May 14, 1957 A. J. WAGNER 2,792,206

BUTTWELD PIPE MANUFACTURE

Filed May 20, 1954 3 Sheets-Sheet 1

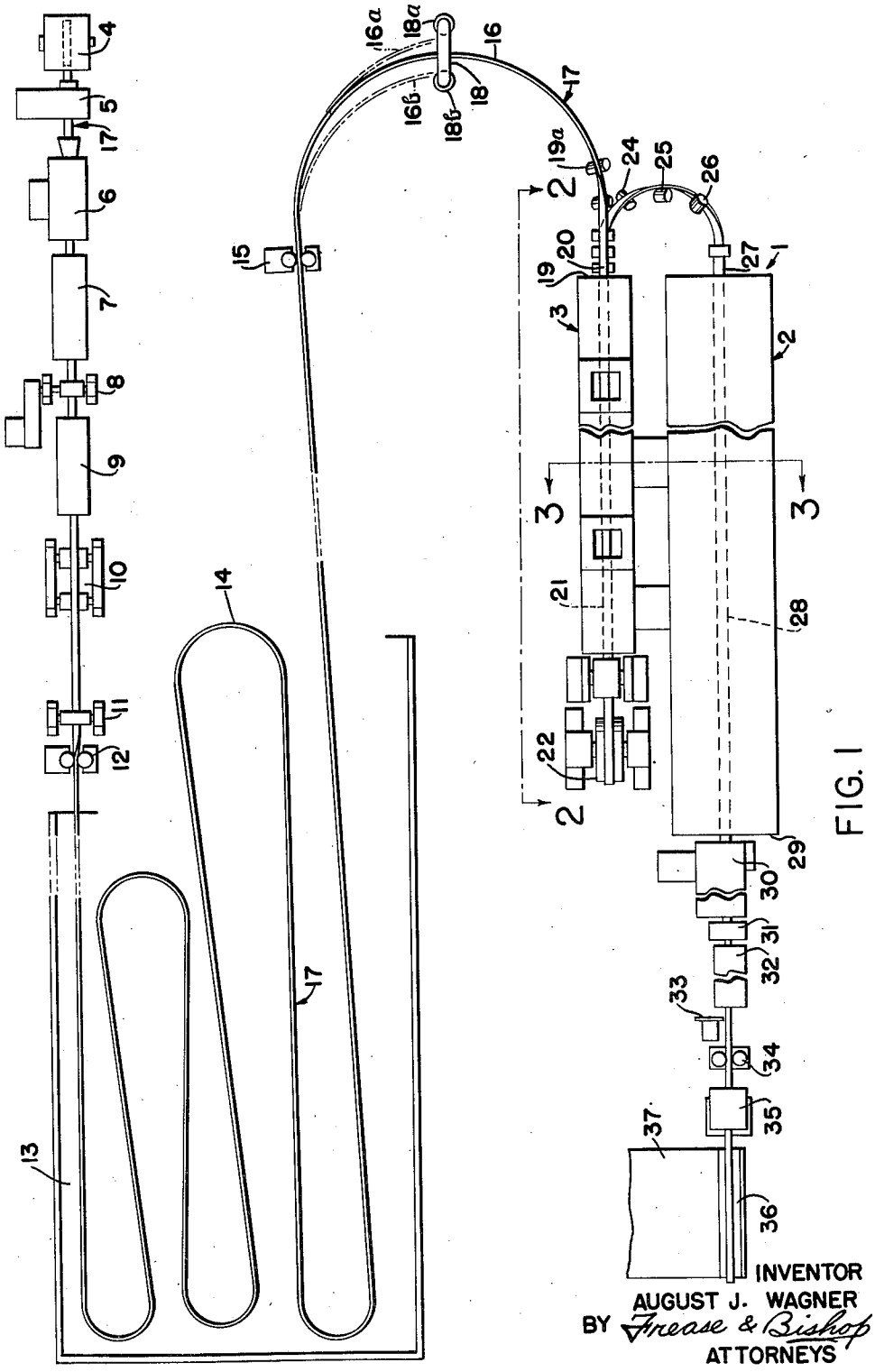


FIG. 1

INVENTOR
AUGUST J. WAGNER
BY Frease & Bishop
ATTORNEYS

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BUTTWELD PIPE MANUFACTURE

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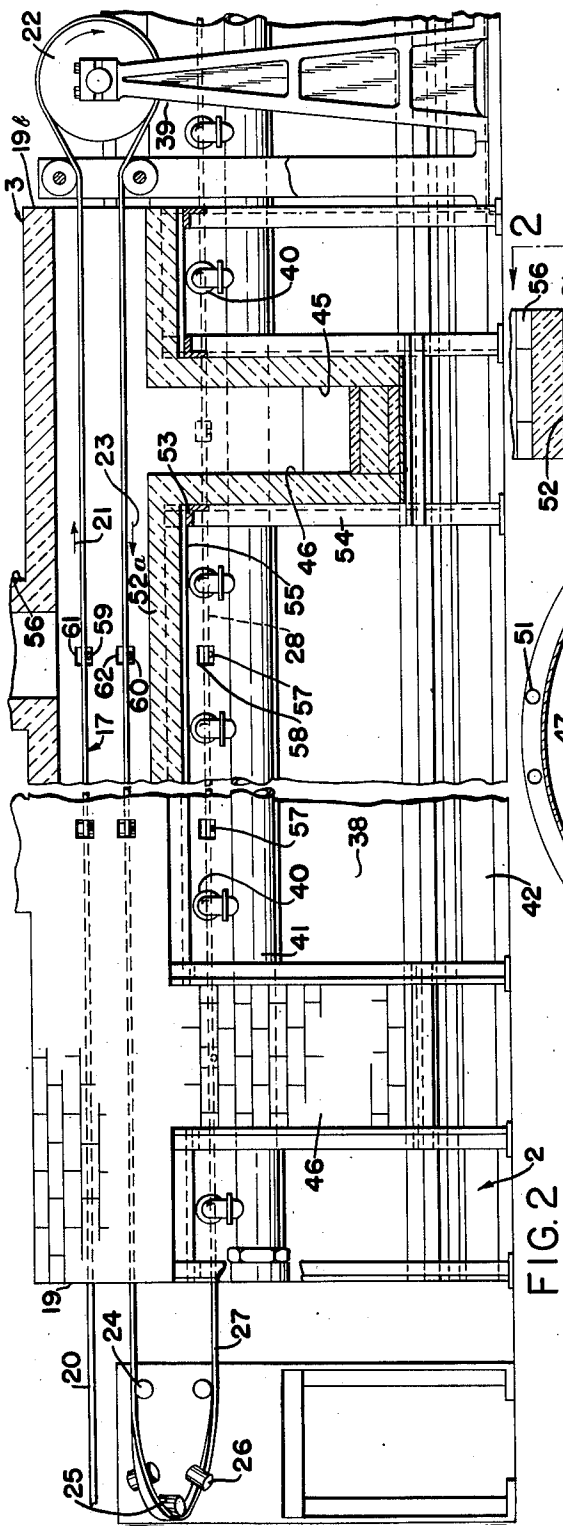


FIG. 2

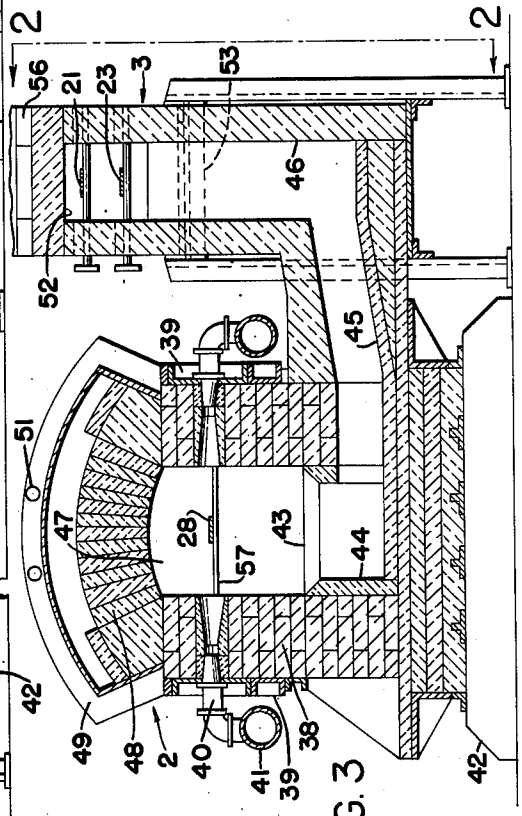


FIG. 3

INVENTOR.
AUGUST J. WAGNER
BY Frease & Bishop
ATTORNEYS

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BUTTWELD PIPE MANUFACTURE

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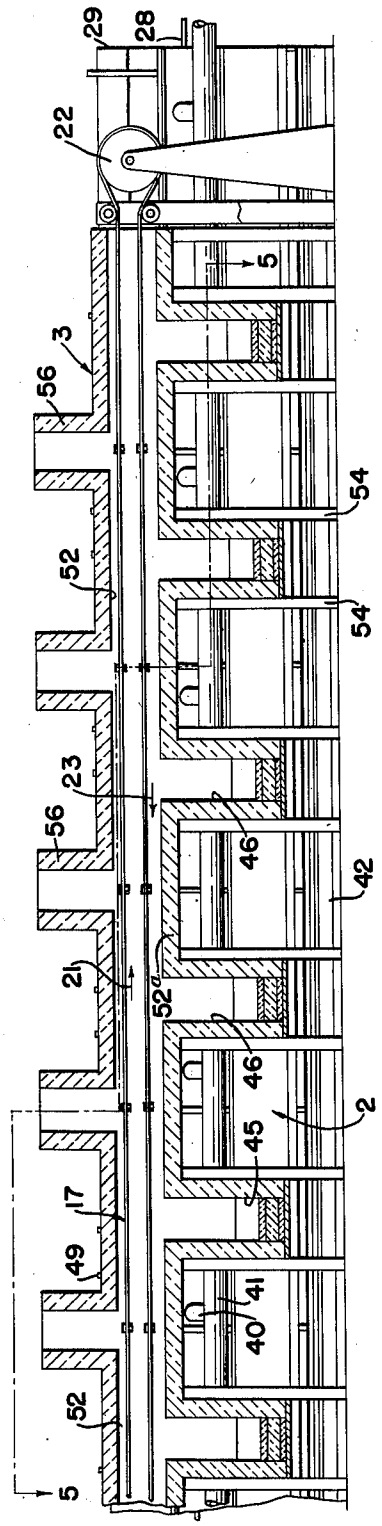


FIG. 4

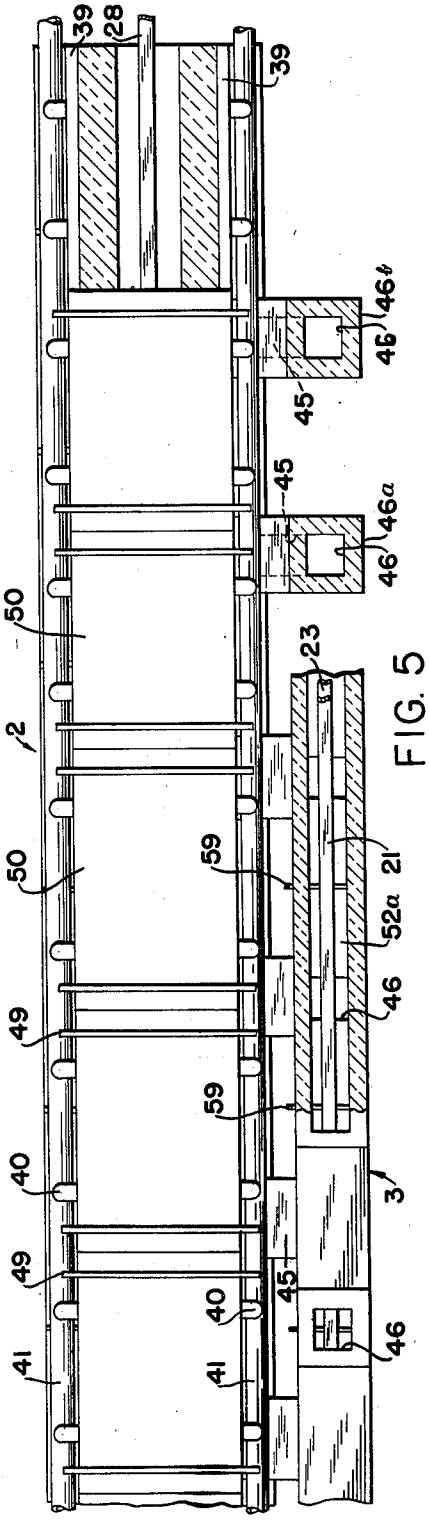


FIG. 5

United States Patent Office 2,792,206 Patented May 14, 1957

2,792,206

BUTTWELD PIPE MANUFACTURE

August J. Wagner, Sharon, Pa., assignor to Sharon Tube Company, Sharon, Pa., a corporation of Pennsylvania

Application May 20, 1954, Serial No. 431,184

10 Claims. (Cl. 263—3)

The invention relates to the continuous manufacture of buttweld pipe from skelp and more particularly to the preheating of skelp in conjunction with the main skelp heating furnace from the waste heat of the main heating furnace as the skelp travels continuously from a source of supply to and through the main heating furnace for producing continuous buttweld pipe or tubing.

Ordinarily in the manufacture of buttweld pipe, skelp or hot rolled steel strip of proper width and thickness to make a desired pipe size and wall thickness is uncoiled from skelp coils, passed through a roller leveler, and the ends of successive strips are welded together end to end. The strip or skelp then moves through pinch rolls, conveyors, etc., to a looping zone to provide sufficient slack so that the heating furnace may be continuously fed with strip while the ends of successive strips are being welded together at a previous station. The strip is then passed through vertical pinch rolls whose speed is co-ordinated with the subsequent forming and welding rolls of the pipe mill and then passes around a secondary loop and between control contacts to speed up or slow down the vertical pinch rolls as the secondary loop becomes smaller or larger.

The strip or skelp passes from the secondary loop into the main heating furnace where it travels through a sufficient furnace length to heat the skelp from room temperature to a strip edge temperature of about 2600° F. just as the skelp leaves the furnace and enters the series of forming and welding mills where the strip is formed to tubular shape in cross-section and the heated edges are brought into contact and are welded together. The welded pipe then passes through a series of break-down rolls, and then through a hot saw; and cut lengths of pipe are discharged from the hot saw along a conveyor and through sizing or descaling rolls to a kick-out mechanism which discharges pipe lengths onto a cooling rack.

In the usual construction and operation of the main heating furnace, gas burners are disposed along each side of the furnace at close intervals directed against the strip edges and the furnace temperature is maintained at about 2800° F. in order to obtain the desired strip edge temperature of 2600° F. as the strip leaves the furnace continuously at high speed. The waste heat gases from the burners pass through openings in the bottom of the furnace chamber into a series of stacks or chimneys located adjacent one side of the furnace.

Such heating furnace has a relatively small passage through which the skelp continuously passes while supported on skid bars with the strip edges located so as to be impinged by the burner flames. The furnace chamber is lined with refractory material supported at the sides by structural members through which the burners extend and in which the burners are mounted. These structural members ordinarily are formed as castings or metal plates. It is thus impossible to gain access to the main furnace chamber through the furnace side walls for refractory repairs. Accordingly, refractory-lined roof cover members or bungs, that may be removed quickly by an overhead crane, are provided so that upon removal of the bungs which form the roof of the heating furnace, repairs to the furnace chamber may be made.

The operation of the described skelp heating furnace involves a relatively high gas consumption when the equipment is operated with a continuous strip speed through the furnace of say 750 feet per minute, because it is necessary to heat the strip edges in say a 110-foot furnace heating chamber length from room temperature to 2600° F. Moreover, when it is attempted to operate the equipment at a higher strip speed of up to say 1000 feet per minute or more, the gas consumption increases enormously. Also, there is an exceedingly large waste heat loss from the gases discharged from the heating chamber after the strip edges have been heated by burner flame impingement, said waste heat loss occurring at the mouths of the stacks or chimneys adjacent one side of the furnace after the waste heat gases pass from the furnace heating chamber through the openings in the bottom of the furnace chamber to the stacks.

The maintenance of a 2800° F. furnace temperature required to provide a 2600° F. strip edge temperature as the strip emerges from the heating chamber in continuous furnace operation causes frequent failures of the refractory furnace lining. Such refractory failures cause frequent shutdowns for repairs; and each shutdown consumes a considerable amount of time for cooling the furnace, removal of the bungs, making the refractory lining repairs and again bringing the furnace up to temperature. In other words, with the required heating furnace high temperature operation, furnace refractory life is relatively short and refractory maintenance costs are very high.

Moreover, whenever there is any stoppage of strip travel through the furnace heating chamber for any reason, the high furnace temperature substantially immediately burns out the length of strip in the furnace and considerable time and expense are involved in again threading a strip through the furnace chamber for resuming operation of the equipment.

Another difficulty experienced in the operation of the described furnace is the difficulty in heating the edges of the strip uniformly, because of the exceedingly rapid rate of heating the strip edges from room temperature to 2600° F. in travelling through a 110-foot furnace length at a speed of 750 feet per minute and upwards. Any slight variation in the rate of heating, as by failure of one or more burners directed against the strip edge, causes a change in the strip edge temperature as the strip emerges from the furnace, resulting in improper pipe forming and welding conditions. In other words, with high speed operation, it is very difficult to maintain proper heating control.

Moreover, because of the rapid rate of heating required for high speed operation, there is a substantial temperature differential between the strip edge temperature and the temperature of the center zone of the strip as it emerges from the furnace and passes to the forming and welding rolls, which sometimes causes difficulties in properly executing the forming and welding operations when there is non-uniformity in these temperature differentials, lengthwise of the strip.

Also, the maintenance of the proper forming shape just ahead of the forming rolls is dependent somewhat upon the amount of tension applied to the strip, and yet any substantial tensioning of the strip as it passes through the heating furnace must be avoided because otherwise the strip will pull apart when travelling at high speed in the high-temperature zone of the furnace.

All of these difficulties have resulted in very costly

operation of a buttweld pipe mill, and the difficulties become especially critical when relatively small-sized pipe is being manufactured, such as ⅛", ¼" and ⅜" buttweld pipe.

Accordingly, it is a general object of the present invention to provide a new skelp heating furnace construction and operation which avoids the stated difficulties and substantially reduces the cost of operation of a buttweld pipe mill.

Moreover, it is an object of the present invention to provide an improved skelp heating furnace construction and operation with which mill production can be increased as much as 25% with up to a 25% increase in strip speed without any substantial increase in gas consumption for heating; or with which the same rate of production can be maintained without an increase in strip speed but with a gas consumption reduction of about 25%.

Also, it is an object of the present invention to provide an improved skelp heating furnace construction and operation which enables the furnace heating temperature to be reduced by some 200 degrees, say from 2800° F. to 2600° F., while at the same time providing for more evenly and uniformly heated strip with a strip edge temperature of approximately 2600° F. as the strip emerges from the heating furnace and passes to the mill forming rolls.

In addition, it is an object of the present invention to provide an improved skelp heating furnace construction and operation which reduces refractory maintenance costs by as much as one-half or more, due to the lower 2600° F. furnace temperature maintained.

Also, it is an object of the present invention to provide an improved skelp heating furnace construction and operation by which waste heat losses from the gases discharged from the furnace are substantially reduced.

Also, it is an object of the present invention to provide an improved skelp heating furnace construction and operation in which a substantially lower rate of heating is maintained in the main heating chamber, thus providing for much greater flexibility in and closer control of heating, and providing for more even and uniform heating not only of the strip edges but of the strip throughout, so that a more uniform product from the welding standpoint is produced.

Also, it is an object of the present invention to provide an improved skelp heating furnace construction and operation in which an increased drag—without breakage-causing tension—is exerted on the strip as it passes through the main heating chamber, which drag, coupled with the more uniformly heated strip as it is delivered from the furnace to the forming rolls, provides an optimum forming shape in the strip just ahead of the forming rolls, resulting in a better, more uniform and sounder weld.

Also, it is an object of the present invention to provide an improved skelp heating furnace construction and operation which in use produces an improved buttweld pipe product in which the welding seam can hardly be discerned and which product closely approaches a seamless tube in characteristics.

Also, it is an object of the present invention to provide an improved skelp heating furnace construction in which the skelp is preheated in a plurality of counter-directional passes by heating chamber waste gas heat immediately after waste gases emerge from the main heating chamber and immediately prior to introducing the skelp into the main heating chamber.

Moreover, it is an object of the present invention to provide an improved skelp heating furnace construction in which the skelp is preheated by heating chamber waste gas heat while at the same time providing for direct access to the main heating chamber of the furnace for furnace repairs through removable furnace roof bungs or covers.

In addition, it is an object of the present invention to provide an improved skelp heating furnace construction including a heating chamber accessible from the top for repairs, structural refractory-supporting and burner-mounting side walls, and waste gas outlet passages in the furnace bottom wall, with an adjacent preheating chamber, heated by the waste heat gases discharged from the main heating chamber, through which preheating chamber the strip may be passed in a plurality of counter-directional passes prior to entry into the main heating chamber.

In addition, it is an object of the present invention to provide an improved skelp heating furnace construction with a preheating chamber while retaining accessibility to the main furnace heating chamber through removable top bungs which may be removed quickly for making refractory repairs, burner repairs, and for removing cinder, slag, brick bats, etc. from the main furnace chamber.

Moreover, it is an object of the present invention to provide an improved skelp heating furnace construction having a main heating chamber and a separate preheating chamber closely connected with the main heating chamber while retaining ready access to the main heating chamber.

Furthermore, it is an object of the present invention to provide an improved skelp heating furnace construction and operation in which the skelp is heated in a plurality of passes through the furnace installation without subjecting the skelp to the high temperature heat of the main heating furnace during more than one pass, so as to minimize the amount of skelp destroyed in the event of slowing down or stopping the speed of the strip as it passes through the furnace installation.

Also, it is an object of the present invention to provide an improved skelp heating furnace construction in which the strip is passed in a plurality of counter-directional passes through various heating zones of the furnace without involving rethreading difficulties following a line shutdown and burnout of that portion of the strip in the main heating chamber.

Als, it is an object of the present invention to provide an improved skelp heating furnace construction and operation in which an additional drag is imposed on the strip passing through the main heating chamber equivalent to the additional weight of strip pulled through a connected preheating chamber, while maintaining sufficient heated strip strength to enable the strip to be pulled at high speed—as much as 1000 feet per minute or more—through the heating chamber without pulling the strip apart.

Also, it is an object of the present invention to provide an improved skelp heating furnace construction and operation which substantially eliminates "run outs," that is the running out from the mill of the pipe being formed; and which also eliminates welding troubles heretofore encountered in the operation of buttweld pipe mills.

Moreover, it is an object of the present invention to provide an improved skelp heating furnace construction and operation which, on the one hand, eliminates the indicated difficulties that have been especially critical and costly in the manufacture of small sized buttweld pipe, such as ⅛", ¼" and ⅜" buttweld pipe; which, on the other hand, enable a larger sized pipe with any desired wall thickness, such as ½", ¾" and 1" pipe to be produced on a mill designed for the production of up to ⅜" buttweld pipe; and which improved furnace construction and operation are likewise applicable to, and eliminate the same difficulties in the operation of, buttweld pipe mills for producing pipe considerably larger than one-inch pipe.

Finally, it is an object of the present invention to provide an improved skelp heating furnace construction and operation which can be incorporated readily at low cost in existing pipe mills to solve the stated problems in the art, to eliminate the difficulties enumerated, to generally improve buttweld pipe mill operations and products, and

to obtain the foregoing advantages and desiderata in a simple and effective manner.

These and other objects and advantages apparent to those skilled in the art from the following description and claims, may be obtained, the stated results achieved, and the described difficulties overcome by the methods, steps, operations, procedures, constructions, arrangements, combinations and sub-combinations which comprise the present invention, the nature of which are set forth in the following general statements, a preferred embodiment of which—illustrative of the best mode in which applicant has contemplated applying the principles—is set forth in the following description and shown in the drawings, and which are particularly and distinctly pointed out and set forth in the appended claims forming part hereof.

The nature of the improvements in skelp heating furnace construction of the present invention may be stated in general terms as including a main skelp heating chamber through which a strip is passed continuously, having removable roof or cover bungs, having burners along the side walls of the chamber directed to impinge heating flames against the edges of a strip being passed through the chamber, and having waste gas exist passages extending from the bottom of the main heating chamber to stacks or chimneys located at spaced intervals along one side of the furnace; and a preheating tunnel extending longitudinally of the furnace alongside the main heating chamber, having bottom communication with the main heating chamber stacks and top communication with auxiliary stacks, the preheating tunnel being provided with strip supporting skids for supporting a plurality of counter-directional strip passes therein, a strip return roll at one end thereof, strip entry guide means at the other end thereof, and strip exit guide means at said other end directing and feeding continuously moving strip material emerging from the preheating tunnel into the entry end of the main heating chamber.

The nature of the improvements in skelp heating furnace operation of the present invention may be stated in general terms as preferably including the steps of passing continuously moving strip material in a plurality of counter-directional passes through a preheating tunnel, heating the strip therein from room temperature to 1000° F. to 1400° F. or more uniform strip temperature throughout as the strip leaves the preheating tunnel, then passing the strip in one direction through a main heating chamber, further heating the strip in the main heating chamber from preheated temperature uniformly to about 2600° F. while maintaining approximately a 2600° F. furnace temperature in the highest heated zone of the main heating chamber, pulling the strip through the main heating chamber and preheating tunnel by the pull of the pipe mill forming and welding rolls, and preferably supplying the heat for strip preheating in the preheating tunnel from the waste heat of the gases discharged from the main heating chamber.

By way of example, the improved skelp heating furnace construction and operation are shown somewhat diagrammatically in the accompanying drawings forming part hereof, wherein:

Figure 1 is a diagrammatic view illustrating a buttweld pipe mill incorporating the improvements of the present invention;

Fig. 2 is an enlarged side elevation view, partly in section and broken, looking in the direction of the arrows 2—2, Figs. 1 and 3, illustrating the improved skelp heating furnace construction;

Fig. 3 is a transverse section through the main heating chamber and preheating tunnel of the improved skelp heating furnace construction taken on the line 3—3, Fig. 1;

Fig. 4 is a longitudinal sectional view on a smaller scale illustrating the improved preheating tunnel construction; and

Fig. 5 is a plan view of the improved skelp heating furnace construction, partly in section, taken on the line 5—5, Fig. 4.

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

Referring more particularly to Fig. 1, the improved skelp heating furnace is generally indicated at 1 including a main furnace portion generally indicated at 2 and the improved preheating tunnel generally indicated at 3 associated therewith. The skelp heating furnace 1 forms a part of a buttweld pipe mill installation which preferably includes a coil box or uncoiler 4, in which coils of hot rolled strip or skelp 17 are placed for being uncoiled, a roller leveler 5 through which the strip, unwound from the coil, is fed for flattening, and a flash welder 6 where the tail end of the skelp on its way through the mill is flash welded to the front end of the oncoming coil to maintain continuous operation.

The flash welded strip then passes through a stripping device 7 which removes excess metal from the flash weld, and then to a stand of pinch rolls 8 which position the tail end of the strip in the flash welder 6. The strip then passes along a conveyor 9 over magnetic rolls 10 and stands of idler rolls 11 and vertical rolls 12 which turn the strip 17 on edge to feed the same to a loop storage zone 13 where the strip runs on edge on the floor in a series of loops as indicated at 14.

The pinch rolls 8 are operative during the positioning of the strip ends in the flash welder 6 and during the stripping of the flash from the flash welded joint. After the stripping is completed, the pinch rolls 8 are released so that the strip is conveyed by the roller leveler 5 into the storage looping zone 13, the magnetic rolls 10 assisting in feeding the skelp into the storage loops 14.

The storage loops 14 provide a sufficient supply of skelp to assure uninterrupted operation of the mill while the uncoiler 4 is stopped to permit the coil ends to be joined by the welder 6. The strip is pulled out in a reverse direction from the storage loops 14 by a driven set of pinch rolls 15 which feed the strip into a secondary loop 16 before it enters the preheating tunnel 3.

The speed of the strip 17 in secondary loop 16 is controlled by a control mechanism 18 which coordinates the operation of the pinch rolls 15 and the forming and welding rolls at the exit end of main heating chamber 2. If the secondary loop 16 becomes too large as indicated in dot-dash lines at 16*a*, the loop strikes contact 18*a* of control mechanism 18 which slows down the pinch rolls 15; while if the secondary loop 16 becomes too small, as indicated in dot-dash lines at 16*b*, the loop strikes control device contact 18*b* which speeds up the pinch rolls 15.

The strip 17 is thus fed by pinch rolls 15 to the entry end 19 of preheating tunnel 3. The strip is turned or twisted before entering tunnel 3, from edge movement at the strip entry guide means 19*a*, to flatwise movement along one or a top pass 20 in the tunnel 3. The strip moves in the direction of the arrow 21 (Fig. 2) through the preheating tunnel 3, around a return roll 22 at the other end 19*b* of the preheating tunnel 3, and back in another or bottom pass in the direction of the arrow 23 (Fig. 2) through the preheating tunnel 3. As the strip emerges from strip pass 23 from the entry end 19 of the preheating tunnel, it passes along strip exit guide means 24, on edge around a loop 25, and then along entry guide means 26 to enter the main heating chamber 2 at 27.

The strip then travels through the main heating furnace 2 in one direction in a single pass as indicated at 28, to the exit end 29 thereof and in a usual manner through buttweld forming, welding, and breakdown rolls, diagrammatically indicated at 30, 31 and 32, to a hot saw 33 which cuts the formed pipe into desired lengths, then through sizing rolls 34, a control device 35 and kickout 36 where the cut lengths are discharged onto a cooling bed 37.

The main heating furnace 2 is of usual construction

(Fig. 3) having refractory side walls 38 supported by structural members 39, burners 40 being mounted at spaced intervals in the structural members 39. The burners 40 are connected with a manifold 41 to a source of fuel-air mixture; and the burners 40 are located at each side of the furnace 2 at spaced intervals along the furnace so that the flame tips therefrom impinge the edges of the strip moving therethrough as indicated at 28.

The side walls 38 are built up from a base 42, and the furnace bottom wall 43 has a series of bottom openings 44 therein communicating through passages 45 with a series of spaced stacks or chimneys 46. The refractory furnace side and bottom walls 38 and 43 thus form a furnace chamber 47 through which the strip passes at 28 while being heated to welding temperature; and the chamber 47 is closed at the top by a refractory arch wall 48 built up in support members 49 to form separable, removable cover members or bungs 50.

Each of the bungs 50 is removable by lifting the same with a crane which may be engaged with the support members 49 at crane hook engaging openings 51 (Fig. 3) so as to expose the heating chamber 47 for repairing the refractory lining thereof, for repairing or replacing burners 40, or for removing cinder, slag, brick bats, etc. from the chamber 47 or the bottom openings 44 therein.

Because of the inherent nature of the construction of the furnace 2 with metal side structural members 39 supporting the refractory furnace side walls 38 and burners 40, it is impossible to gain access to the heating chamber 47 through the side or bottom walls of the furnace. Likewise, since the furnace roof must be removable as described, by utilizing removable bungs 50, it is necessary in the furnace construction to convey the spent gases of combustion from the chamber 47 through passages 44 in the bottom wall and through communicating passages 45 to the stacks or chimneys 46.

In the usual prior construction and operation of such a skelp heating furnace, the series of stacks or chimneys 46 discharged the waste heat gases of combustion from furnace chamber 47 directly to the atmosphere, as represented somewhat diagrammatically by the stacks designated 46*a* and 46*b* at the lower right hand portion of Fig. 5, if such stacks 46*a* and 46*b* are considered as terminating in separate openings to the atmosphere at locations above the top of the furnace roof.

In accordance with the present invention, the usual furnace stacks 46 are reduced in height and are connected by a longitudinally extending preheating tunnel chamber 52 forming the tunnel 3 (Fig. 4), the bottom wall 52*a* of the tunnel chamber 52 being supported on cross members 53 in turn supported on vertical structural members 54. Longitudinal plate members 55 mounted on cross members 53 extend between adjacent stacks 46 as shown in Fig. 2, to support the tunnel bottom wall 52*a*.

Referring particularly to Fig. 4, a series of secondary stacks 56 communicate with the atmosphere through the top wall of tunnel 3 at spaced intervals intermediate the communication between furnace stacks 46 and the tunnel chamber 52.

In this manner, in accordance with the present invention, the waste heat gases of combustion from the burners 40, after the flames impinge and heat the strip passing at 28 through main heating furnace chamber 47, then pass out of chamber 47 through openings 44, passages 45, main stacks 46 to tunnel chamber 52 and thence out through secondary stacks 56.

The main heating chamber 47 is provided in a usual manner with a series of skid bars 57 (Figs. 2 and 3), removable through openings 58 in the side walls 38, for supporting the strip as it passes at 28 through the chamber 47. Similarly, the preheating tunnel 3 is provided with upper and lower rows of skid bars 59 and 60 removable through openings 61 and 62 in the side walls of tunnel 3 for supporting the strip passes 21 and 23 as the strip 17 moves back and forth through the preheating tunnel 3.

In the prior operation of the usual furnace 2, as shown in the drawings, but without the addition of the preheating tunnel 3, it was necessary to maintain a furnace temperature of about 2800° F. in the hottest zone of heating chamber 47 so that as the strip passes therethrough, the strip would be heated from room temperature as it entered the heating chamber 47 to a strip edge temperature of about 2600° F. just as the strip leaves the heating furnace and enters the forming rolls 30. In accordance with the present invention, and by locating the preheating tunnel 3 as close as possible to the passages 45 and communicating with the main stacks 46, the preheating chamber 52 is heated by the waste heat of the gases of combustion to an equilibrium temperature of about 1800° F. which slowly and uniformly and evenly heats the skelp in passing along top pass 21 in one direction and back through bottom pass 23 in the other direction through the preheating tunnel, from room temperature to 1000° F. to 1400° F. or more.

Although the preheating tunnel 3 is slightly shorter than the main furnace 2, as diagrammatically indicated in Fig. 1, there is substantially twice as much strip material in the preheating chamber 52 at any one time as in the main heating chamber 47. However, this strip material in the preheating chamber 52 is not damaged or burned out, in event that strip speed is slowed down or stopped for any reason in operating the mill, because the strip and chamber temperatures in the preheating tunnel are not high enough to burn out or damage the strip in case of such stoppage. On the other hand, the high temperature maintained in the heating chamber 47 and the direct flame impingement on the strip edges burns out that portion of the strip extending through the main heating chamber designated at 28, when there is strip travel stoppage, as is the case with prior operation of the furnace 2 without a preheating tunnel.

Accordingly, in the event of strip burnout, it is only necessary to thread a new strip section through the main heating furnace when operations are resumed, in the same manner as heretofore required, without requiring any complicated rethreading operation of the strip along the two passes 21 and 23 in the preheating tunnel.

I have discovered that in operating the improved skelp heating furnace construction described, including the improved preheating tunnel 3 coordinated with the main heating furnace 2 in the manner described, it is unnecessary to maintain a furnace temperature in the main heating chamber higher than about 2600° F. in order to heat the strip as it passes through the main heating chamber 47 to welding temperature of about 2600° F.

This advantage of the new construction arises because the strip has been preheated uniformly and evenly throughout to above 1000° F. before it enters the main heating chamber 47, and the strip temperature thus needs only be raised some 1600° F. or less rather than 2530° F. in passing through the main heating chamber 47.

This advantage leads to a number of other advantages. First, the strip heating in the main heating chamber 47 is accomplished with a considerably lower rate of heating which is subject to much more accurate control so that the temperature of the strip emerging from the heating chamber 2 can be controlled much more accurately.

Second, since the heating in main heating chamber 47 is carried out not only at a lower rate of heating but under conditions of more accurate control, the strip or skelp is heated to welding temperature in the main heating chamber 47 to provide a very uniform strip edge temperature, and with greater uniformity of temperature lengthwise at any zone of the strip across its width.

Third, because of the uniformity in strip heating, and because of the increased drag on the strip (the additional amount of strip in the preheating tunnel) which increases the tension on the strip somewhat at the forming rolls,

a more pronounced forming shape ahead of the forming rolls occurs which provides better and more uniform welding conditions and a sounder weld.

I have discovered further, the in operation of the tube mill in accordance with the present invention, the reduction in main heating furnace temperature required to be maintained, from 2800° F. to 2600° F., reduces refractory maintenance costs for the furnace by as much as one-half or more.

Furthermore, I have discovered, that, by maintaining the same strip speed in a skelp heating furnace constucted and operated as described in accordance with the present invention, as compared with the same furnace not including the improved preheating tunnel construction, gas consumption is reduced by about 25%. On the other hand, with the same gas consumption as heretofore, required, if the furnace is constructed and operated in accordance with the present invention, a 25% increase in production can be obtained by increasing the strip speed through the furnace.

Furthermore, I have discovered that because of the lower rate of heating in the upper temperature range in the main furnace, and because of the better heating control that can be maintained, a more uniform buttweld pipe product is produced from the standpoint of the resulting weld therein.

Also, the improved furnace construction and operation is provided, and the stated advantages are obtained, without in any manner disturbing normal access to the main furnace heating chamber for repairs, and without requiring any complicated rethreading operations after strip burnout.

In other words, it is possible, without any interference by the preheating tunnel, to gain quick access to the main heating chamber to make repairs where required from time to time without completely tearing down the furnace installation.

Although there is an increase in the drag on the strip by the weight of the strip being pulled through the preheating chamber **52**, which has the described desirable effect of producing a better forming shape just as the heated strip enters the forming rolls **30**, nevertheless the strip is not subjected to sufficient tension at high temperature as to pull the strip apart. This is accomplished by the coordination between the speed of the pinch rolls **15** and the forming and welding rolls, by maintaining the desired secondary loop **16**; so that the only effective tension on the strip in the heating furnace where it has the least strength is the drag of the weight of the strip being pulled through the preheating tunnel and main heating chamber. This improved arrangement enables the improved buttweld pipe mill to be operated at speeds as high as 1000 feet per minute or more without pulling the strip apart in the main heating chamber.

Accordingly, the improved skelp heating furnace construction and operation of the present invention provides the described advantages in the manufacture of buttweld pipe; overcomes prior difficulties that have been particularly troublesome; enables production in existing mills to be increased, gas consumption and maintenance costs to be reduced, larger sized pipe to be made in existing mills, and an improved resulting product to be made; and solves existing problems in the art, overcomes the stated difficulties and obtains the foregoing advantages and desiderata in an extremely simple manner.

In the foregoing description, certain terms have been used for brevity, clearness and understanding; but no unnecessary limitations are to be implied therefrom beyond the requirements of the prior art, because such terms are utilized for descriptive purposes herein and not for the purpose of limitation and are intended to be broadly construed.

Moreover, the description of the improvements is by way of example, and the scope of the present invention is not limited to the exact details illustrated, or to the specific temperatures referred to, or to the exact article sizes described.

Thus, although the improvements in skelp heating furnace construction and operation have been described herein with reference to a particular pipe mill installation, designed primarily for making small-sized pipe, it is understood that the improvements may be incorporated in the construction and operation of skelp heating furnaces having much greater lengths, or larger sized skelp heating furnaces for pipe mill installations for the manufacture of larger sized buttweld pipe of say up to two inches and even larger.

Furthermore, the equilibrium temperature of the waste heat gases resulting in the preheating tunnel may be higher than the described 1800° F. temperature, and may be as high as say 2200° F., which would result in a preheated skelp temperature substantially higher than 1000° F. The limitation on the maximum temperature in the preheating tunnel is that it must be low enough that the skelp will not be melted or burned out in the preheating tunnel in event that travel of the skelp is stopped for any reason for any substantial length of time. Since skelp normally melts at a sustained temperature of about 2375° F., a 2200° F. maximum preheating tunnel temperature provides a safe upper limit without burnout in event of skelp travel stoppage in the preheating tunnel.

Physical limitations in the construction of any particular pipe mill skelp heating furnace may prevent obtaining an equilibrium temperature in the preheating tunnel as high as desired, from the waste heat gases alone. For this reason, it is within the scope of the present invention to provide additional burners for the preheating tunnel for maintaining any desired preheating tunnel temperature below 2200° F.

Furthermore, the construction and operation of the improved skelp heating furnace is also applicable to skelp heating furnace installations having recuperators for supplying heated combustion air for the air-gas mixture supplied to the main furnace burners. Where recuperators are used, it is normally necessary to supply dilution air from dilution air blowers to cool the waste heat gases somewhat before introducing the same into the recuperators where the combustion air is heated. If the improved preheating tunnel construction of the present invention is incorporated in a recuperator-equipped skelp heating furnace, the drop in temperature of the waste heat gases as the same pass through the preheating tunnel provides the necessary temperature drop so that these gases then can be introduced directly into the recuperators as the gases pass from the preheating tunnel without the necessity of using any dilution air blowers.

Having now described the features, discoveries and principles of the invention, the operation and procedures of preferred method steps thereof, the construction and operation of the new furnace construction, and the advantageous, new and useful results obtained thereby; the new and useful methods, steps, operations, procedures, discoveries, principles, combinations, sub-combinations, arrangements, constructions and elements, and mechanical equivalents obvious to those skilled in the art, are set forth in the appended claims.

I claim:

1. Skelp heating furnace construction including longitudinally extending side and bottom walls forming a longitudinally extending main skelp heating chamber through which a strip is passed continuously, in one direction from entry end to pipe forming and welding rolls, removable roof means for said chamber supported on said side walls, burner means extending through the side walls at spaced intervals along the sides of said chamber directed toward the edges of a strip passing continuously through the chamber, a series of main stacks located at spaced intervals at one side of said chamber, walls forming

waste heat combustion gas passages communicating through said bottom wall and the side wall at said one side of said chamber between the chamber and said main stacks, walls forming a preheating tunnel chamber extending longitudinally and alongside of the main heating chamber, support means for said preheating tunnel, said main stacks communicating with said tunnel chamber, auxiliary stacks supported on and located at spaced intervals along the tunnel walls communicating with the tunnel chamber, longitudinally spaced upper and lower strip support means in said tunnel, and means for continuously passing the strip in a plurality of counter-directional passes through said preheating tunnel chamber prior to entering the strip into the main heating chamber.

2. Skelp heating furnace construction as set forth in claim 1 in which the waste heat gas passages communicate between the bottom of the main heating chamber and the main stacks, in which the main stacks communicate with the bottom of the preheating tunnel chamber, and in which the auxiliary stacks communicate with the top of the preheating tunnel chamber.

3. Skelp heating furnace construction as defined in claim 1 in which the preheating tunnel chamber terminates at one end as a strip-entry-exit located adjacent the entry end of the main heating chamber and extends therefrom to a remote end, and in which the means for continuously passing the strip in a plurality of counter-directional passes through the tunnel chamber includes return roll means at the remote end of the tunnel chamber.

4. Skelp heating furnace construction as defined in claim 1 in which the preheating tunnel chamber terminates at one end as a strip-entry-exit and extends therefrom to a remote end, in which strip entry guide means is provided at said one end of the tunnel, in which strip return roll means is provided at the remote tunnel end, and in which strip exit guide means is provided at said one end of the tunnel directing and feeding the continuously moving strip emerging from the preheating tunnel entry-exit into the entry end of the main heating chamber.

5. Skelp heating furnace construction as defined in claim 1 in which the means for continuously passing the strip in a plurality of counter-directional passes through the preheating tunnel includes means for feeding the strip to the preheating tunnel, means for pulling the strip from the main heating chamber, and means for maintaining the same strip speed as it is fed into the preheating tunnel as the speed of the strip as it is pulled from the main heating chamber, whereby the only tension on the strip in the main heating chamber as it is passed continuously therethrough is the drag of the weight of the strip material in the main heating chamber and preheating tunnel as it is being pulled therethrough.

6. The method of heating continuously moving skelp for a buttweld pipe mill, including the steps of passing continuously moving skelp first in a plurality of counter-directional passes through a preheating tunnel and then in one direction through a separate main heating chamber, heating the skelp from room temperature to 1000° F. to 1400° F. or more uniform skelp temperature in the preheating tunnel while maintaining the preheating tunnel temperature below 2200° F. and further heating the skelp in the main heating chamber from preheated temperature uniformly to about 2600° F. skelp edge temperature while maintaining approximately a 2600° F. furnace in the highest heated zone of the main heating chamber.

7. The method of heating continuously moving skelp for a buttweld pipe mill, including the steps of passing continuously moving skelp first in a plurality of counter-directional passes through a preheating tunnel and then in one direction through a separate main heating chamber, heating the skelp from room temperature to 1000° F. to 1400° F. or more uniform skelp temperature in the preheating tunnel while maintaining the preheating tunnel temperature below 2200° F., further heating the skelp in the main heating chamber from preheated temperature uniformly to about 2600° F. skelp edge temperature while maintaining approximately 2600° F. furnace temperature in the highest heated zone of the main heating chamber, gas-firing the main heating chamber to perform the heating operation therein, and supplying the heat for heating the preheating tunnel from the waste heat of the gases of combustion discharged from the main heating furnace.

8. The method of heating continuously moving skelp for a buttweld pipe mill, including the steps of passing continuously moving skelp first in a plurality of counter-directional passes through a preheating tunnel and then in one direction through a separate main heating chamber, heating the skelp from room temperature to above 1000° F. skelp temperature in the preheating tunnel independently of the temperature maintained in the main heating chamber, further heating the skelp in the main heating chamber from preheated temperature to about 2600° F. skelp edge temperature, and supplying the heat for the preheating operation from waste heat discharged from the main heating chamber.

9. The method of heating continuously moving skelp for a buttweld pipe mill, including the steps of passing continuously moving skelp in one direction through a preheating tunnel, then passing the skelp in the other direction back through the preheating tunnel, and then passing the skelp in one direction through a separate main heating chamber, uniformly heating the skelp from room temperature to above 1000° F. skelp temperature in the two passes in the preheating tunnel, further heating the skelp in the main heating chamber from preheated temperature to uniform skelp edge temperature of about 2600° F. in the main heating chamber while maintaining approximately a 2600° F. furnace temperature in the highest heated zone of the main heating chamber, and supplying the heat for the preheating operation from waste heat discharged from the main heating chamber.

10. The method of heating continuously moving skelp for a buttweld pipe mill having driven forming and welding rolls, including the steps of feeding skelp continuously to a preheating tunnel, passing the skelp in one direction through the preheating tunnel, passing the skelp back in the other direction through the preheating tunnel, passing the skelp in one direction through a separate main heating chamber, pulling the skelp through the main heating chamber and preheating tunnel by the driven pipe mill forming and welding rolls, heating the skelp from room temperature to above 1000° F. in the preheating tunnel, further heating the skelp in the main heating chamber from preheated temperature to about 2600° F. skelp edge temperature, and coordinating the feeding and pulling speeds imparted to the skelp to be the same so that the only tension on the skelp as it is pulled through the main heating furnace is the drag of the weight of the skelp portions passing through the preheating tunnel and main heating furnace.

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