Oct. 23, 1934. M. C. SUMMERS 1,978,235

METHOD OF MAKING BUTT WELDED TUBES

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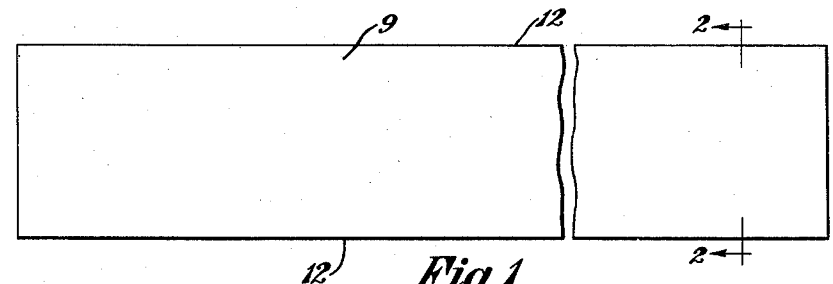

Fig. 1

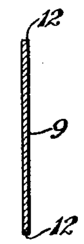

Fig. 2

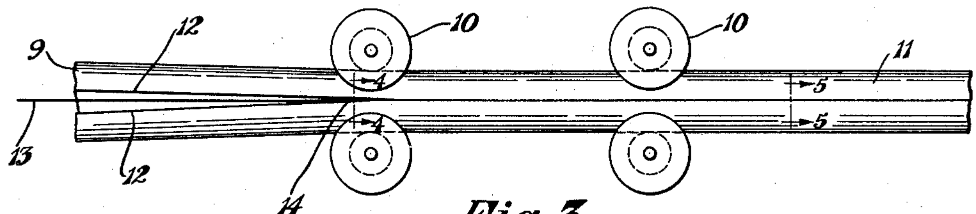

Fig. 3

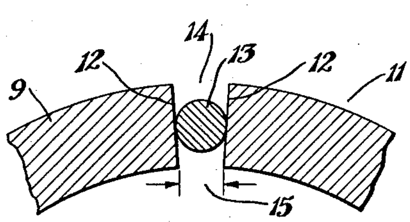

Fig. 4

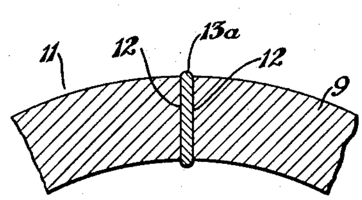

Fig. 5

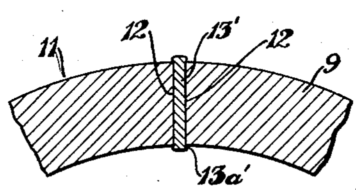

Fig. 6

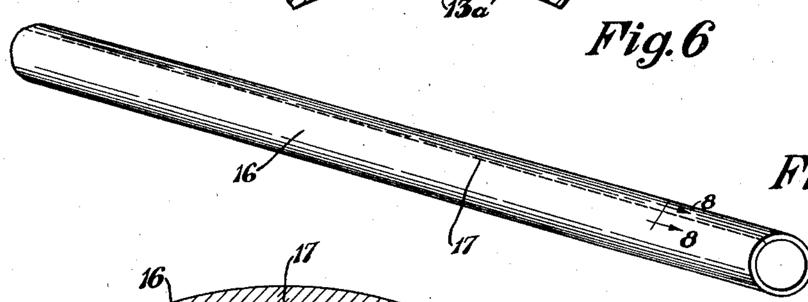

Fig. 7

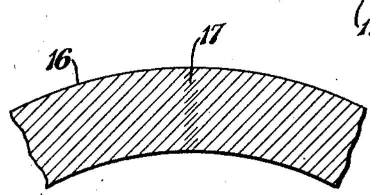

Fig. 8

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METHOD OF MAKING BUTT-WELDED TUBES

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7 Claims. (Cl. 113—112)

The invention relates to the butt-welding of tubes and more particularly to methods of making tubes from strip metal formed to tubular shape and provided with butt-welded joints, and of making steel tubes from strip metal formed to tubular shape and provided with copper-butt-welded joints.

It is known that steel pieces may be welded together by applying copper at a joint between the pieces and heating the same to beyond the melting point of copper, in a hydrogen atmosphere, so that some of the copper goes into solid solution in the steel, and some of the iron is dissolved by the copper to produce an integral copper-iron alloy bond or weld, which under desired conditions comprises approximately 97% iron and 3% copper with no free copper present. It is likewise known that such copper welds are actually stronger than the steel itself.

It has heretofore been proposed to braze the abutting edges of tubes for use as umbrella sticks by forming a tube from strip metal with a slit, and by forcing a brass wire, coated with flux, in place in the slit, after which the tube is heated until the brass flows and forms a brazed joint.

A satisfactory brazed joint suitable for use in umbrella sticks can possibly be made in this manner, but in carrying out such a method the brass wire utilized for forming the brazed joint must be relatively thick so that it will have sufficient inherent strength that it may be forced into the slit in the tube; with the result that when the brazed joint is formed, a large amount of free copper is present in the brazed joint, which free copper and therefore the joint, is much weaker than the tube thereby formed. Moreover, such a brazed joint is materially weaker than the copper welded joint described above.

Accordingly, such brazed tubes with weak joints cannot be safely used for the piping of fluids under pressure, as for instance for hydraulic brake lines, refrigeration system lines, and the like.

It has also been proposed that tubes may be made by forming a sheet metal tube blank with edges abutting, by then laying a copper wire within the tube blank adjacent to the abutting edges and by thereafter heating the blank and wire to the melting point of copper whereby the molten copper flows into the space between the abutting edges. However, while some satisfactory joints may be made in this manner under ideal precision conditions, yet the proposed making of tubes in this way is very expensive because the tube blank is proposed to be initially wrapped with an asbestos tape or confined within a refractory material mold for holding the abutting edges of the tube blank together, or for preventing the same from separating during the subsequent heating operation.

Moreover, all of the tubes made in this manner must have their abutting edges located on the bottom side thereof during the heating operation, for otherwise the copper from the wire laid adjacent to the abutting edges will not flow between the abutting edges when melted. Likewise, the tube blanks must be maintained substantially level during the heating operation, for otherwise the resulting joint will not be uniform, but the copper will flow to one or another end of the tube when molten. And finally, the heating operation per se, is very expensive because of the fact that the tube blanks are confined within either a refractory mold or an asbestos tape wrapping.

Accordingly, such a method of making tubes is impractical because of the excessive expense occasioned by the necessity for wrapping and unwrapping, or molding and stripping the tube blanks; the necessity of specially locating and levelling the tube blanks during the heating operation; and because of the excessive amount of heat required for carrying out the heating operation.

The present invention contemplates the making of tubes with butt-welded joints, which joints are as strong or stronger than the tube metal itself, as distinguished from weaker brazed joints, while avoiding the difficulties and expense encountered in carrying out the heretofore proposed methods of making tubing just described.

Thus, while copper-butt-welded joints per se, first described above, are known to have great strength, no method has heretofore been known by which a uniformly strong copper-butt-welded joint could be incorporated in a satisfactory and inexpensive manner in a tube formed from strip metal.

I have discovered that a very uniform, strong and efficient copper-butt-welded joint may be provided in a tube formed from strip metal if certain conditions are controlled and coordinated in the proper manner.

First, a very small amount only of copper or the bonding material must be utilized in order that there will be practically no free copper present in the copper-butt-welded joint, which if present would weaken the same.

Second, the small amount of copper or bonding material for forming the copper-butt-welded joint must be held in place between the adjacent tube blank edges which are to be welded without the occurrence of a spreading action between the tube blank edges during the heating operation; without requiring the tube to be specially positioned with regard to the adjacent tube blank edges; and without requiring the tube to be level during the heating operation.

And third, the heating operation must be carried out with such a co-ordination between the time and temperature of heating that no spreading occurs between the adjacent blank edges during the heating operation.

More particularly, I have discovered that these conditions may be controlled and coordinated by pinching, clamping or otherwise gripping a thin copper or bonding material strip or wire between the abutting edges of the tube blank as the tube blank is formed, and by then quickly heating the tube blank to a temperature of 1950° F. and upwards for a pure copper bonding material butt-weld in a steel tube for a very short period of time. In this manner, the required small amount of copper or bonding material may be utilized, and the copper or bonding material will be held in place and no spreading will occur between the tube blank edges during the heating operation.

Accordingly, it is a further object of the present invention to utilize in a method of making a tube with a butt-welded joint or a copper-butt-welded joint, the step of inserting a copper or bonding material strip between the edges of a tube strip as the tube strip is being formed to have a tubular shape, and clamping the copper or bonding material strip between the abutting edges of the tube strip during the forming operation so that the formed tube blank per se securely holds the copper or bonding material strip in fixed position between its abutting edges.

It is likewise an object of the present invention to control the heating operation so that a spreading does not occur between the tube blank edges during the heating operation, and so that the copper or bonding material strip remains securely clamped between the abutting tube blank edges during the heating operation until the butt-welded joint has been formed.

These and other objects may be obtained by the improved methods and steps thereof described herein in detail and claimed, and which are shown more or less diagrammatically in the accompanying drawing, in which,—

Figure 1 is a diagrammatic plan view of a steel strip from which the improved copper-butt-welded steel tubes may be made;

Fig. 2 is a sectional view taken on the line 2—2, Fig. 1;

Fig. 3 is a diagrammatic plan view of a portion of the steel strip shown in Fig. 1 passing through rolls for being formed to a tubular shape, and showing a thin wire being fed to and clamped between the abutting edges of the strip;

Fig. 4 is a greatly enlarged fragmentary sectional view taken on the line 4—4, Fig. 3;

Fig. 5 is a fragmentary sectional view similar to Fig. 4, taken on the line 5—5, Fig. 3;

Fig. 6 is a fragmentary view similar to Fig. 5, showing a copper strip clamped between the abutting edges of the tube blank;

Fig. 7 is a diagrammatic perspective view of a portion of a finished improved copper-butt-welded steel tube; and

Fig. 8 is an enlarged fragmentary sectional view taken on the line 8—8, Fig. 7.

Similar numerals refer to similar parts throughout the various figures of the drawing.

In carrying out the improved tube butt-welding method for making copper-butt-welded steel tubes, a strip indicated diagrammatically at 9 in Figs. 1 and 2, which may be a steel strip, or a strip slit from a steel sheet or stripsheet, is passed through a tube forming machine, which may be a usual type of continuous tube rolling machine indicated diagrammatically at 10 in Fig. 3. The strip 9 in passing through the tube forming rolls 10 is formed to have a tubular shape, as indicated generally at 11 in Fig. 3, and the free edges 12 of the strip 9 are brought up to adjacent alignment with each other.

Up to this point, the steps in making the tubing are merely the common practice of forming or making tubes; and the present improved method then departs from the usual practice, by providing for introducing a small copper or bonding material wire 13 between the edges 12 of the strip 9 just as the edges 12 are being brought into adjacent alignment, as at the place 14 indicated more or less diagrammatically in Fig. 3 and as shown in Fig. 4.

At this place, the space 15 between the strip edges 12 is sufficient to accommodate the copper wire, but as the tube 11 continues to pass through the forming rolls 10, the edges 12 are pressed more closely together so that the copper wire 13 is compressed, pinched, squeezed, or otherwise securely clamped or retained between the edges 12 of the steel strip 9 and thereby held securely in place. The clamping or squeezing of the copper wire 13 so distorts or spreads the wire that the same may take the general form of a strip indicated diagrammatically at 13*a* in Fig. 5, which strip 13*a* is securely clamped between the edges 12 of the steel strip 9, from which the tube 11 is formed.

Thus, if the copper wire 13 had not been introduced between the edges 12 of the steel strip 9, the said edges 12 would have been brought into aligned abutting and pressing contact; but because the wire is introduced between the free edges 12 of the strip 9 as the tube 11 is formed, the copper wire 13 is compressed, clamped, pinched or otherwise securely held or retained between the edges 12 of the strip 9 from which the tube 11 is formed.

It may be desirable to utilize copper or bonding material strips rather than copper wire, and in such event, a copper strip 13′ is fed between the edges 12 of the strip 9 as the strip is passing through the forming machine 10 so that the thin copper strip 13′ as shown in Fig. 6, is securely clamped, pinched, squeezed or otherwise held securely in place between the adjacent edges 12 of the strip 9 formed to make the tube 11. When a copper strip is used as shown in Fig. 6, there may only be a very slight distortion or compression of the same, as indicated at 13*a*′, but some distortion or compression of the same does occur in order that the copper strip is securely held in fixed position between the edges 12 of the tube blank.

Of course, the size of the copper or bonding material wire 13, or the thickness of the copper strip 13′ may be varied in accordance with the desired wall thickness of the tube 11 and therefore the thickness of the strip 9, so that the correct amount of copper is present for satisfactorily forming a true copper-butt-welded joint. However, by feeding the copper strip between the free edges 12 of the strip 9 as the tube 11 is being formed, and securely pinching, compressing and holding the same between the free edges, the exact amount of copper or bonding material necessary for making a true welded joint may be provided, which in fact is only a very small amount of copper or bonding material.

For example, if a one-half inch outside diameter steel tube is to be made with a 0.035 inch wall thickness, a 0.0005 to a 0.005 inch copper wire may be used or a 0.0005 to a 0.002 inch strip having a width of 0.035 to 0.050 inches may be used.

The formed tube 11 with a copper or bonding material strip 13*a* or 13*a'* pinched between the abutting edges 12 thereof, is then placed in a heating furnace wherein a non-oxidizing or reducing atmosphere is maintained, and the said heating furnace may be of the type generally known as a continuous bright annealing furnace.

The furnace temperature is maintained at such a degree that the copper strip is quickly heated to a temperature of 1950° F. and upwards, when the edges of the tube are bonded together by a copper-butt-welded joint. I have discovered that if the tube is quickly heated to a temperature of 1950° F. and upwards, no spreading occurs between the edges 12 of the formed tube 11, and the copper strip 13*a* or 13*a'* is therefore held in position between the tube edges 12 until a satisfactory and uniform copper-butt-welded joint has been formed.

Thus, when the tube is heated quickly to 1950° F. and upwards, the strains which may be present in the outer skin or region of the strip metal 9, in consequence of the forming thereof to tubular shape, are believed to be relieved, before relief of the strains present in the inner skin or regions of the tubularly formed strip, due to the temperature difference between the outer and inner regions of the strip.

The relief of the strains in the outer regions of the formed tube does not, however, cause a spreading action to occur between the edges 12, and because of this fact, and of the fact that there is a lag in the time when the strains are relieved in the inner regions of the tube walls, during which time lag the alloy in the butt-welded joint begins to form, no spreading action occurs between the edges 12.

It is, however, possible to utilize temperatures above 1950° F., provided that the tube is quickly heated to the maximum temperature.

For example, if a one-half inch outside diameter steel tube having a wall thickness of 0.035 inches and having either a 0.0005 to 0.005 inch copper wire, or a 0.0005 to a 0.002 inch strip compressed between its adjacent aligned edges, is quickly heated to a temperature of 1950° F. and upwards in a preferably reducing atmosphere, the copper or bonding material strip is satisfactorily held by the tube in correct position and a uniform and satisfactory copper-butt-welded joint is formed.

If the size of the tube is varied without changing its wall thickness, approximately the same conditions as to copper or bonding material strip size, heating temperature and time of heating are maintained. If the wall thickness of the tube is increased or decreased, the amount of copper or bonding material may be increased or decreased accordingly.

In addition, if the wall thickness is increased, the time of heating or the heating temperature may be slightly increased accordingly from those given in the examples herein.

After the heating operation has been performed, the tube is cooled and the finished tube 16 shown in Fig. 7 with a copper-butt-welded seam or joint 17 shown in Figs. 7 and 8 is thereby produced.

It is pointed out that it is neither necessary nor desirable to use any flux in connection with making the copper-butt-welded seam or joint according to the improved method of making steel tubes when a reducing atmosphere is utilized; although it may be necessary to use some flux if merely a non-oxidizing atmosphere is used.

By carrying out the method of making steel tubes set forth herein, the seam or joint 17 is a true copper weld in which some of the copper goes into solution in the steel and some of the iron from the steel is dissolved by the copper to produce an integral copper-iron alloy bond, which under desired conditions with a proper amount of copper originally used, comprises approximately 97 per cent iron and 3 per cent copper with no free copper present; and such a weld, bond, seam or joint is termed herein a "copper-butt-welded" joint, as distinguished from a "brazed" joint, which is one in which material excess of copper is by intention or necessity initially used with the result that a material amount of free copper is present in the resulting joint, thereby materially weakening the joint.

The heating operation has been described as being carried out in a bright annealing furnace, which as stated, is preferably of a continuous type and may for example be a sixty foot furnace with entrance rolls, a heating zone and a cooling zone through which formed tubes may continuously pass.

The heating zone in such a furnace is preferably approximately twelve feet long and the tubes being welded are continuously passed through the heating zone preferably at a speed of approximately four feet per minute so that any portion of any tube, is, under the conditions given in the above examples, heated to a temperature of 1950° F. and upwards.

By making a tube in this manner, the copper-butt-welded joint thereof is as strong or stronger than the steel itself and may be subjected to bending, forming, drawing and flaring. Moreover, since the heating operation is carried out in a bright annealing furnace under a preferably reducing atmosphere, a dead soft bright annealed tube results, which may be galvanized, tinned, or provided with a baked enamel or porcelain enamel coating without pickling. Moreover, the tubes may be directly copper or nickel or chromium plated, or soldered, without performing any special operations thereupon.

Such tubes may be used as conduit for electrical wiring, for refrigeration system lines, for motor vehicle gasoline, hydraulic brake and oil lines, for steering columns for automobiles and motor boats, or for any other purposes for which tubing is used. If it is desired that the tubes be hardened or stiffened, the dead soft tubes may be given a slight draw.

In the description of the invention, copper has been referred to, but it is clear that either brass or bronze or silver solder wire or strips, each of which contains copper, may be used in place of copper; so that when the term "copper" is used herein and in the appended claims, the same is intended to include copper and copper bearing alloys.

In the event that brass or bronze or silver solder is utilized, the time and temperature of the heating operation must be varied accordingly, since the melting points thereof are somewhat lower than that of pure copper; but in any event, the temperature maintained is one "about" the melting point of the bonding material, whether it be copper, brass, bronze or silver solder. Likewise, the bonding material, whether it be copper, brass, bronze, silver solder or the like, has a lower melting point than that of the strip metal from which the tube is formed.

Likewise, copper wires or strips are referred to generically herein and in the appended claims as "copper strips", because, while a copper wire or strip of any shape may be initially fed between the edges of the steel strip when the same is being formed, the copper wire or strip is compressed to have generally a strip formation, as indicated at 13*a* and 13*a'* in Figs. 5 and 6 of the drawing.

Moreover, under certain conditions, a copper paste may be applied to the edges 12 of the strip before or during the forming of the tube, so that the copper particles in the paste are pinched or compressed between the tube edges when formed and during heating to produce a copper-butt-welded steel tube.

And finally, when the term "steel strips" is used herein, the same is intended to include ordinary steels, alloy steels, stainless steels and other similar metals with which a butt-welded joint may be formed.

Likewise, it is clear that a tube may be made from non-ferrous strip metal with a welded joint according to the improved method by utilizing a bonding material having a lower melting point than that of the tube strip; as for instance by making the tube from a strip of non-ferrous metal such as brass comprising say 85 per cent copper and 15 per cent zinc and pinching between its two edges while being formed, a strip of silver solder, a silver wire, or a strip of a suitable alloy such as a high zinc brass, which have a lower melting point than the tube strip, and then heating the same quickly to a welding temperature to form a butt-welded joint.

I claim:—

1. The method of making a copper-butt-welded steel tube, which includes forming a tube from a steel strip to bring its free edges into adjacent alignment, pinching a copper strip between said adjacent edges while forming the tube, and then heating the formed tube quickly in a non-oxidizing atmosphere to 1950° F. and upwards to form a copper-butt-welded seam between said tube edges without relieving the pinch of the tube edges upon said copper strip.

2. The method of making a copper-butt-welded steel tube which includes forming a tube from a steel strip to bring its free edges into adjacent alignment and at the same time compressing a copper strip between said adjacent edges, and then heating the formed tube quickly in a reducing atmosphere to 1950° F. and upwards to form a copper-butt-welded seam between said tube edges without relieving the hold of the tube edges upon said copper strip.

3. The method of making a copper-butt-welded steel tube which includes forming a tube from a steel strip to bring its free edges into adjacent alignment, feeding a copper wire between said adjacent edges and compressing the wire to flatten and pinch the same between said adjacent edges while forming the tube, and then heating the formed tube quickly in a reducing atmosphere to 1950° F. and upwards to form a copper-butt-welded seam between said tube edges without relieving the hold of the tube edges upon said flattened copper wire.

4. In a method of making a copper-butt-welded steel tube formed from a steel strip, the steps of inserting a copper strip between the edges of the steel strip as the steel strip is being formed to tubular shape, pinching the copper strip between the steel strip edges during the forming operation so that the formed tube per se securely holds the copper strip in fixed position between its edges, and then heating the formed tube to form a copper-butt-welded joint between its edges.

5. The method of continuously making a copper-butt-welded steel tube which includes continuously forming a tube from a steel strip to bring its free edges into adjacent alignment, pinching copper between said adjacent edges while forming the tube, and then continuously heating the formed tube quickly in a reducing atmosphere while retaining said copper in position between said edges until fusion takes place to form a copper-butt-welded seam between said tube edges.

6. In a method of making a butt-welded tube formed from a metal strip, the steps of inserting a strip of bonding material having a lower melting point than the tube strip between the edges of the tube strip as the tube strip is being formed to tubular shape, pinching the bonding strip between the tube strip edges during the forming operation so that the formed tube per se securely holds the bonding strip in fixed position between its edges, and then heating the formed tube to form a butt-welded joint between its edges.

7. A method of continuously making a butt-welded tube, which includes continuously forming a tube from strip metal to bring its free edges into adjacent alignment, pinching a bonding strip having a lower melting point than the tube strip between said adjacent edges while forming the tube, and then continuously heating the formed tube quickly in a reducing atmosphere while retaining said bonding strip in position between said tube edges until fusion takes place to form a butt-welded seam between said tube edges.

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