

May 28, 1929.

W. J. ROBINSON

1,715,099

METAL TUBE AND METHOD OF MAKING SAME

Filed Nov. 20, 1922

4 Sheets-Sheet 1

Fig. 2.

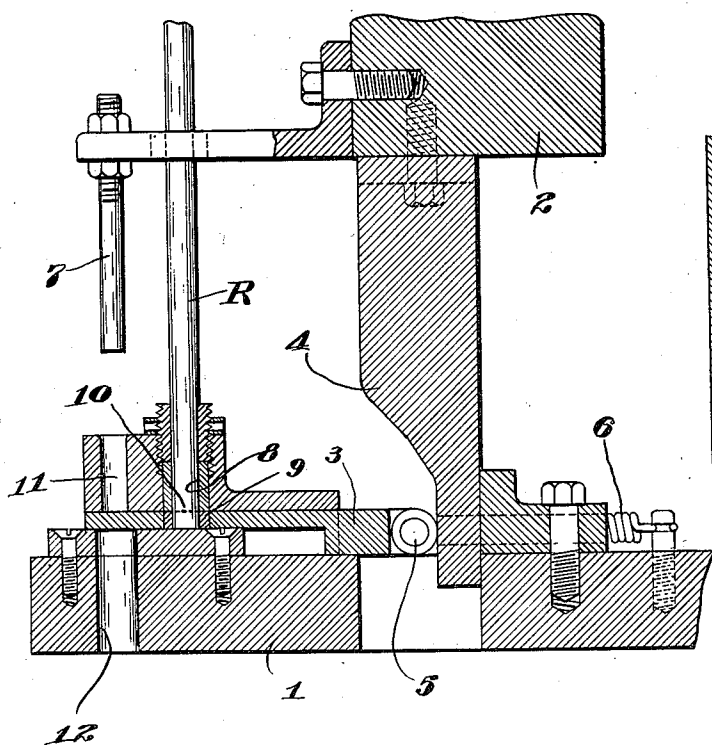


Fig. 3.

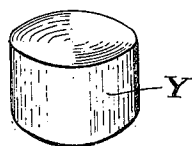
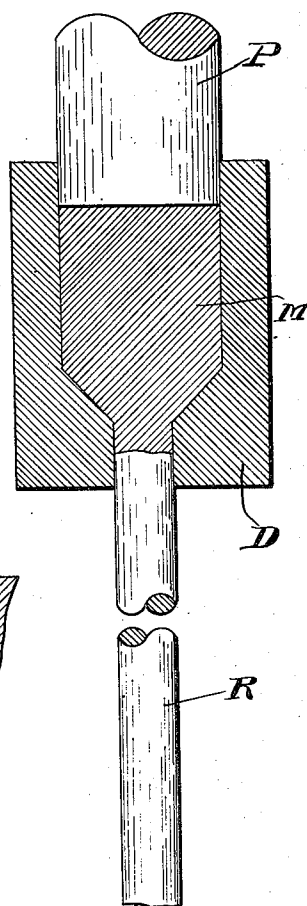


Fig. 1.



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Fig. 4.

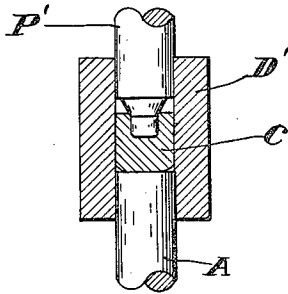


Fig. 6.

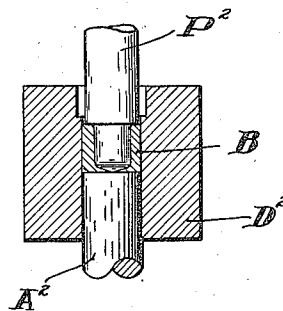


Fig. 5.

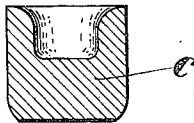


Fig. 7.

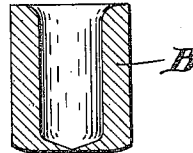


Fig. 8.

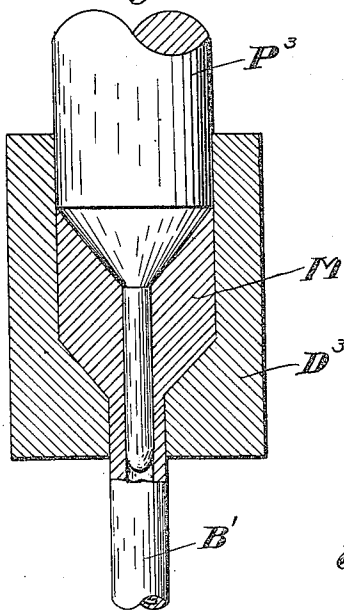
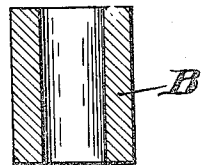


Fig. 9.



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Fig. 10

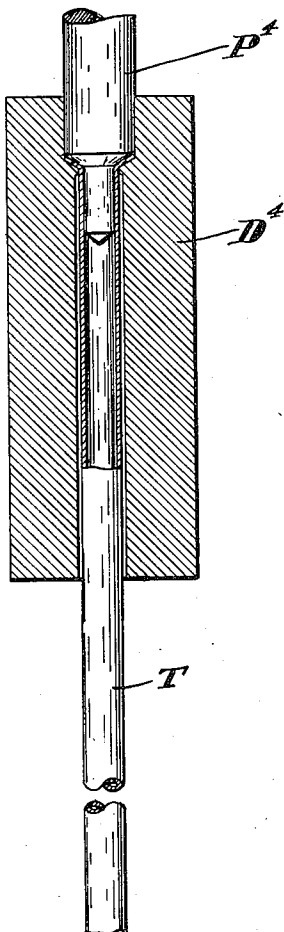


Fig. 11.

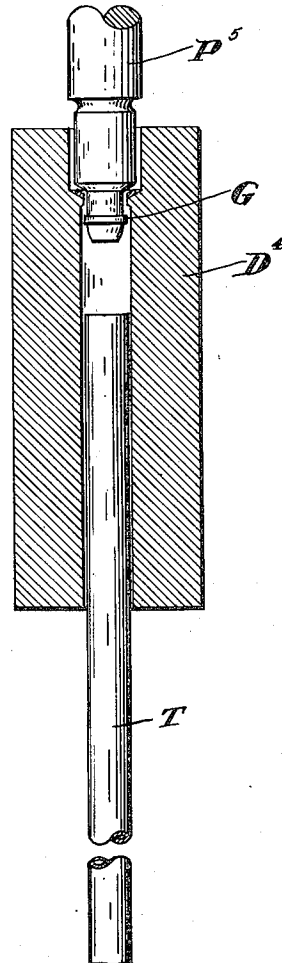
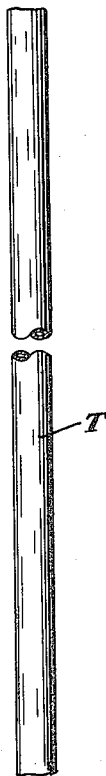


Fig. 12.



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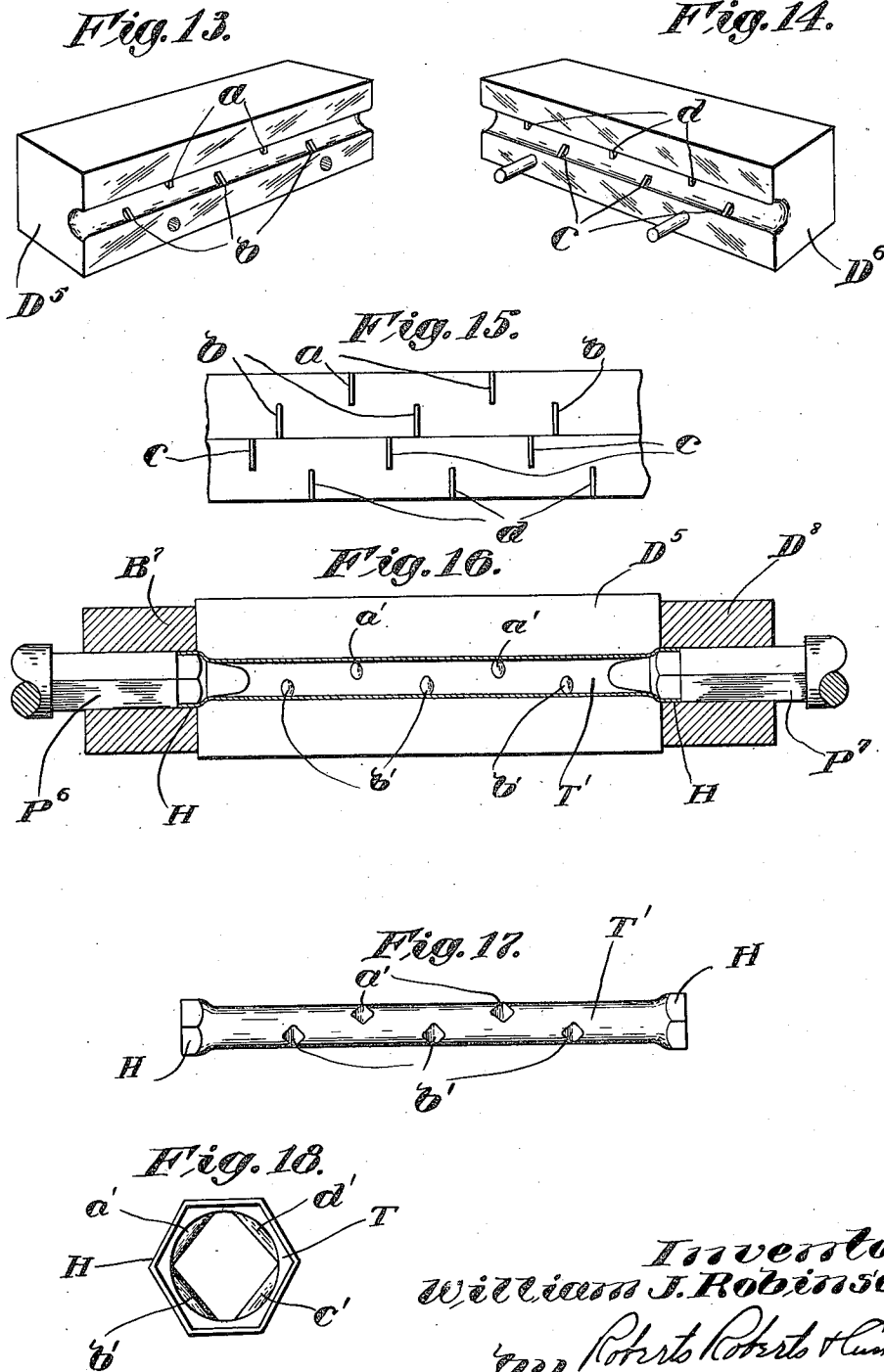
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METAL TUBE AND METHOD OF MAKING SAME

Filed Nov. 20, 1922

4 Sheets-Sheet 4



Patented May 28, 1929.

1,715,099

UNITED STATES PATENT OFFICE.

WILLIAM J. ROBINSON, OF LOWELL, MASSACHUSETTS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO WINCHESTER REPEATING ARMS COMPANY, OF NEW HAVEN, CONNECTICUT, A CORPORATION OF DELAWARE.

METAL TUBE AND METHOD OF MAKING SAME.

Application filed November 20, 1922. Serial No. 602,289.

This invention relates to metal tubes and more particularly to thin metal, usually copper tubes, for the radiators of automobiles, and other heat exchangers, the walls of such tubes having a thickness of the order of five-thousandths of an inch.

Heretofore it has been customary to make radiator tubes and other thin tubes from sheet copper stock by stamping a disc from the stock and then bending up the margin of the disc to form a cupped blank which is then annealed and thereafter extruded into the form of the tube by the single stroke of an extruding plunger. I have found this method unsatisfactory in many respects and I believe the following to be a substantially correct explanation of the reasons therefor.

In cupping a flat disc the center becomes the bottom of the cup and the surrounding part becomes the side-wall or rim of the cup. The metal in the latter part is condensed, whereas at the corner between the side wall and bottom it is bent and therefore to some extent stretched. This bending produces incipient fractures which persist throughout subsequent operations and is so pronounced especially in cups intended for the extrusion of small diameter tubes as to prohibit their manufacture on a commercial basis.

Thin tubes made from sheet stock as above described frequently have wrinkled walls and often display cracks in the walls. Moreover, such tubes have a tendency to develop leaks or fractures in subsequent manipulations. For example, in making radiator tubes it is desirable to hex the ends of the tubes for assembly into groups and also to indent the walls to form air baffles within the tubes. When using tubes made from sheet material as described, the hexing and indenting is not uniform and the tubes are frequently distorted and cracked in these operations. Also the making of the cups involves a considerable waste of metal because the pieces of metal intervening between the round discs in the flat sheet are necessarily lost as waste.

In making tubes from cast blanks there are difficulties due, I believe, to the fact that the blanks do not consist of homogeneous metal nor of equal amounts of metal and therefore are not well suited to flow uniformly under extrusion by impact pressure.

The principal objects of the present invention are to overcome the aforesaid disadvantages

and difficulties, to make tubes by hammer-stroke extrusion which are stronger and more uniform, to extrude tubes more economically both with respect to the elimination of wastage and the wear on the dies, to extrude the metal into tube form without need of heating the metal and so as to make thin walled tubes, especially tubes about a quarter inch diameter and about nine inches long, which are substantially free from internal stresses, which will not wrinkle, and which will not readily crack when indented or otherwise shaped for radiator or other uses.

My improved method involves the cutting of a rod into sections to form cylindrical blanks, having substantially parallel grain throughout and causing the metal to flow by impact extrusion in a direction which is parallel to the axis and grain of the blank, into the form of a tube. The metal is extruded cold, that is without preheating. The cylindrical form and parallel arrangement of the grain of the blank is secured by using a section of a rod which is formed preferably by an extrusion process or other process adapted to produce lines of flow approximately parallel to each other and to the axis of the rod. The rod from which the blanks are cut is circular in section and may be a tubular rod, in which case the rod sections may be extruded without any preliminary shaping. However, if the rod is a solid rod, the rod sections are preferably provided with axial openings before being extruded. The axial openings may extend entirely through the blanks so as to form hollow cylindrical blanks or rod sections or they may be in the form of indentations extending only part way through so as to form hollow cup-shaped blanks or rod sections. When these openings are formed by punches they are preferably produced in two stages, the first stage producing an axial dent in one end of the blank and the second stage extending the opening either wholly or substantially through the blank. The outer surfaces of the blanks are kept smooth and true in these indenting operations, by confining the blanks in dies of suitable diameter while being punched.

If the blanks are formed with axial openings extending entirely therethrough, the resultant tubes are open at both ends which is preferred. If the axial openings extend only part way through the blanks, tubes open at

both ends may be formed by puncturing the bottom of the cupped blank by the former of the extruding plunger in the initial state of the extrusion operation.

5 In any case I have ascertained that the rod from which the blank is cut must be homogeneous in respect to its crystalline structure and in respect to the distribution through the metal of such impurities as may be present. Any rod stock is suitable which complies with these requirements. Any extruded rod is generally found to do so, because such rod is produced from a large sized ingot, generally quite pure. Rolled stock is apt to be
10 non-homogeneous if it is rolled from an ingot that was poured in a horizontal mould, because in such case the impurities tend to rise during the cooling so as to occupy the upper part of the ingot after it has set. When
20 such an ingot is rolled into rod, the impurities therein will be found more on one side than the other, but the use of rolled rod stock is nevertheless satisfactory and within the invention and can be produced of sufficiently
25 homogeneous condition to avoid much of the waste that has heretofore been incident to the impact extrusion of tubes from sheet stock.

My improved method results in tubes whose metallurgical structure is strong and smooth,
30 whose walls are of uniform thickness, and which are adapted to be indented or otherwise shaped without fracturing. The crinkled condition found in prior tubes, indicating strained and over-worked metal, is
35 entirely absent. These advantages I believe to be due to the use of blanks cut from rod stock, and in some measure to the use of a blank having substantially parallel grain throughout and to the working of the metal
40 longitudinally of the axis of the blank in each stage of the process.

According to the present invention, involving the use of rod stock, there is practically no waste material, each rod-section
45 blank being substantially wholly converted into tubular form. This is a marked advantage over the prior methods using sheet stock where about one-third of the stock is wasted in stamping out the disc blanks.

50 In order more clearly to set forth the invention certain concrete examples have been illustrated in the accompanying drawings, in which:—

Fig. 1 is a diagrammatic view of one method of making rods for use according to the present invention;

Fig. 2 is a sectional view of the machine for cutting the rods into sections;

Fig. 3 is a perspective view of a rod section;

Fig. 4 is a diagrammatic illustration of one step in forming the blank;

Fig. 5 is a sectional view of the blank as shaped in the step shown in Fig. 4;

Fig. 6 is a diagrammatic illustration of the next step in forming the blank;

Fig. 7 is a sectional view of the blank after the forming step shown in Fig. 6;

Fig. 8 shows another method of forming the rod for use according to the present invention, this rod being tubular;

Fig. 9 is a section of the rod formed as illustrated in Fig. 8;

Fig. 10 is a diagrammatic illustration of the extrusion of the blank into the form of a tube;

Fig. 11 is a similar view of a succeeding stage of the process;

Fig. 12 is an elevation of the resulting tube;

Figs. 13 and 14 are perspective views of dies for indenting walls of the tube for radiator purposes;

Fig. 15 is a development of the operative faces of the dies, showing the distribution of the indenting elements;

Fig. 16 illustrates, more or less diagrammatically, the method of simultaneously hexing the ends of the tube and indenting

Fig. 17 is a side view of the finished tube; and

Fig. 18 is an end elevation of the finished radiator tube.

In Fig. 1, I have shown, more or less diagrammatically a common way of forming copper rod, namely by forcing a mass of pure copper M softened by heat through a restricted round opening into the form of a rod R, D representing the die through which the metal is forced, and P the plunger which is hydraulically operated. The rod R is cut off in lengths and passed through sizing or straightening rolls and is then ready to be cut up into sections to form blanks.

Fig. 2 illustrates suitable means for cutting the rod R into sections, rapidly and uniformly and without deforming the structure of the rod. This machine comprises a bed plate 1, a vertically reciprocating head 2 and a horizontally reciprocating slide 3. The head 2 has a depending cam arm 4 adapted to actuate the slide 3 through the medium of cam roll 5, a spring 6 being provided to hold the cam roll 5 against the cam 4. The head 2 also carries a plunger 7 adapted to force the rod sections from the machine after being severed. The rod R is fed downwardly through an opening 8 into the opening of an annular die 9 carried by the slide 3. As the slide is forced to the left by the cam 4, a section of the rod is severed along the dotted line 10 and is then carried into alignment with the opening 11 and the plunger 7. Upon further descent of the head 2, the plunger 7 forces the rod section Y from the die 6 through the opening 12. The rolling of the rod in the process of manufacture produces a slightly hardened surface thereon which

tends to resist deformation of the blank by the shearing machine and enables the latter to produce a clean cut which is desirable.

Figs. 4 and 6 illustrate, more or less diagrammatically, ways of forming the axial opening in the rod section. In Fig. 4 D^1 represents a die, P^1 a plunger, and A a bottom or ejector plunger. The severed rod section, after being first annealed, is placed in the die D^1 with the plunger A held in the position indicated, and the plunger P^1 is then forced down into the rod section until the rod section is formed substantially into the shape indicated at C in Figs. 4 and 5, the plunger P^1 is then withdrawn and the plunger A advanced to remove the blank from the die. The blank is then placed after another annealing, in die D^2 , Fig. 6, with the plunger A^2 in the position indicated, whereupon the plunger P^2 is advanced until the blank is formed into substantially the shape indicated at B in Figs. 6 and 7. The plunger P^2 is then withdrawn and the plunger A^2 advanced to remove the blank from the die.

In each of the operations illustrated in Figs. 4 and 6, the flow of metal is along the axis of the rod blank, the surrounding dies restraining the metal against lateral flow as the plungers advance axially into the blanks, and the displacement of the metal is equal in every radial direction, so that the metal in the resulting blank is of uniform condition on all sides of its longitudinal axis.

In the operation shown in Fig. 6, the forming plunger may pass either entirely through the plunger so as to leave a small axial opening in the base of the cup B or it may be advanced only to the point where the base of the cup B is very thin as shown in Fig. 7.

Fig. 8 illustrates, more or less diagrammatically, the method of extruding a hollow rod section, or blank, in which the grain is longitudinal of the rod. In this figure, D^3 represents an extruding die, P^3 the hydraulic extruding plunger, M^3 a mass of hot copper and B' the resulting tubular rod. Fig. 9 represents a section of this blank on a larger scale.

Fig. 10 illustrates the operation of extruding the blank into the form of a thin tube adapted for radiator purposes or other uses. In this figure, D^4 represents the die, P^4 the extruding plunger, and T the resulting tube. With the plunger P^4 retracted the blank (for example the blank B of Fig. 7 or the blank B' of Fig. 9) is placed in the die D^4 and the plunger P^4 is caused to strike it a sharp blow which squirts or extrudes the metal through the restricted annular orifice formed between the lip at the bottom of the die cavity and the reduced diameter extension, or former, on the end of the plunger P^4 . This orifice gives the shape to the tube which then projects or hangs therefrom by the unextruded portion, or flange, still remaining in the die cavity. It will be understood that the extrusion is done

with the metal in a cold or normal temperature and that the blank is flooded with oil at the moment of plunger impact. The extrusion operation may be carried on in any suitable apparatus, such for example as that shown in Hooker Patent No. 918,154 and such apparatus is commonly used in an ordinary crank type press running at a speed of about 120 operations a minute, as customary for the impact extrusion process. The blank, when ready for introduction into the extrusion die is shaped to fit the same snugly and the indentation therein is carefully made so as to be central of the blank and to fit the former on the extruding plunger. Preferably the copper in the blank is of the grade known as electrolytic, although the process is applicable to any metal which offers substantially the same resistance to cold extrusion as copper and copper alloys. If it is desired to make an open end tube from a closed bottom cup blank such as shown in Fig. 7, the forward end of plunger P^4 may be pointed to puncture the base of the blank before extrusion begins.

After the plunger P^4 has made its stroke into the position shown in Fig. 10, it is retracted and a trimming plunger such as shown at P^5 in Fig. 11, is advanced into the die D^4 . The plunger P^5 has an annular shoulder G which severs the flanged upper end of the tube to trim and release the tube T, the severed flange being carried out of the die by the shoulder G as the plunger P^5 is retracted.

The resulting tube T shown in Fig. 12 is extremely thin and at the same time strong and uniform. In the case of radiator tubes for example, the tubes are commonly .268 inches in diameter and have a wall thickness of .006 inch. Such tubes can not be commercially produced from sheet stock by cold impact extrusion as far as I am aware. For the purposes of illustration it has been necessary to show the walls of the tubes disproportionately thick. They are commonly about nine and a half inches long and for automobile radiators they are then cut in two or more sections.

The indenting dies D^5 and D^6 shown in Figs. 13 and 14 have opposing semi-cylindrical recesses in which are provided indenting die elements a , b , c and d , these die elements being distributed both axially and circumferentially of the recesses. Fig. 15 shows an effective distribution of these die elements, it being understood that the indentations produced by the die elements will also be distributed as illustrated in Fig. 15.

The tube T or a section thereof is placed between the dies D^5 and D^6 whereupon the dies are closed together to indent the walls of the tube, the semi-cylindrical recesses engaging the tube on all sides of each die element to prevent the tube from being distorted or collapsed. After the die elements have been

fully advanced, so that they entirely surround the tube, end forming plungers P^6 and P^7 are advanced into the ends of the tubes, the plungers having hexagonal ends adapted to co-
 5 operate with hexagonal dies B^7 and D^8 to hex the ends of the tubes. In this operation die elements a, b, c and d , which are intruded into the walls of the tube, hold the tube against longitudinal movement, thereby insuring that
 10 the tube is hexed the same axial distance at both ends.

Figs. 17 and 18 illustrate the resulting tube T' having the hexed ends H and the baffle indentations a', b', c' and d' . By forming
 15 the tubes as herein described, these indentations can be formed uniformly and without cracking or deforming the tubes.

I claim:

1. The method of making metal tubes
 20 which comprises extruding metal into the form of a rod, cutting a section from the rod to form a blank, and subsequently causing the unheated metal of the blank to flow longitudinally of the axis of the blank into the form
 25 of a thin tube.

2. The method of making thin metal tubes which comprises flowing metal into the form of a hollow rod, cutting off a section of the rod to form a hollow cylindrical blank, and
 30 extruding the unheated metal longitudinally of the blank into the form of a thin tube.

3. The method of making metal tubes which comprises forming a rod by causing a body of metal when cold to flow longitudinally of the axis of the rod, cutting a section
 35 from the rod to form a blank, and causing the unheated metal of the blank to flow longitudinally of said axis into the form of a tube.

4. The method of making radiator tubes which comprises flowing metal into the form
 40 of a tube from a blank having substantially parallel grain throughout, the flow being longitudinal of the grain of the blank, and indenting the tube transversely of the grain.

5. The method of making radiator tubes
 45 which comprises extruding metal into the form of a tube from a blank having substantially parallel grain throughout, the extrusion being longitudinal of the grain of the blank, and forming baffles in the tube by indenting the wall of the tube transversely of
 50 the grain.

6. The improvement in the art of making tubes by cold impact extrusion out of copper, which consists in making a copper blank with
 55 longitudinal grain parallel to the axis of said blank and then subjecting said blank, unheated, to the impact of an extruding plunger in the direction of said axis and thereby extruding the metal through an annular ori-
 60 fice.

7. The process of making tubes which comprises as steps forming a cylindrical rod of electrolytic copper of substantially homogeneous character and having its grain run-
 65 ning parallel to its axis, cutting said rod transversely to form a cylindrical blank, axially indenting one end of the blank, placing the blank in the die of an extruding press with the indented end of the blank opposed
 70 to the press plunger, and actuating the plunger to extrude the blank in an axial direction into a thin walled tube.

Signed by me at Lowell, Mass., this 17th day of November, 1922.

WILLIAM J. ROBINSON.