

Oct. 6, 1942.

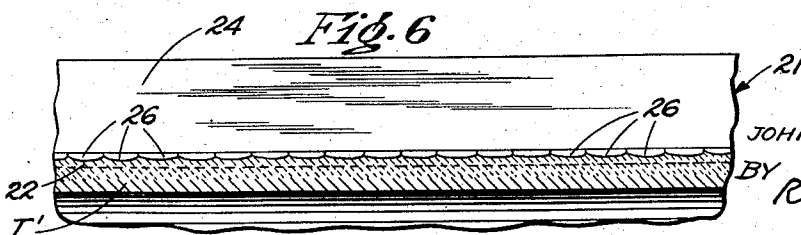
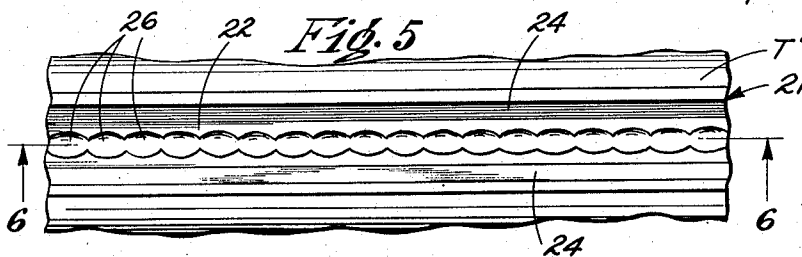
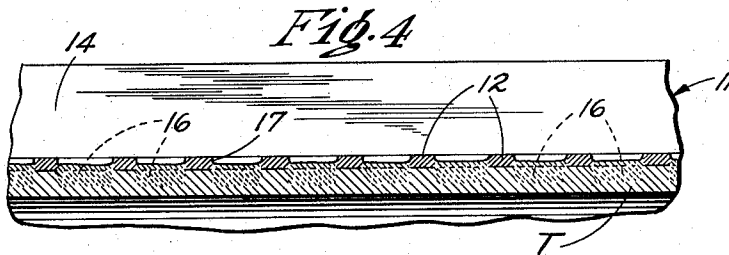
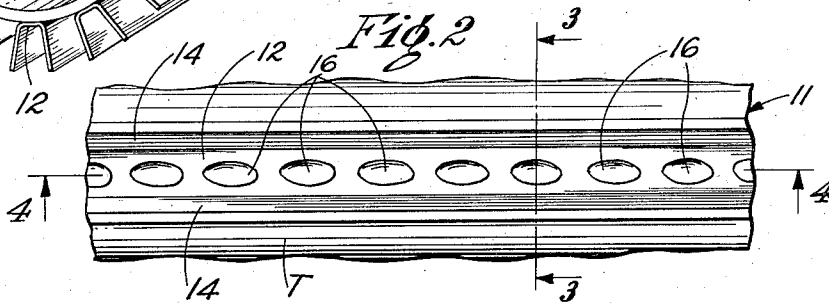
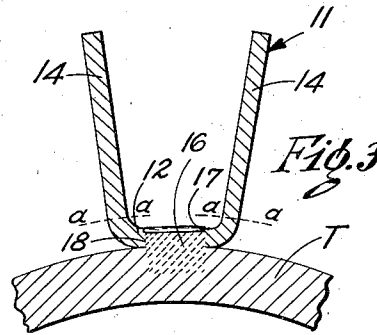
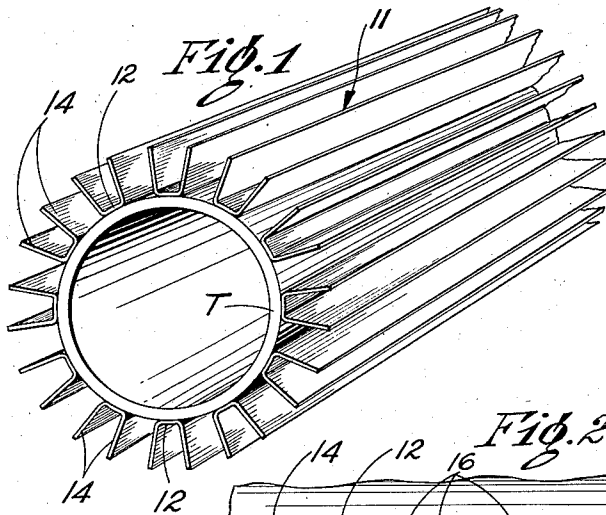
J. W. BROWN, JR

2,298,250

APPARATUS FOR MAKING FINNED TUBES

Filed April 16, 1941

2 Sheets-Sheet 1



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APPARATUS FOR MAKING FINNED TUBES

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2 Sheets-Sheet 2

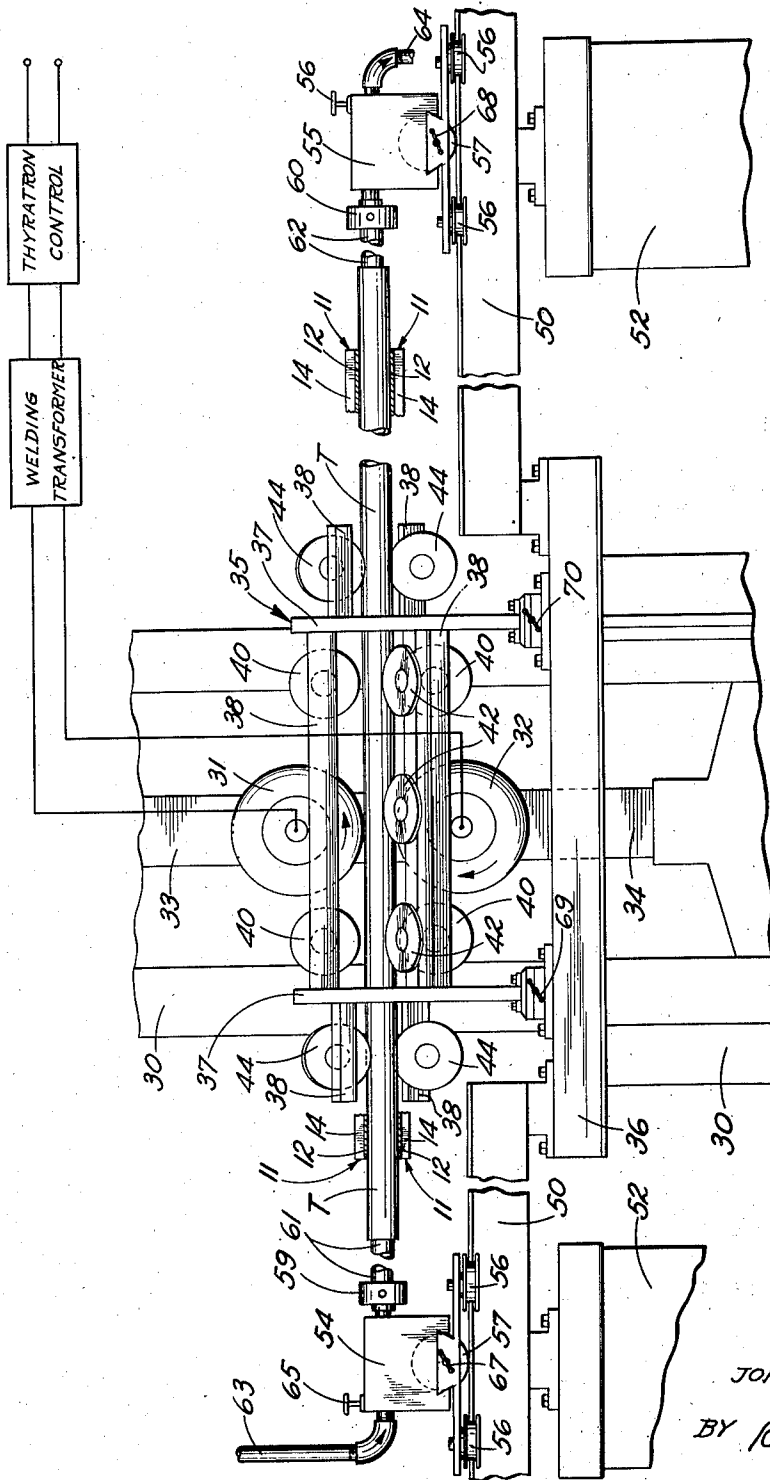


Fig. 7

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UNITED STATES PATENT OFFICE

2,298,250

METHOD OF MAKING FINNED TUBES

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Application April 16, 1941, Serial No. 388,835

5 Claims. (Cl. 219-10)

This invention relates to a method of attaching metallic fin members to the exterior of metal tubes for producing finned tubes adapted particularly for use as heat exchange conduits, although the tubes are also useful as structural members. This application constitutes, insofar as common subject matter is concerned, a continuation in part of my copending applications Serial No. 240,328, filed November 14, 1938, now Patent No. 2,261,136, dated Nov. 4, 1941, and Serial No. 323,593, filed March 12, 1940.

In the manufacture of heat exchangers it is desirable to augment the area of the fluid conducting tubes employed by securing fins of various types to the exterior of the tubes. Fins extending longitudinally of the tubes are particularly desirable in some types of installations because of the desirable flow characteristics which can be obtained in the fluid surrounding the tube. Various methods have been proposed for securing such fins to the exterior of tubes but so far as I am aware, all prior methods have been open to serious objections in that they were expensive and did not connect the fins to the tubes in such manner that full advantage could be taken of the heat transferring capacity of the fins, that is, in prior types of finned tubes the transfer of heat from the tube to the fins has been inefficient.

It is accordingly among the objects of my invention to provide an economical and efficient method of attaching fins to tubes which will produce finned tubes wherein an adequate path is provided for the flow of heat from the tube to the fins. Another object is to provide a method which can be adapted to the production of various types of tubing. Another object is to provide a method of making finned tubes which can be carried out rapidly and efficiently. Another object is to provide a method of making tubes of high strength and durability. Further and more specific objects of my invention will become apparent from the following description of a preferred form thereof, reference being made to the accompanying drawings. The essential characteristics are summarized in the claims.

Briefly, my invention contemplates the production of finned tubes of the type in which each fin member comprises a fin proper and a base portion welded to the tube; for example, each fin member may be of sheet metal preformed to either a U-shaped or an L-shaped cross-section with the base of the U or L, as the case may be, welded to the exterior of the tube. According to my method, the bases of two oppositely disposed fin members preferably are welded simul-

taneously to the tube by electric resistance welding to produce substantially identical rows of welded areas, the welds preferably being evenly spaced in such a manner that the welded area between the bases of the fin members and the tube is such that the rate of heat transfer from the tube into the base of the fin member will be at least substantially as great as the rate of heat transfer from the base of the fin member to the fins themselves.

Preferably the welding operation is carried out with opposite pairs of welds made by the use of two roller electrodes pressed against the bases of two oppositely disposed fin members, with the current flowing through the tube from the weld in one fin base to that in the other fin base. The operation is carried out so that the heating and the corresponding expansion of the tube is equal along the opposite sides of the tube with the result that the tubes are not warped or curved during the welding operation. The invention is described herein in conjunction with the simultaneous welding of a pair of fin members, but it is to be understood that, with the proper apparatus, more than two fin members may be simultaneously welded to the tube, if desired, in which case the fin members are preferably spaced equally circumferentially so that with substantially equal heating there will be no bowing of the tube. Further, the successive welds are made so rapidly, with such a short time interval between successive welds, that the tube is progressed between the welding electrodes faster than heat is conducted longitudinally of the tube to an extent sufficient to materially soften the base portions of the finned members or the tube itself in the region engaged by the electrodes.

By this method the electrodes, which must exert considerable pressure in order to make proper welds, engage metal which is still relatively cool and has not been unduly weakened by heat. This prevents the damaging of the bases of the finned members and distortion of the tube which would occur if the welding operations and the relative movement of the tube and electrodes were carried out at such slow speeds that the heat generated in the making of one pair of welds had time to travel ahead to soften the tube and fin members in the areas next to be welded before the welding pressure and heat are applied thereto. By my method, the tube is not materially weakened by the heat at the time the welding pressure is applied, thus the tube not only has strength to resist distortion, but also to resist

the welding pressure and thus make possible the production of successful welds without the use of an internal support or mandrel. This necessitates, of course, control of the welding current, pressure and speed, and the use of a high amperage current so as to reduce the time required for each pair of opposed welds.

In order to carry out my method efficiently and rapidly, I preferably employ a welding machine of the continuous type, embodying electrode rolls engaging the bases of finned members on opposite sides of the tube and provided with means for governing the intensity of the welding current and also means such as the well-known "Thyratron" control, for accurately governing the time and duration of flow of current. The apparatus for carrying out my invention also preferably embodies a jig or fixture for supporting and guiding a tube and fin members in their passage through the machine, the jig preferably being arranged to permit rapid and accurate indexing of the tube, and being provided with means for supporting the ends of the tube to prevent sagging, and for supplying a cooling fluid to the tube if desired.

Referring now to the drawings, Fig. 1 is a perspective view illustrating a section of finned tube made according to my invention; Fig. 2 is a fragmentary plan view on an enlarged scale, illustrating one of the finned members secured to the tube; Figs. 3 and 4 are fragmentary sections through the tube as indicated by the lines 3—3 and 4—4 respectively on Fig. 2; Figs. 5 and 6 are views similar to Figs. 2 and 4, but show a slightly modified form of tube, and Fig. 7 is an elevation showing a portion of a welding machine adapted to carry out my method and provided with my apparatus for supporting and guiding the tube and fins through the machine.

As shown in Fig. 1 of the drawings, a finned tube made according to a preferred form of my invention may comprise a tubular member T to which a number of fin members 11 are secured. Each fin member is preferably of channel section as shown in Fig. 3 and may comprise a base portion 12 and fins 14 formed integrally therewith, the base and fins being of substantially the same thickness. The base portions may be curved slightly, as shown, to conform substantially to the outer surface of the tube.

It will be evident to those skilled in the art that the transfer of heat from the tube T to the fins 14 must take place through the base portion 12. Further, the limiting factor in the flow of heat from the base portion 12 to the fins 14 is found in the longitudinal sectional area of the fins adjacent the base; i. e., the regions indicated at *a—*a** in Fig. 3. Per unit of length, this area is, of course, proportional to the thickness of these sections.

It follows, then, that if full advantage is to be taken of the heat transferring capacity of the fins 14, the path or paths for the flow of heat from the tube T to the base 12 must be at least equal in area to the combined areas of the fins 14 in the regions *a—*a**. To accomplish this result I secure the channel members 11 to the tube by a series of resistance welds indicated diagrammatically at 16 and having a combined area per unit of length at least substantially equal to the longitudinal sectional area of the fins 14 at the junctures between the fins and the base portion 12.

The desired area can be readily secured by a series of resistance welds spaced as shown in the

drawing and any increase in area is of no material advantage so far as heat transfer efficiency is concerned, for, in any event, the transfer of heat to the fins 14 will be limited to the conductive capacity of the portions *a—*a** of the fins. An important advantage in securing the fins to the tube by intermittent welds is found in the fact that if the tube is subjected to a sudden heat shock in service the fins can buckle or stretch in the regions between welds without subjecting the tube itself to unduly large forces, whereas if the fins were welded continuously to the tube such an action would not be possible and a heat shock might have the effect of damaging the tube.

A further and important advantage of utilizing intermittent welds will be apparent from a consideration of Figs. 2, 3 and 4. As shown in a somewhat exaggerated fashion in Figs. 3 and 4, the production of the weld between the base portion 12 and the tube T results in a thinning of the base portion in the region of the weld because of the electrode pressure required to produce a welded connection, the amount which the metal has been thinned being indicated at 17. The area available for transfer of heat from a welded area to the base is determined by the product of the thickness of the welded area at its juncture with the remainder of the base and the perimetric length of the welded area.

While the thickness of the base is reduced in the zone 18 to a thickness less than the thickness of the flanges in the regions *a—*a**, adequate paths for the flow of heat into the base, that is, paths with areas at least substantially as great as the paths for flow of heat from the base into the fin portions, are provided by my arrangement wherein the fins are secured to the tube by a series of equally spaced resistance welds. As shown in Fig. 2, by utilizing a series of resistance welds, the limiting cross-sectional area becomes the peripheral area of the minute cylinders which constitute projections of the welded areas through the base. The axial length of each of the cylinders is the distance indicated at 18 while the periphery of each is substantially the same as the periphery of the adjacent welded area 16.

The welding operation is carried out so that the combined perimetric lengths of the welded areas and, correspondingly, of the cylinders in the arrangement shown in Fig. 2, exceeds the total length of the flanges on section of tubing illustrated, the total perimetric length of the welded areas having at least substantially the same proportional relationship to the total length of the flanges as the original thickness of the base bears to the thickness of the welded areas. Thus the increase in perimetric length as compared to the length of the flanges, at least offsets the decrease in section due to the welding operation and there is no loss in efficiency of heat transfer at this point. For example, in a one inch length of tube with a channel section fin member having a thickness of 0.031 inch, the cross-sectional area at the base of the fins will be 0.062 square inch. If the welding operation is carried out in such a manner as to produce about three uniformly spaced welds to the inch with each welded area being of slightly oval form, a little more than $\frac{1}{4}$ inch long and $\frac{3}{16}$ inch wide, the periphery of each spot will be about $\frac{3}{4}$ inch. With three such spots to the inch, and the thickness of the metal in the region of the welds being reduced to 0.028 inch, the limiting area for the transfer of heat from

the welded areas to the remainder of the base of the tube will be $3 \times \frac{3}{4} \times 0.028 = 0.063$ square inch.

As an example of a procedure which I have found to be satisfactory in welding low carbon steel channel section fins of a thickness of about .031 inch, to a low carbon steel twelve-gage tube having an outside diameter of 2 inches, with the welded area substantially as described above, I engage the bases of the channel members with electrode rolls having a width of about $\frac{3}{4}$ inch with an electrode pressure of 900 to 1,000 pounds. The current employed is preferably about 12,000 amps., at 6-8 volts. Each weld is made with a duration of current of 3 cycles of 60-cycle, single phase, alternating current, the current being shut off for a period of 3 cycles between welds, the fins being welded to the tube at a speed of 18 to 20 feet per minute, this speed being amply sufficient to prevent the tube from being deformed by the pressure of the electrodes.

As described above, with this procedure the total welded area between the bases of the fins and the tube is sufficient to give an ample path for conduction of heat to the bases and the periphery of the welded areas in the bases is such that there is an ample path for the flow of heat from the region of the welds into the adjacent areas of the bases.

As another example of a procedure which gives satisfactory results, fins composed of stainless steel containing 4% to 6% of chromium and having a thickness of .031 inch may be welded to a twelve-gage tube composed of the same material with a current of about 9600 amperes, the control being arranged to have the current flow to produce the welds for a period of 2 cycles, the current being shut off for a like period between welds. An electrode pressure of 900 to 1,000 pounds is employed with electrodes $\frac{3}{4}$ inch wide, the operation being carried on at a speed of from 12 feet to 14 feet per minute. This procedure gives about seven welds to the inch, the welds overlapping slightly.

A section of finned tubing made according to the above outlined method is illustrated in Figs. 5 and 6 of the drawings wherein the channel member 21 is secured to the tube T' by a series of welded areas 26 joining the base 22 of the channel to the tube. It will be noted that these welded areas are more closely spaced than those illustrated in Figs. 2 and 4, with the result that the welds overlap, producing a scalloped weld extending longitudinally of the fin. The area of these welds exceeds the longitudinal cross-sectional area of the fins 24 in the region adjacent the juncture of fin and base and by reason of the scalloped edges the perimeter length of the welded areas exceeds the total length of the flanges 24, so that in spite of the fact that the thickness of the fin base is reduced by the welding operation, an adequate path for the flow of heat from the welded areas to the adjacent portions of the base is provided by reason of the increased length of the weld giving an adequate cross-sectional area for the flow of heat. This type of weld also produces a tube that is resistant to heat shock, for the scalloped welds provide zones where the welded connections are quite narrow, thus permitting some buckling of the fins to take place and preventing damage to the tube.

It will be evident that the greatest increase in length can be obtained when the welded areas are just tangent to each other. Welds of this

type are particularly advantageous in conjunction with the welding of fins of thin section where the thickness of the fin base is reduced by a considerable percentage by the welding operation so that a material extension of the perimeter length of the welded areas is required in order to insure an adequate path for the flow of heat. It is to be understood that welds of this type are included within the terms "spaced" or "intermittent" as the terms are used herein, for while the welded areas overlap, their centers are spaced and they are produced by intermittent currents and the intermittent character of the welds can readily be determined by an inspection of a welded sample.

As those skilled in the art will appreciate, the speed, pressure, current and timing may be varied to give the desired results with different materials, sizes and conditions of operation. The procedures outlined are given merely by way of example.

By carrying out the welding operations as described above and by maintaining the conditions on both sides of the tube as identical as possible, the heating effects on both sides of the tube are so nearly alike that the tube is not warped or bent by the welding operation. With diametrically opposed electrodes, the flow of current is substantially evenly divided in its flow through the walls of the tube from one fin base to the other, with the result that the heating effects of the current in the tube are minimized, and equalized between opposite sides of the tube. Preferably, alternating current is employed in making the welds and the timing is arranged so that the current flows for a whole number of cycles in making each weld, for by so doing the heating effects in both of the simultaneously produced welds will be identical, and leakage through the jig and the frame of the machine will not cause unequal heating and resultant bowing of the tube. If direct current is employed, or if the duration of the welds includes fractional parts of cycles, for example, two and one-half cycles of current flow per weld, then the direction of flow of current preferably should be reversed between each successive weld. This reversal of the polarity of the electrodes prevents leakage of current to ground through the jig and frame of the machine from causing unequal heating effects on opposite sides of the tube. If desired, a cooling fluid such as water may be passed through the interior of the tube in order to further cool the same but this operation is ordinarily not essential. The cooling fluid may be maintained under pressure to act a core within the tube, but for ordinary sizes and gages of tube I do not find this to be essential. Further, the electrodes may be cooled if desired, but in that event, care should be exercised to see that the cooling effect is the same on both electrodes.

In Fig. 7 I have illustrated an apparatus adapted to carry out my method. As shown, the apparatus may include a conventional welding machine, only a portion of the frame 20 of the machine being illustrated in the drawings. The welding machine includes electrode rolls 31 and 32 suitably driven and supported in brackets 33 and 34, provided with means such as air operated plungers (not shown) for urging the electrodes towards each other. In order to guide the tube and fins through the machine I employ the jig indicated generally at 35 and supported by the frame member 36 mounted on the welding machine. The jig

may comprise a frame consisting of plates 37 and a plurality of longitudinal members 38 and preferably welded to the plates to form a rigid structure. The frame members may be constructed of any suitable metals. A plurality of rollers are mounted upon suitable bearings carried by the longitudinal members 38 and arranged to guide the tube and the fins through the machine and to provide for convenient indexing of the tube for welding of a plurality of fins thereto.

To guide the fins and position them properly for the welding operation two pairs of fin alignment rolls indicated at 40 are provided, one pair being on one side of the welding rolls 31 and 32 and the other pair being disposed on the other side of the welding rolls. To retain the tube in position and accurately centered with respect to the electrodes, and thereby to insure that the welds will be diametrically opposite each other, three pairs of tube centering rolls 42 are employed. In order to accurately space the fins upon the tube two pairs of indexing rolls 44 are preferably employed. These rolls are angularly spaced from the alignment rolls 30 by an amount equal to the angle between adjacent pairs of fin members. The narrow electrode rolls fit down into the channel members and engage the bases of oppositely disposed channel members. Thus when the current is caused to flow, welds will be formed in the contacting zones of the channel members and tube, the current flowing around the circumference of the tube and the two welds being made simultaneously.

In order to support the ends of the tubes as they are being welded a rigid beam 50 extending on either side of the welding machine may be provided, the outward ends of the beams being supported by pedestal members 52. Carriages 54 and 55, supported by rollers 56, 57, support the opposite ends of the tubes through the medium of connecting devices such as the collars 59 and 60 and associated mandrels 61 and 62 which may be arranged, if desired, to make a fluid tight connection with the tube so that a cooling fluid such as water may be supplied to the interior of the tube through the connection 63 and discharged through the outlet 64. The flow of fluid may be controlled by valves 65 and 66, the arrangement being such that fluid pressure may be applied to the interior of the tube to assist in supporting the tube against the pressure of the electrodes, if desired. As the tube and fins progress through the machine the carriages travel along with the tube on the I-beam 50 and thus support the tube and prevent it from sagging because of its own weight. This structure is particularly important in the production of long lengths of finned tubing but is not necessary with shorter, more rigid tubes. Screw means controlled by handles 67 and 68 are provided for transverse adjustments of the supports, and the jig is also provided with screws for transverse adjustment as indicated at 69 and 70. The apparatus is described and shown in greater detail, and is claimed in my application Serial No. 323,593, of which this case is a continuation in part.

In operation, a length of tubing is fed into the machine with two oppositely disposed channel members 11 positioned thereon, the channel member being engaged by the fin alignment rolls 40 and the tube being engaged by the tube centering rolls 42. When the tube and fins reach the electrode rolls 31 and 32, the current is turned

on, being controlled and timed in the desired manner, for example, as specified above. The tube and fins are then progressed continuously through the machine, say from left to right as shown in the drawings by the electrode rolls which are power operated. This operation welds the two oppositely disposed finned members to the tube by a series of welded areas such as those indicated in Figs. 2 to 6.

As the tube is discharged from the machine the welding current is cut off, the tube withdrawn from the jig, another pair of fin members assembled therewith and the tube rotated to bring the pair of finned members which had just been welded to the tube into alignment and engagement with the indexing rolls 44. When this is done the fin alignment rolls will guide the new pair of finned members to be next welded to the tube in their proper position with respect to the fins theretofore welded to the tube. The machine is preferably reversible so that these operations can be carried out on the right-hand side of the machine, assuming that the first welding operation was carried out with the tube moving from left to right as shown in the drawing. Then, when the tubes and fins have been properly fed into the machine, the welding current is turned on and the welding electrodes are driven to progress the tube and assembled fins back through the machine in a direction from right to left, as shown in the drawings, thus welding another pair of finned members to the tube. This sequence of operations is continued until the desired number of pairs of finned members have been welded to the tube, six pairs being employed in the embodiment shown in the drawing.

In the event the cooling arrangement illustrated in Fig. 5 is employed, the mandrels 51 and 52 should be of sufficient length that the operation of welding the fins to the tube can be completed in both directions without the necessity of disengaging the tube therefrom. When this is done it will only be necessary to give the tube a fraction of a turn within the coupling members in order to index it between the successive passes through the machine.

From the foregoing description of my invention it will be evident that by my method finned tubes having advantageous characteristics can be produced economically and rapidly. Tubes made according to my method not only are efficient from the standpoint of heat transfer but also have great structural strength and are not liable to failure because of heat shocks. My method can be carried out rapidly and expeditiously, to accurately weld fins to tubes. According to my method, the welding operation may be controlled so as to produce welds which will give the proper heat transfer and structural strength characteristics to the completed assembly.

Various changes and modifications in my invention will be apparent to those skilled in the art. It is therefore to be understood that my patent is not limited to the preferred form of my invention described herein and that it is contemplated that changes and modifications within the scope and spirit of my invention may be made by those skilled in the art. Therefore it is to be understood that the description herein is given by way of example and not by way of limitation and that my patent is not limited to the methods described herein or in any manner other than by the appended claims when given the range of equivalents to which my patent may be entitled.

I claim:

1. The method of making finned tubes which comprises providing separate fin members, each having a fin portion and a continuous base portion adapted to engage the outer surface of a tube, assembling a pair of such members with a tube with the base portion of each member engaging the exterior of the tube and extending generally longitudinally thereof, and with the members disposed substantially diametrically opposite each other, and resistance welding said base portions to said tube, without internal mechanical support for the tube, by engaging each of said base portions with a roller electrode, exerting welding pressure upon said base portions toward the axis of the tube by said electrodes, causing a welding current to flow between said electrodes through said base portions and through the wall of the tube and around the circumference thereof, and moving said assembly with respect to said electrodes at a sufficiently high speed that the tube in the regions adjacent the welding zone at any instant remains sufficiently cool to retain sufficient strength to resist the pressure exerted by the electrodes without substantial deformation.

2. The method of making finned tubes which comprises forming separate fin members, each having a fin portion and a continuous base portion adapted to engage the outer surface of a tube, assembling a plurality of such members with a tube with the base portion of each member engaging the exterior of the tube and extending generally longitudinally thereof, and with the members substantially equally spaced from each other circumferentially of the tube, and simultaneously resistance welding said base portions to said tube, without internal mechanical support for the tube, by engaging each of said base portions with a roller electrode, exerting welding pressure upon said base portions toward the axis of the tube by said electrodes, causing a welding current to flow between said electrodes through said base portions and through the wall of the tube and around the circumference thereof, and moving said assembly with respect to said electrodes at a sufficiently high speed that the tube in the regions adjacent the welding zone at any instant remains sufficiently cool to retain sufficient strength to resist the pressure exerted by the electrodes without substantial deformation.

3. The method of making finned tubes which comprises providing separate channel section fin members, each having two fin portions and a continuous base portion adapted to engage the outer surface of a tube, assembling a pair of such members with a tube with the base portion of each member engaging the exterior of the tube and extending parallel to the axis thereof, and with the members disposed substantially diametrically opposite each other, and resistance welding said base portions to said tube, without internal mechanical support for the tube, by engaging each of said base portions with a roller electrode, exerting welding pressure upon said base portions toward the axis of the tube by said electrodes, causing a welding current to flow between said

electrodes through said base portions and through the wall of the tube and around the circumference thereof, and moving said assembly with respect to said electrodes at a sufficiently high speed that the tube in the regions adjacent the welding zone at any instant remains sufficiently cool to retain sufficient strength to resist the pressure exerted by the electrodes without substantial deformation.

4. The method of making finned tubes which comprises providing separate channel section fin members, each having two fin portions and a continuous base portion adapted to engage the outer surface of a tube, assembling a pair of such members with a tube with the base portion of each member engaging the exterior of the tube and extending parallel to the axis thereof, and with the members disposed substantially diametrically opposite each other, and resistance welding said base portions to said tube, without internal mechanical support for the tube, by engaging each of said base portions with a roller electrode, exerting welding pressure upon said base portions toward the axis of the tube by said electrodes, causing an alternating welding current to flow between said electrodes through said base portions and through the wall of the tube and around the circumference thereof, moving said assembly with respect to said electrodes at a speed between 12 to 25 feet per minute and interrupting the current to provide from 3 to 12 welded areas per inch of base, the speed, the thickness of the tube and fin members, and the welding current all being correlated so that the tube in the region adjacent the welding zone at any instant remains sufficiently cool to retain sufficient strength to resist the pressure exerted by the electrodes without substantial deformation.

5. The method of making finned tubes which comprises forming separate fin members, each having a fin portion and a continuous base portion adapted to engage the outer surface of a tube, assembling a pair of such members with a tube with the base portion of each member engaging the exterior of the tube and extending generally longitudinally thereof, and with the members disposed substantially diametrically opposite each other, and resistance welding said base portions to said tube, without internal mechanical support for the tube, by engaging each of said base portions with a roller electrode, exerting welding pressure upon said base portions toward the axis of the tube by said electrodes, causing an intermittent, alternating welding current to flow between said electrodes through said base portions and through the wall of the tube around the circumference thereof, and moving said assembly with respect to said electrodes at a sufficiently high speed that the tube in the region adjacent the welding zone at any instant remains sufficiently cool to retain sufficient strength to resist the pressure exerted by the electrodes without substantial deformation, and whereby each of said base portions is welded to said tube by a series of substantially evenly spaced welded areas.

JOHN W. BROWN, JR.

CERTIFICATE OF CORRECTION.

Patent No. 2,298,250.

October 6, 1942.

JOHN W. BROWN, JR.

It is hereby certified that error appears in the above numbered patent requiring correction as follows: In the heading to the drawings, Sheets 1 and 2, title of invention, for "APPARATUS FOR MAKING FINNED TUBES" read --METHOD OF MAKING FINNED TUBES--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 17th day of November, A. D. 1942.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.