May 12, 1936. J. L. ANDERSON 2,040,164

METHOD FOR MAKING WELDED PIPE OR TUBING

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Fig. 1.

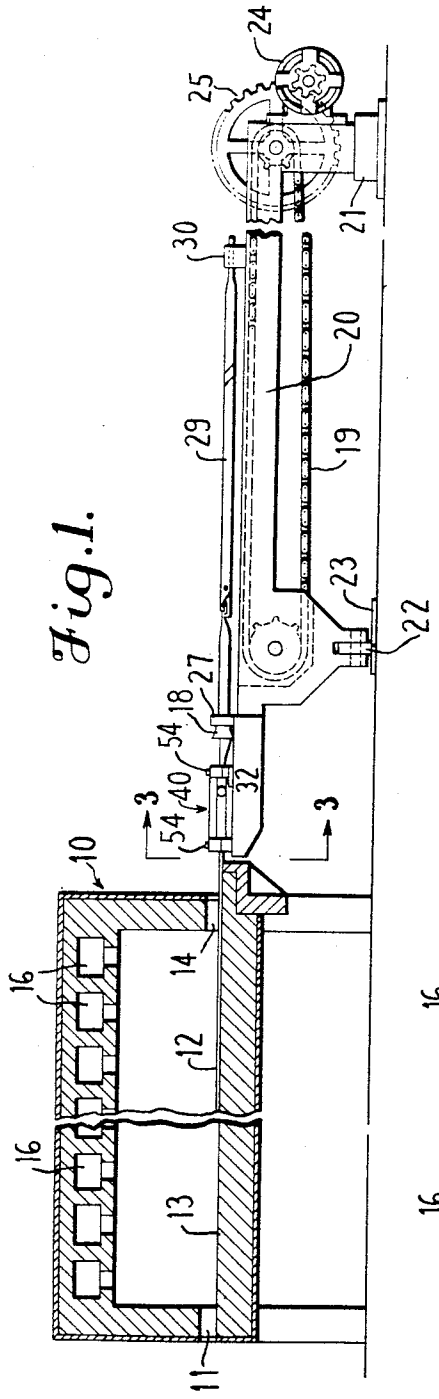

Fig. 2.

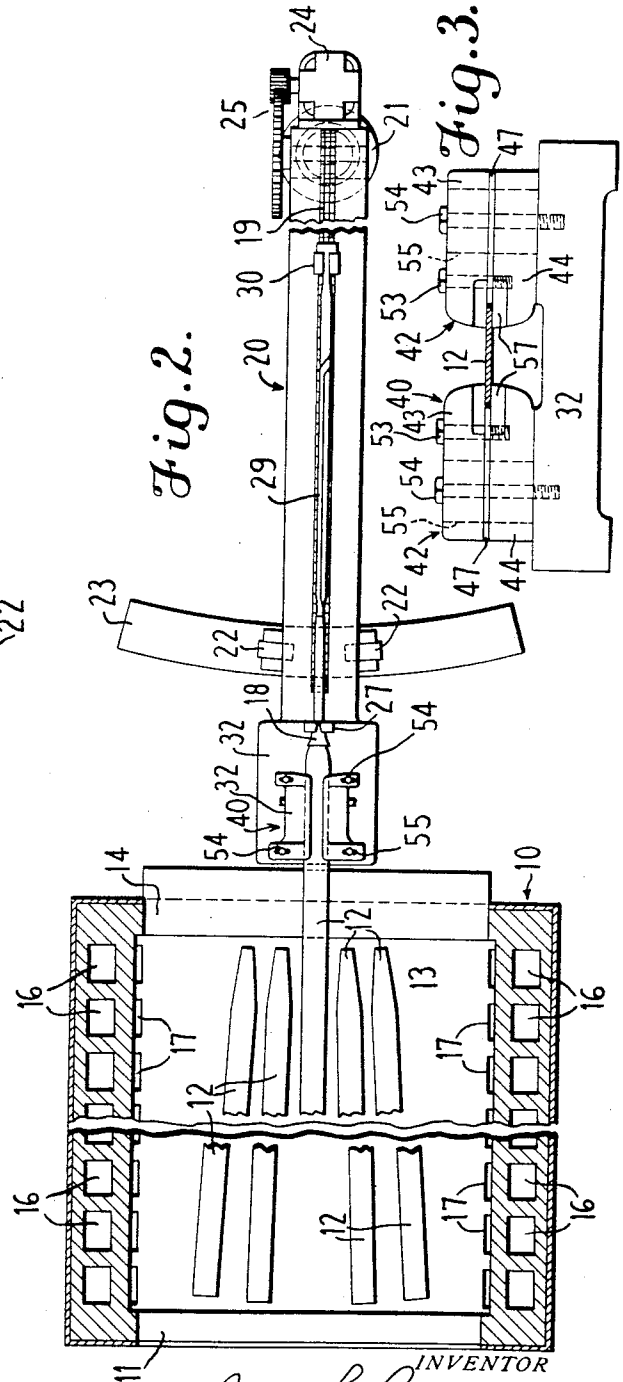

Fig. 3.

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Fig. 4.

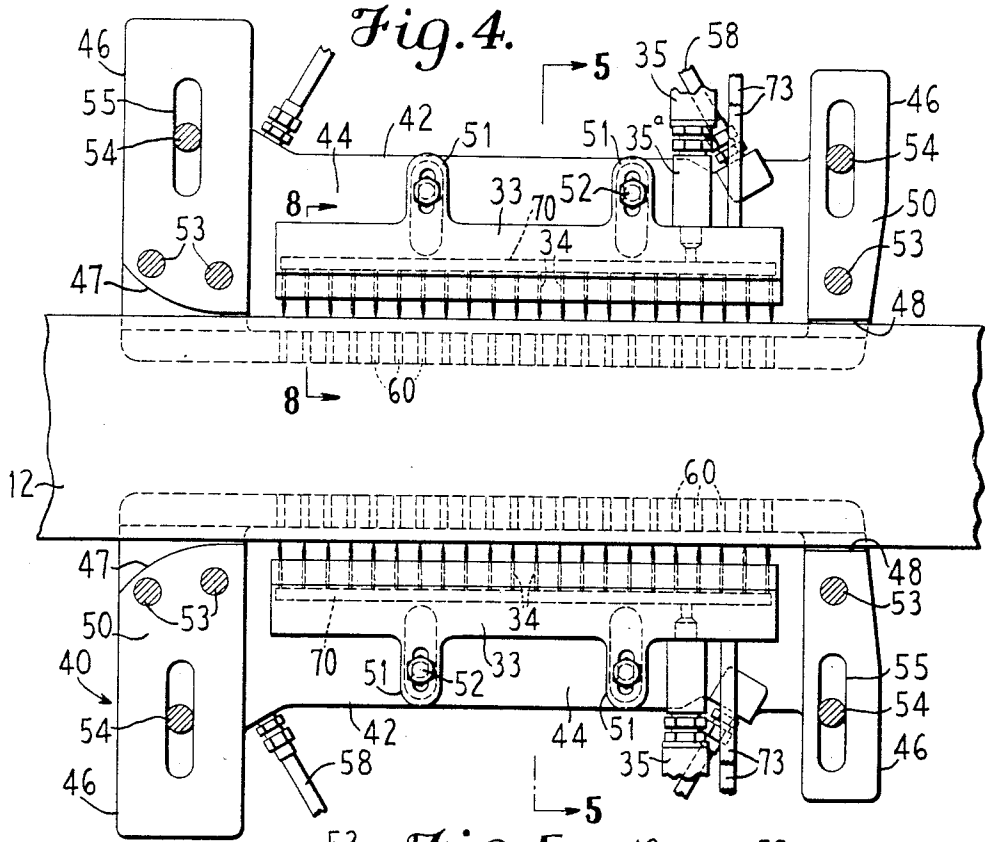

Fig. 5.

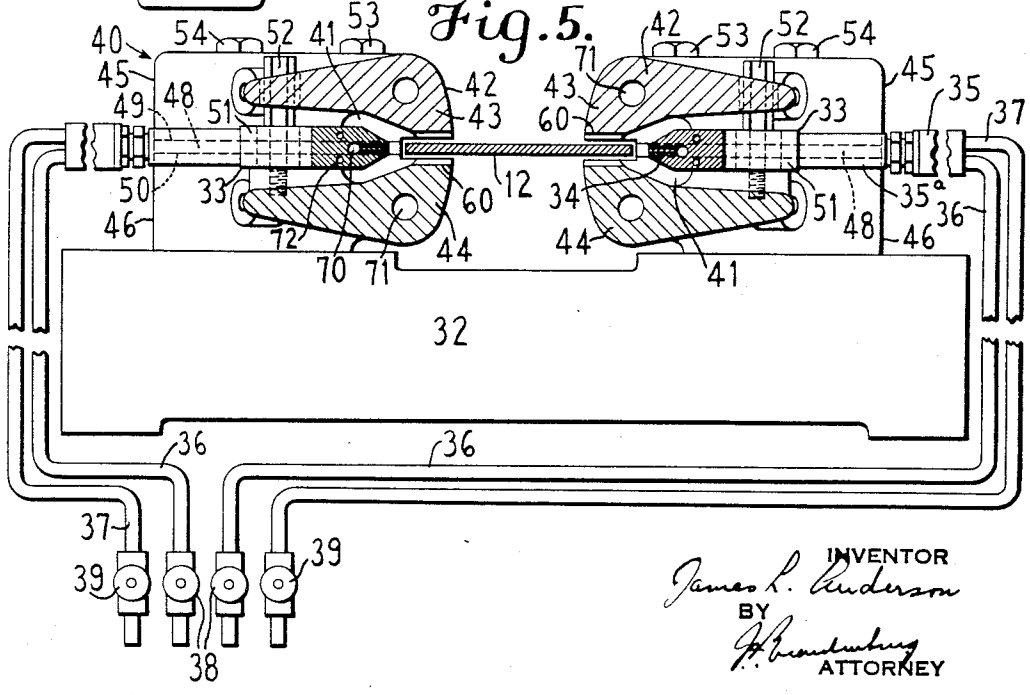

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Fig.6.

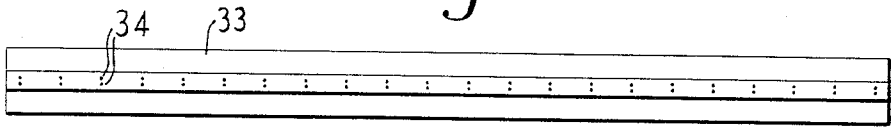


Fig.7.

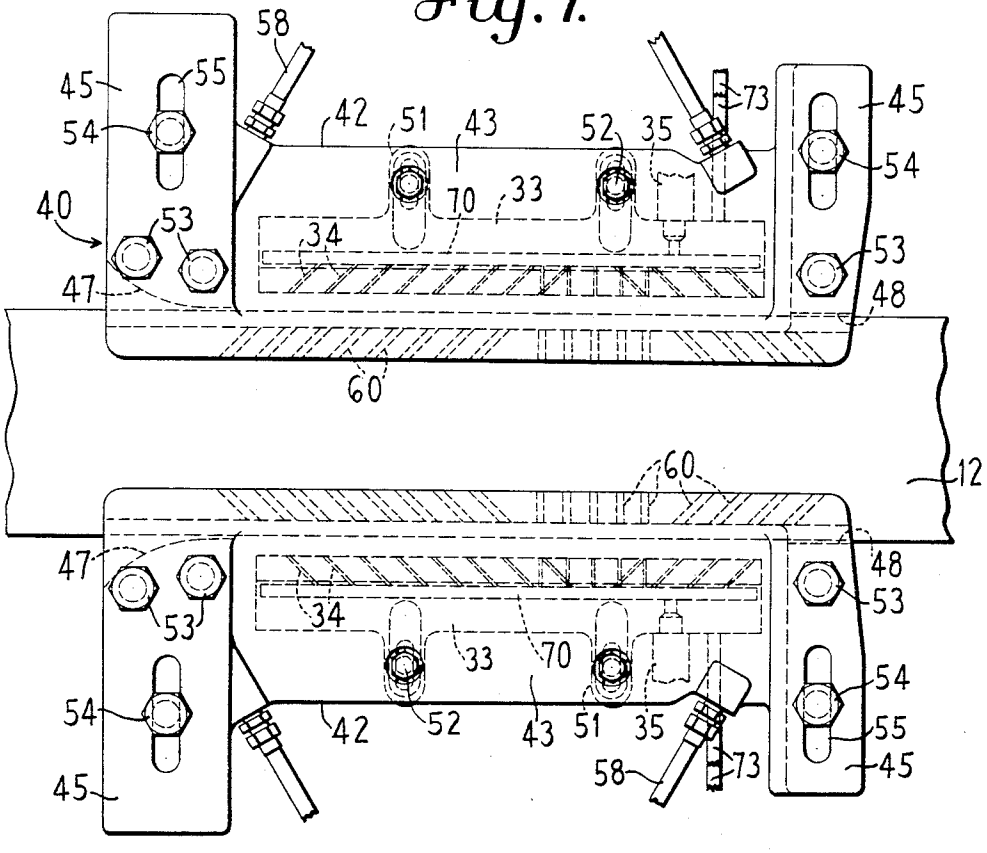
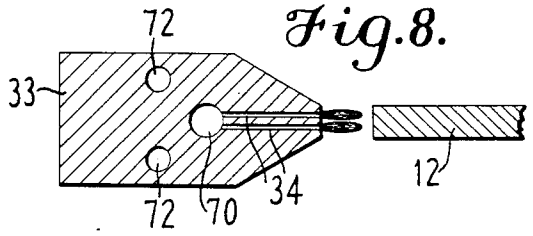


Fig.8.



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2,040,164

UNITED STATES PATENT OFFICE

2,040,164

METHOD FOR MAKING WELDED PIPE OR TUBING

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Application December 26, 1933, Serial No. 703,901

12 Claims. (Cl. 205—12)

This invention relates to the art of making pipe and tubing from furnace-heated skelp or strip. The drawbench bell-weld method is the one most generally used, and the invention will be illustrated in its application to an operation of that kind, though the invention is not necessarily limited to the specific instrumentalities employed. The drawbench bell-weld method has been practiced for more than half a century, and the bulk of welded pipe and tubing up to and including the two-inch size is still thus produced, though the product has long suffered in comparison with seamless tubing and with superior welded tubing made by more modern, though slower, methods. The advantages of the drawbench method are that the strip skelp is bent into tubular form and welded in one simple operation, that the operation is rapid and the output large, and that the tubing may be made from inexpensive skelp. Against these, are serious and generally recognized drawbacks, namely, that bell-welds are of inferior strength and are apt to develop leaks, so that such pipe and tubing is unsatisfactory for various purposes, and that so large a part of the product is defective and must be scrapped, the rejects often amounting to more than 20 per cent. of the output of a mill; and as much as 20–30 per cent. additional must often be sold for second class pipe.

The bell-weld method has remained essentially unchanged and, notwithstanding numerous auxiliary improvements, is practiced today substantially as follows. Skelp strips are introduced into a furnace at such intervals that a number of skelps lie in the furnace in different stages of being heated to the "welding heat". The front part of the furnace, where there is an opening for the withdrawal of the strips, is not as hot as the central part of the furnace. The strips are therefore placed with their front ends a distance back from the opening. The front ends of the skelps are usually prepared by being tapered and bent upward. The skelps are withdrawn one at a time by the chain of a drawbench and by means of a long tongs which is first applied to the bent-up end of a skelp and later on engaged with the chain. The speed of drawing ranges from about 250 feet to about 650 feet per minute, according to the practice of different plants and depending more or less upon the size of pipe and the character of the material. The front end of the hot strip skelp strikes the bell die, which is supported against a head block, and each cross-section of the strip as it is pulled through the bell is curved to circular form and its edges are forced together under great pressure, accompanied by a reduction in diameter of the circular form. In some instances, the material is drawn through two dies, one behind the other. When the tube is drawn, the bell die drops away from the head block and is carried off for cleaning and inspection, another bell being used for each length of tubing. Before each drawing, a bell is passed over a tongs and the tongs are engaged with the front end of a skelp. When the welder decides by looking in through the opening of the furnace that the skelp longest in the furnace is ready to be drawn, he throws the tongs into position to be caught by the next arriving of two or three dogs on the chain circuit, or a hook is pushed down into the chain to pull the tongs and skelp.

The measure of success of this method of manufacture depends on the ability of the welder to judge by eye the moment when the skelp in the furnace has attained the temperature which will insure that when the skelp reaches the bell, the edges will be in condition to stick together under the pressure created in the passage of the tube through the reduction orifice. If the skelp is drawn too soon, the weld will be weak or skippy, while if the skelp is left in the furnace too long the metal becomes overheated or burned, to the detriment of the weld and of the pipe length as a whole. If the skelp becomes too soft and weak in the furnace, the material cobbles, or parts under the strain of the pull through the die, a not infrequent occurrence which delays the work and may cause the loss of the skelps in the furnace. Softening of the body of the skelp accounts also for caving, a condition in which the edges bend inward of the tube in the orifice of the die instead of abutting squarely.

Much molten scale and oxide streams off the skelp at the exit from the furnace, and again at the bell, and pernicious oxide is included in the welds. Not only does the oxidation of the metal cause an actual loss in weight of material, but the flying slag and oxide are a serious trouble to the workers. The temperature in the furnaces varies in different parts and the welding crew must repeatedly readjust the air and gas flows to attain some semblance of uniformity. The condition of the furnace atmosphere in respect to oxidation is a matter which can not be known to the welder. Between the furnace and the bell there is a gap where the white hot skelp is exposed to the action of the air. In different

plants this distance may vary from less than a foot to approximately three feet. The shorter the distance the more acute the discomfort to the welder from the heat of the furnace, but the less the opportunity for oxidation and cooling of the hot metal in the air. On the other hand, the distance may not be so great that the length of the tongs necessary to reach into the furnace would make them unmanageable. As a manner of making welds this manufacture of pipe and tubing is inherently poor.

Hot rolled skelp for the manufacture of pipe is one of the lowest priced steel products and is made under conditions which do not insure fine quality or uniformity. Skelp is rolled, prepared and used with little regard to analysis, weldability or accuracy in width or edge form, and little, if any, attempt is made thoroughly to deoxidize the metal as made at the steel mill. Under ordinary pipe making operations, considerable oxidation is present in the seam, as well as gas pockets, when furnace welding temperature only is relied upon.

Approximately twenty years ago it was proposed to improve the making of bell-weld tubes by blasting the hot skelp with air between the furnace and the bell, so as to clean the edges and also in order that the skelp might be heated to a relatively low heat in the furnace and still be welded. The action of such a blast is in part mechanical and in part chemical, heat being generated in the skelp, if it is already at or above a critical temperature, by combustion of the carbon and manganese of the metal, with consequent alteration of the composition of the steel. At the same time there is rapid oxidation or burning of the iron, represented by a deluge of sparks and the accumulation of debris in the vicinity. As the air blast acts upon the entire surface of the skelp, there is a considerable loss of material, the action being somewhat like the cutting of steel by oxygen. The great accumulation of slag on the apparatus is a serious drawback. The extent to which the edges are cleaned of pre-existing scale, oxide and sand, and the degree to which the temperature can be raised by the preferential reaction between the carbon of the steel and the oxygen content of air, are obtained by an action which depends upon oxidation, so that pipe made from air-blasted skelp can scarcely be free of oxide in the weld. In order to blow away as much of the oxide as possible, a strong blast must be used, and the heating produced by combustion of constituents of the metal is necessarily limited by the cooling effect of the blast.

In the manufacture of wrought-iron pipe, weld quality and weld strength have been particularly unsatisfactory, and whether because of the relatively low carbon content or because of the large amount of slag present in wrought-iron, little if any benefit has been obtained in that department of the art when the air blast has been tried. On the other hand, various steels, including relatively high carbon steels, containing much above 0.10% carbon, are unavailable for ordinary pipe welding operations because of the fact that such steels are too sensitive to the furnace temperatures required for welding. It is an advantage of my process that it makes possible successful production of excellent pipe and tubing from substantially any material including wrought-iron, high carbon steels, and special alloys, and another advantage is that it is practicable to produce butt-welded pipe of the larger sizes which have been made in the expensive lap-weld manner, which pipe when made by this process are superior to lap-weld products.

My invention involves the application to the edges of the skelp, after the skelp has been heated to approximately a white heat in the furnace, and along its passage to the forming and welding die or dies, or equivalents, of intense, distributed heating which is controlled in a perfectly definite, certain and facile manner, to heat to fusion, and at the same time purify, the surfaces which are to be united together. This is accomplished by causing the edge portions of the skelp to move rapidly through lanes where they are exposed to the action of flame jets composed of a burning mixture of commercially pure oxygen and fuel gas, such as acetylene, butane, propane and the like, the flame temperature of which is about two or more times the temperature of the skelp as it leaves the furnace, and which are fully capable, if given the opportunity, of speedily melting the hot metal away. The process depends upon the relation between the speed of travel of the skelp past the flames, the longitudinal distribution of the intense flame heating and the volume of gases supplied to the jets. Burning, destructive melting or cutting into the edges must not occur. I have demonstrated in actual operation that destruction of the skelp, which persons experienced in the bell-weld art considered to be inevitable when the process was proposed, is readily avoided if a proper relationship is observed, and that on the contrary it is practicable to preserve the original edges of the skelp, while bringing the edge surfaces to a condition of incipient or actual fusion and rendering the sub-surface metal plastic for a substantial depth so that a perfect union is insured when the edges are then brought together. This intensive heating of the edges is accomplished over a considerable longitudinal distance but very quickly measured in time, the transit of each two similarly located points on the skelp edges through the parallel high-temperature lanes being a matter of but a fraction of a second. While the high-temperature products of combustion flow across the upper and lower surfaces of the skelp and thus minimize heat conduction losses, the regions of very intense heat lie in rather narrow belts adjacent the tips of the cones of the flames, these belts being the lanes referred to. For this reason and because of the rapidity with which heat is put into the edges, the body of the skelp does not become so hot as to lose the strength necessary for pulling through the die or as to cause it to crumple or to assume an imperfectly tubular form with its edges out of alinement and overlapping, nor is the metal softened to any excessive distance inward of the edges that would cause caving.

While the traveling skelp edges are receiving successive inputs of heat from flame sources far above the temperature to be attained in the metal, the edges are also enveloped in heated reducing gases given off from the combustion, or separately introduced. The repeated heating and fusing permits the release of occluded gases from the edge metal, and as the surfaces approach a virtually fluid state any residual gas pocket depressions that may remain are extremely small or are entirely eliminated. Meanwhile, the active reducing action of the highly heated envelope gases completely deoxidizes the surfaces, so that

purified edge surfaces, between which the weld is to be made, are assured.

The strong heatings which bring the surfaces to the verge or to the actual point of fusion, together with the intervening stages of deoxidation result in the production of bell-weld quality which has never before been approached. The unions which are obtained are uniform, continuous, free of granulation and oxide, without pinholes, and of extraordinary strength as shown by crushing, expansion and hydrostatic pressure tests. The tube product is to all intents and purposes seamless. While the region of the seam may be recognized on carful examination, the ordinary characteristic seam mark of seamed tubing is usually absent, this being due to the squeezing to the surface of the fused or plastic metal of the oxide-free edges as the skelp is forced into tubular from with its edges in abutment. With this process, better welds are obtained with less than the usual amount of pressure and reduction in passage through the welding die. Hence for a given size of die orifice and a given diameter of pipe product, narrower skelps may be used, the power requirement is reduced, and wear on the bells is likewise reduced. The pipe in its passage through the welding die is worked principally in the region of the weld, which was not true in former bell-weld practice. This mechanical working of the weld has the effect of producing a fine grain structure and counteracts any tendency of the heating to produce a large grain structure. While a flash or upset on the inside is not usually desirable if the product is to be used to conduct fluids, a small internal flash may be produced if desired as a visual index of thoroughness of welding, though pipe made by this process is so strongly knit in the weld that a flash is not needed as reinforcement. On the outside no flash could exist, if a bell is used, because the bell would iron it flush with the circumference.

The deoxidizing effect of the combustion gases on the surfaces that are united is evidenced by the condition of the interior of the pipe. It is customary in bell-welding to curve the skelp downward so that the weld is made at the bottom of the tube. In the process now disclosed, the envelope gases flowing beneath the skelp where it is still flat are trapped within the hot tube as it is formed and remove much of the oxide from the bore, any remaining being in the form of a loose scale.

The regions of highest temperature being at or very near the tips of the flame cones, it is important to centralize the strip skelp in its travel through the edge heating and purifying pass, in order that both edges shall be brought to substantially the same exceptionally favorable welding condition. For this purpose, I provide edge guides for the skelp, and also, preferably guides to keep the skelp traveling level with the flame jets, though the latter guides are less important. I have found that edge guides which allow ample clearance for hot and inaccurately made skelp suffice to keep the spacing between the edges and the two lines of flame jets substantially uniform from the standpoint of result.

The flame lanes are preferably enclosed in a retort or retorts affording channels in which the marginal portions of the skelp run and from which little or no actual flame emerges. This part of the invention involves a special method of heating with oxyacetylene or similar flames, whereby the combustion is confined to the regions of the work which are to be intensely heated or brought to fusion. The reducing gases, such as hydrogen and carbon monoxide, given off from the cones, spread out and protect the edge metal and are burned by the oxygen of the air and such oxygen as may pass through the cones. The air for this secondary combustion may be aspirated or it may be supplied under low pressure, or the retort may be more completely closed and oxygen may be supplied to its interior to support the secondary combustion. The use of the retort effects an economy in gases, notwithstanding that the proportion of pure oxygen to the proportion of acetylene or other fuel gas must be relatively greater than would otherwise be required, because the portions of the retort that receive the skelp edges are entirely filled with confined burning gases, and it has the further advantage of keeping within the retort the envelope flame, which is usually of large volume. However, the flames might be unconfined.

While the process may be accommodated to existing arrangements in which the distance from the furnace to the die is comparatively short, it is an advantage that the drawbench and die may be located as far away from the furnace as will still permit the skelp in the furnace to be reached with the tongs. In this respect there is a benefit to the workers, since the overpowering heat from the furnace can be endured by the welder only because streams of air are played upon him, in addition to which, in some plants, there are curtains of water descending over the front of the furnace, or curtains of chains hung in front of it to carry off some of the heat. Whereas ordinarily the greater the space between the furnace opening and the die, the greater is the loss of heat from the skelp before it reaches the bell and the greater the necessity for leaving the skelp in the furnace until it is in danger of being overheated, under my process the welder's station may be removed from the furnace to the maximum practical distance, since the method of superheating the skelp edges absolutely precludes cooling down of the skelp and not only minimizes the opportunity of oxidation in the air but provides a means for reducing the oxides already present. Furthermore, while the invention is not limited to heating the skelp in the furnace to a lower temperature than has been the average of practice heretofore, it is no longer necessary to leave the skelp in the furnace over a final indefinite period in which it is difficult to tell by the eye what state the metal has reached. Thus, the welder may withdraw the skelp when it has reached a temperature which shows uniform fusing of the surface oxides, secure in the knowledge that the alternate heating and reducing action of the flames will bring the edges to an advantageous welding heat and automatically free them of gases, oxides and slag. It may be said that it is an object of the invention to eliminate an element of uncertainty and poor control that has accounted for much of the losses in the production of bell-weld pipe and to introduce positively controllable factors which relieve the welder and insure important gains in the quantity and quality of merchantable product.

Contrary to what might be expected, it has been found that the consumption of extra gases in this process is very economical, particularly so considering the great improvement in the pipe and tubing thus produced and the avoidance of

so much scrap loss. For oxygen and acetylene, the cost of gases per ton of pipe or tube of any size is only a fraction of the scrap losses due to defective welding with old pipe welding methods.

The drawings illustrate the application of the invention to the bell-welding form of operation for the manufacture of pipe and tubing.

Fig. 1 is a somewhat diagrammatic side view, partly in elevation and partly in section, of apparatus for carrying the invention into effect in that form of execution. A skelp is shown in the act of being formed and welded. Intermediate portions of a skelp-heating furnace and of a drawbench are broken out because of lack of space.

Fig. 2 is a plan view, partly in section, of the apparatus shown in Fig. 1.

Fig. 3 is a view on a larger scale taken on the line 3—3 of Fig. 1, showing the entrance end of the retort and the skelp-guiding means.

Fig. 4 is a plan view, on a still larger scale, of the retort and skelp guide, with the upper portion removed to show the torches. The high temperature cones of the flames are indicated in their relation to the skelp edges, no attempt being made, however, to show the envelope flame and gases.

Fig. 5 is a transverse section on the line 5—5 of Fig. 4, with the upper part of the retort in place.

Fig. 6 is an edge view, on a yet larger scale, of one of the burner blocks.

Fig. 7 is a plan view of the retort with the top in place. This view illustrates a disposition of jet passages and gas channels which extends these regions of heating beyond the effective length of the systems of jet orifices.

Fig. 8 is an enlarged cross-section through a portion of the skelp and one of the burner blocks.

The numeral 10 designates a skelp-heating furnace having an entrance 11 at one end, through which skelp strips 12 are introduced into the furnace to lie on the bottom 13 until they become highly heated, and a skelp discharge opening 14 at the opposite end, through which the skelps are withdrawn one at a time. The hot gases of combustion of oil or gas fuel and air which heat the skelp in the furnace may enter through flues 16 and pass out of the skelp heating chamber through flues 17. Naturally, the particular construction of the furnace and its mode of heating may be varied. In some skelp or strip heating furnaces the burner or burners deliver their flame directly into the skelp chamber.

In a bell-weld plant, the heated skelp is moved from the furnace and through a bell 18, which constitutes a forming and welding die, by pull applied to the forward end of the skelp and exerted by the chain 19 of a drawbench 20. The drawbench may be pivotally supported at 21 at its end remote from the furnace and at its end near the furnace may be supported by wheels 22 movable on a track 23, so that the drawbench can be shifted into line with each skelp next to be drawn from the furnace. The chain of the drawbench is constantly driven by a motor 24 through gearing 25.

While the skelp is being drawn, the bell 18 is supported against a head block 27 mounted on the drawbench at some distance from the skelp discharge opening of the furnace. With this invention there is no necessity for placing the bell close to the furnace. A sufficient distance is to be provided to enable the edges of the rapidly moving skelp to be intensively heated, fused and purified in the manner which will be described, and also to allow for the bending of the flat strip to circular form and for removal of the bell. With proper distribution of the intense heating of lines of flame of oxygen and acetylene, or other fuel gas, and with proper regulation of the amounts of these gases that are delivered, and depending also upon the speed at which the skelp is moved, that portion of the distance from the furnace to the bell which is devoted to the preparation of the edges may vary from about a foot to thirty inches. In the drawbench operation, the reach of the tongs 29 need be the only limitation on the distance to which the bell is removed from the front of the furnace.

As previously explained, the tongs are passed through the bell and are engaged with the front end of a skelp in the furnace. When the skelp is ready to be drawn, the rear end of the tongs is engaged with the chain by means of a hook, or with a dog 30 on the chain, whereupon the skelp is pulled through the forming and welding bell.

The provisions for heating and purifying the skelp edges are mounted on a base 32 forming an extension of the frame of the drawbench projecting into proximity to the front of the furnace. The intense heating instrumentalities here disposed comprise two elongated burner blocks 33 arranged at opposite sides of the path of the skelp. These burners are of the type which is adapted to handle a mixture of oxygen and hydrocarbon gas supplied under pressure and to deliver the mixture through a multiplicity of flame jet orifices 34. Each burner block is supplied with the gases through a stock 35 to which pipes 36, 37 are connected to conduct the gases from the sources of supply. The pressures of the gases supplied to the burners are regulated by adjustable pressure regulators (not shown), and the respective flows are further adusted by oxygen and fuel valves 38 and 39 shown in Fig. 5, these valves being disposed at a convenient control station. The internal passages in the stocks and burner blocks need not be illustrated in detail. Suffice it to say that the oxygen and fuel gas, the latter preferably acetylene, are mixed by suitable mixers in the stocks 35 or in the stems 35^a of the burner blocks, that the mixture is distributed by longitudinal passages 79 in the blocks and issues in jets through the orifices 34, and that the burning of these jets creates a very high temperature. With a mixture of oxygen and hydrocarbon, such as acetylene for example, the amount of pure oxygen mixed with the fuel gas is much less than the amount required for combustion, the highest temperature being realized at or very near the tips of the inner cones of the flames, which represent the primary stage of combustion. These cones are relatively short. In the case of a ribbon flame of oxygen and acetylene, which may be employed in my process, the cone may extend about an eighth of an inch from the outlet of a slit orifice, whereas with small, individual orifices such as shown in the drawings the cones may extend a quarter of an inch or more. In this way longitudinal lanes or belts are established where the temperature is so high that it would quickly melt away the metal of the hot skelp if the latter were to pause in its rapid movement. While an excessive degree of exactitude is not required, the burner blocks are to be so disposed and the skelp is to be so guided that the courses through which the skelp edges travel lie in or

closely adjacent these lanes. By proper adjustment of the factors of rate of movement of the skelp, flame intensity and distribution lengthwise of the skelp, and consumption of gases, the lateral edges of the still unbent, furnace heated skelp can be brought in a very short space of time to a condition in which there is superficial melting of the edge faces and a material softening of the metal below the faces, this softening being deep as compared with the superficial condition but involving only slight portions of the width of the strip so that the strength of the skelp necessary to withstand pulling through the die and to prevent caving is preserved. The edges are not melted down, however. It has been demonstrated that the form of the original edges, with the original corners at top and bottom, can be kept in the portions to be abutted together to form the weld.

Large amounts of hot unconsumed combustible gas pass out from the flame cones and these, gradually taking oxygen from the surrounding air, form an envelope flame of relatively low intensity but still of very useful heat value. The envelope gases are actively reducing in their nature, and in the highly heated condition to which the edges of the skelp are raised these gases combine swiftly with detrimental oxide present on the portions to be welded and completely deoxidize them. The hot products of combustion also pass across the upper and lower surfaces of the skelp, thus reducing conduction losses from the edges, without overheating the body of the skelp. As the skelp is gathered together and brought to the tubular form in its closer approach to the bell, where the weld is made at the bottom of the tube, much of the still unconsumed reducing gases are trapped inside the tube and deoxidize the bore.

While the reducing gases, additional quantities of which may be separately supplied if the main flames should be deficient in envelope, are doing their work of destroying oxide, the intense increment heating by the lines of flame cones acts to release any gases originally present in the skelp near the surfaces of the edges to be united. Thus gas pockets, which have been one cause of weak or defective welds in pipe, are eliminated.

In the particular burner the orifice face of which is shown in Fig. 6, there are forty-four small flame orifices arranged in pairs so as to cover the width of the edge face of the skelp without the necessity for closely confining the skelp vertically, the centers of the orifices being spaced apart vertically three-thirty-seconds of an inch, and in the direction of travel being spaced five-eighths of an inch, these figures being given by way of illustration of a practical construction. However, a single line of jets may be employed, the jets may be staggered at slightly higher and lower levels, or ribbon flames may be used.

The skelp is preferably heated in the furnace until its surface oxides show uniform fusion. The temperature to which the skelp is heated in the furnace before it is withdrawn is within the range known as white heat, but when the skelp edges pass the systems of oxy-hydrocarbon flame there is a noticeable change in the appearance of the edge regions. Narrow and rather sharply defined marginal bands of brillant white develop, causing the body of the skelp, by contrast, to appear tinged with color. When these bright bands show no dark spots and are of a width on top, usually about an eight of an inch, which the welder quickly comes to recognize as proper, it is known that the conditions under which the operation is being performed will result in high grade welded pipe or tubing.

Provisions for increasing the heat efficiency of the burners and at the same time preventing inconvenience to the workers by spreading flame, and for guiding the skelp in definite relation to the lanes of intense heating, will now be described.

A retort guide **40** is secured to the base **32** and is provided with slotted passages between upper and lower portions of the retort through which the lateral portions of the skelp move. Except for these marginal portions the top of the skelp is left uncovered, and there is also space beneath it, for the passage of the tongs. The burner blocks **33** are entered within lateral chambers **41** of the retort and are secured in positions to direct their flame jets against the skelp edges. In the particular construction illustrated the retort comprises two transversely spaced retort bodies **42**.

Each retort body comprises upper and lower sections **43**, **44** hollowed to form the chamber **41** and formed with mating portions **45**, **46** at the front and rear ends. Shims **47**, **48** are preferably interposed between these mating portions to establish the proper vertical distance between the surfaces **49**, **50** of the retort sections which overlap the upper and under surfaces of the margin of the skelp. It is intended that the vertical dimensions of these skelp passages be such as to permit free movement of the skelp and to make it fairly straight, without undue resistance, if it is more or less undulatory. Guidance of the skelp in the lateral sense is even more important, and in a drawbench operation this guidance is particularly useful at the entrance to the region of edge treatment, or before that region is reached by the successive cross-sections of the skelp. The forward shims **47** of the two retort bodies may be made to serve as these edge guides. The rear shims **48** may also guide the edges, but it is not necessary that they do so. The shims acting as edge guides may be made of, or plated at their edges with, copper or other metal which will not tend to stick to, or be readily worn by, the edges of the hot skelp drawn from the furnace. Too close lateral confinement of the edges of the skelp is not permissible, but I have ascertained that a total lateral clearance may be given which will be ample to allow for variations in the skelp and for practical operation and still keep the skelp edges suitably spaced from the orifice faces of the burner blocks **33**.

In Fig. 4 it will be observed that these burner blocks are set back with relation to the ends of the shims **47** which laterally guide or restrain the skelp. The positions of the burner blocks with respect to the edge guides is a matter of importance, and for that reason the burner blocks are provided with slotted ears **51** through which clamping screws **52** pass into bosses on the lower retort sections, on which the burners are supported and trued. The slots in the ears extending transversely to the length of the burner blocks make it possible to set the burners at the precise position of retreat with respect to the edge guides which is desirable under particular conditions.

The upper and lower sections of each retort body, together with the shims or guides, are clamped together by screws **53**. Other screws **54** may secure the retort bodies to the base. For a given width of skelp and given size of pipe it is

not necessary to vary the transverse distance between the edge guides or the two sides of the retort, but such adjustment may be provided for, either to take care of different pipe sizes, or to meet other conditions that may be encountered. For such purposes the mating portions of the retort bodies may be provided with slots **55** extending in the transverse direction, through which slots securing screws **54** are passed into the base.

The forward ends of the retort guide bodies, that is to say the ends nearest the furnace, are formed with flaring entrances **57** for the skelp.

In order to save the retort sections from injury by the excessively high temperature developed by the reaction of the fuel gas with oxygen, the sections are provided with cooling passages **71**, through which water is passed from and to pipes **58**. The retort may be made of cast-iron, but with bronze castings the water cooling is more effective and the retort is more durable. The burner blocks must also be provided with cooling passages **72** so that they may be sufficiently water cooled to save them from destruction. Pipes **73** conduct water to and from these passages.

The backs of the retort chambers **41** are open for the entrance of air, and there is sufficient space around the burner blocks in these chambers to permit the air to reach the envelope gases which are released from the flame cones, the temperature of which is on the order of upwards of 4000° to 6000° F. and which require the presence of air to burn their effluent in order that the main flames may continue to burn. It is sufficient to draw in this atmospheric air, but the air may be supplied under slight pressure. As previously explained, these reducing gases scavenge the skelp metal of oxide, by chemical rather than by blast action, and also convey heat to the body of the skelp so as to maintain the temperature of the body and keep down conduction losses from the edges. In order to apply the burning envelope gases more effectively, the surfaces **49**, **50** of the retort sections which overlap the lateral portions of the skelp may be grooved to provide channels **60** in line with the jet orifices **34**. The jet orifices and the channels may be perpendicular to the skelp edges, as shown in Fig. 4, or the forward and rearward groups of orifices and channels may be inclined against and with the direction of movement of the skelps, respectively, in order to elongate the distance over which the superheating and purifying is effected.

In the manufacture of steel pipe and tubing from skelp, the temperature to which the skelp should be heated in the furnace is on the order of 2400°–2500° F., this being subject to variation depending upon the nature of the steel or steel alloy and the judgment of the welder. While the object of this invention is not particularly to underheat the skelp in the furnace, since furnace heating is economical, it is an advantage that the welder does not have to try to decide from uncertain appearance of the skelp when it is in condition to make a fair weld, but can withdraw it at a condition which is definite to the eye and beyond which further changes are difficult to detect, knowing that a perfect weld will be made.

In wrought-iron pipe manufacture, the process has certain other special advantages. Wrought-iron, because of its slaggy composition, does not lend itself well to welding, and such welding pipe is tested by crushing rather than by the much more exacting expansion tests applied to steel pipe. The value of wrought-iron pipe is for services where resistance to corrosion is desired. Banes of the wrought iron pipe industry have been blistering and enameling. At a skelp heat in the furnace below that which has been necessary to make passable welds, wrought-iron skelp develops blisters, and it reacts with the pebble bottom of the furnace to form an "enameled" surface on the under side of the skelp, which becomes the inside surface of the pipe. This enamel practically defies any method of removal and makes it impossible to do any satisfactory job of galvanizing the bore of the pipe. To a lesser degree enameling has been a trouble also in the manufacture of steel pipe. With the process disclosed herein it is easy to heat the skelp to a temperature at which enameling or blistering do not occur, and then whip the edges of the skelp to a temperature and state which insure a vastly better product than was made before. For wrought-iron skelp it is desirable under this process to take the skelp from the furnace at a temperature between approximately 2200°–2400° F., to insure against blistering and enameling. It will be understood that temperatures for steel or wrought-iron pipe are given by way of illustration, since the compositions of materials are not fixed.

Steel pipe and tubing made by this invention show remarkable resistance of the weld under expansion tests. This test is made by driving tapered drifts or plugs into the ends of the cropped tubes. The break when it occurs with the product of this process may take place in the wall outside of the weld rather than in the plane of the weld, or it may strike back and forth across the weld. On the average, the welds withstand more than double the expansion that the welds of former products could resist. For "mechanical" tubing such strength is of signal importance. These tubes can be reduced by cold drawing to less than half the original size and bent to serve for practically any use in which mechanical strength is necessary.

These tubes will withstand twisting without weld failure even when twisted from ten to twenty complete turns, indicating a thoroughness of weld which is not attainable in the ordinary way. Under hydrostatic pressure tests, pipes made by the process, whether of steel or wrought-iron, withstand such internal pressure far in excess of pipe made by any comparable process.

Pipes made by this process are usually subjected to a hydrostatic test pressure at least twice the normal pressure used and will actually withstand without distress pressures five times the higher pressure test, permitting these pipes to be used for services which the ordinary pipe will not endure. Scrap losses and losses in "seconds" are reduced to a minimum or virtually eliminated.

Production runs indicate that as high as 98% perfect pipe may be made over a day's run while over an extended run the production will vary between 90% and 95%, showing a very marked increase over former methods.

Pipe and tubing made by this process is generally smoother on the outer surface as the usual weld line is seldom visible and the inside surface has a much lighter or a loosely adhering scale which permits pickling for galvanizing or subsequent drawing or reworking operations to be ac-

complished in half an hour as compared with ten to twenty hours under the ordinary method of bell-welding. This is a very important feature where the total production must be pickled, as the equipment and space required is reduced to a minimum.

The lower temperature to which the skelp is heated and the protection of the skelp from atmospheric oxidation by the reducing gases bathing the entire surface during the passage from the furnace to bell, reduces or eliminates the weight losses common to the bell method of pipe production.

In actual operations a material saving in weight of material usually lost has been realized. The benefit to the workers is evidenced by the fact that face shields and other shields to protect them from hot flying slag and oxide have been discarded.

The invention has been described in connection with bell-welding because the bell-weld practice is so familiar and so large a proportion of welded pipe has been made in that manner. The invention is quite applicable, however, in connection with idle forming and welding rolls used as rotating dies instead of the bell die, or in connection with driven rolls for driving, forming and welding the skelp without a drawbench.

I claim:

1. The process of manufacturing high-grade butt-welded tubing from strip material, which comprises heating the flat strip to a high temperature, then causing the edges of the heated strip to pass rapidly and uninterruptedly through spaced lanes of intense heating where flames of oxygen and fuel gas are directed against the faces of the strip edges, while also subjecting the edges to the action of hot reducing gases, whereby the lateral edges of the strip are brought to surface fusion of the metal and are rendered plastic and are simultaneously purified of oxide and freed of occluded gases, and immediately after the edges reach such condition bending the traveling strip into tubular form and bringing together the thus prepared edges.

2. The process of manufacturing tubing which consists in heating flat strip material to a white heat in a furnace, passing the strip from the furnace to bending and welding steps performed upon the strip in transit, previously establishing narrow longitudinal lanes of intense heating by flames having a temperature approximately twice the temperature of the strip as it leaves the furnace and extending between the furnace and the region where the strip is bent and welded, and guiding the edges of the hot strip so that they follow said lanes.

3. In the manufacture of butt-welded tubing by passing the furnace-heated skelp through forming and welding means, the process which comprises applying directly to the edge faces of the heated skelp, between the furnace and the forming and welding means, the radiant and conveyed heat of extensive systems of oxygen and hydrocarbon flame capable of quickly melting away the hot metal, but so correlating the heating by these flames with the speed of travel of the skelp that the skelp edges remain intact and are made ready to be strongly welded.

4. The process of manufacturing substantially seamless tubing with the skelp-heating furnace, forming and welding die and drawbench, which consists in heating the skelp in the furnace, drawing the skelp through the die, guiding the edges of the skelp in passage from the furnace to the die, and subjecting the faces of the guided skelp edges between the furnace and die to the close application of distributed flame having a temperature above 4000° F., after which the skelp is bent and welded in the die.

5. The process of manufacturing tubing, which comprises heating skelp in a furnace before said skelp is bent to tubular form, drawing the heated skelp through a welding bell to form said skelp into a tube and bring the seam edges together, previously establishing narrow parallel lanes of intense heating by oxygen and hydrocarbon flame, extending between the furnace and the bell, and guiding the edges of the skelp at the entrance to said lanes to control the spacing of the faces of the skelp edges from said lanes of flame.

6. The process of manufacturing butt-welded tubing, which comprises heating skelp in a furnace before bending said skelp to tubular form, quickly passing the heated skelp from the furnace to forming and welding operations, subjecting the faces of the skelp edges upon leaving the furnace and for a considerable distance to the intense heat of small cones of combustion of hydrocarbon premixed with oxygen, so correlating this heating with the speed of travel of the skelp that, whereas all the body of the skelp retains its strength, the edges are fused and rendered deeply plastic without loss of form, in preparation for the ensuing welding operation, and meanwhile purifying said edges and protecting them from oxidation.

7. In the manufacture of tubing, the process comprising heating skelp or strip in a furnace before said skelp or strip is bent to tubular form, passing the furnace-heated skelp to forming and welding operations, previously establishing lanes of oxygen-hydrocarbon mixture flames closely paralleling the paths of the skelp edges between the furnace and the regions of forming and welding, controlling the heating by these flames in relation to the speed of travel of the skelp so that the faces of the skelp edges are highly superheated without loss or injury of metal, confining said flames and the envelope gases liberated thereby, admitting air to the region of confinement to burn partially the envelope gases, and discharging the hot products of combustion including reducing gases over the surfaces of the skelp.

8. The process of manufacturing tubing which comprises heating skelp in a furnace before bending said skelp to tubular form, drawing the hot skelp from the furnace, bending it downwardly to tubular form and forcing the edges together at the bottom of the tube to weld the edges, superheating the skelp edge faces by flames of oxygen and hydrocarbon in the passage from the furnace to the welding region, simultaneously bathing said edges in reducing gases, discharging reducing gases beneath the skelp and trapping these gases in the tubing as it is formed.

9. The process of manufacturing tubing in which skelp is heated in a furnace before said skelp is bent to tubular form, the heated skelp is withdrawn from the furnace, and the edge faces of the skelp subjected to alternating intense heating and reducing actions until said edge faces are brought to the temperature of fusion and are purified, and thereupon the skelp is progressively forced into tubular form and the fused and deeply plastic edges are pressed together.

10. In the manufacture of tubing, the method of preparing the edges of skelp for welding which comprises applying oxygen-fuel flames directly

to the edge faces of the skelp while the latter is in steady motion and before it is formed into a tube, closely confining the combustible gases issuing from said flames while admitting additional combustion-supporting gas to the region of confinement so that the flame combustion is retained and concentrated at the edges of the skelp, and delivering the hot products of combustion over the surfaces of the skelp.

11. The method of making welded pipe and tubing from flat furnace-heated skelp, which method comprises drawing the skelp from the furnace past lanes of high-temperature oxy-fuel gas flames, pointing the flames directly against the edge faces of the skelp while moving the skelp ahead with continuous motion and guiding it at the region of said flames to maintain the edges in a substantially constant relation to the lanes of flame throughout the length of said lanes, forming the skelp and bringing the edge faces together immediately after they move beyond the lanes of oxy-fuel gas flames and the reducing atmosphere afforded by the envelope gases from said flames, and before the edges at their high temperature have been exposed for any substantial time to oxidation by the air.

12. In the manufacture of welded pipe and tubing from furnace-heated skelp, the method comprising passing the skelp between lanes of high-temperature flame, aimed directly at the surfaces of the edge faces, as the skelp comes from the furnace, to increase the temperature of the edge faces and the adjacent metal, guiding the edges in the region of the flames to prevent waving or lateral displacement of the edges while passing said lanes of flame, confining the envelope gases or products of combustion from the flames in the region of the skelp edges to increase the heating effect of the flames and to protect the highly heated edges from the oxidizing action of the air, forming the skelp and bringing the edge faces together immediately after said edges pass beyond the lanes of high-temperature flame.

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