Aug. 20, 1968 W. L. ULMER ET AL 3,397,445

METHOD OF MAKING BIMETAL TUBING

Filed Sept. 30, 1965 2 Sheets-Sheet 1

FIG. 1

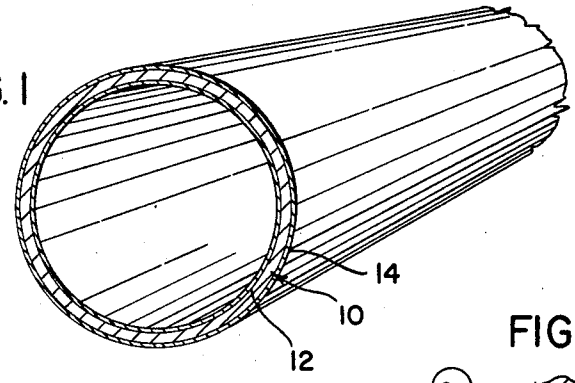


FIG. 2

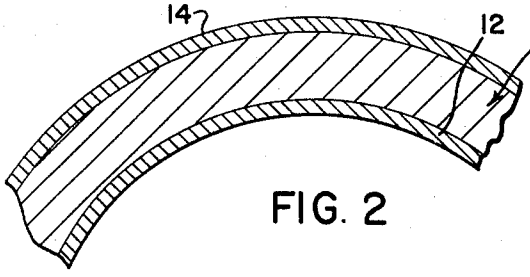


FIG. 4A

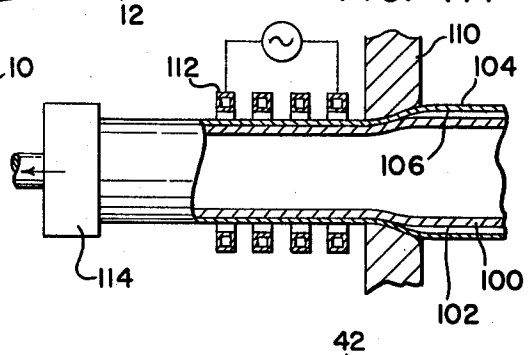


FIG. 4

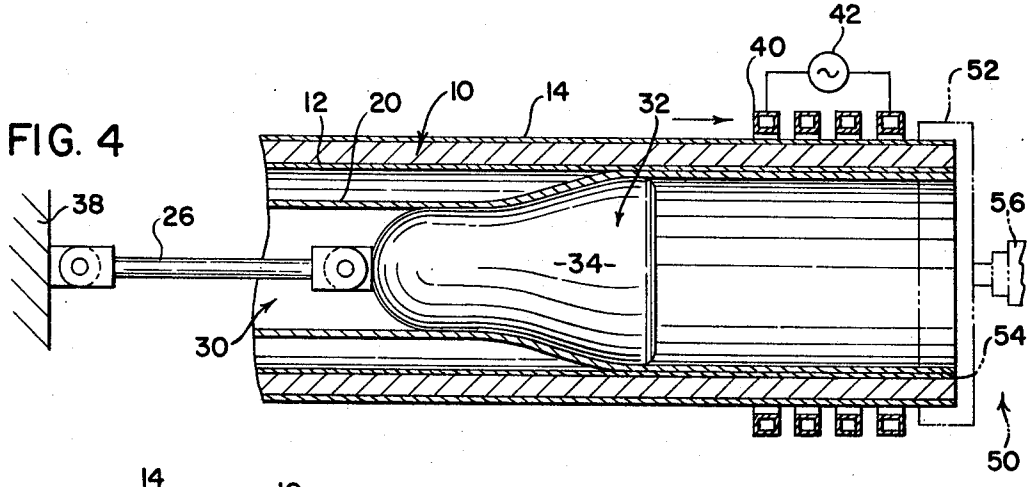
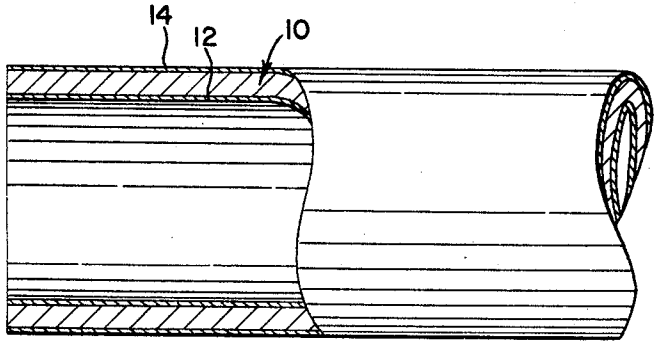


FIG. 3



INVENTORS.
WILLIAM L. ULMER &
HARRY W. McQUAID
BY
Tilberry & Body
ATTORNEYS

METHOD OF MAKING BIMETAL TUBING

Filed Sept. 30, 1965 2 Sheets-Sheet 2

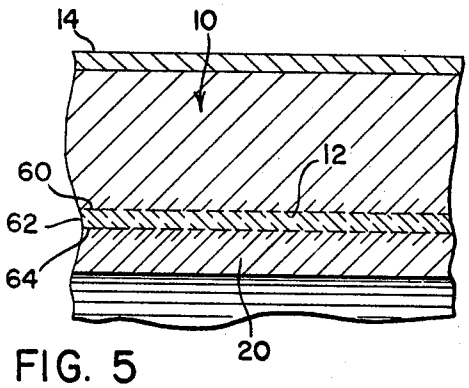


FIG. 5

FIG. 6A

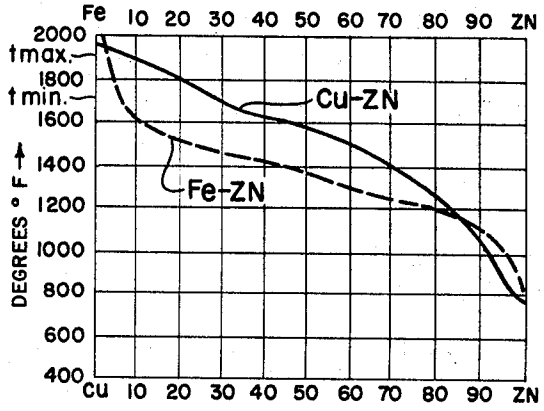


FIG. 6

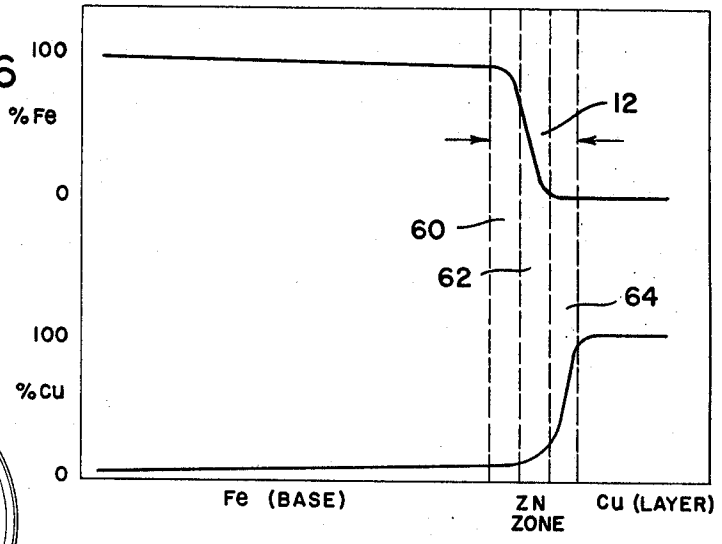


FIG. 7

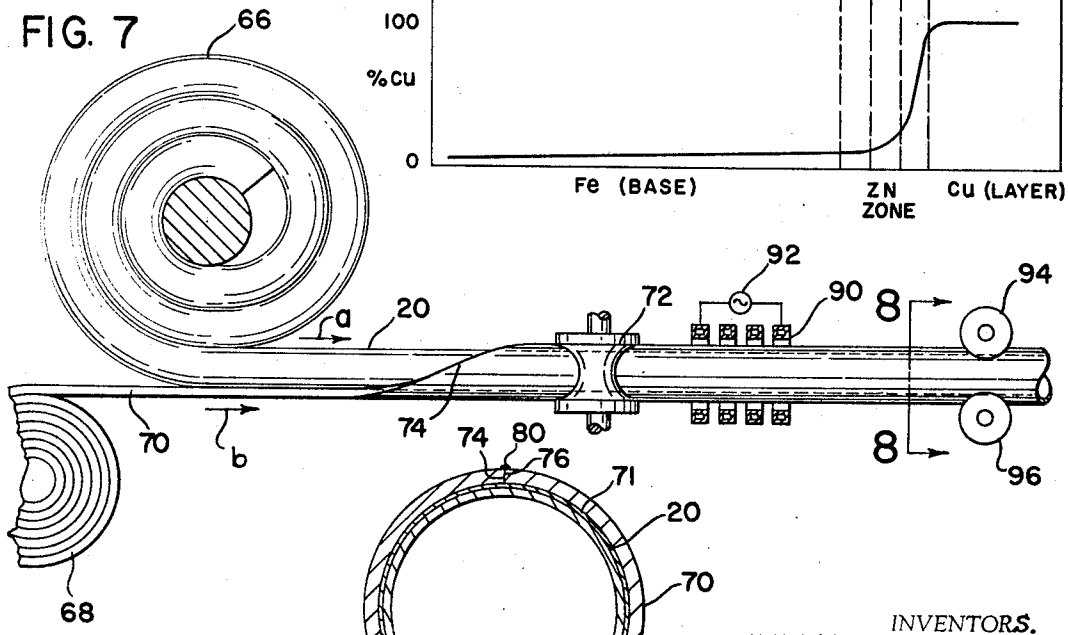


FIG. 8

INVENTORS.
WILLIAM L. ULMER &
HARRY W. McQUAID
BY
Tilberry & Body
ATTORNEYS

United States Patent Office

3,397,445

Patented Aug. 20, 1968

3,397,445

METHOD OF MAKING BIMETAL TUBING

William L. Ulmer, 2480 Kenilworth Road, Cleveland, Ohio 44106, and Harry W. McQuaid, Cleveland, Ohio; said McQuaid assignor to said Ulmer

Filed Sept. 30, 1965, Ser. No. 491,590

3 Claims. (Cl. 29—474.4)

ABSTRACT OF THE DISCLOSURE

There is provided a method of joining a copper base layer onto a ferrous base member wherein zinc is first alloyed to the ferrous member and then the copper base layer is applied. Thereafter, pressure is applied between the layer and the member while the member is progressively heated to a temperature in the general range of 1700° F.–1900° F.

The present invention pertains to the art of metal tubing and more particularly to a bimetal tubing and a method of making the same.

This invention is particularly applicable to a bimetal tubing having an outer tube or sleeve of ferrous metal and an inner tube or sleeve of a cupreous or copper based metal, and it will be described with particular reference thereto; however, it will be appreciated that the invention has much broader applications, and it may be used to join two dissimilar metals into a unitary body.

In recent years, there has been a drastic increase in the use of copper tubing, even though the cost of copper tubing has been, and still is, substantially higher than the cost of iron or steel pipe having similar physical characteristics. This increased use of copper tubing, irrespective of its higher cost, results from the ability of copper tubing to handle fluid which tends to corrode the inner surface of the lower priced iron or steel pipe. The superior corrosion resistance of copper tubing makes this tubing a necessary element in many refrigerating units, liquid conduit systems and other similar installations.

In view of the cost differential between the high corrosion resistant copper tubing and the low corrosion resistant standard iron or steel pipe, extensive efforts have been devoted to the development of a pipe or tubing having, at the same time, the higher corrosion resistant properties of copper tubing and the lower cost of the standard iron or steel pipe. Heretofore, this development work has been singularly unsuccessful.

It has been known for some time that the corrosion resistant characteristic of copper tubing results from the continuous copper surface in direct contact with fluid being conveyed. There is no need, from a corrosion resistant standpoint, for forming the outer casing of the tubing from copper. In other words, as long as the inner surface of the tubing is formed from copper, the remainder of the tubing can be produced from iron or other ferrous based metal without reducing the resistance of the tubing to corrosion by liquid flowing therethrough. Consequently, a major portion of the above-mentioned development work to find a substitute for copper tubing has been directed toward the production of an iron or steel pipe with an inner continuous surface of copper or similar material. At first, the inner surface of a standard iron

or steel pipe was coated with a thin continuous layer of copper. This process was unsatisfactory because it was impossible to provide a uniform, continuous coating of copper on the inner surface of the pipe, especially when the pipe had a relatively small inner diameter. The copper coating within the pipe had various areas where the ferrous base metal was exposed to fluid being conveyed through the pipe. The pipe would therefore corrode at these exposed areas. The rate of corrosion was somewhat accelerated due to the galvanic action between the adjacent iron and copper at the inner surface of the pipe.

In our copending application, Ser. No. 170,479, filed Feb. 1, 1962, now Patent No. 3,203,824, we have disclosed a method of forming a continuous coating of copper on the inner surface of a standard ferrous pipe; however, the process disclosed and claimed in this prior copending application has not been generally adopted by the trade because the cost of producing the pipe does not, at this time, justify the required re-tooling for this process.

In view of the disadvantages of coating the inner surface of ferrous pipe with a thin layer of copper, it has been suggested that a copper sleeve be inserted within an iron or steel pipe. Although this arrangement appears to be theoretically feasible, it has been unsuccessful in practice. Heretofore, the copper sleeve inserted within the iron pipe could not be bonded securely to the inner wall of the pipe. Consequently, during thermocycling of the pipe, the inner sleeve would separate from the pipe and form gas pockets which were insulators to the conductivity of the heat through the wall of the pipe. When this pipe was to be used in a refrigerating unit, these gas pockets seriously limited the usefulness of this pipe. In addition, the inferior bond between the inner copper sleeve and the outer iron pipe created serious difficulties while the pipe was formed into intricate shapes. For instance when the pipe was bent, the sleeve would separate from the inner wall of the pipe and cause restrictions at the bend. Separation of the sleeve from the inner surface of the pipe was exaggerated during the bending operation because the inner sleeve would be elongated or shortened a different amount than the surface against which it was abutted.

It has also been suggested to provide a laminated strip having a layer of copper and a layer of iron or steel. This strip was rolled into a pipe with the edges of the strip being overlapped. Thereafter, the seam of the rolled strip was sealed by various arrangements. This particular type of pipe was unsuccessful because of its high cost when compared to the cost of copper tubing or similar tubing.

All of these disadvantages and others are completely overcome by the present invention which is directed toward a bimetal tubing and method of making same, which tubing includes an inner copper based sleeve and an outer ferrous pipe with the sleeve and pipe being joined to each other in a manner to produce substantially integral tubing.

In accordance with the present invention, there is provided an improvement in a metal tubing including an outer shell or sleeve formed from a first metal and an inner shell or sleeve formed from a second metal. The improvement in accordance with the invention includes a bonding layer between the two shells, this layer comprises primarily a third metal having a melting point below the melting point of the first and second metals. This intermediate layer is metallurgically bonded to the outer shell by an

alloy of the first and third metals and to the inner shell by an alloy of the second and third metals.

By providing an intermediate alloyed joint between the inner and outer shells forming the tubing, the inner shell cannot separate from the outer shell during subsequent use of the tubing.

In accordance with another aspect of the present invention, there is provided a method of joining copper onto a ferrous base having a mounting surface, this method comprises the steps of alloying a thin layer of low temperature melting metal selected from the class consisting of zinc, tin, silver and aluminum, onto the mounting surface; applying a layer of copper based metal onto said mounting surface; exerting a high pressure between said surface and said copper based alloy; and, simultaneously, heating the ferrous base and copper based metal to a temperature below the melting temperature of the ferrous base and the copper based metal and substantially above the melting temperature of the low temperature melting metal whereby the low temperature melting metal alloys with the copper based metal.

By providing the successive alloying of the low temperature melting metal with first the ferrous base and then the copper based metal, an alloyed joint is formed between the ferrous base and the copper based metal. This alloyed joint has proven to be inseparable so that the two separate metals are joined as a unit and cannot be inadvertently separated.

The primary object of the present invention is the provision of a bimetal tubing having an outer metal sleeve and an inner metal sleeve which tubing is economical to produce and durable in use.

Another object of the present invention is the provision of a bimetal tubing having an outer metal sleeve and an inner metal sleeve which tubing is a unitary structure.

Still another object of the present invention is the provision of a bimetal tubing having an outer metal sleeve and an inner metal sleeve which tubing has an alloyed joint between the sleeves and formed from a metal dissimilar from the metal or metals forming the sleeves.

These and other objects and advantages will become apparent from the following description used to illustrate the preferred embodiment of the invention as read in connection with the accompanying drawings in which:

FIGURE 1 is a pictorial view illustrating, somewhat schematically, the outer sleeve utilized in the present invention;

FIGURE 2 is an enlarged, cross-sectional view, illustrating somewhat schematically, a modification of the outer sleeve shown in FIGURE 1;

FIGURE 3 is a cut-away, cross-sectional view illustrating the modified outer sleeve as shown in FIGURE 2;

FIGURE 4 is a cross-sectional, side elevational view illustrating, somewhat schematically, the method contemplated by the present invention;

FIGURE 4A is a cross-sectional, side elevational view showing, somewhat schematically, a modification of the method illustrated in FIGURE 4;

FIGURE 5 is an enlarged, cross-sectional view taken generally along line 5—5 of FIGURE 4;

FIGURE 6 is a graph illustrating an aspect of the present invention;

FIGURE 6A is a graph illustrating certain properties of the metals utilized in practicing the present invention;

FIGURE 7 is a side elevational view showing, somewhat schematically, a modification of a preferred embodiment of the invention contemplated herein; and,

FIGURE 8 is an enlarged, cross-sectional view taken generally along line 8—8 of FIGURE 7.

Referring now to the drawings wherein the showings are for the purpose of illustrating preferred embodiments of the invention only and not for the purpose of limiting same, FIGURES 1–3 show a somewhat standard iron or steel pipe **10**. This pipe may be formed from a variety of ferrous materials; however, in practice, the pipe is the type known commercially as "black iron pipe." For the purpose of this discussion, the pipe **10** may also be defined as an outer shell or sleeve; however, it will be appreciated that whether termed a pipe, shell or sleeve, the pipe **10** is a relatively high strength tubular member which could support, by itself, the flow of fluid therethrough. In accordance with the invention, the pipe **10** is provided with an inner layer **12** of a metal having a melting point substantially below the melting point of the metal forming the pipe and, also, substantially below the melting point of copper which is to be inserted within pipe **10**, in a manner to be hereinafter described in detail. Also, the metal forming the layer **12** must be soluble in both the metal forming the pipe **10** and in copper. A variety of metals, such as zinc, tin, silver and aluminum, will have the above-mentioned characteristics; however, in practice, the layer **12** is formed from zinc.

The layer **12** must be alloyed to the inner surface of pipe **10**; therefore, the zinc layer is placed on the inner surface of the pipe by a hot dip galvanizing process. This galvanizing process is common in the art of coating pipe; therefore, it is not herein described in detail. Since the layer **12** is alloyed to the pipe **10**, a metallurgical bond is formed between the layer and the pipe so that the layer will not separate from the pipe during subsequent use thereof. Since it is somewhat more difficult to provide only an inner layer of alloyed zinc on the pipe, in practice the pipe **10** has the inner layer **12** and an outer layer **14** of alloyed zinc formed during the hot dip galvanizing process. These two alloyed layers are clearly shown in FIGURES 2 and 3.

Referring now to FIGURE 4, a copper tubing or sleeve **20** is inserted within the pipe or sleeve **10**, and, for the purpose of easy insertion, the outer diameter of the copper sleeve is at least a few thousandths of an inch smaller than the inner diameter of the ferrous sleeve **10**. The difference in the diameters of the sleeves is exaggerated in FIGURE 4 so that the essence of the invention will be more evident. After the sleeve **20** is inserted within sleeve **10**, an apparatus **30** mechanically expands the sleeve **20** into tight physical contact with the sleeve **10**. A variety of arrangements could be utilized for expanding the copper sleeve **20**; however, in accordance with the preferred embodiment of the invention, there is provided a mandrel **32** having an external surface **34** tapering outwardly from left to right. The mandrel **32** is fixedly secured in a given position by a rod **26** secured onto a physical restraint **38**.

In front of the mandrel **32** there is provided a multi-turn induction coil **40** connected across a high frequency power source, schematically represented as a generator **42**. At the end of the composite sleeve structure, beyond the coil **40**, there is provided a sleeve pulling mechanism **50**. This mechanism is schematically shown as including a clamp **52** for engaging the outer surface of sleeve **10** and a clamp **54** for engaging the inner surface of sleeve **20**. These clamps are illustrated schematically as dashed lines because a variety of clamping arrangements could be used without departing from the intended spirit and scope of the present invention. The clamps **52**, **54** are secured onto a puller **56** which may take a variety of structural forms, such as a rod and cylinder or a chain and pulley. Such pullers are well known in the art of extruding pipe and similar elongated elements.

In operation, the mandrel **32** expands sleeve **20** into tight engagement with the inner layer **12** of sleeve **10** as the puller **56** pulls the sleeves **10**, **20** past the mandrel. Thereafter, the induction heating coil **40** raises the temperature of the tightly engaged sleeves **10**, **20** by inducing current flow within the sleeve structure in a manner well known in the induction heating art. As the temperatures of the sleeves increase, the copper sleeve tends to expand outwardly a greater amount than the outer sleeve **10**; therefore, an extremely high pressure is exerted between sleeve **20** and the zinc layer **12**. The temperature of layer **12** is increased substantially above the melting point of the metal forming the layer, but below the melting point of the sleeves **10**, **20**. In practice, the temperature of layer **12** is increased to approximately 1700°–

1900° F. This temperature is substantially below the melting temperature of the sleeve **10** and somewhat below the melting temperature of sleeve **20**.

As the layer **12** is heated to a temperature substantially above its melting temperature, the layer **12** tends to liquefy; however, during this liquefaction the copper forming sleeve **20** starts to dissolve in or alloy with the metal, such as zinc, forming layer **12**. As shown in the graph of FIGURE 6A, when the alloying process increases the amount of copper dissolved in or alloyed with layer **12**, the solidification temperature of the resulting alloy adjacent sleeve **20** increases toward the heated temperature of layer **12**. This causes a solidification of the alloyed layer **12** so that an alloy of copper and zinc is formed at the boundary between layer **12** and sleeve **20**. Referring again to FIGURE 6A, it is noted that the alloyed inner face or bond between layer **12** and pipe **10**, formed during the previous galvanizing operation, does not liquefy because the solidification temperature of this alloyed bond is not reached during the heating step. If there is a tendency for the bond between layer **12** and pipe **10** to liquefy, this only increases the alloying of the zinc with the iron to further increase the solidification temperature of this particular region in layer **12**. Because of the difference in thermal expansion, during the alloying of layer **12** with the copper in sleeve **20**, a high pressure is maintained on the layer **12** during the alloying process.

Referring now to FIGURES 7 and 8, there is illus- separated into three separate somewhat roughly defined strata **60**, **62** and **64**. Stratum **60** includes an alloy of iron and the metal forming layer **12**. Stratum **62** remains substantially unchanged and unalloyed. Stratum **64** is an alloy of copper and the metal forming layer **12**. Assuming that the metal forming the layer is zinc, the composition of the strata **60**, **62** and **64** is illustrated, somewhat schematically, in FIGURE 6. It is noted that the composition of the layer **12** changes from high iron to low iron in a direction away from sleeve **10** and changes from high copper to low copper in a direction away from sleeve **20**. In this manner, the layer **12** forms a metallurgical bond between sleeves **10**, **20** so that these sleeves are now an integral unit and subsequent processing of the resulting bimetal tubing cannot separate the inner copper sleeve from the outer ferrous sleeve. The inner copper sleeve provides the necessary corrosion resistance, and the outer ferrous sleeve provides the necessary strength so that this composite or bimetal tubing is relatively inexpensive and still has the attributes of copper tubing.

It has been found that a fine powder of copper formed in a slurry and coated on the outer surface of sleeve **10** substantially enhances the alloying characteristics between the layer **12** and sleeve **10**. Various other slight changes may become obvious to those skilled in the art after consideration of the invention defined herein.

Referring now to FIGURES 7 and 8, there is illustrated a method and apparatus for forming the composite sleeve structure before the expanding and heating steps illustrated in FIGURE 4. A coil or spool **66** of copper tubing **20** is conveyed along a given path *a*, represented by an arrow in FIGURE 7. At the same time, a coil **68** is provided with a strip **70** conveyed along a path *b*, represented by an arrow in FIGURE 7. The strip **70** is formed from a ferrous material and has an inner galvanized zinc layer **71**, shown in FIGURE 8, or a layer of another appropriate metal, such as tin, silver, and aluminum. The tubing **20** and strip **70** are conveyed through forming rolls **72** (only one of which is shown), which forming rolls converge the edges **74**, **76** of strip **70** into a longitudinally extending seam **80**.

In essence, the forming rolls wrap the strip **70** around the tubing **20** to form an outer sleeve. After the converging edges **74**, **76** have been joined, an inductor **90**, powered by an appropriate supply of high frequency, represented as generator **92**, raises the temperature of the converging edges to seam weld the edges together at seam

80. This is shown in FIGURE 8. The resulting composite sleeve structure is pulled through the welding apparatus by drive rolls **94**, **96**. It is appreciated that FIGURE 7 is only schematic in nature and that various structural features of the apparatus have been omitted for the purpose of simplicity.

The composite or resulting structure produced by the apparatus illustrated in FIGURE 7 is shown in FIGURE 8. The inner sleeve or tubing **20** is encircled by the strip **70**. Although the sleeve **20** is shown as abutting layer **71**, in practice there is a slight spacing between the sleeve and the layer. After the composite sleeve structure is formed in accordance with the method shown in FIGURE 7, the composite structure is then further processed in accordance with the method illustrated in FIGURE 4. It is appreciated that the strip **70** could be wrapped around the tubing or sleeve **20** with a lapped joint instead of the welded seam **80**. Other similar provisions could be made for making the composite sleeve structure preparatory to practicing the invention as illustrated in FIGURE 4.

A modification of the method shown in FIGURE 4 is illustrated in FIGURE 4A. Ferrous sleeve **100** has an outer surface **102** provided with a hot dipped zinc layer. Concentric with said sleeve **100** is a copper base sleeve **104** having an inner surface **106**. By pulling the sleeves **100**, **104** through a sinking die **110** and an induction heating inductor **112** by a puller **114**, the outer sleeve **104** is contracted around sleeve **100** so that the surface **106** is forced tightly against surface **102**. Thereafter, the inductor **112** raises the temperature of the sleeves and the zinc alloys with the copper of sleeve **104** to form the alloyed joint previously discussed.

The present invention has been described in connection with certain physical embodiments; however, various changes may be made in these embodiments without departing from the intended spirit and scope of the present invention as defined in the appended claims.

Having thus defined our invention, we claim:

1. A method of forming bimetal tubing, said method comprising the steps of:

(a) providing a ferrous metal tube having an inner surface;

(b) alloying a thin layer of zinc onto said inner surface;

(c) inserting a copper base tube into said ferrous base tube, said copper base tube having an outer diameter substantially smaller than the inner diameter of said ferrous base tube;

(d) mechanically expanding said copper base tube into gagement with said ferrous base tube; and

(e) after expanding said tube, inductively and progressively heating said two tubes to a temperature in the approximate range of 1700° F.–1900° F. whereby said zinc is alloyed progressively with said copper base tube and then solidifies due at least in part to the increasing solidification temperature of said zinc-copper alloy.

2. A method of joining a copper base metal onto a ferrous base metal member having a mounting surface, said method comprising the steps of:

(a) alloying a thin layer of zinc onto said mounting surface;

(b) applying a layer of copper base metal onto said mounting surface;

(c) exerting a high pressure between said surface and said copper base metal; and,

(d) inductively and progressively heating said ferrous base member and said copper base metal layer progressively along said member to a temperature in the approximate range of 1700° F.–1900° F. while said pressure is maintained between said surface and said layer whereby said zinc is alloyed with said copper base metal and then solidifies due at least in part to the increasing solidification temperature of said zinc-copper alloy.

3. The method as defined in claim 2 wherein said member is elongated and said heating step is performed by moving said member and said copper layer with respect to an induction heating inductor.

References Cited

UNITED STATES PATENTS

930,927	8/1909	Berkstresser	29—474.4
1,193,667	8/1916	Corey	29—474.4
1,650,321	11/1927	Bundy	29—474.1
2,775,029	12/1956	Bennett et al.	29—474.3
2,787,827	4/1957	Karmazin	29—527 X
3,025,596	3/1962	Ward et al.	29—474.4 X

3,091,848	6/1963	Frank	29—479 X
3,156,042	11/1964	Reed	29—474.4 X
3,167,857	2/1965	Saito et al.	29—479 X
3,205,573	9/1965	Seal et al.	29—474.4

FOREIGN PATENTS

225,421	9/1958	Australia.

OTHER REFERENCES

Fiat Final Report #595, December 1945, pp. 1–7.

JOHN F. CAMPBELL, *Primary Examiner.*

J. L. CLINE, *Assistant Examiner.*