

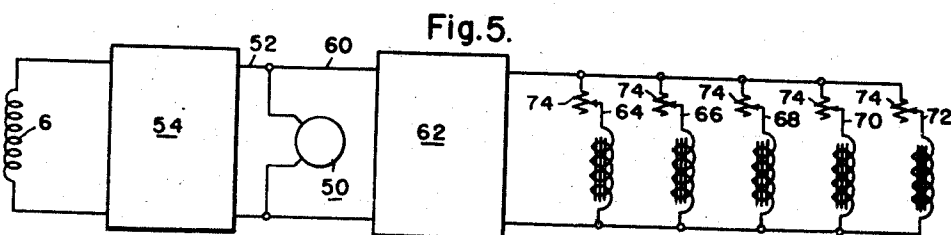
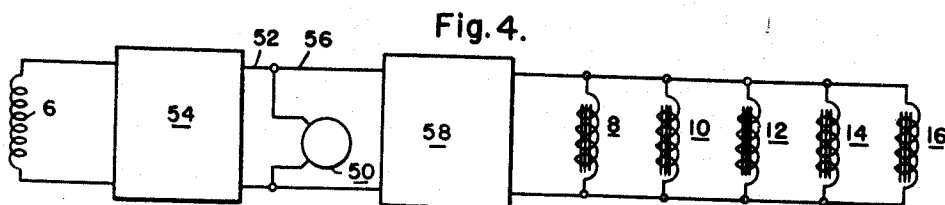
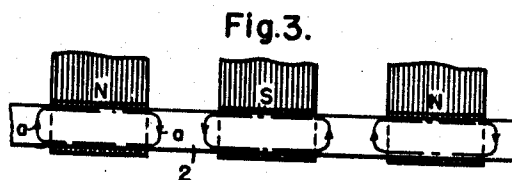
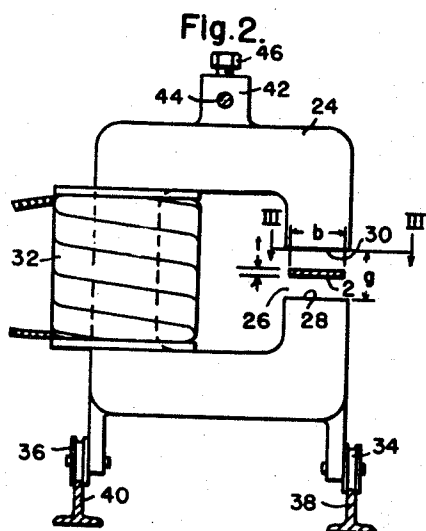
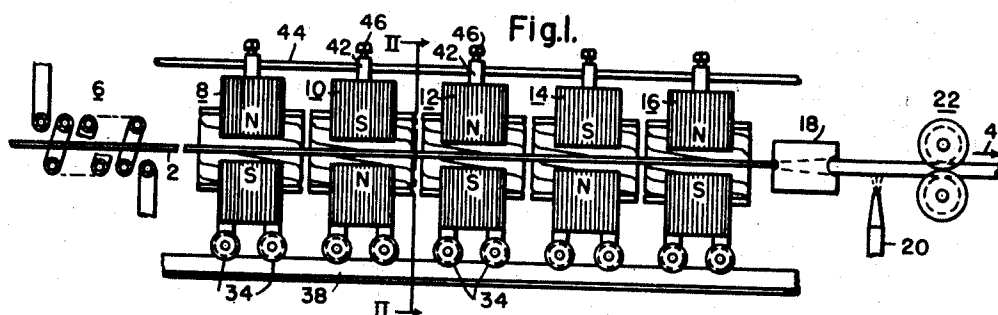
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2,647,982

MANUFACTURE OF SEAM WELDED TUBES

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WITNESSES:

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MANUFACTURE OF SEAM WELDED TUBES

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1

This invention broadly relates to the making of seam welded tubing or pipes from a strip of metal; and more particularly, this invention is directed to the making of seam welded tubing or pipes from a strip of iron or steel, which is more commonly identified in this art as skelp.

In the making of tubing in accordance with present practice, a piece of skelp which is substantially at room temperature is heated to tube-forming and welding temperature in a furnace. The heated skelp, after leaving the furnace, passes through tube forming rolls which bend the skelp into a hollow split cylinder with an open seam. A jet of air and oxygen blows against the edges of the split cylinder, melting the surface metal of the skelp-edges; and a pair of weld rolls subsequently press the molten edges together for a butt weld. The gas jet has the added function of blowing slag and other foreign material from the edges to be welded. The welding rolls are followed by additional means which pull the skelp through the furnace and size the tubing after it is welded. A special saw, arranged to move periodically in accordance with the speed of the tubing, is used to cut the red hot tubing into the desired lengths, after which the tubing is cooled, straightened, tested, cleaned, oiled and packaged for shipment.

The speed at which the skelp to be made into tubing or pipe by the aforesaid conventional method is limited by the length of conventional electric-resistor or gas-fired furnace that is required. By way of illustration, to make tubing from cool skelp that is $\frac{1}{16}$ of an inch thick, 3 inches wide and is travelling from 250 to 450 feet per minute, will require a gas fired furnace that is about 150 feet long. There are several disadvantages to the use of such furnaces. A large furnace must be maintained at the high temperature required for welding and heats all of the material of the skelp to such temperatures. In a gas-fired furnace, its refractory lining deteriorates under the high temperature of the combustion gases; and the heat lost by radiation and otherwise is exceptionally high. It is also disturbing when, for any reason, it is necessary to stop the movement of the skelp through the furnace for more than five minutes or so. In such case, the radiant heat from the walls of the furnace melts the skelp even though the heating means of the furnace may be shut down.

On object of my invention is to provide a compact and efficient furnace means that can be used for making seam welded tubing without the aforesaid disadvantages.

Another object of my invention is to provide a means and method for making seam welded tubing that heats the border portions of the skelp to much higher temperatures than the middle of the skelp.

In accordance with my invention I preheat the skelp to a temperature near its Curie point, this heating being preferably done by a longitudinal

2

flux induction heating means. After preheating, the skelp is further heated by additional transverse flux induction heating means. Thereafter, the skelp passes on to the forming rolls and weld rolls. A system comprising longitudinal flux and transverse flux heating is disclosed in Patent No. 2,448,011 of G. W. Penney and myself, and dated August 31, 1948. However, in accordance with my present invention, the induction heating means heats the border portions of the skelp to a much higher extent than the central portions of the skelp; and the induction heating coils of both the longitudinal flux induction heating means and the transverse flux induction heating means can be energized with alternating current of a frequency in the order of that obtained with rotary alternators, namely, approximately 10,000 cycles.

By heating the edges or border portions of the skelp much more intensely than the center portion a great savings in power consumption is obtained in the application of induction heating apparatus to the making of tubing or pipe by seam welding. The skelp can be so heated in several different ways, but in accordance with the preferred form of my invention the transverse flux induction heating means comprises separate core-structures of simple form which are arranged along the path of travel of the skelp and are supported so that the space between them can be adjusted.

Features and innovations of my invention, in addition to the foregoing, will be discernible from the following description which is to be taken in conjunction with the accompanying schematic drawing, in which

Figure 1 is a longitudinal, elevational view of apparatus embodying my invention,

Fig. 2 is a sectional view substantially on the line II—II of Fig. 1,

Fig. 3 is a partial sectional view, on line III—III of Fig. 2 showing a general way the manner in which induced currents flow in the skelp as it passes through the transverse flux induction heating means,

Fig. 4 is a simplified wiring diagram of a mode for energizing the induction heating means of Fig. 1, and

Fig. 5 is a simplified wiring diagram of another mode for energizing the induction heating means.

In accordance with my invention, a strip 2, preferably skelp, is moved lengthwise in the direction of the arrow 4 by any suitable means along a predetermined path formed by apparatus that includes means for processing the strip. Such means defines a work-passage in said path, and comprises successively in the direction in which the strip moves: a longitudinal flux induction heating means comprising a helical induction heating coil means 6; a transverse flux induction heating means comprising one or more transverse flux core-structures, five of them being indicated at 8, 10, 12, 14 and 16; a forming roll

means 18; an air-oxygen jet-means 20; and a welding roll means 22.

The strip 2 passes axially through the longitudinal flux coil means 6 which is constructed in any suitable manner known to the art and serves to heat the strip 2 substantially uniformly completely across the width of the strip.

The transverse flux core-structures may take any suitable form, but in the preferred embodiment each comprises a laminated shell-type core 24 (Fig. 2) having an air-gap 26 defined by pole-faces 28 and 30 of the shell-core. These pole-faces define part of the work-passage for the skelp and are parallel to the direction of movement of the skelp. A field coil or coils 32, preferable of water-cooled copper tubing, are wrapped around any desired leg of the shell-core 24 for magnetizing the shell-core with transverse flux that passes from one pole-face 28 to the other pole-face 30, or vice versa. Fig. 1 shows the cores extending outwardly from the same edge of the skelp; but if desired consecutive cores can extend in opposite directions so that each core extends outwardly from an edge of the skelp in direction opposite to that of the immediately adjacent core. This permits the cores to be brought closer together, if necessary. Preferably the core-structures are so constructed and energized that the fluxes through each pair of consecutive cores at any instant are in opposite directions.

It is indicated in Fig. 2, each pole-face preferably has a width laterally across the work-passage which is greater than the width, b , of the skelp; and the air-gap has a depth, g , which is greater than the thickness, t , of the skelp. The forming-roll means 18, the air-oxygen supply jet-means 20 and the pressure welding roll means 22 can follow conventional design and enter into the combination of my invention insofar as they are part of a new means and method for making seam welded tubing from skelp which is non-uniformly heated across its width before being bent.

In the preferred operation of the apparatus thus far described, the longitudinal flux induction heating means preheats the skelp to a temperature preferably to Curie point. This type of heating is well known and the skelp will be heated substantially uniformly across its width. Immediately after leaving the longitudinal flux coil means 6, the skelp passes into the transverse flux induction heating means for further heating. The principles and theory under which strip is heated by transverse flux is indicated in my Patent No. 2,448,009, dated August 31, 1948. Briefly, with an arrangement of the type shown in Fig. 2, efficient power transfer to the skelp through the magnetic field is obtained when.

$$b \sqrt{\frac{4\pi^2 f i 10^{-9}}{r g}} = k_i b \geq 2.0$$

Where b is the width of the skelp in centimeters; f is the frequency in cycles per second of the A. C. supply that energizes the field coil means 32; t is the thickness of the skelp 2 in centimeters; r is the electrical resistivity of the skelp in ohm-centimeters; and g is the depth of the air-gap 26 in centimeters. Preferably, the resistivity, r , is that of the skelp at substantially its highest temperature but average or other values can be used since some degree of tolerance is permissible.

Under the foregoing conditions, approximately 86% of the total heating effect of the longitudinal

currents induced in the skelp by the transverse flux in the core-structure will lie within a distance δ centimeters from each of the edges of the skelp where

$$\delta = 5040 \sqrt{\frac{r g}{f t}}$$

Thus, when it is desired to exaggerate the edge heating of the strip, the frequency, f , is chosen with the other quantities to make δ small in comparison to the strip width, b .

The individual core-structures induce current in the skelp which flows in paths such as shown, for example, by the broken lines of Fig. 3. The illustration in this figure is entirely diagrammatic and is not presented as an accurate indication of the distribution of the current in the portions of the skelp passing through the transverse flux induction heating means. However, it is generally true that the induced current tends to link the magnetic flux inducing it. However, because of the limited width of the skelp, the crosswise parts, a , of each current-flow path is limited to the width of the skelp; and the longitudinal parts, b , of the induced current are concentrated along the edges of the strip. The width of the core-structures longitudinally and transversely of the skelp, and the spacing between the core-structures determine the concentration of the current in the different parts of the current-flow paths, other things being equal.

A manner in which the heating by the induced current is distributed across the skelp can be controlled by adjustably supporting the core-structures, as well as by a suitable choice of the parameters affecting the heating as explained in my aforesaid patent.

A simplified means for adjustably carrying the core-structures so that the spaces between them can be changed is shown in Figs. 1 and 2. A side of each of the core-structures 8, 10, 12, 14 and 16 is provided with sets of wheels 34 and 36 which ride on rails 38 and 40. The opposite side of each of the core-structures is provided with a guide bearing 42 that can be slid on a stationary lengthwise guide rod 44, and is fixed thereto by a set screw 46. Accordingly, the core-structures can be placed in desired positions along the length of the work-passage for the skelp and can be secured in whatever position each may be adjusted to. Such adjustment changes the average magnetic flux over the full length occupied by the core-structures and the spaces therebetween.

As an indication of the operation of my device, skelp may be passed through the longitudinal flux induction heating means for raising its temperature to the Curie point. From this point the series of transverse flux core-structures induces current in the skelp as represented in Fig. 3 with the current concentrated near the edges of the skelp so that the principal heating will occur in these regions. The core-structures also put heat in the center portion of the skelp. By suitable choice of the parameters, as previously described, or by controlling the summation of the lengths of the spaces between core-structures to the total overall length occupied by the core-structures and spaces therebetween, the temperature of the edges of the skelp can be raised much higher than that at the center. The edge-temperatures should be adequate for welding, while that in the central portions need be sufficient only to permit the skelp to be readily bent.

An important feature of the invention resides

5

in the fact that both the longitudinal flux heating means and the transverse flux induction heating means can be energized with electric power having a frequency in the order of that obtained from rotary alternators, although for very thin skelp it would probably be more desirable to use higher frequencies for energizing the longitudinal flux coil 6.

Any suitable connections can be used for energizing the different induction heating coils from a rotary alternator. In Fig. 4 a rotary alternator is indicated at 50. It supplies a branch circuit 52 which includes the helical coil 6 of the longitudinal flux induction heating means and any suitable current-adjusting and phase-controlling apparatus 54. The alternator 50 also supplies, in parallel with the branch circuit 52, a second branch circuit 56 which includes a current-controlling and phase-controlling network 58 that feeds the field coils 32 of the different core-structures 8, 10, 12, 14 and 16 in parallel.

If desired, the current through each of the field coils 32 of the individual core-structures 8, 10, 12, 14 and 16 can be separately adjusted. A circuit of this kind is represented in Fig. 5. In this figure, the branch circuit 52 is the same as that of Fig. 4. However, a circuit 60, in parallel with the branch circuit 52, comprises a phase-balancing network 62 which feeds, in parallel, a plurality of circuits 64, 66, 68, 70 and 72, each of which includes the field coil 32 of a separate core-structure and a coil adjusting means 74 therefor. Obviously, still other circuits can be used to energize the field-coils.

As an illustration of the principles underlying my invention, skelp which is $\frac{1}{16}$ inch thick and 3 inches wide and is travelling at 1000 feet per minute, can have its edges heated to 2450° F. and have a large temperature gradient inwardly of its edges, so that at a distance three-quarter inch from the edges, the skelp has a temperature of about 1700° F., this temperature of 1700° F. being close to the average temperature of the central portion of the skelp. To this end, a 9600 cycle per second source of power is recommended, capable of supplying the longitudinal flux induction heating means with approximately three times the power to be supplied to the transverse flux induction heating means.

While I have described my invention in a form now preferred, it is obvious that the principles are subject to application in many different ways and the structures are also subject to considerable modifications. Thus, for example, instead of core-structures such as shown in Fig. 2, core-structures such as shown in my aforesaid Patent No. 2,448,009 can be utilized.

I claim as my invention:

1. Tube-forming means comprising, in combination, means providing a work-passage through which skelp is adapted to be moved longitudinally, said means comprising successively along said work-passage: a longitudinal flux coil means, a transverse flux induction heating means comprising a core-structure having a pole face along said work-passage, tube forming roll means, an air-oxygen jet, and welding roll means.

2. Tube-forming means as defined in claim 1 but further characterized by energizing means comprising a rotary alternator-means connected to said longitudinal flux coil means and said induction heating means.

3. Tube-forming means comprising, in combination, means providing a work-passage

6

through which skelp is adapted to be moved longitudinally, said means comprising successively along said work-passage: a longitudinal flux coil means, transverse flux core-structure means comprising a magnetizing field coil means and a pole face along said work-passage, tube-forming roll-means and welding roll-means; and adjusting means associated with said field coil means so as to provide considerably more heating of the edges of the skelp than the central portions of the skelp just prior to its entry into said tube-forming roll-means.

4. Tube-forming means comprising, in combination, means providing a work-passage through which skelp is adapted to be moved longitudinally, said means comprising successively along said work-passage: a longitudinal flux induction heating means, and a plurality of spaced core-structures each comprising a pole-face substantially paralleling said work-passage on a side thereof, and magnetizing means; and supporting means supporting said core-structures in adjustably spaced relation along said work-passage.

5. Tube-forming means as defined in claim 1 but further characterized by adjusting means for adjusting the separation between said core-structures longitudinally of said work-passage.

6. Tube-forming apparatus comprising, in combination, means providing a work-passage through which skelp is adapted to be moved longitudinally, said means comprising successively along said work-passage: a helical induction heating coil which is substantially co-axial with said work-passage, a plurality of core-structures each comprising a pole-face substantially paralleling said work-passages on one side thereof, and coil means for establishing a magnetic field passing through said pole-face and across said work-passage; supporting means supporting said core-structures in adjustably spaced relation along said work-passage; a rotary alternator for energizing said helical induction heating coil; and means for adjusting the average amount of magnetic flux provided by said magnetic fields of said core-structures with respect to the total extent of said work-passage between the far ends of said core-structures.

7. A tube-forming apparatus as defined in claim 6 but further characterized by said core-structures being separate and the last said means comprising energizing means to supply current to said coil means, and current adjusting means.

8. Apparatus of a type described comprising, in combination, a plurality of separate core-structures, each comprising a shell-type core having an air-gap and field coil means for magnetizing the associated core, and supporting means for supporting said core-structures with their air-gaps longitudinally in line so that an elongated metal strip can pass therethrough, said supporting means comprising means for adjusting the longitudinal spacing between said core-structures.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,932,423	Sessions	Oct. 31, 1933
1,967,129	Neale	July 17, 1934
2,448,011	Baker et al.	Aug. 31, 1948
2,453,019	King	Nov. 2, 1948