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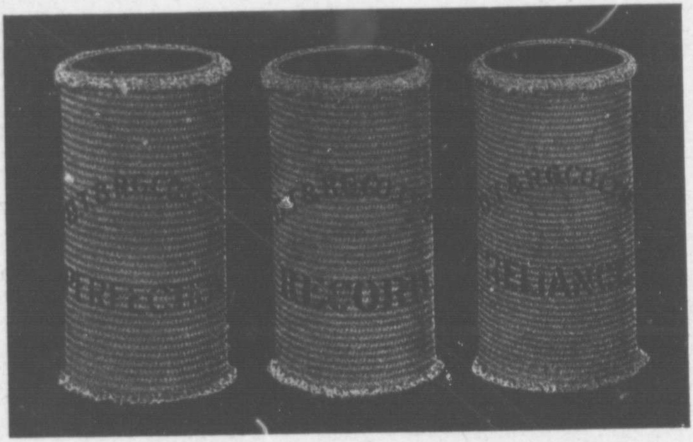

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OFFICIAL PROCEEDINGS

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PROCEEDINGS OF THE CENTRAL RAILWAY AND ENGINEERING CLUB OF CANADA MEETING.

PRINCE GEORGE HOTEL, TORONTO, May 17, 1910.

The President, Mr. Duguid, occupied the chair.

Chairman,—

The meeting will now come to order.

The first order of business is the reading of the minutes of the previous meeting. As you have all had a copy it will be in order for someone to move their adoption.

Proposed by Mr. Wickens, seconded by Mr. Jefferis, that the minutes of the previous meeting be adopted as read. Carried.

Chairman,—

The next order of business is the remarks of the President.

I am not going to take up your time with any remarks, as we have a very important paper to-night I will leave my remarks out.

The next order of business is the reading of the names of the new members.

NEW MEMBERS.

Mr. W. A. Conroy, Fitter, C. P. Ry., Toronto.
Mr. J. Powell, Asst. Foreman, C. P. Ry., Toronto.
Mr. T. McKenzie, Bursar, Mercer Reformatory, Toronto.
Mr. E. Walker, Machinist, Consumers' Gas Co., Toronto.
Mr. A. J. Roberts, Loco. Foreman, G. T. Ry., Stratford.
Mr. P. Brazier, Boilermaker, G. T. Ry, Stratford.
Mr. H. M. Patton, Asst. Storeman, G. T. Ry., Stratford.
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R. Dudman
A. W. Cleveland
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J. Thompson
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P. Jerreat	J. C. Donald	J. E. Wiese
J. Sim	J. Duguid	J. J. Dunn
L. S. Hyde	C. L. Worth	

Chairman,—

I may say on behalf of the Picnic Committee, that we have had two meetings of the whole committee, and it was decided that we would have the excursion to Beaverton Beach on Saturday, June 18th. A special train via the Canadian Northern Railway will leave the Union Station at 9 a.m.

I think when the rest of the Committees get here we will hear a little more about the Picnic.

The next order of business is the reading of papers and the discussion thereof.

We have with us to-night Mr. Dunn, of the Shelby Seamless Tube Co., who will read a paper on "The Manufacture of Seamless Steel Tubes," and I have much pleasure in calling on Mr. Dunn to read his paper.

SEAMLESS STEEL TUBES.

Manufacturing Processes and Properties.

BY J. JAY DUNN, CHIEF ENGINEER, SHELBY STEEL TUBE CO.,

ELLWOOD CITY, PA.

Mr. Chairman and Gentlemen,—I wish to say parenthetically that the title of this paper is a little too ambitious. I have been only able to describe one of the leading processes of manufacture, and to mention a few others. To have taken them up fully would have made the paper of entirely too great length.

A seamless tube is one made in such a manner that adjacent particles of material were adjacent from the time of the first meeting of the particles in the casting.

A tube formed by bringing together particles which, prior to the existence of the tube, were separated, cannot be called seamless. For some purposes for which tubes are used, it is sufficient to bring together the originally separated particles without uniting them in any way; such a tube cannot convey fluids without leakage, nor is it suitable to resist torsional stresses; but, in cases where the tubular form is the main consideration and the stresses to be resisted inconsiderable, tubes made in this manner meet frequent requirements.

The range of usefulness of a tube formed by bringing together particles of the material originally separated, is greatly extended by uniting such particles so that they cannot readily separate. This union is effected in numerous ways, such as seaming, soldering, brazing, riveting or welding. Conductors for roof water and pipes used for speaking tubes are usually made with some form of locked joint called a "seam," both with and without soldering. In cheaper grades of bicycle tubing and umbrella rods, the originally separated particles are united by brazing. The shells of steam boilers, and, less frequently, steam and water pipes, have the fastening effected by riveting. Practically all gas, steam and water pipes are welded to unite the particles separated originally.

All of these constructions are inherently defective, inasmuch as it is impossible to uniformly unite the originally separated particles so as to have a strength equal to the seamless portion of the material.

For this reason, shortly after the making of tubes by butt and lap-welding became a practicable operation, inventors turned their attention to processes for making seamless tubes. One of these early inventions is that of J. D. M. Sterling, of Birmingham, who, in 1854, patented a process of casting steel into tubular or hollow cylindrical forms and then extending them in diameter or length or both, by hammering, by drawing or rolling, or by combining such processes. In 1882, R. Elliott, of Newcastle-on-Tyne, proposed a method for producing seamless tubes by an extrusion process in which liquid or plastic metal was forced through a die and over a mandrel in a manner similar to that used for making lead pipe.

At about the same time, several patents were granted covering methods of making seamless tubes by successive drawing operations, starting with a flat circular plate or blank. This method will produce tubes having a less variation of wall thickness due to eccentricity of bore and having a surface freer from apparent defects, than any other so far developed. Unfortunately, the cost of production by this process is too great to permit its use for sizes smaller than, say, 6-inch by 3-16-inch wall, smaller sizes coming into competition with the much cheaper piercing process. The method was tried out thoroughly in the manufacture of bicycle tubes, but had to be abandoned for the above reason. However, it is in use at the present time for making the largest sizes of seamless tubes.

It is probable that ninety-five per cent. of the output of seamless tubes is manufactured by methods based on the Man-

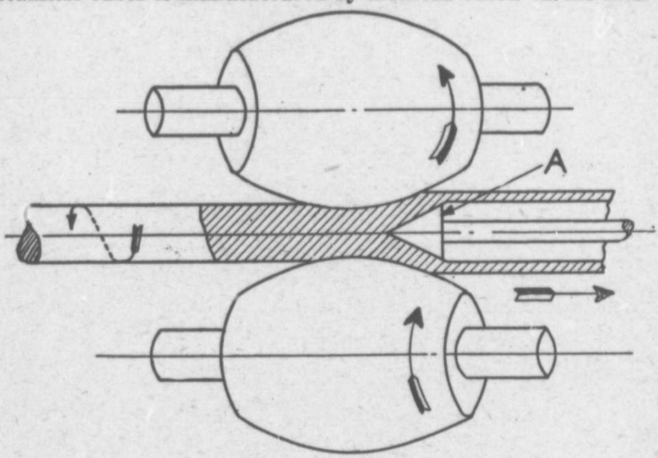

FIG. 1

nesmann process. The first patents were granted to the Mannesmanns in 1885. The specifications describes the process, thus:

"The process consists firstly in imparting to the piece to be rolled a rope-like twist as regards the outer fiber. For this purpose the blank or piece to be operated on is made to rotate betwen two plain discs or between two or more conically-shaped or otherwise formed rollers, and thereby to advance slowly. In consequence of the different speeds of rotation of the two ends of the blank, a twist similar to that of a wire rope is imparted to the fiber of the rolled product."

Tubes are formed by fixing a mandrel in front of the centre of the blank. In 1886, the Mannesmanns filed another specification stating that their process "consists mainly in working upon the outside of a solid blank by external rolls or rollers in such a manner that the blank assumes a tubular

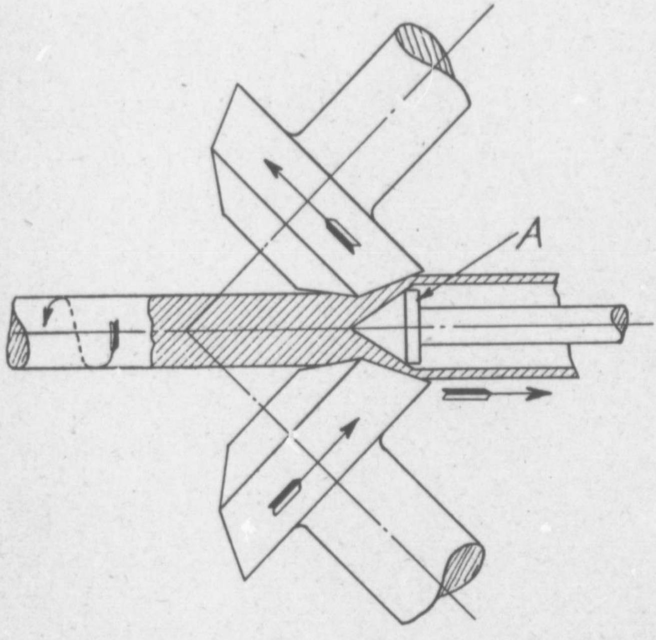

FIG. 2

shape, either no core or mandrel being employed or else a core or mandrel being employed for the purpose of smoothing the inside of the pipe or tube thus formed, reducing the thickness of its sides or shell and enlarging its internal diameter." Figures Nos. 1, 2 and 3 show various types of rolls and discs

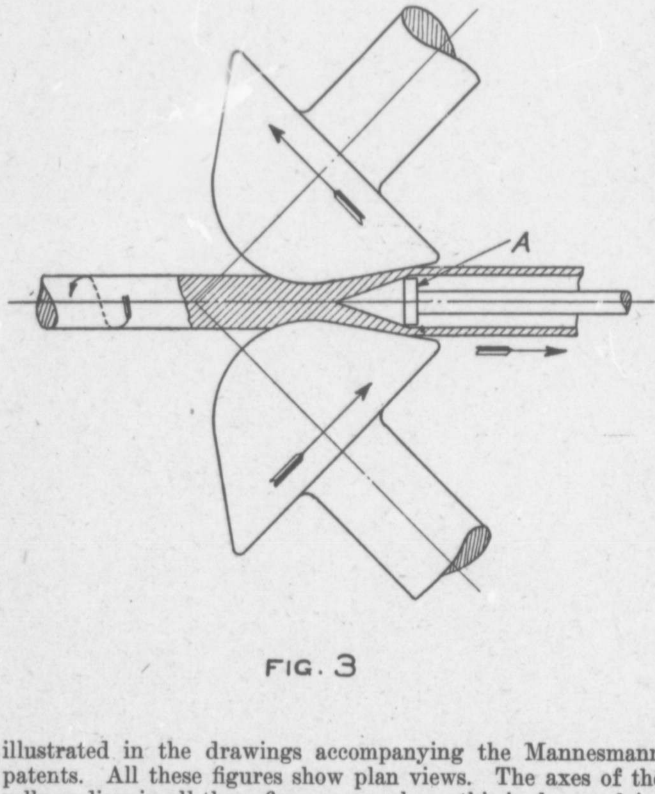

FIG. 3

illustrated in the drawings accompanying the Mannesmann patents. All these figures show plan views. The axes of the rolls or discs in all three figures are askew; this is shown plainly in Fig. 1, but is not evident in Figs. 2 and 3. Clearly the rolls in Fig. 1, when rotated in the direction indicated by the arrows, will cause the piece of metal between the rolls to rotate about the axis of its cross-section and at the same time advance in the direction of its axis. This advance is due to angularity of the roll to the axis of the metal blank. The same action takes place with the discs arranged as in Figs. 2 and 3. This is made clear by Fig. 4, in which the circles are sections of the discs and blank made by planes cutting the axis of each at right angles and intersecting in the point of contact between the disc and blank. Rotation of the disc about its axis A-B in the direction of the arrow, will tend to move the blank in the direction of the arrow C. This motion, by the action of the opposite disc and with the assistance of

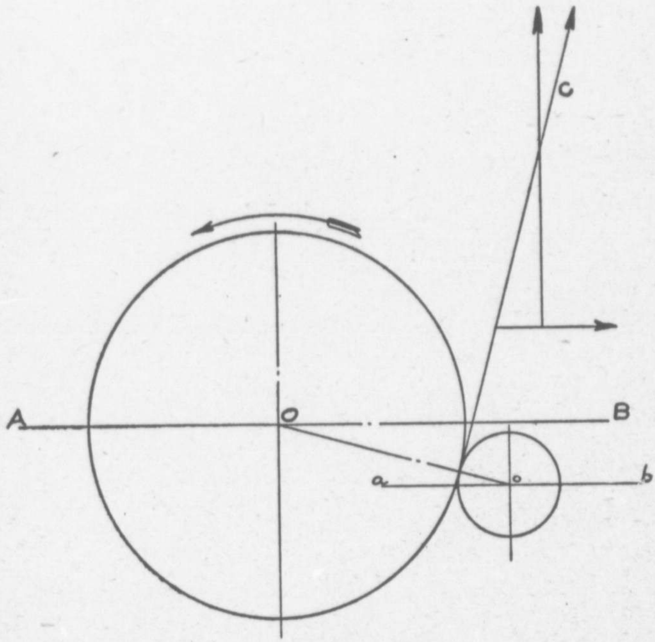

FIG. 4

guides to maintain a balance, is resolved into two motions at right angles to each other; that is, the blank rotates on its axis and at the same time has a longitudinal movement in the direction of its axis. In the plan views, Figs. 1, 2 and 3, the metal of the blank is shown in intimate contact with the mandrel A. However, as the metal is confined only along the line of contact of the blank with the rolls or discs, the metal is free to flow in other directions; this it does as shown in Fig. 5, which is a vertical section at right angles to the axis of the blank. A is portions of the section of the discs or rolls, M is the section of the mandrel, and B is the partially formed blank; direction of rotation is shown by the arrows. Evidently the rotation of the blank through this elliptical section causes severe strains in the metal of the blank, due to the constantly changing curvature. Additional severe strains are caused by the rolls or discs tending to impart a somewhat different speed of rotation to the blank at each point of contact. This varying speed of rotation causes the fibres of the material to assume a helical direction on the formed blank. The com-

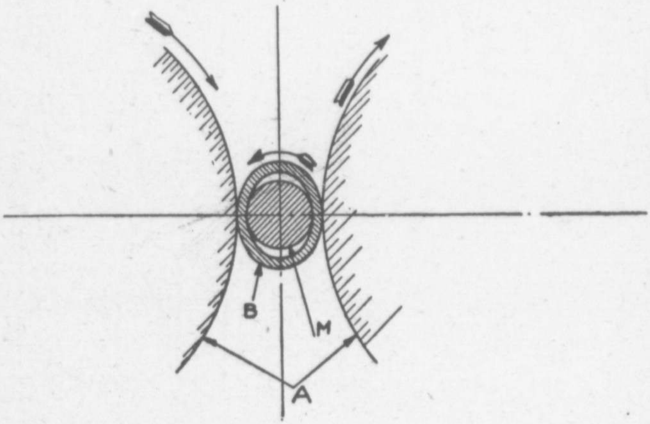

FIG. 5

bined stresses are so severe that very small defects in the material of the blank are torn apart and enlarged, causing a seam in the formed blank or tube. At this date it seems odd that the helical formation of the fibres of the formed blank or tube, with its attendant unnecessary stresses of the material, should have been one of the advantages claimed for the process.

To overcome the helical formation of the fibres in the pierced billet and its resulting unnecessary stresses on the material, R. C. Stiefel, of Ellwood City, Pa., proposed an arrangement of discs for which he was granted patents in 1895; this arrangement is shown in Fig. 6. From this figure it is evident that, at each section of the billet at right angles to its axis, the sum of the speeds of those parts of each disc A and B which are tangent to the section of the billet, is constant. With this arrangement of discs, there can be only one point in the line of travel of the billet at which the disc will rotate without slip. At all other points a slippage occurs, positive on one disc and negative and equal in amount on the other disc. This slippage has no other effect on the operation than to slightly increase the amount of power required. With proper combination of size of solid and pierced billet, form and size of piercing mandrel and disc angles, the Stiefel arrangement of disc wires will pierce billets without changing the arrangement of fibre of the solid billet. Under practical conditions of operation, the twisting of the fibres is always slight.

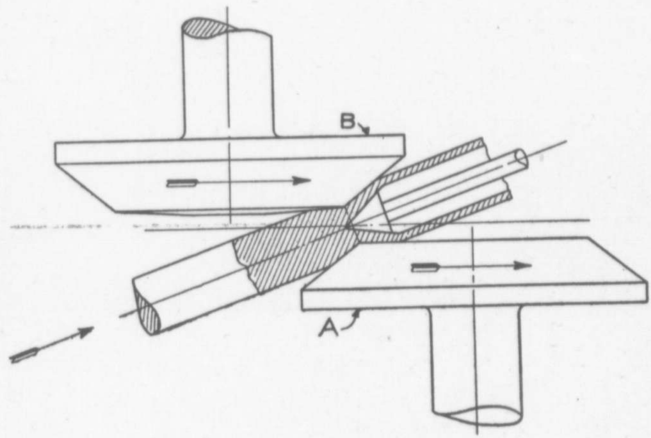

FIG. 6

One other method has been used extensively for making the hollow billets required for making seamless tubes, viz., the Ehrhardt Process. The process is described in the patent specification as a new method of simultaneously punching and shaping iron and steel block in red hot or white glowing state. The material in the shape of a square or rectangular bar, after heating, is placed in a matrix of circular section and a hole forced through the bar by a simple punching operation; the difference in the section of the material and the matrix permits the metal to flow sidewise and so reduces the tendency of the metal to compress under the punch. The method has had a limited application in Europe, but was abandoned in America.

Hollow billets produced by piercing have considerable variations in size and the surfaces are more or less corrugated by the action of the discs and piercing mandrels. It is not to be expected that a hot operation involving a reduction in the sectional area of the metal of, in many cases, seventy per cent., should produce a shape with uniformity. Consequently, the billet, after being put into tubular form by the piercing operation, is subjected to various finishing operations, such as rolling, swaging, or cold drawing, or a combination of these operations.

At this time the leading makers are producing large quantities of seamless boiler tubes by hot work only. As the process is typical of all operations used to bring the pierced billet to a fairly uniform size and to a section more suitable for cold drawing, it will be well to describe it in some detail to the exclusion of other little-used methods. The solid steel billet goes to the piercing mill at a temperature of about 1,200 degrees Centigrade. It is pierced to tubular form with a diameter of 1-8-inch to 1-4-inch larger than the diameter of the

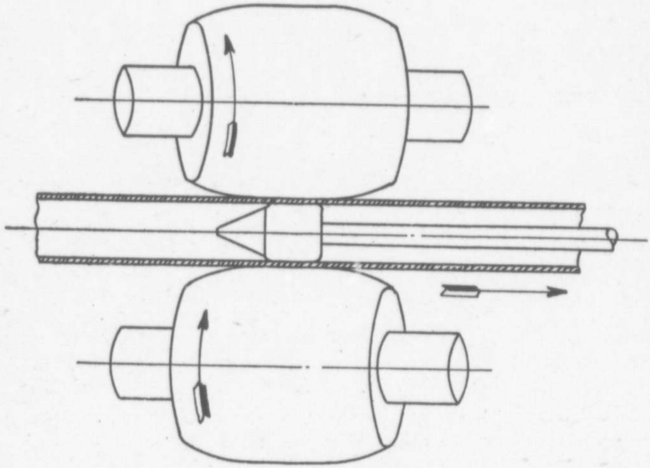

FIG. 7

finished tube and with a wall thickness of 7-32-inch or heavier as may be required by the final guage. After piercing, the hollow billet is transferred to a receiving table located in front of a stand of ordinary two-high rolls having approximately circular grooves slightly smaller in diameter than the finished tube. In the pass line of the groove and back of the roll, lies a long mandrel or rolling bar supported in suitable guides and having longitudinal movement prevented by anchoring in a heavy backstop which in turn is anchored to the roll housing. The rolling bar is hollow to permit a circulation of water for the purpose of keeping the rolling bar at a low temperature. The end of the rolling bar is adapted to reecive a pin which carries a conically-shaped mandrel of cast iron. It is this mandrel which determines the inside diameter of the rolled tube. In rolling, the tube is entered in the grooves of the rolls, which grip it firmly and force it over the mandrel and so reduce the wall of the billet. The tube is returned to the front side of the mill and successive passes given through the rolls until the desired wall thickness is obtained. Fifty per cent. is the practical limit of reduction in area that can be accomplished without re-heating after the piercing operation.

After rolling, the tube is transferred to a reeling or cross-rolling machine which rolls out any scratches on the inside of the tube, made by the rolling mandrel, and also removes all scale, giving the tube a smooth finished surface. The reeling machine is quite similar to a piercing mill, consisting of a pair of rolls with axes angular to the axis of the tube operated on, and having a long bar, free to rotate, for supporting the reeling mandrel. Fig. No. 7 shows the arrangement of the rolls.

From the reeling machine, the tube is delivered to the sizing mill, where it passes a groove of the exact dimension of the finished tube, plus the allowance for shrinkage. After sizing, the tube passes through a cross-roll straightener and thence to the cooling table, completed and ready to be cut to length.

The leading makers have so perfected auxiliary machines for this rolling process that the tube is handled mechanically throughout the entire operation, from the delivery of the solid billet to the piercer to finished tube on the cooling table.

The two-high mill rolling method is well adapted to the manufacture of hot finished tubes in quantities of a size from 2 1-2 inches to 6 inches outside diameter, in gauges from No. 12 B. W. G., to 1 1-6 inches wall thickness, with the provision that the inside diameter be not less than 2 1-8 inches. The flexibility of the rolling bar and strength of the rolling mandrel present practical difficulties in producing tubes with smaller inside dimension. A method for rolling a hot finished tube with an inside diameter as small as 1 1-4 inches and gauge as light as No. 13 B. W. G., is in an advanced experimental stage and gives every promise of final success. The method substitutes, for the stationary rolling bar and mandrel of the two-high mill process, a moving mandrel having a diameter the same as the inside diameter and a length somewhat greater than the finished tube. The rolling is done on a continuous mill; succeeding operations are practically identical with those of the two-high mill process.

Hot finished seamless boiler tubes were first placed on the market in the year 1905, so the process is barely five years old. Each year has seen an improvement in quality and increase in quantity manufactured, so it is now safe to predict that the time is coming when all seamless boiler tubes will be made hot finished.

In the early days of the seamless tube industry, the tube produced by the hot operations was far from accurate as to diameter and gauge. Later, while it was possible to obtain accuracy in dimensions, it was still impossible to produce more than a limited range of sizes without a prohibitive cost. The demand for seamless tubes covers a wide range of sizes, several manufacturers producing more than 2,000 sizes in the course of a year.

The simplest method of meeting this condition was cold drawing. The tube from the hot mills, more or less inaccurate as to size and rough as to surface, is pointed, that is, reduced, on one end for a distance of six to twelve inches to a diameter slightly less than that of the tube intended to be made. After

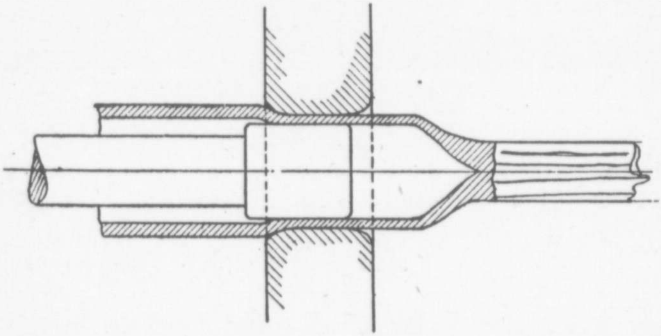

FIG. 8

pointing, the scale is removed by immersion in hot dilute sulphuric acid. The tube is then covered with lubricant inside and outside and is then ready for drawing.

In the cold drawing operation the tube is pulled through a hard steel or chilled iron die and over a mandrel, reducing both the outside and the inside diameters, but different amounts, so that the wall is also reduced. Figure No. 8 shows the relation of die, mandrel and tube, with its point or tag for the grip. The tube leaves the die with a speed of from fifteen to thirty feet per minute; the reduction effected in the area of the cross-section will average sixteen per cent. on tubes No. 16 B. W. G. and lighter, and twenty to twenty-five per cent. on heavier tubes up to the capacity of the bench. The force required to pull the tube through the die is approximately 90,000 lbs. per square inch of reduction in area at a speed of five feet per minute, and 115,000 lbs. per square inch of reduction at a speed of thirty feet per minute. These figures are for basic open hearth steel of about .15 per cent. carbon. The tube leaves the die with a surface more or less bright, depending largely on the lubricant used. It is much smoother as to surface and is hard and brittle to a degree depending on the reduction made and its previous condition of hardness. This hardness and brittleness is entirely removed by annealing at a temperature slightly above the lower critical point; in practice, the tube is heated to 720 degrees Centigrade. Sucessive cold drawing operations folowed by annealing and pickling operations are given the tube until it reaches the desired size. With care in the annealing and pickling, the surface becomes smoother with each cold drawing. After the third operation, all traces of the hot work have been removed.

Cold drawing has no effect on the material that cannot be entirely obliterated. The volume of the grains of the metal is the same as before the operation, being simply elongated in the direction of the axis of the tube. It is, therefore, advisable to anneal at a refining temperature prior to cold drawing unless the final work in the hot operations was done at a lower temperature. The importance of this point has not been generally recognized.

The first requisite of material for seamless tubes made by the piercing process, is soundness. A blow-hole, crack or check or pipe in the ingot, which would roll down and pass unnoticed in a rail, shape or plate, will, through the expanding of the piercing operation, develop a defect which cannot escape detection. It is, therefore, imperative that steel for seamless tubes be made specially for the purpose. Basic open hearth steel is used almost exclusively, although there is no reason why Bessemer steel should not be satisfactory if made with proper care. Crucible steel of 1.00 per cent. carbon has been made into seamless tubes for special purposes.

For all boiler tubes and for most mechanical purposes, a B. O. H. steel of the following analysis has proved very satisfactory:

Si	Up to .20 per cent.
S	Under .04 per cent.
P	Under .03 per cent.
Mn	.40 to .60 per cent.
C	.14 to .19 per cent.

This material can be made sound, is stronger and more dutcile than iron, and will weld readily. It is tough, but will cut clean with proper tools, and is ideal for case hardening. This material in the form of hot finished boiler tubes gives the following results on tensile test:

Elastic limit ....36,000 to 42,000 lbs. per square inch.
Maximum strength ....56,000 to 62,000 lbs. per square inch.
Elongation in 8-inch....18 to 22 per cent.
Reduction of area.......50 to 60 per cent.

This material in cold drawn tubes varies in physical properties with the heat treatment as follows:

Anneled at 400 degrees C., or what has come to be known as the Finish Anneal:

Yield point ....55,000 to 80,000 lbs. per square inch.
Maximum strength ..... 1,000 to 5,000 lbs. per square inch higher than the yield point.
Elongation in 2-inch....18 to 25 per cent.
Elongation in 8-inch..... 3 to 10 per cent.
Reduction of area.......30 to 45 per cent.

The wide range of the above figures is due to variation in the amount of cold work.

Annealed at the lower critical point, or the Boiler Tube Anneal, or the Soft Anneal, as it is variously known, gives the following results:

Yield point ....27,000 to 32,000 lbs. per square inch.
Maximum strength ....49,000 to 54,000 lbs. per square inch.
Elongation in 8-inch.....24 to 28 per cent.
Reduction of area.......50 to 60 per cent.

Boiler tubes should always be annealed in an open furnace where the whole charge is open to observation throughout the operation. Careful work will leave the material uniformly soft and with only a slight dusty oxide.

Annealing in retorts with slow cooling will reduce the oxidation slightly, but it will at the same time reduce the yield point at least 5,000 lbs. per square inch without altering the ductility.

Cold drawn material of about .15 per cent. C., annealed at the upper critical point, or at a refining temperature, gives the following tensile results:

Yield point ....34,000 to 39,000 lbs. per square inch.
Maximum strength ....52,000 to 58,000 lbs. per square inch.
Elongation in 8-inch.....26 to 32 per cent.
Reduction of area.......52 to 62 per cent.

The refining temperature produces a loose, heavy scale, but this is immaterial for many purposes. For hollow stay bolts, this makes probably the best material that has been used for the purpose.

For mechanical purposes requiring greater strength than can be obtained with the low-carbon steel, seamless tubes are made of steel with carbon ranging from .30 to .40 per cent. The same heat treatments are applied to this material as are used with the low-carbon steel, the increase in strength being due to the carbon alone. A 3 1-2 per cent. nickel steel with carbon running from .20 to .30 per cent. is also used where ductility combined with great strength and resistance to shock is required.

For special purposes much harder materials than any of those mentioned are made into seamless tubes. An example is the rolling mill bars used for making hot finished tubes, mentioned above. These bars are subjected to tremendous shocks and are limited in size by the conditions of their service. For these a chrome nickel steel of .50 per cent. carbon is used, giving a material with a yield point of over 220,000 lbs. per square inch.

Seamless boiler tubes have been in extensive use for about twelve years and their merits are now generally acknowledged. However, boiler tube specifications are still drawn without recognition of the difference in the method of manufacturing seamless and lapwelded tubes. Several large railway systems still adhere to the quenched bending test requirement, which, applied strictly, cannot be met by the material it is necessary to use in a seamless tube. The test was originally intended to detect laminations or telescoping in iron tubes; as these defects do not occur in seamless tubes, the requirement should be eliminated. The usual wording of the specification is that the test piece shall be heated to a cherry red in daylight and quenched in water at 70 degrees Fahr. This temperature is above the lower critical point of the steel and even when the carbon is as low as .12 per cent the treatment results in a material increase in hardness and a coresponding loss of ductility, such that the majority of tests will fail. If the specification called for the test piece to be quenched from a temperature of 800 degrees Cent., which is a fair interpretation of the term "cherry red," manufacturers would not attempt to make seamless tubes to meet the requirement. If, on the other hand, the specification required a punching temperature of 700 degrees Cent., seamless tubes would pass the test without difficulty. To be fair to the seamless tube, the requirement should be eliminated, or, in fairness to the manufacturer, the temperature of quenching should be specified more precisely.

Another point of difference between lapwelded and seamless boiler tubes, which is not recognized by locomotive boiler tubes specifications, is the variation in gauge. Many specifications call for a variation in gauge of not more than plus or minus .010 inch, except at the weld, where a tolerance of plus .015 inch is allowed. Why should not this be changed to read, "plus .015 inch to minus .010 inch?"

Seamless tubes have one inherent defect which has resisted all efforts to overcome; namely, lack of concentricity of bore with the outside surface. The eccentricity is due to the deviation of the piercing mandrel from the axial line in the piercing operation; the amount of this deviation seems to be a lineal function of the wall thickness. No subsequent operation can alter the amount of the eccentricity. Experience shows that the variation from the average wall thickness, due to ecentricity, is approximately as follows:

60 per cent of the product will vary less than 5 per cent. of the wall thickness.

80 per cent. of the product will vary less than 7 per cent. of the wall thickness.

97 per cent. of the product will vary less than 9 per cent. of the wall thickness.

3 per cent. of the product will vary more than 9 per cent. of the wall thickness.

In addition to the variation in wall thickness due to eccentricity, is the variation in the average wall thickness. This latter variation is fortunately so small in amount as to be negligible as compared to the eccentricity.

The regular mill inspection holds the wall variation to a limit of plus or minus 10 per cent. of the wall thickness.

To illustrate this variation in wall thickness and what it means in the inspection, limits of variation for different specifications are given below:

No. 11 M. M. Gage=.125 inches.

Mill inspection—10 per cent. limit:

Maximum wall, .137 inches.
Minimum wall, .113 inches.
Material passed, 97 per cent. of amount inspected.

Certain R. R. specifications—plus or minus .010 inch limit:

Maximum wall, .135 inches.
Minimum wall, .115 inches.
Material passed, 89 per cent. of amount inspected.

Proposed specification—limit of plus .015 inch and minus .010 inch:

Maximum wall, .140 inches.
Minimum wall, .115 inches.
Material passed, 97 per cent. of amount inspected.

It is seen that the usual variation allowed on lapwelded tubes, when applied to 11 ga. seamless tubes will pass the same percentage of material as the usual mill inspection;

while the limits sometimes specified for seamless tubes reject a considerable percentage for a very trifing variation.

When applied to tubes of 13 ga. or lighter, an allowance of plus or minus .010 inch becomes excessive, while for 6 ga. it is entirely inadequate.

The departments of the United States Navy have recognized this peculiarity of seamless tubes and drawn a neat and effective specification in accordance therewith, by requiring a minimum gauge with a maximum limit to the weight.

There can be no question but that a specification drawn by the consumer and the manufacturer in consultation will in the end prove the most satisfactory to both.

Chairman,—

We have all listened with a great deal of attention to Mr. Dunn's paper, and the meeting is now open for discussion. Anyone may now ask any questions they wish.

There are a number of foreman boiler makers, and boiler-makers here, who are, without doubt, very much interested in boiler tubes, and I hope they will not be backward in getting up and asking for any information which they think would be of benefit to them.

We have with us to-night Mr. Patterson, Master Mechanic of the Grand Trunk Railway Shops at Stratford, and I will call upon Mr. Patterson to open the discussion.

Mr. Patterson,—

I can assure you that it affords me a great deal of pleasure to be present at the meeting of the Club this evening. Most of you are aware that we have been very busy at Stratford building new shops so that my attendance at the meetings during the last year has been limited.

I am pleased to see a good representation of the Stratford members here to-night, also glad to hear from the Secretary's report the new names proposed for members of the Club from Stratford.

The members of this Club are very much indebted to Mr. Dunn for the excellent paper which he has given us to-night and we are all very much interested in the subject of tubes and this does not apply to railroad men only, and while perhaps we who are in the railroad business are more concerned in what happens these tubes after they have been applied, than in the actual manufacturing, yet it is of great interest and of profitable interest to us to know what enters into the manufacturing of tubes as it would probably be the means of our being able to handle them more intelligently in active service, also to decide what class of tubes we should recommend.

We have had a good deal of experience with all classes of tubes, charcoal iron, lap welded and seamless steel tubes. Now we have very little trouble as a rule when applying new sets of tubes to a boiler, but what concerns us most are tubes that we repair, that is by welding a safe end on them. My experience has been that you will sometimes get tubes that you can weld easily and they will give good satisfaction and sometimes we get tubes which are difficult to weld with even our most experienced men. We had one lot of tubes which particularly gave us trouble in this respect. We find that a good many tubes were burnt in the welding, the heating point of welding being so close to that of burning the material that we had great difficulty in making our welds without burning the material. We find if these tubes are overheated to the slightest extent, they develop cracks. We also find that when we do not heat the tubes enough, we would get an adhesion so that the welds would stand but the weld was not perfect.

We find the charcoal iron tubes weld perfectly and we would weld set after set without having one defective tube. These, as you know, would also stand the expanding and the beading and as far as the shop was concerned, they would give perfect satisfaction, but it was claimed that when they got out on the road in actual service, their life was not as long as steel tubes.

In regard to the testing of seamless steel tubes, we have made a number of tests as described by Mr. Dunn and which is the standard test recommended by the American Railway Master Mechanics' Association, and while there are some parts of this that Mr. Dunn does not consider a fair test for seamless tubes, we find by these tests that we can pretty clearly define whether the tubes are going to be suitable for our purposes or not and we test all our tubes by this test, but as before stated, while we find some tubes will stand the test, yet we sometimes find that we do not get the service out of them which we expected. However, I think any tube that will stand the rolling, beading and welding and the test recommended by the American Railway Master Mechanics' Association, will give pretty good results in actual service if they receive proper care, and I think the results obtained from tubes, that is the mileage depends a great deal upon the conditions and usage which the tubes are put to.

I think the short or long life of tubes for any locomotive or stationary boiler is practically governed by the conditions of the locality, that is to a great extent. Of course, I realize that if they are not properly cared for, their life will be shorter than if they had received the average attention, but the condition of the water is almost entirely responsible for the durability of the tubes.

For instance, on the Grand Trunk, on our extreme Eastern Division around Island Pond and Gorham, we have tubes that run almost as long as you would care to keep them in the boiler. The reason is on account of the excellent water which we have in that district. Coming west a little, around Ottawa and Montreal, we find our engines will make from 80 to 120 and 130 thousand miles before the tubes require to be renewed. When you come farther West around Toronto and Stratford, if you get 40,000 to 45,000 miles on an average, you are getting very good service, that is with the same class of tubes that we use on the Eastern Division, so that it is under the conditions which the tubes are used and the water which makes a great difference in the length of service which they will give.

Of course, there are some exceptional cases, the material in some tubes will cause them to last longer than others in the same service. We have had some tubes which were very hard and would get loose in the sheets after they were put in and we found it most difficult to keep them tight. Then again, we had others which we found it almost impossible to weld but these are exceptions to the general conditions and I might say that we have used both steel and iron tubes and have got excellent results from both kinds.

Do not think that there is anything further which I wish to say but would like to bring that one question to Mr. Dunn's attention "Why is it that the point of welding and the point of burning in the same class of steel tubes is so very close." He will no doubt have had some experience in that line and will be able to enlighten us.

Mr. Berry,—

I did not get here in time to follow the paper all through.

As Mr. Patterson says, local conditions have a good deal to do with the efficiency of tubes. I think from my experience that any class of material will do better in good water than bad. I have made careful enquiries in different places all over the Grand Trunk System and over other roads, and I find that there is one class of material, which, worked up and under the same conditions, will give better satisfaction in one district than it will in another. I think possibly that if the water in a certain district was analyzed and material made to meet the conditions of that district, better results would be obtained.

I know that as far as local conditions are concerned that we get three or four different kinds of material. The boiler-maker gets used to a certain kind then probably he gets a harder material than he has had before and he treats it in the same way that he treated the other, and of course it does not give satisfaction. Then, possibly, he will get a softer material and he will work on it as he did on the harder material and the first thing you know it is all rolled to pieces.

I think, as I said before, that if the manufacturers of tubes would look around and analyze the water in the districts in which the tubes are to be used, they would be able to make tubes suitable for that district.

I am sure that it affords me great pleasure to be here and listen to this paper on "The Manufacture of Tubes."

Mr. Wickens,—

I may say that I have enjoyed this lecture very much. It is a good thing for everyone to have an opportunity for learning something about "The Manufacture of Tubes."

The average locomotive tube is better taken care of than stationary boiler tubes, and most of my experience has been with stationary boilers. There has been a great deal of trouble with stationary boilers. When we got seamless steel tubes we thought we were going to be entirely out of trouble, but this has not proved to be the case.

The principal difficulty we meet with in ordinary stationary boiler practice is the fact that steel tubes pit quicker than the old iron tube used, and it does not seem to make much difference what water is used. There are places where the iron tube did well, and again there are places where the steel tube did better than the iron. I think the steel tubes will stand rolling and beading a little oftener especially if the man repairing them uses discretion and does not spoil the tube to start with.

I had a case a short time ago where the mill had five boilers in it, the older boilers had lap welded charcoal iron tubes, and in the new ones they were steel tubes and in a short time we had to renew about half of the steel tubes in two of the boilers, and the superintendent said he would not have any steel tubes, but would have the old American lap welded iron tubes, and he got them.

There is something in the steel that seems to be affected by water that will not touch iron at all, and this is a point I should be very much gratified to get some knowledge on, as I have had a good many troubles of that character. If there is anything in the water that causes this it should not be very troublesome to treat the water. If it is in the tubes it is up to the man that makes the tubes to treat them.

I am very much pleased to have been able to listen to Mr. Dunn, and I believe Mr. Dunn knows enough to help us with some of these troubles.

Mr. Taylor,—

I think we shall have to take our hats off to "Seamless Steel, Tubes" that is smaller sizes than the ordinary 2½" or

4″ tubes, that is where it is necessary to use 1¼″ or 1⅜″ tubes, as we find it very difficult to handle lap-welded iron tubes of this size.

We have had great difficulty with seamless steel tubes splitting before they have been put into service. As soon as they have been put in the boiler and water turned on before any pressure has been applied we have found they have developed cracks and I would like to hear something about this, probably there is some carelessness in the annealing.

When seamless tubes came out we thought we had the identical thing, but after putting these tubes in we found they did not stand up as long as the ordinary lap welded tubes, we found that they pitted, and soon became loose in the head, something the old tubes did not do.

I would like to hear the cause of that splitting explained, if possible, as we are handling some of those tubes now, and I am anxious to know how that takes place.

Mr. Ord,—

When your President came down before the meeting opened and requested that I give you a few words on the tube question, I told him not to call on me as I was afraid that natural modesty and lack of practice in public speaking would cause me to decline to say anything.

The tube question is one that has received a great deal of attention and discussion extending over a number of years. Committees from the Master Mechanics, Master Blacksmiths and Master Boilermakers have spent considerable time on it, and as one who has followed their reports rather closely, I have come to think that the more the question is studied and the more thoroughly it is understood, the less one feels inclined to say anything about it.

The excellent paper and illustration by sketches which we have just had from Mr. Dunn, describing the various processes of tube manufacture, is of general interest and especially to those of us who are tube users, but this side of the tube question does not strike home in the same personal way to motive power men as does the working of the tubes when setting them in the engines, the way they stand in service, and the facility with which they can be repaired and welded up when this becomes necessary.

The main controversy at present is, "Steel or Iron Tubes," and the gentlemen who have to maintain these in service wish to hear something about this.

About twelve months ago a committee of five experienced foremen boilermakers from different parts of the United States were appointed to deal with this whole question of tubes. A few years ago these committees and very likely these same gentlemen would have given us a mass of details which would make one's head ache but the report seems to bear out the fact that steel tubes give just as good service as iron tubes and vice versa, and that with an oil furnace the different classes of iron and steel tubes weld equally as well. In an open coke or coal fire, some opposition is met owing to the impurities in fuel.

The great difference in opinion to which attention is called, is principally due to the difference in local conditions as just explained by Mr. Patterson.

For instance, no longer ago than yesterday, I was talking to a foreman boilermaker from the state of Michigan, and he told me that up to about three years ago, they used all iron tubes and about that time they commenced to use steel tubes and have found that the steel pits right through within two years' service.

Gentlemen, I did not come down here prepared to talk on the tube question and if I should get started into details, I would not know where to stop, moreover, I am the third speaker from the Grand Trunk and Mr. Patterson has given you an account of our experience, there are doubtless many gentlemen waiting to ask Mr Dunn some questions and I will make way for them.

Mr. Woodward,—

I wish to take exception to what Mr. Patterson and Mr. Ord said about local conditions.

I am one of the local men, that is one of the men who work in round houses, and I want to say that it is not their fault that the tubes fail. Mr. Patterson said that in some places they get 70,000 miles and more, but if they get 45,000 and 50,000 around here they are doing well, but I want to impress on Mr. Patterson that this is not the fault of the local men.

Mr. Patterson,—

I think Mr. Woodward has misinterpreted what I said. What I said in regard to local conditions was in reference to the water. My remarks referred to the locality in which the engines were running, and not the local conditions under which they were repaired, and I want to make it quite clear to Mr. Woodward that what I said was that at Montreal they can get 100,000 or 130,000 miles out of the tubes, while up here we can only get 40,000 or 45,000 miles, no reference being made to the shops.

Mr. Woodward,—

I am sorry I misunderstood what Mr. Patterson meant; I thought his local conditions meant local men.

Mr. Lewkowicz,—

While I have been listening to the paper and the discussion, one or two points have come to my mind.

Cannot tube manufacturers help users to overcome the troubles due to local water conditions mentioned by previous speakers. If users, as suggested by Mr. Dunn, consulted with the manufacturers to try and adapt the chemical properties of the metal used in making the tubes, and not attempt to make one unchangeable set of tests, might they not get better results in this way. I do not know whether the chemical properties in the tubes could be changed to overcome the difference in local conditions, but I should think it would be possible for the manufacturer to change the mixture of the metal to meet certain conditions.

Mr. Taylor,—

I would like to hear a little about the splitting of the tubes before they are put into service, and I would like Mr. Dunn to speak about that.

Chairman,—

Mr. Dunn will reply to all the questions at once, after everyone has asked for the information he requires. Mr. Dunn is taking a note of the questions as they are asked.

Mr. Black,—

There is one part of the question that has not been brought up. This is the question of the service the tubes give when they are applied, and I would like to ask Mr. Dunn, or anyone who can give me the information, if there are any tests made of the metal used in the manufacture of boiler tubes for extreme expansion and contraction that locomotive tubes are subject to. That seems to be one of the greatest troubles. The metal that the tubes are composed of does not seem to be able to stand the hard usage that tubes are put to, if we could get that question solved I think the tube question would be eliminated.

Mr. Jefferis—

I think the subject has been very ably handled by Mr. Dunn, who has so kindly come all the way from Ellwood City, Pa., to give us such an instructive paper to-night, and also by the boilermakers. I think this is the boilermakers night. The engineers, mechanics, moulders, and draughtsmen, etc., have had their night, and this is the boilermakers night. It is the time for them to air their views and troubles, as we shall not have Mr. Dunn here at the next meeting.

There is one question I would like to ask Mr. Dunn, would he tell us if there are any troubles to look for that we have not already found.

I think Mr. Patterson and the gentleman from different points have covered this subject very ably, and I do not think there are many more questions that could be asked, and I think if we can get Mr. Dunn to answer the questions that have been asked, and tell us how to get 300,000 miles out of locomotive boilers and tell us how to run stationary boilers for 10 or 15 years without any leaks, I think we will all go home very much pleased.

Mr. McRobert,—

I have had considerable experience with various kinds of water in all parts of the world, and I have handled boilers that have run 300,000 or 400,000 miles without showing any leakage in the tubes. I have known boilers to run eight years and the tubes remain tight. I may say this was in marine service. We used steam which had been condensed and was used over again in the form of feed water.

We never used to see any leaks in the tubes and we had multi-tubular boilers from 180 to 215 pounds pressure.

The Chairman,—

What kind of tubes did you have?

Mr. McRobert,—

They were steel tubes.

Mr. Patterson,—

I should have thought the regulations would have called for the tubes to have been removed.

Mr. McRobert,—

Not necessarily.

Chairman,—

I will now call upon Mr. Dunn to answer the questions that have been asked.

Mr. Dunn,—

The information that I have gathered during the last ten years has been sometimes in favor of the iron tubes and sometimes in favor of the seamless steel tubes. Sometimes I hear of an extra good endurance test of seamless tubes, and then I hear of a bad one. Without question, variation in local conditions is a greater factor than the material in the tube. I know of one plant in New York, where we put in a set of tubes in 1902 and took them out in 1907, and had to put in another set in 1908. A metallurgist investigated the matter carefully and could not find out definitely what was wrong. Another set of tubes was put into this boiler and so far we have had excellent reports of them. There was something strange happened to that second set of tubes.

There are places where charcoal iron tubes give the best service, there are places where the Bessemer lap-welded steel tubes give the best service, and there are places where the seamless steel tubes give the best service. But I am of the opinion that seamless steel tubes, taken all round, will give the best results. This contention is well borne out by the fact that the consumption of seamless steel tubes has steadily increased.

In regard to corrosion I would place the order of merit as follows:—

Charcoal Iron Tubes.
Seamless Steel Tubes.
Lap welded Steel Tubes.

But slight and perhaps unnoticed changes in the conditions of service will completely reverse this order.

In the order of merit for durability in the stationary boiler and on the road, I would place:

Seamless Steel Tubes.
Lap welded Steel Tubes.
Charcoal Iron Tubes.

Charcoal iron tubes will resist corrosion, due to the fact that the slag in the material prevents the corrosion of the charcoal iron. But slag is a brittle material, has almost no tensile strength, and so the iron tube is, by the weakening effect of the slag, to that extent less fit to resist the stresses to which a tube, and especially a locomotive tube, is subjected.

As to the question of changing the chemical properties of steel to suit different kinds of water, as mentioned by one member, more than 99% of the material of a tube is iron, so that the range of possible variation in tubes of ordinary material is too small to affect any useful result. Ordinarily, special materials are prohibited by their excessive cost.

So there is no hope of preventing corrosion by having analysis made of the water, and changing the component parts of the metal to suit local conditions. The point desirable is to keep the phosphorus and sulphur as low as possible, commercially, and to keep the material uniform, chemically and physically. Preferably, it should be finished at a low temperature, so as to leave the surface of the tube in a refined condition.

The quality of the tube is very easily found by splitting the tube with a cold chisel, and if the grains of metal are bright and crystalline, the tube is not as good as if the grains were of a dull grey luster.

Manufacturers generally have not realized the importance of chemical and physical uniformity in their product. Their raw material was purchased in the open market under loose specifications and inspection, and the process of manufacture caused wide variations physically.

About four years ago we established a laboratory with a competent metallurgist in charge to investigate as fully as possible the process of manufacturing seamless tubes as it related to the quality of the product. This has resulted in a steady and decided improvement in the uniformity of seamless tubes as turned out by our company. The progress was helped materially by our control of the manufacture of the raw material.

Lack of physical uniformity is due to irregularity in annealing, although this was in charge of men supposed to be experts. The difference in atmospheric conditions from day to day necessarily affected the results. We have worked out a system now whereby the work is done exactly the same from day to day; reliable pyrometers have been installed on all annealing furnaces and the entire operation reduced to a system that eliminates judgment on the part of the men doing the work.

As an example of the general lack of definite knowledge of the results of annealing cold drawn material, I would mention a specification which recently came to my attention. The customer had employed an engineer who specified that the tubes were to contain 16% of carbon, and the tensile strength was not to exceed 45,000 pounds per square inch. It was possible to make these tubes, but it brought the elastic limit so low that I should not be surprised to hear that these tubes were causing trouble within six months.

The question was asked about tubes of small diameter splitting before they were put into service. I am of the opinion that this splitting is due to the tube having been cold drawn when it was not in a condition to be worked cold. The hot work on the blank was finished at so high a temperature as to leave the blank coarsely crystalline. This matter has been tested out and our company has gone to considerable trouble and expense to secure proper physical condition before cold drawing.

One of the gentlemen present intimated that he was not interested in the manufacture of tubes so much as in the use of the tubes. The last paragraph of my paper mentions the necessity of the manufacturer and the user getting together. I can know very little of the use of boiler tubes and perhaps you know as little of their manufacture. In order to develop a product, it is necessary to know something of both. This knowledge it also necessary in order to draw up an intelligent specification; otherwise you are going to require something not essential which will increase the cost, or you may omit something which will not affect the cost, but will be injurious to the product. At an instance, I would again cite the quench test contained in numerous specifications for seamless steel locomotive tubes. This test requites a strip or section of tube to stand bending without failure after being heated to a cherry red in daylight and quenched in cold water. The requirement was copied into specifications for seamless tubes, from older specifications for welded tubes, no consideration being given to the difference between the two materials. Welded tubes are necessarily made from low carbon material and, hence, can stand the test; while seamless steel tubes are necessarily made from a higher-carbon steel, which hardens slightly under the specified treatment. The test does not copy any service condition and shows no other quality of the material, except that it hardens slightly under the treatment. The evil of the requirement lies in the indefiniteness af the term "cherry red." If the temperature to which the test piece is heated is not more than 700°C., seamless material will stand the test; but, if the test piece is heated to 900°C., a failure is certain. In fairness to manufacturer and user, the specification should be made definite or omitted.

On the other hand, the flattening test, the expanding test, and the crushing test are all practical tests. The expansion test shows the ductility, the flattening test provides against crystallization, and the crushing test indicates very clearly how that tube is going to act under the beading tool.

Chairman,—

For the benefit of the members who are not acquainted with the manner of making these tests, would you mind illustrating them on the blackboard.

Mr. Dunn then described various tests with sketches on the blackboard.

Mr. Dunn,—

I understand that the time is limited. When I get to talking on this subject, I never stop. You have asked a large number of very interesting questions, and I am very sorry that I have not answered them more clearly. I thank you very much for the attention you have given me.

Mr. Patterson,—

I want to apologize to the members present for asking our friend Mr. Dunn to condense his replies to the questions, as there are a number of our members who have to catch the 11 o'clock train, and I am sure you will pardon me when I say how very much we are all interested in Mr. Dunn's remarks, and I do not want any of the members to go away without hearing all he has to say on the subject.

We have to thank Mr. Dunn for coming such a long distance to read this paper, and I am sure every member will carry away with him a great deal of information that he could not otherwise have obtained. There have been points brought out that we cannot learn about by reading.

I have very mnch pleasure in moving a hearty vote of thanks to Mr. Dunn.

Mr. Lewkowicz,—

I take much pleasure in seconding that motion.

If manufacturers in giving users data showed as much frankness as Mr. Dunn has, there would be a great deal more fraternizing, if we may call it that. I think we all owe a great deal to Mr. Dunn for giving us his honest opinions so freely.

Chairman,

You have all heard the motion which has been moved and seconded, that a hearty vote of thanks be tendered to Mr. Dunn for the excellent paper he has read to us to-night, and for his kindness in dealing so fully with the questions that have been asked. What is your pleasure? Carried unanimously.

Mr. Dunn, I have much pleasure in tendering you the hearty vote of thanks of this Clnb.

Mr. Dunn,—

I thank you for your vote of thanks.

Mr. Jefferis,—

Before closing I would made a motion that our Secretary be instructed to send a letter of sympathy from the members of this Club to the Queen-Mother Alexandra. Seconded by Mr. Baldwin. Carried.

Chairman,—

I think some of the Chairmen of the Special Committees in charge of the arrangements of the Annual Outing are now here, and as the other business of the meeting is over, I will now call on them to make their reports.

I may say that this will be the last meeting until September, and at that meeting we will have a paper by Mr. J. A. W. Archer, Manager of the Jeffrey Mfg. Co., of Toronto, on "The Economical Handling of Material by Machinery."

I will now call on Mr. Lewkowicz to say something about the excursion.

Mr. Lewkowicz,—

It has been decided to hold the Third Annual Outing of the Club to Beaverton Beach on Saturday, June 18th. We are going by special train on the Canadian Northern Railway. The train will leave the Union Station at 9 a.m.

Arrangements have been made whereby I think we will have a much better time than heretofore. The tickets will have to be $1.25, on account of the increased cost of transportation, and arrangements have been made for a better dinner to be served than we had at Jackson's Point. I may say that the $1.25 covers transportation and dinner.

Reply cards will be sent out to every member, asking for the number of tickets he wants.

Mr. Baldwin,—

You may naturally wonder why we are not going to Jackson's Point this year, knowing as you do, what a splendid time we had there last year.

I want to say that I was one of the Committee appointed, to visit Beaverton, and I am satisfied that you will have a much better time at Beaverton than you had at Jackson's Point, because we will all be able to go together. Last year and the year before, we went in bunches, but this year we will all be able to go together. The distance is 64 miles, and we can go on the train which leaves the Union Station at 9 o'clock, and I am satisfied that you will bear me out after the excursion, that you have had a much better time than heretofore.

Moved by Mr. Wickens, seconded by Mr. Campbell, that the meeting be adjourned. Carried.