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IRREGULAR SHAPED TUBING FORMED BY ELECTRODEPOSITION

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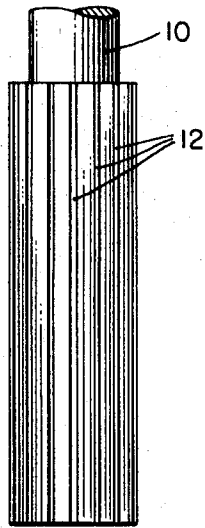


Fig. 1

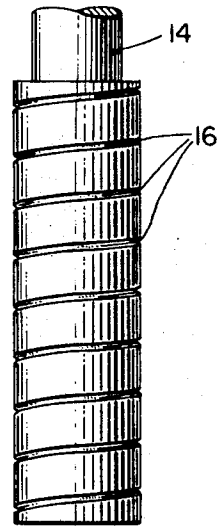


Fig. 2

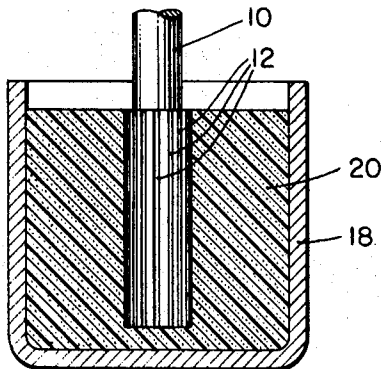


Fig. 3

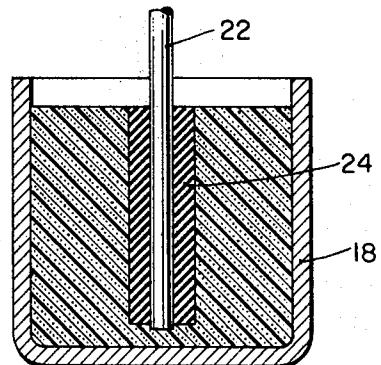


Fig. 4

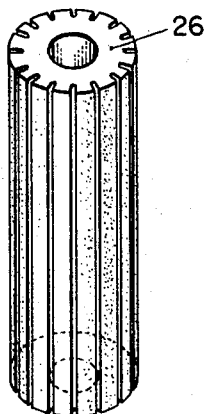


Fig. 5

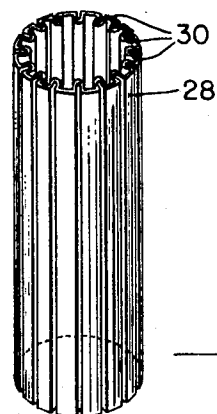


Fig. 6

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IRREGULAR SHAPED TUBING FORMED BY ELECTRODEPOSITION

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5 Claims

ABSTRACT OF THE DISCLOSURE

A method of electroforming tubular articles of irregular shapes is provided. A mold is first cast having a cavity therein corresponding to the particular tubular article to be formed. A flexible mandrel is then formed in the mold correspondingly shaped to the article being formed. After the mandrel is removed from the mold, the tubular article is formed on the mandrel by an electrodeposition process.

Finned tubes for heat exchanger application have been produced by mechanical methods such as by forging or swaging. However, mechanical processes for producing finned tubing have limitations in design and size.

It is known that electroformed tubing can be designed with a wide variety of configurations. For example, there is disclosed in a co-pending application Ser. No. 568,014, filed July 26, 1966 which is now Pat. No. 3,457,157, assigned to the same assignee as the present invention, apparatus for electroforming tubing. The tubing formed may be of irregular shapes. While the method described in this co-pending application is satisfactory in many respects, the rate of formation of the tubing is limited.

Electroplating has been used in forming many types of articles of irregular shapes. In general, when such articles have been formed, a mandrel having a shape of the particular article to be formed is immersed in an electrolytic bath and becomes the cathode in the electrolytic system. Also immersed in the bath is an anode composed of the plating material. A voltage is applied between the anode and the cathode causing a current to pass through the electrolytic solution which electroplating and plates the cathode with the anode material to the desired thickness. In this way articles may be formed with silver, copper, iron, cadmium, nickel and a wide variety of other metals.

It is an object of this invention to provide a novel method for making tubular members of irregular shapes.

It is a further object of this invention to provide an improved method for making tubular members having fins thereon, which may provide good heat sinks.

In accordance with the present invention, a method of electroforming a tubular article of irregular shape including fins thereon is provided. An element having the desired pattern is first provided. A mold is then cast of the element. A flexible mandrel is then cast in the mold. The flexible mandrel is then removed from the mold and plated with metal by an electrodeposition process to form the tubular article. For relatively long length of tubing, thin wall plastic tubing may be extruded and used as the mandrel.

Other objects and advantages of the present invention will be apparent and suggest themselves to those skilled in the art, from a reading of the following specification and claims, in conjunction with the accompanying drawings, in which:

FIGS. 1 and 2 illustrate members having shapes of tubular members to be formed, and

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FIGS. 3, 4, 5 and 6 illustrate some of the various steps which may be taken in forming tubular members, in accordance with the present invention.

Referring particularly to FIG. 1, a metal rod 10 is machined to provide a plurality of longitudinal grooves 12. The grooves may be of various depths or widths depending upon the particular application. In the embodiment illustrated, the machined rod may be designed to produce tubing which may be used as a heat sink, for example. In this case it is desirable that the final article formed have as much conducting surface as possible to permit heat transfer from the interior of a tube or pipe.

Referring particularly to FIG. 2, a metal rod 14 is machined to include a plurality of spiral shaped grooves 16. In this case, the machined rod 14 may be used as a heat sink having a spiralled finned configuration. The tubing which is ultimately formed by the machine bar 14, in addition to providing a large conductive surface, involves grooves which are oriented to resist the flow of fluid therethrough to some extent.

FIGS. 1 and 2 illustrate two specific different shaped members for forming tubes of irregular shape, which may be used as heat sinks or for other applications. It is apparent, however, that a number of other configurations are possible dependent upon the particular use to which the final formed product is to be put.

For purposes of explaining the method or process involved in the subject invention, only the embodiment illustrated in FIG. 1 will be referred to in describing the various steps illustrated in FIGS. 3 to 6. It is apparent however that the steps involved in the member illustrated in FIG. 1 would be similar for the member illustrated in FIG. 2.

Referring particularly to FIG. 3, a container 18 includes a material 20 which is normally in liquid form and which is capable of hardening when subjected to heat. This material, for example, could be vinyl plastisol or other form of rubber or plastic material. The machined rod 10 is inserted into the plastisol or other similar type material 20 and held in place by any suitable means (not illustrated) while the material 20 hardens. When the plastisol is used, it may be heated to a temperature of approximately 350° at which point it begins to gel and solidify. The plastisol material is then permitted to cool. The machined metal rod is then pulled out of the plastisol material 20, leaving an opening or cavity in the hardened material 20. This cavity is shaped to the surface of the tubular member to be ultimately formed.

Referring particularly to FIG. 4, after the rod 10 has been removed and the remaining material 20 in a solid condition, a solid element, which may be a metal rod 22, for example, may be inserted into the cavity and held in position by any suitable means (not illustrated). RTV rubber room temperature vulcanizing in a liquid form 24 is poured into the cavity around the rod 22 or the rod may be inserted last. The rubber is then permitted to harden although it is still soft and flexible. One type of conventional material which may be employed is silicone with a suitable catalyst added thereto.

After the rubber 24 has hardened, the rod 22 is removed. The rubber element 26, as illustrated in FIG. 5, is then collapsed and removed from the cavity mold.

The rubber element 26 is now ready to be used as a mandrel in connection with an electrodeposition process. The element 26 may be coated with a thin layer of silver and put into an electrolytic bath. After suitable connection of the electrodes to a source of power, the electrodeposition process takes place. Because electroplating per se is well known to those skilled in the art, no detailed showing or description of the electrodeposition process is considered to be necessary.

The electrodeposition process may be carried out with a rod inserted into the opening of the rubber element 26 to give support to the rubber element during the electroplating process. Upon completion of the electrodeposition process, the supporting rod may be taken out of the rubber element 26 and the element 26 collapsed. When the element 26 is collapsed, a metallic element 28 which now represents the deposited metal on the rubber mandrel, is in the form illustrated in FIG. 6.

It is noted that the element 28 includes a plurality of inwardly extending portions 30. This arrangement provides a relatively long surface path around the element 28. Because of the relatively large area resulting from the finned arrangement, the element 28 is ideally suited for use as a heat sink because of its ability to conduct a large amount of heat, for example, from fluid flowing within the tubular member. Of course, the tubular members formed are not limited to use as heat sink elements.

Regarding the machined element 14 of FIG. 2, after it has been inserted into the plastisol material 20, and the plastisol material hardened, it may be necessary to turn the metal bar 14 to remove it from the hardened material 20. Of course, the material 20 may be sufficiently soft so as to permit the element 14 to be pulled out without turning. The final element formed as a result of the machine bar 14 will also include inwardly projecting portions or fins making the element ideally suited for heat sink. The spiral element would also offer some resistance to the flow of fluid within the tube. The steps involved in forming the tubular members would be the same when either the elements of FIGS. 1 or 2 are used.

The particular arrangements described are particularly applicable to tubular elements which are relatively short. However, as previously mentioned, it is possible to extrude long pieces of plastic of the shape desired and perform an electrodeposition process on the mandrel formed.

What is claimed is:

1. A method of forming a metallic tubular member having an irregular surface comprising the steps of providing a member with said irregular surface, casting a mold of said member, removing said member from said mold, providing a solid element, casting a flexible mandrel in said mold with said solid element disposed therein, removing said solid element after said casting, removing said flexible mandrel from said mold, and electrodepositing a metal on said flexible mandrel to form said metallic tubular member.

2. The invention as set forth in claim 1 wherein said removal of said flexible mandrel includes the step of collapsing said flexible mandrel after said solid element has been removed therefrom.

3. The invention as set forth in claim 2 wherein said solid element is reinserted into said flexible mandrel prior to the step of electrodepositing of metal.

4. The invention as set forth in claim 3 wherein said member with said irregular surface is attained by providing grooves in a circular rod.

5. The invention as set forth in claim 4 wherein said mold is formed cast in said mold by pouring a plastisol material into said mold, heating said plastisol material to cause it to gel and solidify while in a heated condition.

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