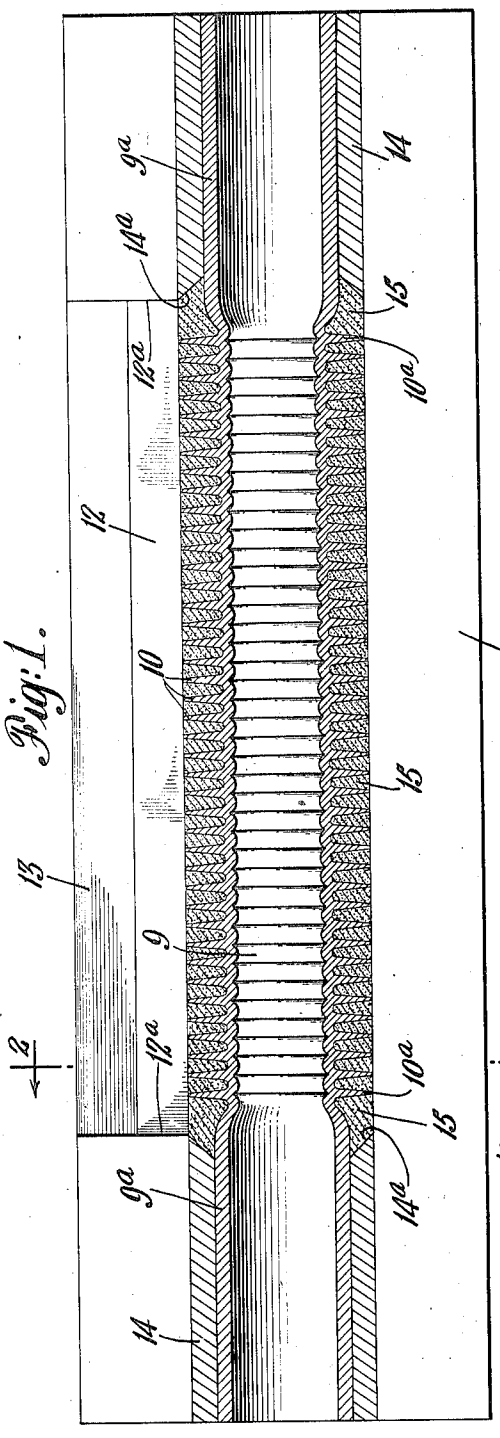
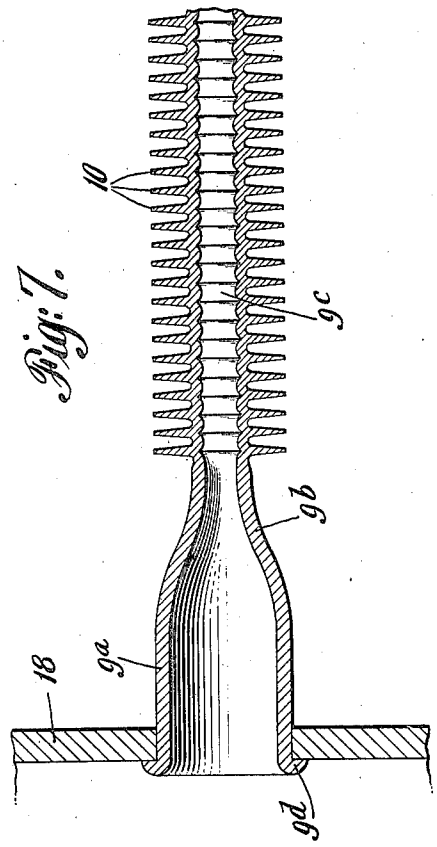
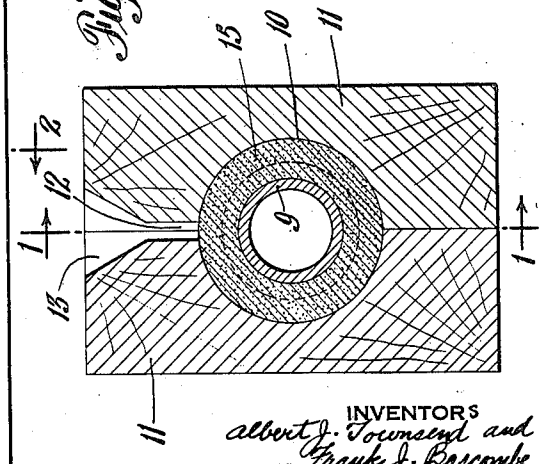
Nov. 14, 1939. A. J. TOWNSEND ET AL 2,179,530

METHOD OF FORMING FINNED TUBING OR THE LIKE

Filed Dec. 13, 1935 4 Sheets-Sheet 1







INVENTORS
Albert J. Townsend and
Frank J. Bascombe
BY
Synnestvedt & Lechner
ATTORNEYS

Nov. 14, 1939. A. J. TOWNSEND ET AL 2,179,530

METHOD OF FORMING FINNED TUBING OR THE LIKE

Filed Dec. 13, 1935 4 Sheets-Sheet 2

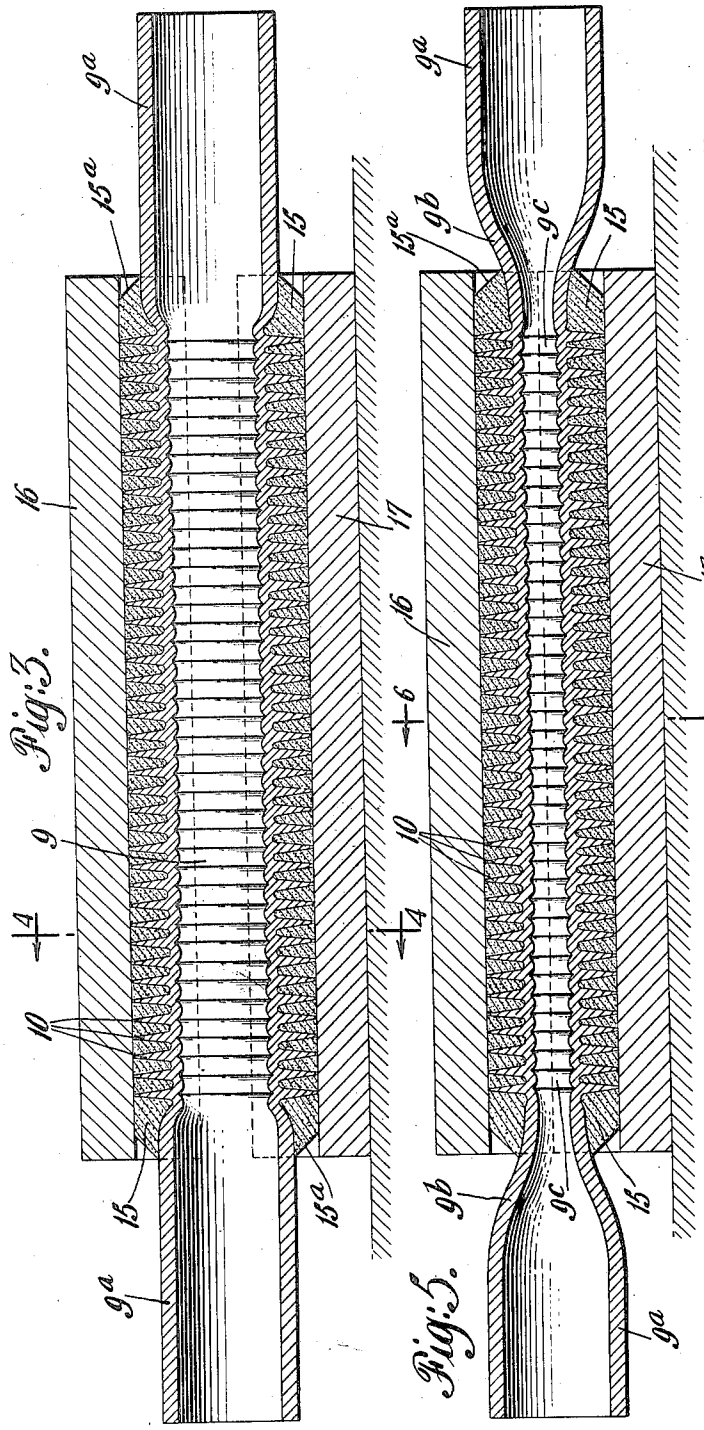


Fig. 3.

Fig. 5.

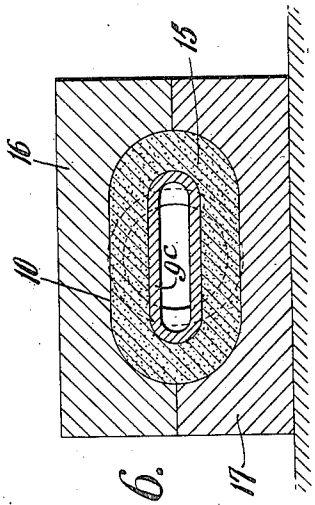


Fig. 6.

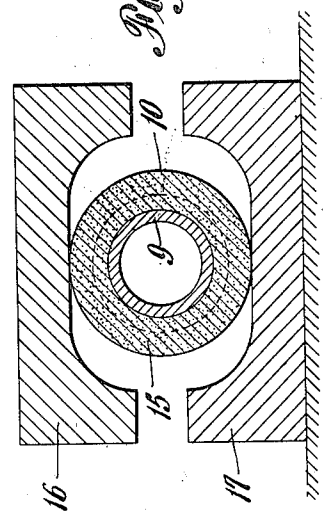


Fig. 4.

INVENTORS
Albert J. Townsend and
BY Frank J. Bascombe
Symmestedt & Lechner
ATTORNEYS

Nov. 14, 1939. A. J. TOWNSEND ET AL 2,179,530

METHOD OF FORMING FINNED TUBING OR THE LIKE

Filed Dec. 18, 1935 4 Sheets-Sheet 3

Fig. 8.

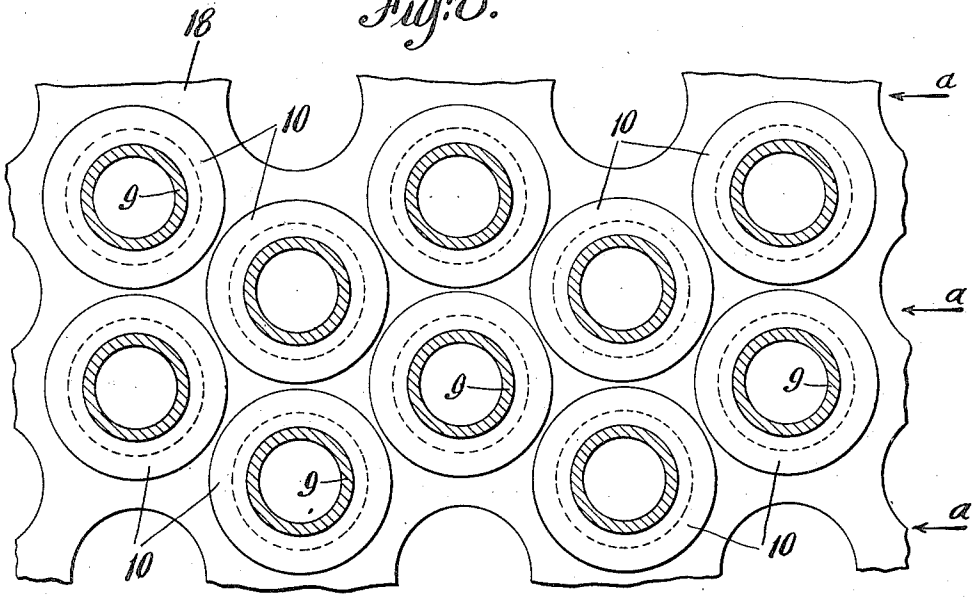
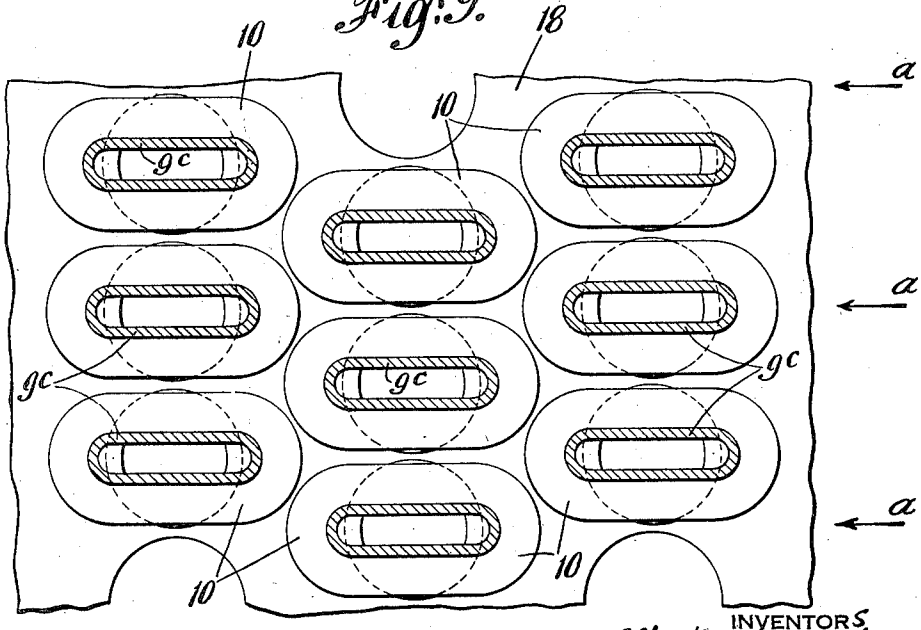


Fig. 9.



INVENTORS
Albert J. Townsend and
BY Frank J. Bascombe
Symmestuedt & Lechner
ATTORNEYS

Nov. 14, 1939. A. J. TOWNSEND ET AL 2,179,530

METHOD OF FORMING FINNED TUBING OR THE LIKE

Filed Dec. 18, 1935 4 Sheets-Sheet 4

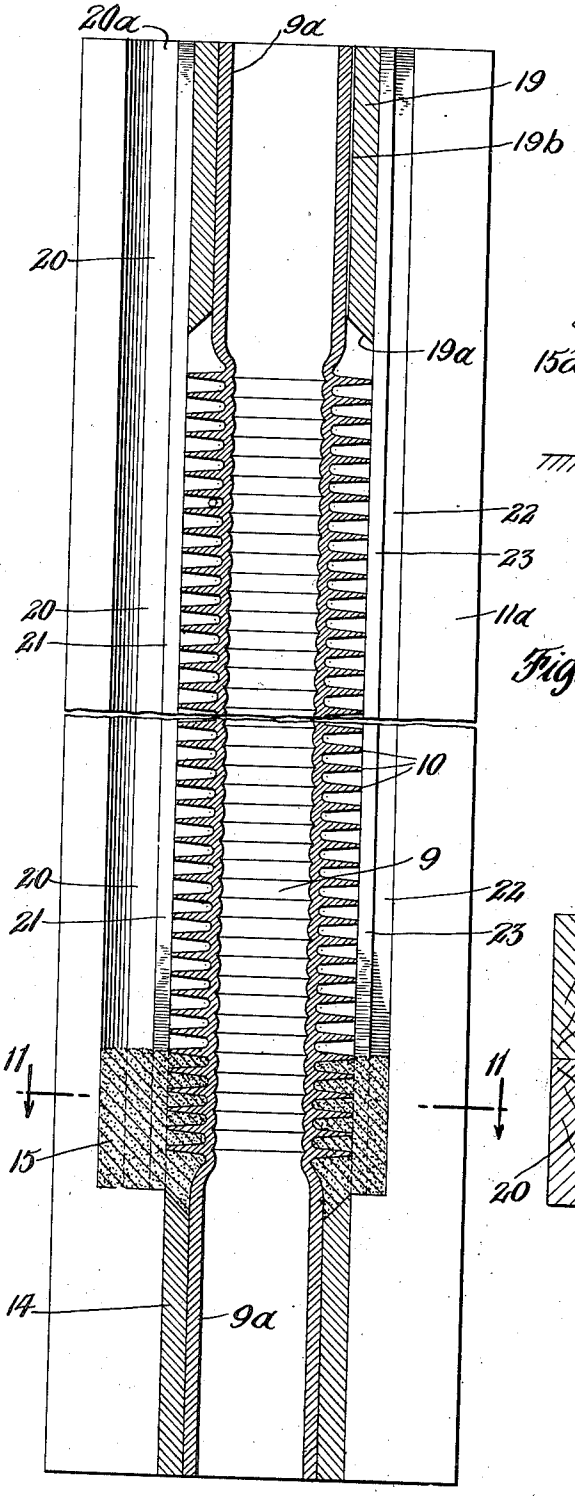


Fig. 10.

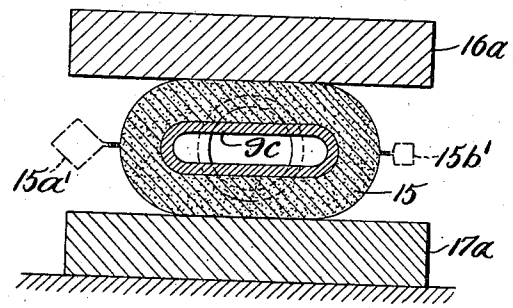


Fig. 12.

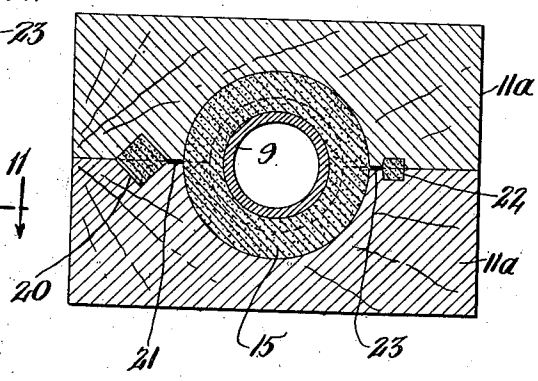


Fig. 11.

INVENTORS
Albert J. Townsend and
BY Frank J. Bascombe
Symmetvedt & Lechner
ATTORNEYS

Patented Nov. 14, 1939

2,179,530

UNITED STATES PATENT OFFICE

2,179,530

METHOD OF FORMING FINNED TUBING OR THE LIKE

Albert J. Townsend and Frank J. Bascombe,
Lima, Ohio

Application December 18, 1935, Serial No. 55,072

8 Claims. (Cl. 29—157.3)

This invention relates to methods of forming finned tubing or the like.

In general, the invention has to do with the shaping or deforming of articles having fins or other protuberances without undesirably deforming or injuring the fins; and more especially it contemplates the production of a novel integral finned tubing of non-circular or flattened cross-section, particularly a novel method for shaping tubing to such form.

The advantages of the invention may be better understood after some consideration of finned tubing in general, and one of its uses. The chief use for finned tubing is as a heat-transfer or radiating element, and for this purpose some tubes have longitudinal fins, some have spiral fins, others circular fins, and still others isolated projections of various kinds. Regardless of the type of fins, however it is customary, because of simplicity of manufacture, to employ tubes of circular cross-section, even though these are relatively inefficient as to heat transfer and wasteful of space when assembled in a bank and leave relatively dead spaces in the interstices between tubes.

In order to overcome these difficulties, tubes of non-circular, for example oval or flattened, cross-section have heretofore been developed, which, in addition to cutting down the interstices in a tube bundle and increasing the amount of tubing which can be presented within a given "face area" to the transversely flowing external cooling or heating medium, also substantially reduce the distance from the inside of the tube wall to the center of the flowing stream of internal heating or cooling medium; but ordinarily such tubes are made as castings which are heavy, crack easily, and are incapable of being bent, or else they are formed as plain flat-section tubes to which the fins are separately attached as by soldering or welding which is costly, tends to weaken the tube itself, and reduces the heat transfer.

One of the primary objects of the present invention is the production of flattened or other non-circular finned tubes or equivalent articles having the various known advantages, without the disadvantages heretofore encountered. A further object is the production of a new article of this general category having certain heretofore unknown characteristics and advantages, and the making of same by new and advantageous methods.

More particularly, the invention has in view the production of a novel finned tube or the like of flattened or non-circular cross-section; preferably one having a major and a minor axis, for example of elliptical or oval cross-section; also such a tube of ductile metal or other bendable material, and having integral finning; further, a non-circular finned tube with circular end portions adapted for easy installation in and removal from tube-plates or headers; and still further, a tube in which the metal of the fins may be strengthened or rendered somewhat thicker adjacent the regions of the relatively flat faces of the tube wall; the present invention being directed to methods for readily and cheaply making, forming or shaping such tubes, and specifically for forming the same from known types of round-section tubing by imposing the desired shape on the article without appreciably rippling or otherwise detrimentally affecting the thin fins thereof. The new and improved tubing made by the method and means of the present invention is claimed in a divisional application, Serial No. 254,356, filed Feb. 3, 1939.

Still more specifically, the invention in its preferred practice involves: the formation of a ductile metallic tube of non-circular section with integral radial or circumferential radiating fins; the formation thereof from a finned tube of round section (for instance a copper, brass, or aluminum alloy tube) by infilling the interspaces between fins with a deformable but substantially incompressible matrix or material, preferably non-adherent, such as lead, Babbitt-metal, other ductile material, or the like, then working the article to the desired shape, and thereafter removing the filler, as by melting the same; and the utilization of means for making such tubing, for example comprising a mold shaped internally to receive a round finned tube in circumferential engagement with the edges of the circular fins thereof, and having a feed slot with one or more openings at an upper part thereof for admission of the fin-supporting material such as molten lead, and preferably also a pair of fibre or metal ferrules formed to interfit between the tube ends and the bore of the mold.

How these and other objects and advantages are attained by the present invention will be evident to those skilled in the art after perusal of the following description, taken together with the accompanying drawings which illustrate the preferred practice of the invention.

Figure 1 is a longitudinal sectional view through a round-section finned tube, in position within a horizontal mold (the view being taken on the line 1—1 of Figure 2, to show in elevation

one half of the mold which is of longitudinally split form), with ferrules in place around the ends of the tube, and showing a matrix or body of material infilled into the interspaces between fins;

Figure 2 is a section through the tube and the complete mold, taken on the line 2—2 of Figure 1, and also showing the filling material;

Figure 3 is a longitudinal section through the encased or infilled tube, removed from the mold and ferrules, and positioned between a pair of press members preliminary to the forming operation;

Figure 4 is a section taken on the line 4—4 of Figure 3;

Figure 5 is a longitudinal section similar to Figure 3 but illustrating the tube as compressed between the press members;

Figure 6 is a section taken on the line 6—6 of Figure 5;

Figure 7 is a view of a portion of a finished tube fitted into a tube-plate or header member;

Figures 8 and 9 are comparative cross-sectional views, respectively, of a bank of ordinary round section finned tubes and a bank of the improved flattened tubes made by the present invention, mounted in headers, and illustrating one of the advantages of tubes made by the practice of the invention;

Figure 10 is a vertical longitudinal section through a long tube and its associated vertical mold (the latter being a modification of the horizontal mold structure shown in Figure 1), the illustration being broken out in the middle;

Figure 11 is a horizontal section taken on the line 11—11 of Figure 10; and

Figure 12 is a sectional view through an encased tube, after removal from the mold of Figures 10 and 11, illustrating the article in its flattened condition between two press members, after the manner of Figure 6, a modified form of press member being here illustrated.

By reference to Figures 1 and 2, it will be seen that a circular-section, ductile, metallic tube 9, having integral spaced-apart heat-transfer elements or circular fins 10, is positioned within the bore or hollow of a retaining box or mold made of two halves 11, 11, the latter being of wood or any other suitable material. Such finned tube or like article may be of any standard or commercially available type suitable for the purpose, such, for example, as the round circular-finned tubing illustrated in the Hoffman U. S. patents numbered 1,842,095 and 1,902,779. Various other types of tubes, for example spiral-fin tubes, can be equally well handled in accordance with the present invention, see for instance the tubing of the Locke Patent No. 1,761,733. The tube may be of any desired length, with plain or flanged end portions of any preferred formation; the tube here shown having straight end portions 9a, of annular cross-section, adaptable to ultimate mounting in any desired manner in tube-plates or the like.

Communicating with the bore of the mold 11 may be one or more openings for the feeding of the filling material to the tube fin interspaces, and in the present instance the feeding opening takes the form of a long slot 12, extending lengthwise throughout and preferably slightly beyond the zone of the finned portion of the tube. This slot or channel may be formed in one or the other of the two mold pieces (where a split mold is employed) or preferably, as here shown, the inner face of each mold member is cut back, so that the two jointly form the slot indicated at 12 which extends from the point 12a adjacent one end of the finned region to the opposite point 12a adjacent the other end of said region. The slot is widened at the top, to form a wide-mouthed groove as indicated at 13, to facilitate the pouring of the infilling material, such as molten lead.

While the feeding slot may be arranged to extend along only a portion of the length of the finned region if it be desired to flatten or otherwise deform only that portion; or while the feeding slot may be coextensive with the length of the finned region, in which event the end fins 10a would serve as closures for the mold bore; the present preferred practice is, as above stated, to extend said slot beyond both ends of the fin zone and to insert a pair of ferrules 14 (which may really be considered as a part of the mold itself, and might alternatively be formed integrally therewith) into the ends of the mold blocks in surrounding relation to the tube ends 9a. These ferrules may be of hard fiber, or of metal, or other suitable material, and are preferably formed with a sloping or reamed end face 14a, the outer peripheral edge of which may register with the ends 12a of the feed slot 12.

With the above described arrangement, when the filling material 15, preferably lead, is poured into the mold, it solidifies to form a deformable matrix embedding the fins and projecting at each end beyond the fin area to form sloping or tapering shoulders 13a, the advantages of which will be apparent after consideration of Figures 3 to 6. While various other materials may be used, lead is preferred, as it is cheap, will solidify in the fin interspaces without adhering to the fins, is deformable but at the same time not so soft as to permit appreciable transverse rippling of the fins during the subsequent tube-flattening operation, and also has a lower melting point than the usual metal tube and may be readily melted off and used again.

The lead-encased tube, after removal from the mold, is placed between suitable dies or rolls, or plain press members of a form shown at 16, 17, in Figures 3 and 4. By application of pressure the lead-sheathed tube is then flattened (or otherwise shaped or formed) to any desired extent, as illustrated in Figures 5 and 6. The press members may be made of a length suited to the intended area to be flattened; and where, as here shown, the entire finned zone is to be flattened, these members may extend slightly beyond the region of the fins, so as to overlie the tapered ends 15a of the encasement. By this arrangement, the distribution of pressure is such that a gradual taper of the tube wall is formed at 9b, intermediate the round tube ends 9a and the flattened tube region 9c.

The final step in the formation of the tube is to remove the matrix, as by melting the same from the tube. The finished flattened tube comes out perfectly clean, undamaged, with its fins in good alignment and apparently somewhat thickened or strengthened in the region of the flattened sides of the tube, and in a condition suitable for use as a straight tube or to be bent into elbows and the like.

A portion of a finished tube is shown in Figure 7, which also illustrates how such tubes may be assembled between a pair of tube-plates or headers 18 (one of which is fragmentarily illustrated); the round ends 9a of the tube being readily adapted to any ordinary type of joint between tubes and headers, such as welding, or by rolling over the end of the tube as shown at

9d, while the flattened portions of the tubes make possible a much closer spacing of tube centers, in one direction of the tube bundle, than could otherwise be arranged. This is brought out quite clearly by a comparison of Figures 8 and 9, showing respectively an assembly of round tubes and of the improved tubes.

From these figures it will also be readily observed that the flattened cross-sectional shape of the interior of the tube results in a more intimate and uniform contact of the internal heating or cooling medium with the heat-transfer surface. It will further be seen that the close spacing of the tube centers, in the direction transverse to the flowing stream of external cooling medium (indicated by arrows *a*) makes it possible to get more tubes into a given front face area, the possible increase being nearly 50%.

The importance of this last-named advantage will be better understood by considering an example. In a condensing locomotive, for instance, where space is at a premium, a substantially increased number of the improved tubes made by the method of this invention can be subjected to a cooling air blast of predetermined flow area, while at the same time the efficiency of each individual tube is greater than that of the ordinary tube. One of the very important results, therefore, would be the substantial reduction in overall volume of space required by the condenser and air duct installation, considered as a whole, for a given condensing capacity.

Referring now to Figures 10, 11 and 12, it should be observed that the vertical type of mold which is there shown is better adapted to the treatment of very long tubes than is the horizontal mold arrangement shown in Figures 1 and 2, particularly when lead is used as the tube-encasing body. The reason for this might be briefly explained as follows:

As the standard round section tube, commercially available, particularly in long pieces, is not absolutely uniform as to straightness, diameter, etc., it may not fit the mold bore very accurately. In a horizontal mold, such as shown in Figure 1, the molten lead, because of its high specific gravity and substantial fluidity, will tend to run lengthwise along the bottom of the bore, through the slight clearance space between the edges of the fins and the mold bore, and unless the lead is poured simultaneously throughout most of the length of the feed groove 13 such longitudinal travel of the lead from the points of feed may at times result in chilling and solidification of the lead at certain regions before the entire matrix is poured. Seams in the completed matrix thus sometimes occur, with the result that during the flattening process the lead may split apart, so that the pressure on the tube at such regions deforms the same or damages the fins.

How this difficulty, sometimes incident to the treatment of very long tubes, is avoided by the vertical mold arrangement, shown in Figures 10 and 11, will now be clearly shown. The elongated tube 9 (shown as broken out in the middle, but which may be 5 or 6 or more feet in length) is fitted within the main bore of the mold which is made of the two halves 11*a*, 11*a*, the lower end 9*a* of the tube fitting snugly in the lower ferrule 14. The upper end 9*a* of the tube fits in the ferrule 19.

The lead feeding bore and slot 20 and 21 correspond, in general, to the feed groove and slot 13 and 12 of Figure 1. However, this feeding system is, of course, closed, except at the upper end of the vertical mold, where the molten lead may be introduced at 20*a*.

Still another bore is provided, this being an air exhaust channel 22, communicating with the main bore of the mold by the slot 23, this air vent system being preferably of smaller volume than the lead delivery system. Because of the internally bevelled face 19*a* of the upper ferrule 19, a secondary air vent is required, which may be formed as a small internal groove 19*b* running upwardly along the inner face of the ferrule or sleeve 19.

When the molten lead or other infilling material 15 is poured into the feed groove 20 through its upper end 20*a*, it fills the fin interspaces, successively, from the lower end of the tube upwardly (a partial filling of the mold being shown in Figure 10). Thus each annulus of lead solidifies as an entirety, without any seams.

When the encased tube is taken from the mold, excrescences of lead, having a cross-sectional shape of the feeding and venting grooves, may remain upon the tube, as indicated in dot and dash lines at 15*a'* and 15*b'* in Figure 12. These can be readily broken off, if desired, particularly if die-shaped press members such as shown in Figure 4 are to be employed. However, it is quite feasible for an ordinary flattening process, if no unusual tube contour is desired, to employ plain flat press members 16*a*, 17*a*, as shown in Figure 12. In fact, by actual test, it has been found that a tube can be deformed practically to the shape shown in Figures 6 and 12, by the use either of a formed press or a flat press, although the formed press gives somewhat greater accuracy, and would probably be essential where unusual tube deformation were required.

While the preferred article and method and means for forming the same, have been illustrated in the drawings, others might be alternatively employed, while still falling within the broad scope of the present invention. For instance, non-tubular articles may be shaped by the method disclosed; also for example, the matrix or encasement might be pre-formed, or made in sections, and subsequently fixed in proper position around the article. Further, the infilling material or matrix might be applied by machine or by hand; and, according to the nature of the particular material chosen, it may be removed physically or chemically or by dissolving. In its broader aspects, therefore, the invention is not limited to the specific embodiments illustrated.

We claim:

1. The method of flattening finned tubing which includes filling spaces between fin elements with a deformable material of hardness sufficient to support the finning during deformation, then flattening the tubing, and subsequently removing said material.

2. The method of flattening finned tubing which includes filling spaces between fin elements with a deformable non-adherent material of hardness sufficient to support the finning during deformation, then flattening the tubing, and subsequently removing said material.

3. The method of flattening round tubing of ductile metal having integral circumferentially-extending finning providing interspaces, which comprises solidifying in said spaces a body of material having a lower melting point than that of the finned tubing, subjecting the thus treated tubing to a flattening operation, and then melting off the material.

4. The method of forming, from a round me-

tallic circumferentially-finned tube, one of relatively flattened cross-section, without rippling the finning, which comprises squeezing said tube with a deformable matrix infilling the fin interspaces.

5. The method of altering the general contour of a hollow bendable article having thin projections, without detrimentally affecting such projections, which includes coating the projections with a stiff but yieldable material without filling the hollow defined by the article, and imposing an alteration of contour upon the thus treated article.

6. The method of flattening a hollow article of ductile metal having thin projections on the exterior surface thereof, without detrimentally affecting such projections, which comprises applying deformable projection-supporting coating exteriorly of said article, and deforming the metal and said coating simultaneously to the desired degree of flatness by imposing external pressure thereon.

7. The method of forming a flattened integrally-finned tube with round ends, from a piece which is of circular section throughout, which comprises applying a filling material to the fin interspaces at least in the zone desired to be flattened, exerting pressure upon such area intermediate the ends as is to be flattened, and thereafter removing the filling material.

8. The method of forming an integrally-finned tube of non-circular section in one zone, circular section in another zone, and tapering section in an intermediate zone, from an initial piece of circular section throughout, which comprises encasing the piece throughout the first zone and over at least a portion of the intermediate zone with a fin-supporting material, and applying pressure to the encased article throughout said first zone and upon the adjacent portion of said intermediate zone.

FRANK J. BASCOMBE.
ALBERT J. TOWNSEND.