

Jan. 19, 1932.

G. E. NEUBERTH

1,842,280

METAL TUBE

Filed April 11, 1931

2 Sheets-Sheet 1

Fig. 1.



Fig. 2.



Fig. 3.



Fig. 4.



INVENTOR

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2 Sheets-Sheet 2

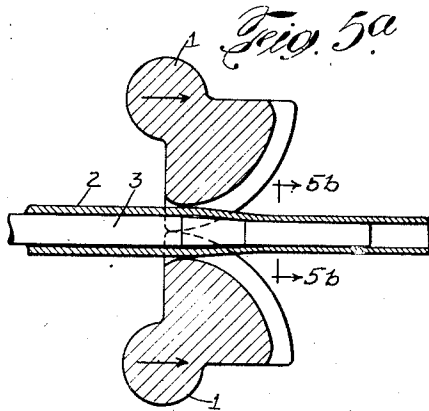


Fig. 5b

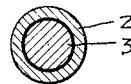
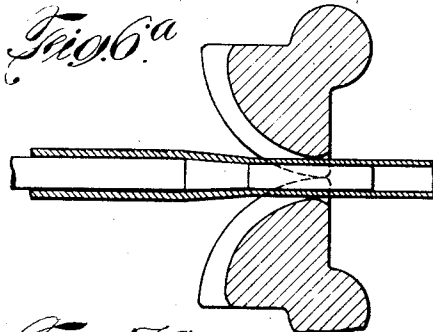


Fig. 6b

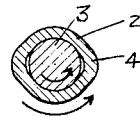
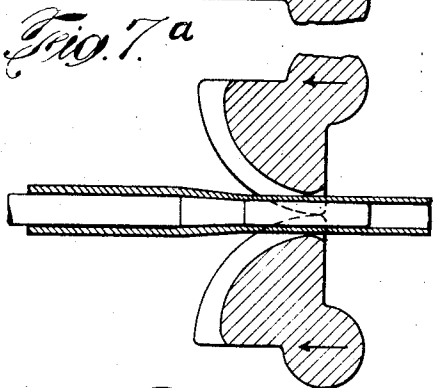


Fig. 7b

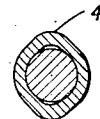
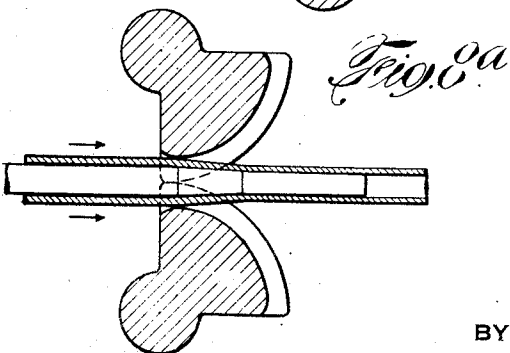


Fig. 8b



INVENTOR

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UNITED STATES PATENT OFFICE

GEORGE E. NEUBERTH, OF NEWARK, NEW JERSEY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO TUBE REDUCING CORPORATION, OF WILMINGTON, DELAWARE, A CORPORATION OF DELAWARE

METAL TUBE

Application filed April 11, 1931. Serial No. 529,534.

When a metallic tube is subjected to tensional stresses in a cold working process so as to elongate it and reduce its cross-sectional area, e. g. in cold drawing, the individual grains or crystals of the metal, when examined microscopically, exhibit what are commonly known as "slip-lines" extending cross-wise of the grain at a substantial angle (30 degrees or more) to the direction of elongation. There may be one or more sets of these slip-lines in each grain, the lines in each set being substantially parallel; and, as a rule, these lines increase and become more apparent with the degree of working as the latter approaches the limiting point where further working causes a rupture of the tube. (See, for example, Figures 15 and 16 in Technical Publication No. 93 of the American Institute of Mining and Metallurgical Engineers, by Frank W. Harris, 1928.) These slip-lines are generally understood to indicate a slippage of the component parts or blocks of each crystal with respect to one another; and are exhibited when, upon the application of mechanical stresses, the individual crystals are subdivided into smaller blocks or fragments which tend to slide upon each other. If these stresses are continued indefinitely, there is complete separation and the crystals are broken along these lines. If in cold drawing, for example, the working of the metal is continued too far, annealing will not consolidate or reorganize the crystals, and rupture of the metal soon follows. In cold drawing, therefore, annealing is resorted to before rupture of the metal occurs in order that the crystals may be consolidated, i. e. returned to their normal condition, in which case the slip-lines disappear. Thus, cold drawing as practiced heretofore, has consisted of alternate drawing and annealing operations which were continued until the ultimate reduction or elongation desired had been reached.

In my copending patent application Serial No. 229,887, filed October 31, 1927, Patent No. 1,810,855, dated June 16, 1931, I have illustrated and described a method of cold working metallic tubes, in accordance with which their elongation and reduction may

be carried to an almost unlimited extent without annealing and with no tendency of the metal to rupture. It results, therefore, that my method of reduction or elongation enables one to reduce, if not dispense entirely with, the alternate annealings.

When I filed my copending patent application aforesaid, I realized that, in accordance with my method, the action of the forces set up within the metal of the tube produced a different result in the metallic structure thereof from any produced by methods of cold working now in common use, and that it was due to this structural difference that the elongation or reduction could be continued indefinitely without rupturing the metal; and in referring to this difference I then stated it as follows: "The (my) method also works the metal of the tube so that it is given a grain or, rather, it has elongated longitudinal fibre established."

When specimens of tubes produced by my process are properly etched to disclose intracrystalline detail and are examined under the microscope or by photomicrographs, (longitudinal sections being taken through the axis of the tube) visible slip-lines which are characteristic of ordinary cold worked metals are lacking in a majority of the grains, if not entirely absent, and instead, lines (which for convenience may hereinafter be called "fold lines" and which for the most part are wholly disassociated from the slip-lines) appear, extending substantially parallel to the axis of elongation, which said lines indicate alternate ridges and valleys in the surface of the etched metal. These ridges and valleys give the appearance, under the microscope and in photomicrographs, of elongated longitudinal fibers.

It is believed that these fold lines may indicate an intracrystalline fragmentation in which the fragments, instead of being disposed in planes extending at an angle to the axis of elongation as in ordinary cold work, are disposed in planes extending substantially parallel to the axis of elongation. Another interpretation of these fold lines is that they may represent fluid movement of molecules within the crystals. In any event, re-

5 regardless of the interpretation, it is found that on tubes disclosing the characteristic fold lines described above, and failing to disclose the ordinary slip-lines in a majority of the grains, cold working may be continued almost indefinitely without annealing. Thus, taking for example mild steel tube and working by known drawing methods, whereas it is possible to make a one and one-half to one reduction without annealing, it is not feasible in ordinary commercial operations to make greater reductions without annealing. The tube formed as a result of this drawing would be highly embrittled.

10 On the other hand, by applying a preponderance of compressive stresses in such manner as to produce a tube disclosing the above described fold lines rather than slip lines it has been found possible, starting with the same mild steel tube, to make a seventeen to one reduction without annealing, and in certain cases even greater reductions may be effected without destroying the characteristics of the metal. When these relatively high reductions are made the crystals appear to be merged so that no distinct boundaries between the crystals can be developed by etching, and the entire surface of the sections shows fold lines.

30 With other metal tubes which can be reduced by cold drawing and cold rolling methods, it has also been observed that where such tubes are worked by compressive stress methods to produce the above described effect, many times as much working can be done without annealing and without destroying the characteristics of the metal.

40 Tubes of certain metals, as for example, Monel metal and certain special steels have not heretofore been successfully reduced by cold drawing methods except at great expense due to the low reductions possible and the necessity of frequent annealing. When worked by my method to produce fold lines rather than slip lines, it has been found possible to reduce such tubes, and to make without difficulty reductions as great as three to one. Greater reductions can be and have been made in certain cases.

50 It will be understood that tubes worked by known drawing and rolling processes may disclose to microscopic examination, occasional grains distributed here and there throughout the metal in which no slip-lines appear or in which the slip-lines produced by cold work lie in planes parallel to the axis of elongation. Conversely, tubes worked by my method may disclose occasional grains in which no fold lines appear or in which slip-lines appear which are disposed in planes lying at an angle to the axis of elongation. In mild steel tubes worked by my process, for example, ordinary slip-lines do not appear in more than one-third of the grains. This may result

from the fact that occasional grains are so shaped or oriented that working by any method causes a result departing from the normal, as represented by the majority of the grains. It has been noted, however, that as working proceeds, the tendency to conform to the normal intracrystalline effect of the working is increased, so that the greater the degree of working, the fewer are these observable departures from the normal.

70 Since one method and apparatus for producing metal tubes having the above described intracrystalline structure is described in my copending application aforesaid, and since I referred to it therein as having "an elongated longitudinal fiber," the present application is to be regarded as a continuation in part of the aforesaid application. An improved method and apparatus for producing tubes having the above described intracrystalline structure is also described in my copending application Serial No. 353,717, filed April 9, 1929, Patent No. 1,810,886, dated June 16, 1931, but it will be understood that the said tubes may be produced by other methods, and the invention herein claimed is in no sense limited to tubes so produced.

85 In the drawings, Figure 1 shows the above described fold lines in the initial stages of their development, this figure being a reproduction of a photomicrograph taken at a magnification of one thousand diameters, of a tube which has been submitted to a two and one-half to one reduction. The initial development of the longitudinal fold lines giving the appearance of an intracrystalline longitudinal fiber is plainly apparent in the crystal extending along the middle of Figure 1 as indicated by reference character *a*. Figure 2 is a similar reproduction of a photomicrograph taken at a magnification of one thousand diameters, of metal which has been submitted to a reduction of six and one-half to one. The development of the fold lines *b* is considerably more marked and the appearance of longitudinal fibres is quite distinct.

100 Figure 3 is a similar reproduction of a photomicrograph taken at a magnification of one thousand diameters of metal which has been submitted to a reduction of thirteen to one. In this figure the development of the fold lines *c* and the appearance of longitudinal fibres is increasingly apparent.

115 In each of the above figures the absence of ordinary transverse slip-lines will be apparent.

120 Figure 4 is a similar reproduction of a photomicrograph taken at a magnification of one thousand diameters of metal worked by an especially effective cold drawing process, and submitted to a reduction of two and one-half to one. In this figure the development of the ordinary slip-lines is apparent at *d*, and a comparison of this figure with Figures 1, 2 and 3 illustrates the difference between

the metal structure here described and claimed and that which is characteristic of known cold working processes.

Figures 5, 6, 7 and 8 illustrate in semi-diagrammatic form a method and apparatus which may be used for the production of tubes having the characteristics hereinbefore described, and, as will be understood, the disclosures of my aforesaid copending applications may be referred to for a more complete disclosure.

Figures 5a and 5b represent the stage in the preferred cycle of operation at which the reducing devices 1 have reached their rear-most position relative to the stock 2 and the latter has just been fed forward relative to the longitudinally fixed tapered mandrel 3. The stock, as shown in Figure 5b, is round and slightly loose on the mandrel from the preceding consolidating action. The arrows indicate that the next movement which will occur will be a forward action of the reducing devices.

Figures 6a and 6b represent the stage in the cycle at which the reducing devices have moved forward to the end of the reducing stroke. The stock, as shown in Figure 6b, is slightly elliptical and ribs or incipient fins 4 show on the side of the tube where the roll grooves met. The arrow indicates that the next movement will be a turning of the tube and mandrel.

Figures 7a and 7b represent the stage in the cycle at which the tube and mandrel have been turned 90° and the reducing devices are ready to commence their rearward movement as indicated by the arrows.

Figures 8a and 8b represent the stage in the cycle at which the reducing devices have completed their rearward movement or consolidating action. The arrows indicate that the next movement will be the forward feeding of the tube along the mandrel.

It will be understood that the invention may be variously modified and embodied within the scope of the subjoined claims.

I claim as my invention:

1. As an article of manufacture a metal tube characterized by this: that the surfaces of a majority of the crystals in a longitudinal section taken through the longitudinal axis thereof appear to be made up for the most part of elongated longitudinal fibres.

2. As an article of manufacture a metal tube characterized by this: that in a longitudinal section taken through the longitudinal axis thereof a majority of the crystals appear elongated with surfaces made up for the most part of elongated longitudinal fibres.

3. As an article of manufacture a metal tube characterized by this: that in a section taken through the longitudinal axis thereof the surfaces of the majority of the crystals appear to be made up of elongated longitudinal fibres and to be free of slip-lines.

4. As an article of manufacture a metal tube characterized by this: that in a longitudinal section taken through the longitudinal axis thereof the surfaces of the majority of the crystals appear to be made up of elongated longitudinal fibres and the surfaces of not more than one-third of the crystals appear to have slip-lines.

5. As an article of manufacture a metal tube characterized by this: that in a longitudinal section taken through the longitudinal axis thereof the surfaces of the majority of the crystals exhibit at least one fold line and are substantially free from slip-lines.

6. As an article of manufacture a metal tube characterized by this: that in a longitudinal section taken through the longitudinal axis thereof the surfaces of the majority of the crystals exhibit a plurality of fold lines and are substantially free from slip-lines.

7. As an article of manufacture a metal tube characterized by this: that in a longitudinal section taken through the longitudinal axis thereof the crystals appear to be merged and the entire surface of the section to consist of longitudinal fold lines.

8. As an article of manufacture a metal tube characterized by this: that in a longitudinal section taken parallel to the longitudinal axis thereof the surfaces of the majority of the crystals appear to be made up of elongated longitudinal fibres and the surfaces of less than one-third of the crystals appear to have slip-lines forming an angle greater than thirty degrees with said axis.

9. As an article of manufacture a metal tube characterized by this: that in a longitudinal section taken parallel to the longitudinal axis thereof the crystals are elongated and the surfaces of a majority of the crystals exhibit no slip-lines.

10. As an article of manufacture a metal tube characterized by this: that in a longitudinal section taken parallel to the longitudinal axis thereof the crystals are elongated and the surfaces of a majority of the crystals exhibit substantially no angular lines other than fold-lines.

11. As an article of manufacture a metal tube characterized by this: that in a longitudinal section taken parallel to the longitudinal axis thereof the surfaces of two-thirds of the crystals exhibit substantially no angular lines other than fold-lines.

12. As an article of manufacture, a metal tube in which the intracrystalline structure is characterized by the presence, in a majority of the crystals, of fold lines extending substantially parallel to the axis of elongation of the tube, and by the substantial absence of slip-lines.

13. As an article of manufacture, a metal tube in which the intracrystalline structure is characterized by the presence, in a major-

ity of the crystals, of fold lines extending substantially parallel to the axis of elongation of the tube and by the absence, from a majority of the crystals, of slip-lines extending at an angle to the said axis of elongation.

14. As an article of manufacture, a metal tube in which the intracrystalline structure, in a majority of the crystals, comprises for the most part fragments disposed in planes substantially parallel to the axis of elongation of the tube.

In testimony whereof, I have signed my name to this specification this 10th day of April, 1931.

15 GEORGE E. NEUBERTH.

CERTIFICATE OF CORRECTION.

Patent No. 1,842,280.

Granted January 19, 1932, to

GEORGE E. NEUBERTH.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, line 47, for the number "1,810,855" read 1,810,885; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 22nd day of March, A. D. 1932.

(Seal)

M. J. Moore,
Acting Commissioner of Patents.

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