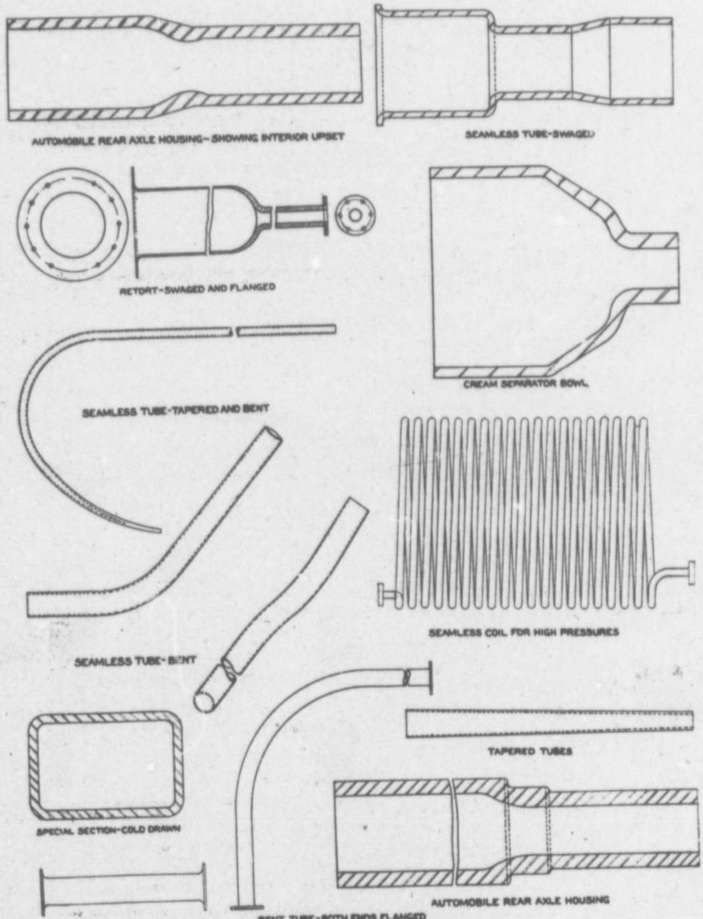
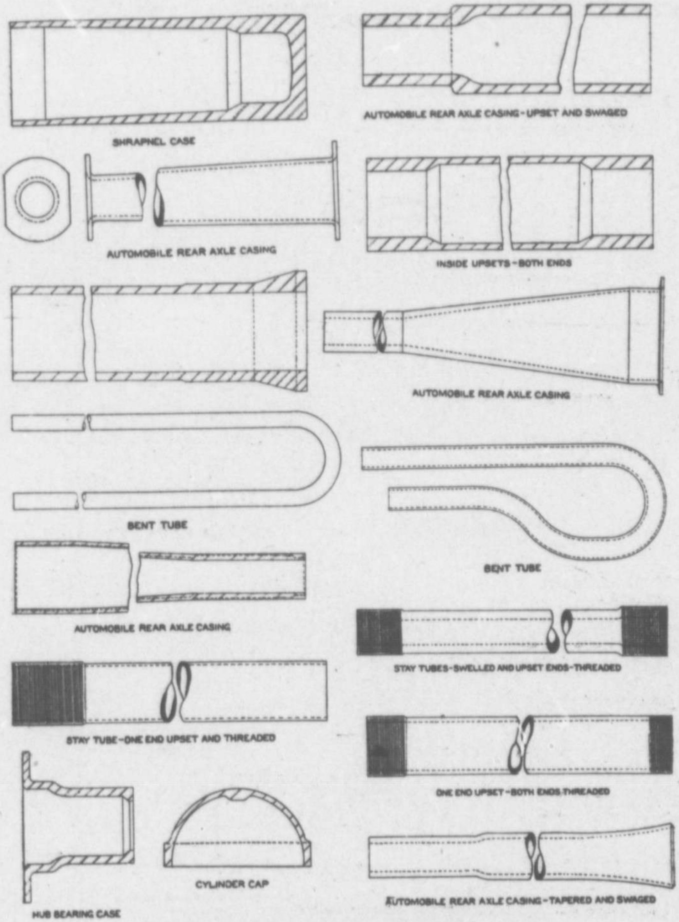
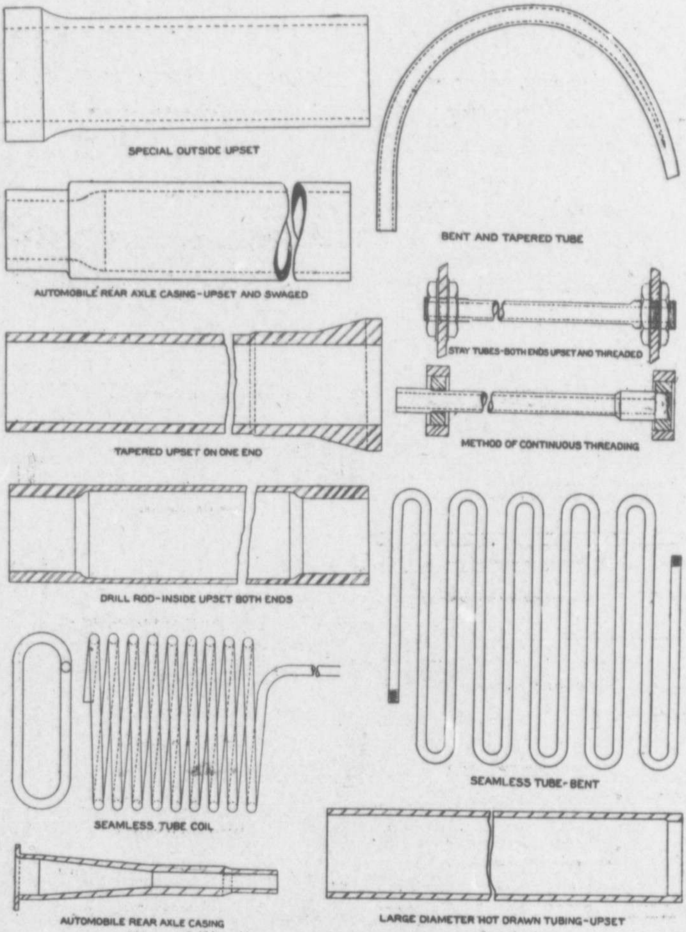


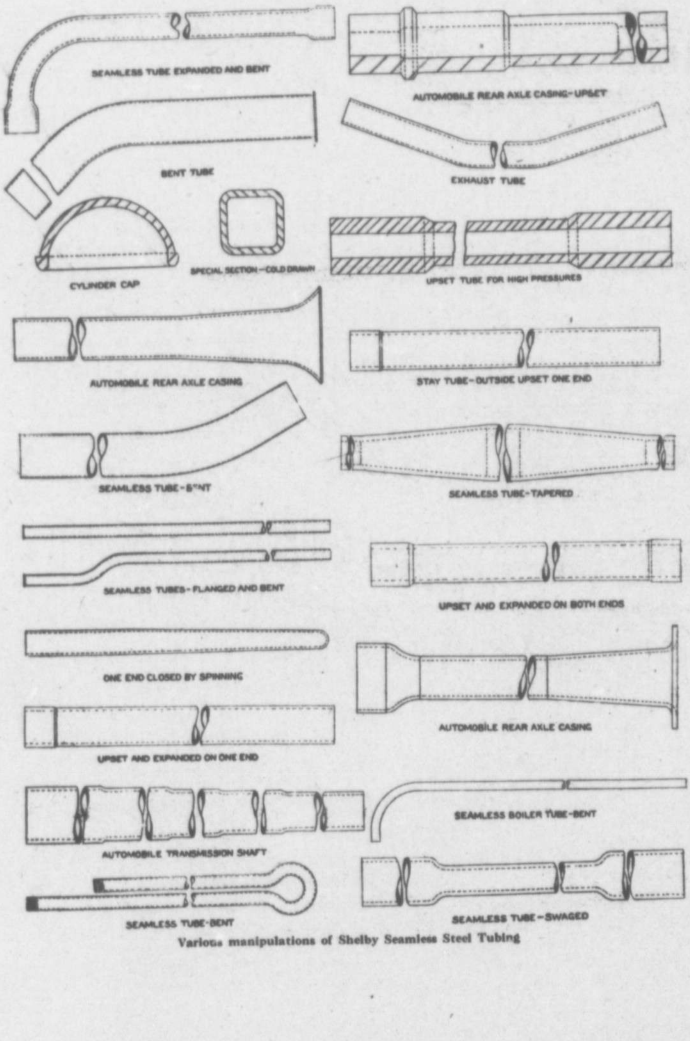
Various manipulations of Shelby Seamless Steel Tubing



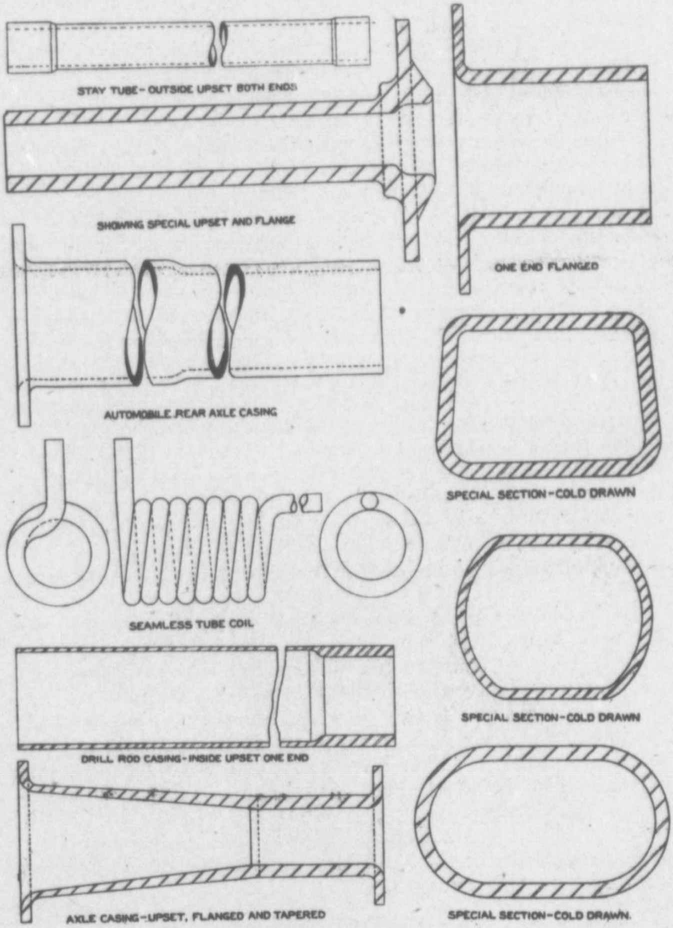
Various manipulations of Shelby Seamless Steel Tubing



Various manipulations of Shelby Seamless Steel Tubing



Various manipulations of Shelby Seamless Steel Tubing



Various manipulations of Shelby Seamless Steel Tubing

Mr Patterson,—

I would suggest as the hour is late there should be no discussion, but that on some future date to arrange for Mr. Speller to return, when there could be a full discussion on the tube question.

Moved by Mr. Patterson, seconded by Mr. T. Walsh that a hearty vote of thanks be tendered Mr. Speller for the most enjoyable and instructive evening which he had given to those present. Mr. Speller having come a considerable distance and at some inconvenience to be with the members of the Club on this occasion, we can assure him the members of the Club very much appreciate trouble which he has taken.

Would also add to this vote of thanks the University Engineering Society who so kindly co-operated with the Central Railway Club and by this means only made it possible that the Club were able to have Mr. Speller, as otherwise they could not have had the moving pictures or the auditorium, which was so kindly arranged for by University Engineering Society.

Mr. T. J. Walsh,—

I take much pleasure in seconding the motion of Mr. Patterson that a hearty vote of thanks be tendered to Mr. Speller of the National Tube Company for his generous exhibition of motion pictures demonstrating the manufacture of seamless and lap-welded boiler tubes, from the ore at the mines to the finished product. Also the manufacture of steam pipe and all other kinds of pipe which are manufactured by this very large firm.

It has been a most interesting and instructive exhibit and has been appreciated very much as in no other way except a visit to the plant could such a demonstration be seen, and very few of us would have the opportunity to make such a visit.

It also gives me pleasure to second the vote of thanks to the Engineering Society of Toronto University who so kindly assisted this evening. They have had installed a motion picture machine at large expense and invited us to its first demonstration.

As president of the Central Railway and Engineering Club of Canada, I thank them for the opportunity of holding our meeting here this evening.

Mr. F. N. Speller,—

My only regret is that so much time has been taken up with the illustrations this evening, as to interfere with the proper discussion of the subject, for this is usually the most practical part of the meeting. This is especially true where men representing all sides of the problem get together as we are this evening.

On account of the breadth of the subject represented by the motion pictures and lantern slides it was impossible to touch on any details, but for the benefit of the members of the Central Railway and Engineering Club, I have given their secretary some notes on the Application of Steel Tubing to Locomotive Construction, and was counting on a full discussion of some of the points raised in this paper.

This meeting has had a double interest to me on account of the presence of so many practical railroad men. Some of the most interesting and useful work I have had the pleasure of being connected with has been done in co-operation with motive power engineers; referring particularly to the boiler tube question. The results of this work are indicated, I believe, in the service tests and milage records shown in tables which have been prepared for publication in your proceedings.

It is through meetings of this kind that the necessary public interest in industrial research may be aroused and a better understanding promoted between the interests of all concerned.

Meeting adjourned at 11.00 p.m.