

E. E. RIES.
 METHOD OF AND MEANS FOR MANUFACTURING METAL PIPE AND TUBING.
 APPLICATION FILED NOV. 30, 1908.

1,093,010.

Patented Apr. 14, 1914.

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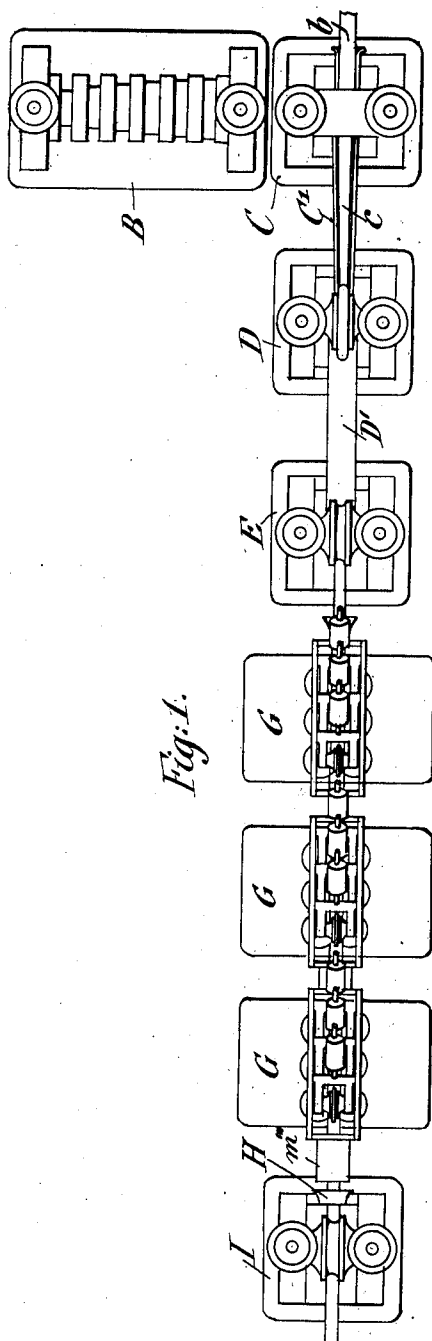


Fig. 1.

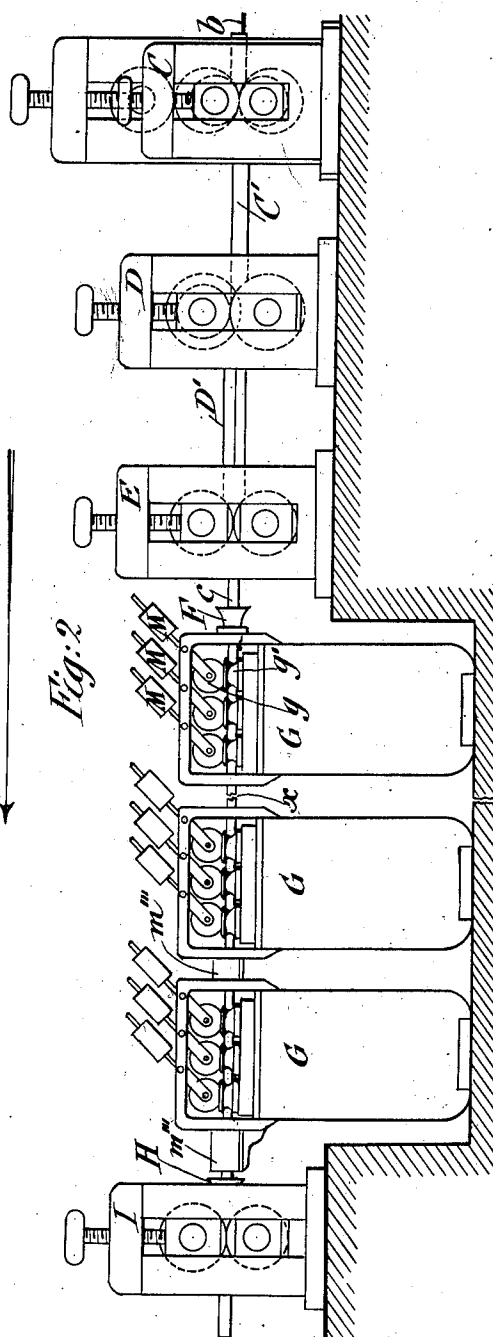


Fig. 2.

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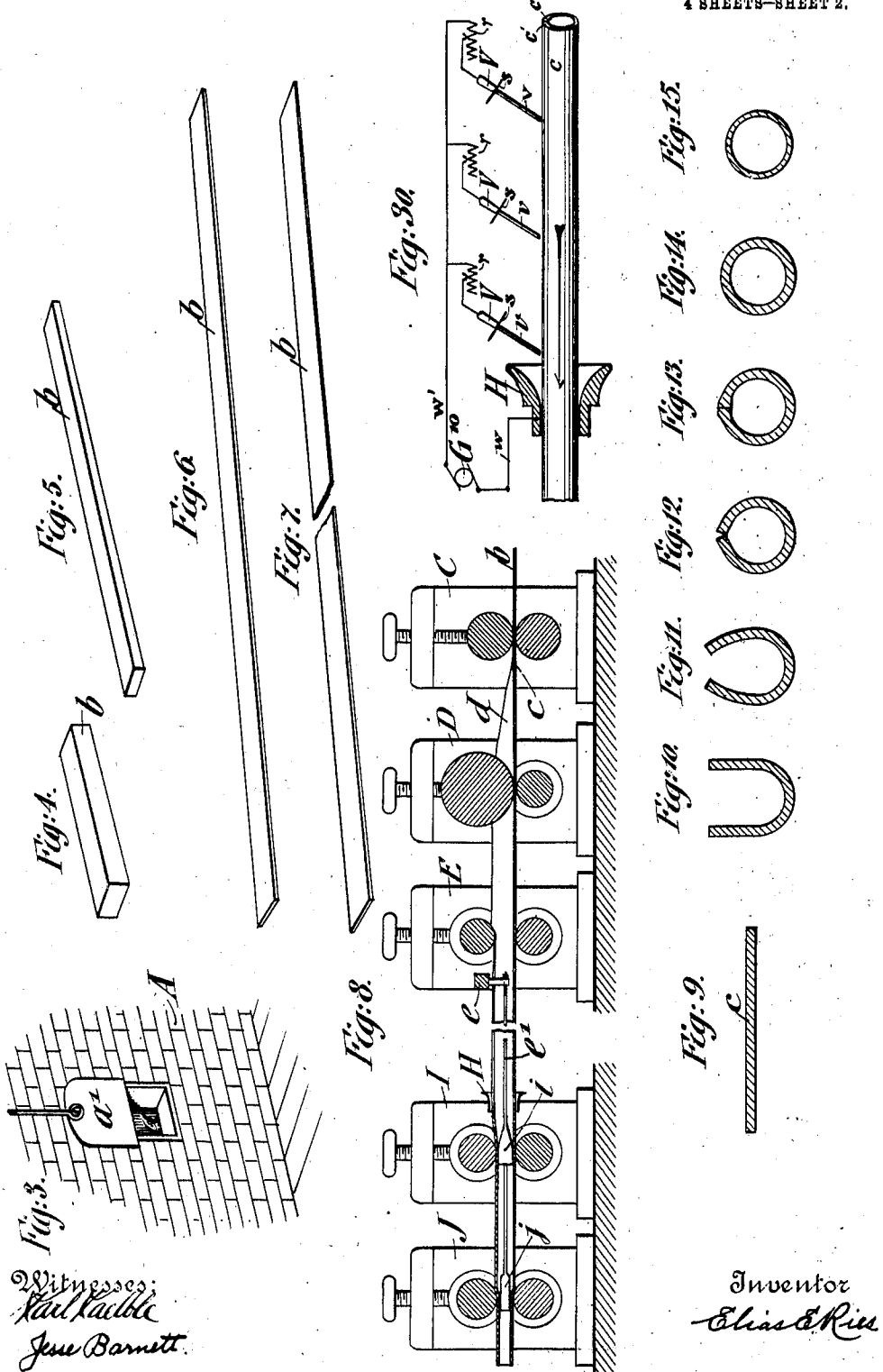
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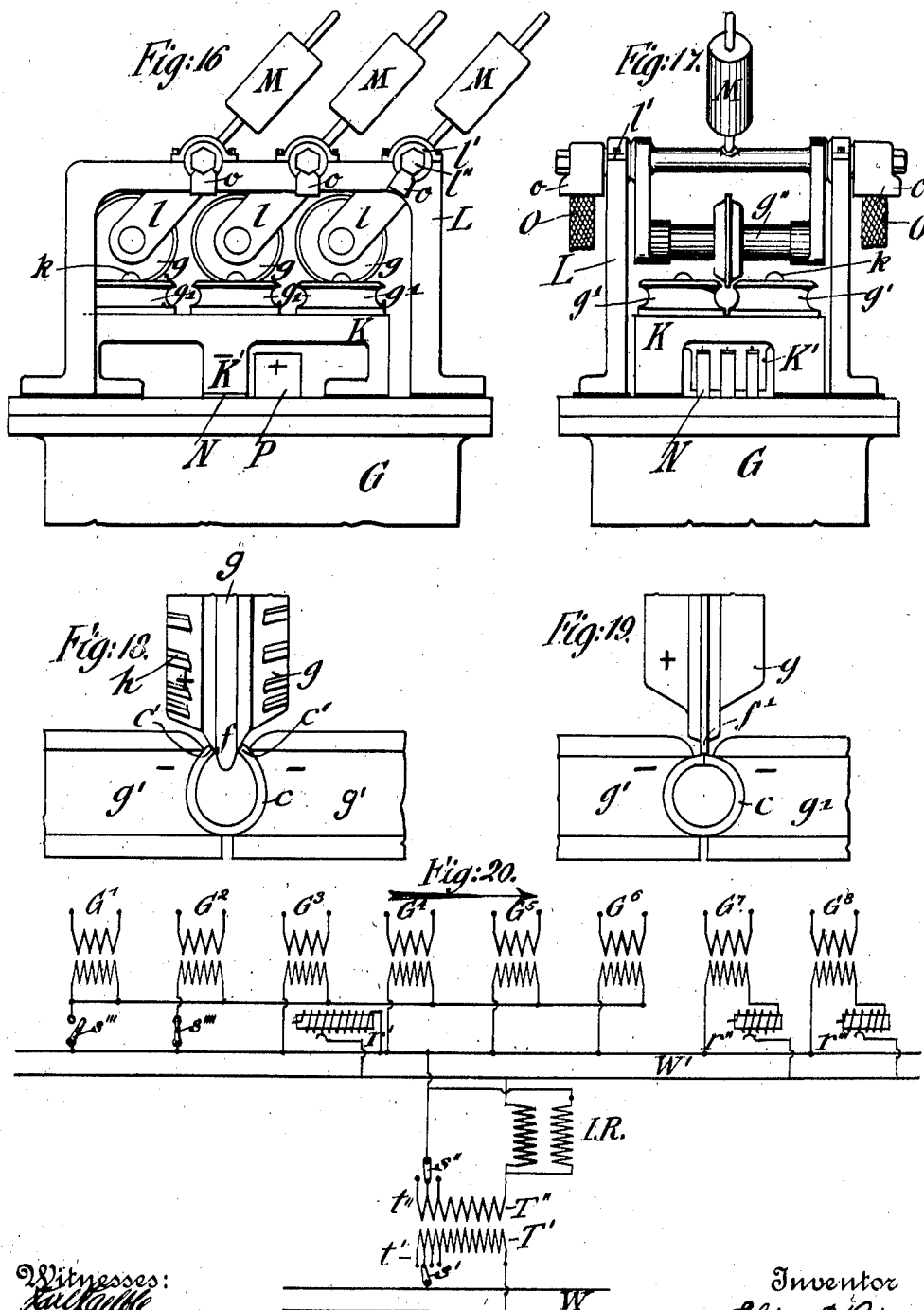
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4 SHEETS—SHEET 2.

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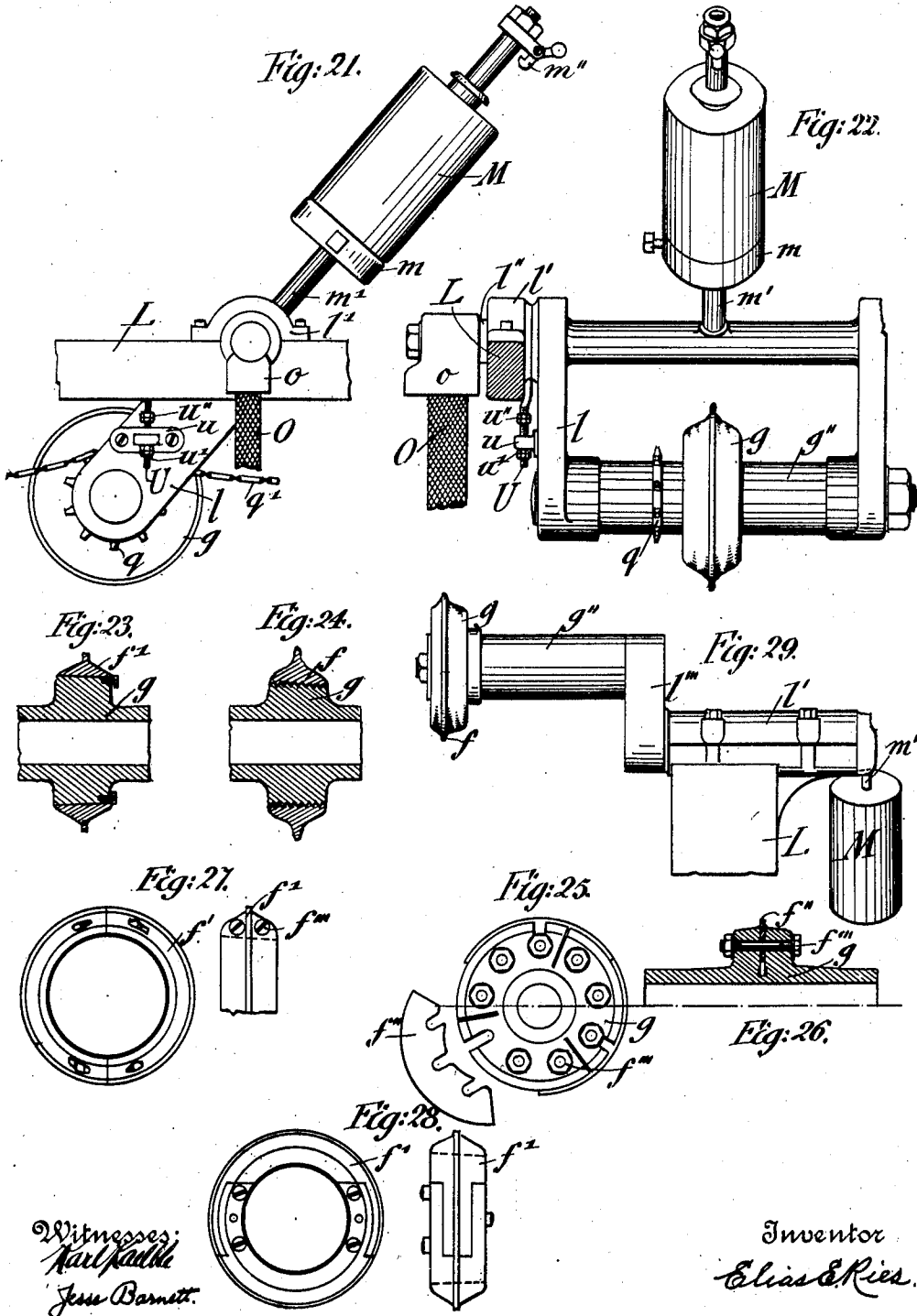
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4 SHEETS-SHEET 4.

1,093,010.



UNITED STATES PATENT OFFICE.

ELIAS E. RIES, OF NEW YORK, N. Y.

METHOD OF AND MEANS FOR MANUFACTURING METAL PIPE AND TUBING.

1,093,010.

Specification of Letters Patent.

Patented Apr. 14, 1914.

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To all whom it may concern:

Be it known that I, ELIAS E. RIES, a citizen of the United States, and a resident of the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Methods of and Means for Manufacturing Metal Pipe and Tubing, of which the following is a specification.

My invention, broadly speaking, relates to certain novel and valuable improvements having for their principal object the manufacture of welded or seamless metal pipe and tubing directly from the heated billet or pile and preferably in one continuous operation, so as to form a completely finished and substantially seamless pipe or tube at a single heat.

Prior to my invention it has not been found practicable to make either welded or seamless drawn tubing directly from the billet at a single heat or in one continuous operation, although it has been generally recognized that such a process would be productive of great economies in the consumption of fuel, time and labor, as well as possessing many other advantages.

In the case of weldless or seamless drawn tubing, whatever the particular process used, the stock from which the tubing is made must undergo several separate reheating operations in annealing furnaces, in order to render the metal sufficiently soft and ductile to permit it to withstand the successive drawing operations to which it is subjected before a tube of the desired finished size or diameter can be produced. This entails not only the initial heating of the billet, but also the aggregate consumption of an enormous additional amount of heat, since the entire mass of metal must be several times raised from a cold state to a red heat, which latter is again lost by being allowed to slowly dissipate during each annealing process before the partly finished tube stock is ready for further reduction.

As only a small portion of the total heat developed in the furnaces is effectively utilized in heating the metal, and since the heat actually imparted to the metal itself is only indirectly useful in its further manipulation, it follows that not only is a large proportion of this heat lost, but that this process also consumes a considerable amount of time for the successive reheating or an-

nealing operations, to say nothing of the heavy extra cost for labor, etc., incident to the frequent handling of the metal. These losses will be apparent when it is stated that in the ordinary manufacture of seamless "cold drawn" tubing, from two to twelve successive passes over the cold draw bench are required, according to the size and gage of the tube, and that between each of these passes it is necessary to anneal, pickle and lubricate the tube to render it soft, free from scale and ductile. It will thus be seen that the total cost of production of seamless tubes of this character is very great.

In the case of longitudinally seamed or "hot-welded" tubing, as generally made, the same wasteful conditions as to repeated heating and handling of the stock from which the tube or pipe is produced likewise prevail, although to a more limited extent than in the case of drawn tubing. The usual method of manufacturing welded tubing, whether the seam is "lapped" or "butt" welded, consists in first heating the "pile" or "billet" in a suitable furnace to a brilliant yellow or white heat, and then forming it into "skelp," i. e., a long, flat web, strip or plate, by feeding it in rapid succession through the several passes of a rolling mill while the metal is still sufficiently incandescent to permit of its proper reduction into a skelp having the requisite gage and width necessary to permit of its subsequent manufacture into a pipe or tube of the desired thickness and diameter. By the time the billet or pile has been rolled into skelp, the metal although still at a bright red heat, is no longer at a sufficiently high temperature to enable it to be welded. Consequently, the skelp or web is allowed to cool, usually after being first cut into a number of sections of a length suitable for shipment, if the skelp is to be marketed as such, or for the purpose of permitting the skelp lengths to be subsequently fed into another furnace in which the manufactured skelp is again heated to incandescence. The incandescent skelp is then taken out and passed through bending rolls which either form it into a tube that is drawn directly through a welding bell or die if the skelp is to be "butt-welded," or which, if the skelp is to be "lap-welded," form it into a partially rounded and lapped over shape, after

which these tubular shaped lengths are once more fed into a furnace, in which they are subjected to a still higher temperature which heats them to the welding point.

5 Sometimes, in the case of heavy pipe, the skelp retains enough of its original heat to permit of its being roughly rounded into approximately tubular or U shape during its final pass through the rolling mill, before

10 it is again fed into the reheating furnace preparatory to its being raised therein to the necessary welding temperature. From this furnace the highly heated tubular skelp lengths are taken out one at a time and

15 finally passed through suitable welding rolls or dies within which is contained a ball or mandrel corresponding in size to the inside diameter of the tube to be formed, and by which the meeting edges of the heated skelp are forcibly brought together and welded.

20 It will thus also be seen that in the manufacture of hot-welded pipe as heretofore practised a number of separate time-consuming operations are necessary and furthermore that a considerable amount of heat is

25 lost in repeated reheating of the skelp, inasmuch as under all of the methods thus far described, not only the edges to be welded, but the entire skelp, must be heated.

30 The process of reheating the rolled skelp by means of furnaces in the manner described, for bending and welding respectively, has the further disadvantage that it leaves both the inner and outer surfaces of

35 the pipe or tube rough and pitted, and the joint itself covered with scale and oxid, so that it has also been found impracticable heretofore to manufacture smoothly finished or high grade pipe or tubing from skelp by

40 these methods. Moreover, it has been found impracticable to produce commercial iron pipe or tubing in this manner from skelp having a thickness of less than approximately

45 one-eighth or three thirty-seconds of an inch, for the reason that skelp of a lighter gage, unless it be dangerously overheated, would not ordinarily retain a sufficient

50 amount of the heat long enough during its passage from the reheating furnace to the welding rolls to permit of welding the edges together. For this reason, certain classes

55 of tube and pipe welded by the methods described and intended for purposes not requiring a high structural strength, must nevertheless have walls considerably thicker

60 than are essential either for brazing or threading purposes, or for withstanding the external or internal pressure if any, to which they are intended to be subjected, thus necessitating the use of a considerable extra

65 weight of metal that serves no useful purpose and thereby still further enhancing the cost of the finished product.

Various additional methods of tube manufacture have from time to time been tried

or proposed, having for their object the local application of heat to the meeting edges or edge portions of either hot or cold traveling tube skelp for the purpose of raising said edge portions to a welding temperature while the skelp was being delivered to or drawn through the welding rolls or dies. These methods generally contemplated the employment of an oil or gas flame, or a series of such flames, applied to the meeting edges of the traveling skelp at a point or points immediately in advance of the welding rolls or dies, the intensity of the flame being augmented, generally to a point or degree of heat greatly in excess of the actual welding temperature, by incorporating or combining therewith a flow of oxygen gas. The heat produced upon the moving skelp by a flame of this character, however, was not easily controlled and the speed of welding was very much curtailed, besides being liable to oxidize or burn the edges or to fuse them in spots, so that none of these proposed methods, so far as I am aware, have proved successful in practice. Furthermore, I have found that even where a number of such gas jets were projected against the edges of a hot tube skelp traveling at anything like the necessarily high rolling speed, a satisfactory weld could not be effected owing to the fact that the outer skin of the metal would fuse and run, and thus become burned or converted into slag before the heat projected by the flame or flames could penetrate sufficiently into the interior of the metal comprising the edges to be welded to insure a proper union of the same.

In a previous U. S. Patent, No. 611,222, granted me on September 20, 1898, I have shown and described, for the first time in this art, a method of and means for manufacturing metal tubing from a moving web or skelp, in which I employed the heating effect of an electric current or currents, both in the form of an electric arc applied to the meeting edges of the skelp, and in the form of electrical heat generated directly in the skelp itself or in the meeting edges thereof, by the passage of a suitable current or currents therethrough at or near the point at which the skelp enters the welding die or rolls, for the purpose of welding and uniting the same together. This latter method has since been successfully used in the production of electrically welded tubing formed from cold skelp, and is still being used for this purpose to a considerable extent. However, the speed of travel of the skelp under this method is necessarily restricted, owing not only to the danger of overheating the contact terminals by reason of the heavy current constantly passing through the same and by the heat developed at their point of contact with the skelp, but also, and more especially, because an appreciable length of

time is required for the current to act upon the metal in order to raise its temperature to the necessary welding heat at the point where the contact-terminals make electrical connection with the skelp, and to enable the heat developed in the metal to properly spread itself over the surfaces to be welded or united. Partly for this and for other reasons it has not hitherto been feasible to either materially increase the speed of the skelp, and consequently the speed of welding the seam, or to employ electric welding for uniting the edges of hot skelp, since in the latter case, owing to such limited speed of travel, the heat originally imparted to the skelp would become dissipated to a very large extent by radiation, convection, etc., before it could be welded.

By my novel process and apparatus herein described I am enabled to greatly increase the speed of the skelp to be welded, or in other words, the speed at which a longitudinal seam or weld of this character may be effected, and therefore to successfully produce electrically-welded pipe and tubing directly from the hot skelp as the latter, under its necessarily high rolling speed, issues from the planishing rolls constituting its final pass through the rolling mill, in the natural course of its manufacture from the heated billet or pile, and while the skelp is still at a bright-cherry or orange heat. I am further enabled by my improved process not alone to convert a heated billet or pile into a perfectly welded pipe or tube while still under its original furnace heat and in one continuous operation, but to do this at the necessarily high rate of travel which the heated metal must have in order to permit of its proper reduction in the several passes of the rolling mill. Furthermore, by means of my process and the apparatus employed by me in connection therewith, I am enabled to produce in this manner an electrically-welded pipe or tube of any desired gage and diameter and practically free from the scale and pitting so noticeable in ordinary hot-welded pipe produced from cold skelp that has been subjected to one or more reheating operations in a furnace or furnaces, and am also enabled, if desired, to subject the welded pipe or tube to a final reduction or finishing process immediately after its edges are united, while still under its original heat or a considerable part thereof and in the same single operation. In short, I am enabled by my invention to accomplish the hitherto unattainable metallurgical feat of producing a completely finished and substantially seamless pipe or tube of any desired size, which will compare favorably both as to appearance and strength with high-grade cold drawn tubing, directly from the heated billet as it comes from the furnace, under its initial heat, in one continuous operation,

without waste of time or material, and with practically but a single handling of the metal.

My invention consists, generally speaking, in reducing the heated billet or pile, after being taken from the heating furnace, into a skelp of the width and gage necessary to form the desired pipe or tube, by feeding it through the successive passes of a suitable rolling mill; in bending the hot skelp as it emerges from the final pass of the rolling mill into approximately tubular form by feeding it through suitable bending rolls; by restoring to the edges of the tubular skelp as it emerges from the bending rolls, at a number of separate points along the line of its travel, a portion of the heat that has been lost by conduction, radiation and convection in the course of its passage through the reducing and bending rolls, in such a manner as to gradually raise the meeting edges of the traveling skelp to the requisite welding temperature, and in then bringing the heated edges together under pressure so as to form a welded joint or seam, which may furthermore, if desired, be drawn down while the welded skelp is still hot, and in the same operation, so as to produce a smoothly finished and practically seamless pipe or tube of uniform gage.

My invention further consists in the employment of means, substantially such as hereinafter described and shown, for carrying out the process just described, and especially for applying to the traveling skelp, or developing in the edges thereof to be welded, the necessary heat energy to cause the same to coalesce and unite when finally brought together under pressure, in such a way as to avoid undue heating or burning of the metal and to prevent the incorporation of scale or oxid in the joint, and thereby insure the formation of a strong and homogeneous union of the metal.

It further consists in means for adapting the supplementary heat developed to the temperature and speed of travel of the heated skelp, and in certain novel methods of and means for conserving and economizing the heat initially residing in the skelp and for controlling and conserving the supplementary heat or heat energy imparted to it.

My invention further consists in the novel utilization of electrical energy as employed by me for the purpose of developing the supplementary heat in the traveling skelp or in the edges thereof, and in the novel apparatus and appliances I have devised for carrying the same into effect, as hereinafter shown and described, as well as in other details of construction and operation that will hereinafter be more fully set forth in the specification and pointed out in the claims.

In the accompanying drawings, forming a part of this specification, Figure 1 is a

plan view showing one arrangement of apparatus and appliances by which my improved method of pipe and tube manufacture may be practically carried out, and Fig. 2, a side elevation of the same. These figures illustrate, from right to left in the direction of the arrow, a three-high rolling mill containing the roughing rolls by which the heated billet or pile is reduced to skelp; a two-high "planishing" or "bull-head" roll adjacent thereto containing the final or finishing pass through which the heated skelp is fed after leaving the roughing mill; a two-high bending roll for bending the heated skelp into a substantially U-shape and for forcing it ahead on its further travel as fast as it is received from the planishing rolls; a second two-high roll in which the open skelp may be further closed into an approximately tubular form; a series of potential-reducing or "heating" transformers or equivalent apparatus for supplying the electrical energy preferably employed by me for the production of the requisite supplementary heat in the edges of the traveling skelp, including means for guiding the skelp and conducting the heating current into the same at a number of separately spaced points along its line of travel; suitable means, such as a bell, for receiving and further closing the tubular skelp after it has been thus reheated; and finally, a two-high welding roll containing a mandrel, for welding the heated skelp edges together and for further forcing the completed tube along its way. Fig. 3 represents a furnace of the usual construction in which the iron or steel billet or pile, shown in Fig. 4, is heated, preparatory to being rolled into skelp. Figs. 5, 6 and 7 are perspective views showing the reduction and elongation that the highly heated billet undergoes in its transformation into tube skelp, at certain stages of its passage through the rolling mill. Fig. 8 is a sectional elevation, taken along the central line of the tube skelp, of some of the rolls shown in Fig. 2, parts of their housings being removed, showing the passage of the skelp therethrough and its formation into a finished tube, a supplemental two-high finishing and reducing roll being added to this equipment. Fig. 9 is a cross section of the skelp shown in Fig. 7, as it appears when it enters the tube forming apparatus, after leaving the planishing rolls, and Figs. 10 to 15 inclusive are cross sectional views of the same taken at various stages during its passage through the bending, heating and welding apparatus shown in Fig. 8. Fig. 16 is a side, and Fig. 17 an end elevation, of part of the casing of one of the several heating transformers showing the tube-guiding and contact-making rollers and their supporting framework and accessory

appliances, these being shown as mounted directly upon the cover of the transformer and suitably insulated therefrom, the projecting ends of the heavy copper secondary terminals of the transformer being likewise shown. Fig. 18 is an enlarged view of a portion of one set of contact rollers as arranged for heating the adjacent edges of an open or partially formed tube, such as illustrated in Fig. 11, while Fig. 19 is a similar view of three contact rollers as arranged for heating the abutting or adjacent edges of a closed or nearly closed tube, such as illustrated in Fig. 12. Fig. 20 is a diagram of the electrical apparatus and circuit arrangement preferably employed by me when the source of heating current or currents is derived from a high-tension alternating current generator located at a distance. This diagram represents eight separate heating transformers of a type shown in Fig. 2, fed from the high tension line through a suitable intermediate step-down transformer and also shows various current regulating and controlling devices whereby the degree of heat developed at various points along the rapidly moving skelp can be accurately and independently adjusted and controlled to suit the requirements of the work. Figs. 21 and 22 are enlarged side and end elevations, respectively, of one of the numerous weighted upper-contact rolls shown in Fig. 2, showing various details of construction. Fig. 23 is a section of a part of an upper-contact wheel provided with a removable contact-making tire or rim adapted to be pressed on to the hub or body portion, while Fig. 24 is a modification of this construction showing a rim and body portion provided with a taper thread. Figs. 25 and 26 represent side and cross sectional views of an upper-contact wheel of the type shown in Fig. 19, provided with removable and replaceable rim-sectors. Figs. 27 and 28 illustrate other modifications of removable rim contact-wheels. Fig. 29 is a side view of an improved form of upper-contact wheel and hanger construction, by means of which the wheel and its current-collecting hub may readily be bodily removed from its shaft. Fig. 30 is a diagram showing another type and arrangement of electrical apparatus by means of which my invention may be carried out. In this arrangement the heating appliances are shown as consisting of a plurality of independently controlled electric arcs, spaced at intervals along the tube skelp in tandem, each being designed and adapted to supply its due or proper proportion of the required total heat to the meeting edges of the rapidly moving skelp.

Referring to the drawings, A (Fig. 3,) represents the heating furnace, having an opening α and a door α' , that is charged in

the usual manner with a number of billets or piles, generally of iron or steel, which are therein heated to the requisite temperature for rolling into skelp. A heated billet as it appears when taken out of the furnace and also at various stages in the process of its reduction into skelp, is represented by the letter *b* in Figs. 4, 5, 6 and 7.

In Figs. 1, 2 and 8, B represents the rolling or reducing mill, C the bull-head or skelp-finishing mill, D and E the skelp bending rolls, F a guiding bell through which the bent skelp is fed into the several sets of current-conducting shoes or contact-rollers, each set consisting preferably of an upper contactor, *g*, that is in electrical connection with one pole of the heating circuit, and of two side-bearing contactors, *g' g'*, that are in electrical connection with the opposite pole of the heating circuit. G, G', are heating transformers whose secondary terminals are respectively connected with the contactors *g* and *g' g'* through the insulated roller-supporting framework mounted on the cover of the several transformers, the several sets of contactors pertaining to each transformer being preferably connected in parallel. H is another guiding bell having a tapering throat adapted to bring the highly heated edges of the partially open skelp toward each other or in contact so as to close the same into tubular form preparatory to welding the same together, which welding operation is effected by the welding rolls I, these latter preferably containing the mandrel *i* between the rolls thereof. The welded pipe may then, if desired, be passed directly from the welding rolls I into the finishing and reducing rolls J, containing the smaller mandrel *j*, the function of these last named rolls being to produce a higher grade of smoothly finished and practically seamless drawn tubing from the welded pipe. The manner in which these several sets of rolls are driven and how they operate upon the skelp will be presently described.

Figs. 16, 17, 21 and 22 show in detail the general construction and arrangement of the combined guiding and contact-making rollers that I prefer to employ for conveying the low-tension heating currents into the skelp, although it will be obvious that I may use various different types of contactors, or modifications of those shown herein, in the practice of my method. The side contact rolls *g' g'*, which also serve to guide the skelp, are shown mounted horizontally upon their supporting table K, being pivotally secured to vertical studs *k*, while the upper contact rolls *g* are shown mounted in hanger bearings *l* that are pivotally journaled in bearings *l'* arranged at intervals along their supporting frame L. The pressure exerted upon the skelp edges by these upper contact

rollers is rendered adjustable by means of sliding counter-weights M that rest against an adjustable collar *m* secured to the projecting arm *m'*. Any one or more of the upper contact rolls *g* may be instantly lifted from and maintained out of contact with the skelp by sliding its corresponding counter-weight M into engagement with a catch *m''* at the extremity of arm *m*, as shown in Figs. 21 and 22.

All the contact rollers and their conducting and supporting framework are preferably made of copper castings, suitably turned or finished at their various bearing surfaces, and of ample size to readily carry without undue heating the heavy electric currents employed. The copper table K, which I will term for the sake of uniformity the "negative" electrode (it being understood that when alternating currents are used it will alternately become positive, so that the terms negative and positive as herein spoken of are merely relative,) is provided with an integral depending slotted lug K' that engages directly with the slotted negative terminal N of the transformer G (Figs. 16 and 17). The copper supporting-frame L, constituting the "positive" electrode, is connected with the slotted positive electrode P of the transformer, either directly or by means of flexible conducting cables, O, connecting with socket-ears, *o*, mounted upon one or both of the extremities of the hanger bearing-shaft *l''*, so that the lower wheels *g'* are negative when the upper wheels *g* are positive, and vice versa, and are furthermore, in the particular arrangement now under consideration, in multiple arc relation to one another.

In Fig. 18 I have indicated the preferred shape of the upper and side rolls when the skelp, *c*, to be heated is partially open or slotted in form, in which case the upper rollers are provided with a wedge-shaped guiding flange or rim, *f*, having contact surfaces adapted to simultaneously make contact with the extreme edges of both lips of the skelp. These lips are made wide enough to leave a clear interval of skelp, having a certain electrical resistance between the line of contact of the center or upper rollers and that of the upper extremities of the two side rollers, respectively. In Fig. 19 I have illustrated the employment of an alternative or modified type of upper roller adapted to heat skelp having its edges in contact instead of open. It will be seen from Fig. 18 that when the approximately tubular skelp *c* is passed through the side contact rolls *g' g'*, and the upper contact roller *g* which is in connection with the positive terminal P of its transformer, is allowed to bear against the separated edges, *c' c'*, of the skelp, and if under these conditions current be passing in the secondary

circuit of the transformer, the positive current flowing from the upper roller will divide itself at these edges, one portion flowing by way of the right hand lip through and across the same to the right hand side contact roller g' , and the other portion flowing by way of the left hand lip through and across the same to the left hand side contact roller g' . From these side rollers the current reunites, passing through the copper table K and lug K' to the negative terminal N of its transformer C.

The flow of current into the skelp from each set of contact rollers, in the directions just described, will cause the projecting or overhanging lip portions of the skelp to heat up, owing to the internal resistance of these lips as compared with the low resistance of the copper contact rollers. Since the shortest paths for the current to follow is from the points of contact made with the skelp edges by the flange f of the roller g , across both lips of the bent skelp c to the upper portions of the side-rollers g' , g' , it follows that substantially only the exposed or projecting lip portions of the skelp c becomes thus heated by the current, since the lower body portion of the tube skelp is out of the direct path of the current.

From an inspection of Fig. 18, it will be obvious that the narrow projecting lip portions c' c' so heated by the current comprise but a very small part of the total amount of metal constituting the skelp c , so that only a minimum amount of electrical energy is required for raising the already glowing lip portions to the necessary welding temperature. Since the width of the projecting lips to be electrically heated does not vary to any considerable extent for different diameters of pipe, it will at once be apparent that by my process an enormous amount of heat energy is saved over existing methods which require the reheating of the entire mass of the skelp or plate in welding furnaces, usually from a cold state, and that this comparative saving of fuel is greater as the diameter of the tube or pipe of any given thickness of wall increases. It will moreover be observed that in the embodiment of my invention now referred to, which I have termed my "divided or three-pole contact method," the heat energy is developed internally of and within the metal itself, and is automatically localized and confined almost entirely to the overhanging lip portions only of the tubular skelp. In other words, no current can flow around the "shunt" formed by the body of the cylindrical tube as in former electric tube welding or seaming methods, nor is the heat developed initially upon the outer surface of the tube compelled to flow inwardly through the metal by thermal conduction in order to

penetrate to and reach the actual surfaces or meeting edges to be welded, as is likewise the case in such former methods, all of which for these reasons involve not only a considerable waste of electrical energy but necessitate either the undue heating and consequent burning of the outer surface of the tube or pipe, or a considerable reduction in the welding speed in order to permit of the gradual penetration of the heat to the joint proper,—a reduction that would preclude the employment of all former contact methods such as the well-known two-pole type, from welding a tube or pipe traveling at anything like the speed necessary for rolling or reducing a hot billet into skelp. Neither does this embodiment of my invention involve the projection of heat energy against the outer surface of the pipe as in the case of furnace and gas heating methods, both of which have been repeatedly tried out and found impracticable for this class of work. There being, as shown in the drawings, three sets of these contacts to each transformer, it follows that the traveling skelp edges are thus independently heated at three separate points in passing over each transformer, and that the total number of separate points at which the skelp may be heated depends only upon the number of active transformers, over which it passes, or rather upon the number of upper contact rollers that are at any given time included in circuit. By cutting out of circuit one or more transformers, or preferably, by lifting up certain of the upper contact rollers that are not required, different gages of tube skelp may be welded, or a given gage welded at a higher or lower speed, without change in equipment.

Referring now once more to the movement of the tube skelp as shown in Figs. 1, 2 and 8, and more especially in the latter figure, it will be apparent that since the hot skelp leaves the bull-head rolls C at a high rate of speed, ranging in practice from three hundred (300) to four hundred (400) feet or more per minute, the various bending, forming, heating, welding and finishing operations must follow each other in rapid succession without break or interruption. It will also be evident from this that the supplementary or auxiliary heating of the skelp edges at such speeds, for the purpose of raising them to the proper welding temperature, must be effected with great rapidity and accuracy. That is to say, the rate at which such supplementary heat is applied to or generated within the skelp, as contemplated by my invention,—owing to the exceedingly brief duration or effective time interval of contact between a given point of the skelp and the point of application or introduction of the heating current,—must

be accurately gaged and adjusted to these special conditions, in order to insure the development of sufficient heat within such limited time and also to avoid overheating of the metal due to variations in the initial temperature of the skelp at its point of delivery to the heating appliances, or to changes in its speed of travel. Furthermore, it is desirable and in some installations necessary to make additional provision to adjust the voltage and volume of the current to the different sizes and thicknesses of wall of pipe or tube to be manufactured in a given equipment, as well as the various reducing and rolling speeds to which different sizes of ingots or billets are subjected in converting these directly into welded pipe by this process.

In order that the method of feeding the skelp through the various rolls may be understood, it should be stated here that rolls C and D are power driven, the speed of D being such as to take up the skelp as fast as it emerges from C. A suitable guiding-die or shoe, C' (not shown in detail,) which may be of any well known or desirable construction, extends between the rolls C and D to partially bend and deliver the skelp into the rolls D, where it is bent into approximately U-shape, as already described. The cross section thus given to the hot skelp materially stiffens it, and enables the rolls D to drive it farther along its way. The rolls E, which bend the skelp into the proper shape to pass through the successive series of heating contact-rollers g, g', g'' , may also be power driven, or if preferred, a suitable guiding die or shoe may be substituted for these rolls, in which case the skelp is forced through the same as well as through the guide F by the frictional pressure imparted to it by rolls D. The bent skelp is then forced successively through the various sets of heating rollers, or if necessary, a supplemental driving roll may be interposed at any suitable point between heating transformers to assist in overcoming the frictional pressure of such rollers. The tube with its edge portions reheated, finally reaches the guiding and closing bell H, through which it enters the welding rolls I. These rolls are also power-driven, and serve to draw the end of the tube skelp without interruption in its speed through the heating rollers, etc., after such end has fully passed through the bending rolls D. The tube finishing and reducing rolls J are likewise power driven, at a speed slightly in excess of rolls I, depending upon the amount of reduction or elongation, if any, to be given the welded tube. It will thus be seen that the speed of all these rolls are adjusted to the requirements of the skelp at different stages of the operations

undergone by it. The driven shafts of these rolls may be suitably geared to a common driving shaft, or they may be independently driven, as desired.

In order to enable me to raise the temperature of the rapidly moving skelp edges to, or slightly above, the welding point, I make use as already stated of a plurality of heating contacts, that extend along the skelp in operative relation therewith in the direction of its line of travel. The number of such heating contacts will depend upon the speed of the skelp, the thickness and width of the lips to be heated; the amount of initial heat residing in the skelp, (if the skelp is to be operated upon while hot,) the amount or proportion of the total heat to be supplied by each contact, and upon other conditions. To take care of these various conditions, I have shown in Fig. 20, which is a diagram of the main and auxiliary circuits and the transforming, current regulating and heating apparatus or appliances, eight (8) separate heating transformers, denoted by G' to G^8 inclusive. These transformers are placed close together (as shown in Figs. 1 and 2,) so as to avoid unnecessary loss of heat by radiation, etc., from the heated skelp between its point of emergence from the bending rolls D, E, and its entrance into the welding rolls I. If each of these transformers be provided with three active heating contacts or sets of heating contacts, as illustrated, there will thus be a total of twenty-four (24) separate points, each spaced a short distance along the skelp from its neighbors, at which the skelp or its edge portions are or may be electrically heated.

Referring to Fig. 20, W represents a high tension alternating current transmission line, across which is placed the primary winding T' of an induction transformer, the secondary winding of which, T'' , is in connection with the distributing circuit, W' . A suitable induction regulator, I. R., is included between the two circuits for varying the intermediate voltage in circuit W' . In addition to regulators, I. R., additional means for varying the potential in the distributing circuit W' may be provided in the shape of primary and secondary taps t' and t'' , controlled by switches s' and s'' respectively. Further control of individual heating transformers is provided by the reactance regulator r', r'' and r''' , and also by the switches s''' and s'''' , which latter are designed for entirely cutting out certain of the transformers, as G' and G^2 , when the entire heating capacity of the plant is not required. In addition to this, any one or more of the individual contactors g may be lifted from the work, as previously explained, thus

affording a perfect adjustment or regulation of the auxiliary heat to suit various conditions.

Fig. 29 illustrates an improved form of upper contact wheel construction, employing a crank having a double contact surface and arranged to rock upon its bearings l' on a horizontal plane below that of the shaft for the contact wheel, g and adapted, through its frame L , to make direct connection with the positive terminal of the heating transformer. This arrangement likewise permits of removing and replacing the overhanging upper wheel, g , with its hub, g'' , without disturbing the electrical connection between its shaft and the transformer.

Figs. 23 to 28 inclusive illustrate various forms of upper contact wheels, g , provided with detachable or separate rims such as f , f' , f'' , etc., preferably for use in connection with the type of hanger frame shown in Fig. 22, in order to permit of replacing the rim when worn without removing the wheel g and its hub g'' from the frame L .

It will be understood that instead of employing the three-wheel type of contact terminals such as shown in Figs. 17, 18 and 19, as a means for supplying heating current to the moving skelp, I may use any other suitable or appropriate type or construction of contactors in practicing my improved method. For example, the two side rollers g' and g'' may themselves constitute the opposite poles or terminals of the heating circuit, and may serve both to guide and to heat the skelp, in lieu of the three-contact arrangement shown.

In Fig. 30 I have shown still another arrangement of heating appliances for practicing my invention. In this I employ a number of electrodes, v , in the form of electric arcs, arranged in tandem along the meeting edges of the tubular skelp, c . The current through these electrodes is independently adjustable by resistance r , and the skelp when properly heated is welded in its passage through the welding bell H , which constitutes the opposite terminal of the heating circuit of generator G^{10} . If these electrodes v are to be manually manipulated they may be provided with handles V and guards or shields s , although in practice it is preferable to have them mounted upon a common frame extending parallel with the traveling skelp and capable of a slight independent motion relative thereto. This frame is so arranged as to be reciprocated back and forth directly over the line of the joint to be heated by the series of arcs. The longitudinal movement of the frame carrying the electrodes, v , result in rhythmically varying the time during which a given length of the joint is subjected to the heating action of a given arc, or in other words, it introduces a variable time factor during

which the ordinarily concentrated heating effect of the arc upon the metal is alternately increased and diminished, according as the arc or series of arcs travel with or against the direction of travel of the skelp. By this novel method and arrangement of apparatus I am enabled to automatically "nurse" the heating effect of the arc upon the moving skelp edges. I thus avoid the scaling, overheating and "burning" of the traveling tube skelp, which has been found so ruinous with all other gas and flame heating methods known to me, by giving the heat an opportunity to spread and thoroughly penetrate into the metal between successive increments or surgings of heat produced by this combination of a progressive forward motion of the metal to be welded or united and a rhythmic reciprocating motion relative thereto of the electric arcs or other sources of concentrated heat.

In the actual operation and practice of my method and apparatus herein described, as applied by me to the manufacture of iron and steel pipe and tubing directly from the billet shown at b in Fig. 4 as it left the furnace A in Fig. 3 at a white heat and passed through the several reductions represented in Figs. 5, 6 and 7, and assumed the successive shapes in passing through the apparatus represented in the right hand portion of Fig. 8 that are shown in cross section in Figs. 9, 10 and 11, it was found that the amount of heat remaining in the skelp c (Fig. 9) after passing through the final bending rolls E (Fig. 8) by which it was given substantially the cross section shown in Fig. 11, prior to its entering the first of the series of electric contact wheels already described, was approximately 2100 to 2200 degrees Fahrenheit. This residual heat represented about four-fifths of the total heat required for welding, so that the supplemental heat which it was necessary to add and which was practically confined to the projecting edge portions of the tubular skelp, was only about one-fifth of the total. In other words, in order to weld the hot traveling skelp, the transformers were called upon to develop on said edges, in the aggregate, a temperature of but 500° to 550° F., at a skelp speed of about 6 feet per second, each transformer with its group of contact wheels contributing its pro-rata proportion of the total. It was furthermore found entirely practicable, with this equipment, to manufacture perfectly welded pipe from old rails or other high carbon steel, a metal that, owing to the small difference between its welding and fusing points, it had previously been found impossible to weld, although, it had been largely used in the manufacture of structural or "open-seam" tubing.

By my improved process and apparatus hereinbefore described, I have successfully

welded hot traveling skelp at rolling speeds up to 400 feet per minute and have produced perfectly welded and completely finished pipe and tubes of various diameters and thickness of wall, directly from the hot billet or pile, in one continuous operation, under the original heat of the billet supplemented by the electrical heat developed at the meeting edges of the traveling skelp, in continuous, unbroken lengths of about 60 feet each, the electric heating and welding of this length of seam being accomplished in the remarkably short time of 9 or 10 seconds. The pipe and tubes thus made were something over three times the length of the ordinary commercial pipe, and were completed, including the reduction, rolling, planishing, bending, shaping, welding, finishing and depositing of the entire tube upon the cooling floor, in less than 60 seconds from the time the billet was taken from the furnace. Moreover, owing to the fact that by this process the rolled metal is at no time subjected to a temperature more than a few degrees above the welding point, and this gradually by successive increments so that the edges are at their highest temperature only when they reach a point immediately in advance of and before entering the welding rolls, it follows that the weld is much superior and the pipe itself much smoother and more free from oxidation, scale, etc., than is found to be the case with ordinary hot welded pipe. Furthermore, I am enabled by my process to manufacture pipe of any desired length, (which may subsequently, if required, be cut or divided, without appreciable waste of metal,) limited only by the size of the ingot or billet and the speed with which the same is reduced to skelp that shall retain a sufficient degree of residual heat to permit of bending the same during the rolling operation into the necessary shape to be acted upon by the contact rollers or other electrodes that I may employ.

By the use of two sets of bending rolls as shown I gain not only added power to force the skelp forward through the series of side contact wheels, thereby avoiding the necessity of driving them separately, but also obtain a more perfect alinement of the open or separated edges of the tubular skelp so as to insure proper engagement therewith of the series of upper contact wheels or electrodes.

Although in the foregoing description I have more particularly set forth the application of my improved process to the manufacture of pipe and tubing directly from the hot billet or pile in a single operation, whereby I am enabled to economically utilize a large portion of the original heat of the billet and save considerable expense in time and labor, it is to be understood that I

do not necessarily limit or restrict myself to the making of such pipe or tubing directly from a hot billet or skelp, as it will be evident that certain novel features of my invention are equally well adapted to the production of electrically welded pipe and tubing from ordinary cold skelp, or from sheet metal plates such as are used in the manufacture of pipe or cylinders of comparatively large diameters. By the use of my multiple contact wheels or electrodes for this class of work, together with various other features of my invention, such tubes or cylinders can be welded at much higher speeds and with greater advantages and economy in the use of current than have heretofore been possible.

What I claim as my invention and desire to secure by Letters Patent, is—

1. The method of manufacturing pipes or tubing from metal skelp, which consists in bending the skelp into an approximately horse-shoe shaped form, heating the separated end portions thereof simultaneously at a plurality of points along the length of the bent skelp so as to raise said ends to welding temperature, and causing then said ends to coalesce and unite by bringing them together under pressure.

2. The method of manufacturing pipes or tubing from metal skelp, which consists in bending the skelp into an approximately horse-shoe shaped form, subjecting the separated end portions thereof simultaneously at a plurality of points along the length of the bent skelp to the heating effect of an electric current or currents so as to raise said ends to welding temperature, and causing then said ends to coalesce and unite by bringing them together under pressure.

3. The method of manufacturing pipes or tubing from metal skelp, which consists in bending the skelp into an approximately horse-shoe shaped form, heating those faces of the separated end portions thereof which are to be brought into contact simultaneously at a plurality of points along the length of the bent skelp so as to raise said ends to welding temperature, and causing then said ends to coalesce and unite by bringing them together under pressure.

4. The method of manufacturing pipes or tubing from metal skelp, which consists in bending the skelp into an approximately horse-shoe shaped form, subjecting those faces of the separated end portions thereof which are to be brought into contact simultaneously at a plurality of points along the length of the bent skelp to the heating effect of an electric current or currents so as to raise said ends to welding temperature, and causing then said ends to coalesce and unite by bringing them together under pressure.

5. The method of manufacturing metal pipes or tubing, which consists in heating a

billet or pile, reducing the same to form a skelp, bending the skelp into an approximately horse-shoe shaped form, heating the separated end portions thereof simultaneously at a plurality of points along the length of the bent skelp so as to raise said ends to welding temperature, and causing then said ends to coalesce and unite by bringing them together under pressure.

6. The method of manufacturing metal pipes or tubing, which consists in heating a billet or pile, reducing the same to form a skelp, bending the skelp into an approximately horse-shoe shaped form, subjecting the separated end portions thereof simultaneously at a plurality of points along the length of the bent skelp to the heating effect of an electric current or currents so as to raise said ends to welding temperature, and causing then said ends to coalesce and unite by bringing them together under pressure.

7. The method of manufacturing pipes or tubing from metal skelp, which consists in bending the skelp into an approximately horse-shoe shaped form, heating the separated end portions thereof simultaneously at a plurality of points along the length of the bent skelp so as to increase progressively the temperature of said ends to welding temperature, and causing then said ends to coalesce and unite by bringing them together under pressure.

8. In an apparatus for the manufacture of metal pipes or tubing from moving skelp, the combination with means for bending the skelp into an approximate horse-shoe shaped form, of a plurality of heating transformers, each transformer having one or more sets of contact terminals leading from the secondary or low tension side thereof to points on the moving skelp adjacent to the separated ends of said skelp and one or more contact terminals bridging over the gap between the ends of the skelp, whereby successive points along the said ends may be simultaneously included in the heating circuits of said transformers.

9. The method of making metal tubing, which consists in rolling a heated billet into a horse-shoe shaped skelp, and while said skelp is still hot from the rolling heat augmenting its residual heat by electrically raising the temperature of the separated ends thereof at a number of successive points along its length until said ends have reached welding heat, and then gradually forcing said ends into contact with each other to cause the same to coalesce and unite under pressure.

10. In an apparatus for making welded tubing, the combination with a rolling mill for rolling hot metal from a billet into a horse-shoe shaped skelp, electrical means for successively and progressively adding heat, and further heating the said already

heated skelp, means for causing the separated edges of said skelp to contact, means for welding together said edges, and means for drawing the finished tube from the welding means.

11. The method of manufacturing pipes or tubing from traveling metal skelp, which consists in bending the traveling skelp into an approximately horse-shoe shaped form, subjecting those edges of the end portions thereof which are to meet progressively and simultaneously to the heating action of an electric current or currents derived from one pole of a source of electric energy, the other pole of which is in electric connection with the skelp at both sides of and at short distances from said end portions, whereby the said end portions are progressively raised to welding heat, and then bringing the said heated portions together under pressure thus causing the same to coalesce and unite.

12. The art or process of forming welded tubing from hot traveling skelp, which consists in electrically generating or developing heat internally in the separated edges of the traveling skelp and then causing said ends to coalesce and unite by bringing them together under pressure.

13. The method of manufacturing welded pipe or tubing in one continuous operation directly from a heated ingot, pile or billet, which consists in feeding the hot ingot, pile or billet as it comes from the furnace directly through several passes of a suitable reducing, rolling and bending mill so as to convert the same into a horse-shoe shaped skelp at a speed that will cause it to issue from the bending rolls at a glowing heat, electrically heating the separated edge portions thereof simultaneously at a plurality of points along the length of the bent skelp, whereby the said separated edge portions of the skelp are subjected to the cumulative heating effect of electric current or currents at a plurality of points along the length of said skelp, gradually raising the temperature of the skelp edges under the influence of said heat currents by virtue of the internal resistance of the metal constituting said edges to a welding heat, and then bringing the said edges together under pressure to weld the same and form a completed tube.

14. In an apparatus for the manufacture of metal pipes or tubing from moving skelp, the combination with means for bending the skelp into an approximate horse-shoe shaped form, of a plurality of heating transformers, each transformer having one or more sets of contact terminals leading from the secondary or low tension side thereof to points on the moving skelp adjacent to the separated ends of said skelp and one or more contact terminals bridging over the gap between the ends of the skelp, whereby

successive points along the said ends may be simultaneously included in the heating circuits of said transformers, means for varying, at will, simultaneously the potential of a plurality of said transformers, and means for varying independently of each other the potential of one or more of the individual transformers.

15. That improvement in the art of forming welded tubing in a single continuous operation directly from a hot pile or billet which consists in rolling said hot pile or billet into tubular skelp while said skelp is hot, augmenting the residual heat in the newly formed hot tube skelp by electrically heating the edges of the skelp at a plurality of separated points in the length of the skelp in such a manner as to localize and confine the heating effect to said edges so as to raise the temperature of said edges gradually to the welding point, and welding said edges together.

16. That improvement in the art of forming welded tubing from metal skelp, which consists in bending the skelp into approximately tubular form, heating the edge portions thereof electrically at a plurality of separate points in the length of the skelp in such a manner as to localize and confine the heating effect to said edges so as to raise the temperature of said edges gradually to the welding point, and welding said edges together.

17. That improvement in the art of forming welded tubing in a single continuous operation directly from a hot pile or billet which consists in rolling said hot pile or billet into tubular skelp while said skelp is hot, augmenting the residual heat in the newly formed hot tube skelp by electrically heating the edges of the skelp at a plurality of separated points in the length of the skelp in such a manner as to raise the temperature of said edges gradually to the welding point, and welding said edges together, and varying, at will the number of separate points at which the edges of the skelp are heated, thereby augmenting the residual heat of the hot skelp by an amount approximately just sufficient to raise the edges to welding temperature.

18. That improvement in the art of forming welded tubing from metal skelp, which consists in bending the skelp into approximately horse-shoe shaped form, developing heat internally in the separated edge portions thereof electrically at a plurality of separate points in the length of the skelp in such a manner as to raise the temperature of said edges gradually to the welding point, and welding said edges together.

19. In an apparatus for the manufacture of metal pipes or tubing from moving skelp, the combination with means for bending the skelp into tubular form preparatory to butt

welding, the juxtaposed edges of the bent skelp corresponding in thickness substantially to that of the body thereof, of a plurality of heating transformers, each transformer having one or more sets of contact terminals leading from the secondary or low tension side thereof to points on the moving skelp adjacent to the juxtaposed edges thereof and one or more contact terminals in engagement with both edges of the skelp, whereby successive points along the said edges may be simultaneously included in the heating circuits of said transformers.

20. In an apparatus for the manufacture of metal pipes or tubing from moving skelp, the combination with means for bending the skelp into tubular form preparatory to butt welding, the juxtaposed edges of the bent skelp corresponding in thickness substantially to that of the body thereof, of a plurality of heating transformers, each transformer having one or more sets of contact terminals leading from the secondary or low tension side thereof to points on the moving skelp adjacent to the juxtaposed edges thereof and one or more contact terminals in engagement with both edges of the skelp, whereby successive points along the said edges may be simultaneously included in the heating circuits of said transformers, and means for varying, at will, simultaneously the potential of a plurality of said transformers.

21. In an apparatus for the manufacture of metal pipes or tubing from moving skelp, the combination with means for bending the skelp into tubular form preparatory to butt welding, the juxtaposed edges of the bent skelp corresponding in thickness substantially to that of the body thereof, of a plurality of heating transformers, each transformer having one or more sets of contact terminals leading from the secondary or low tension side thereof to points on the moving skelp adjacent to the juxtaposed edges thereof and one or more contact terminals in engagement with both edges of the skelp, whereby successive points along the said edges may be simultaneously included in the heating circuits of said transformers, means for varying, at will, simultaneously the potential of a plurality of said transformers, and means for varying independently of each other the potential of one or more of the individual transformers.

22. In an apparatus for the manufacture of metal pipes or tubing from moving skelp, the combination with means for bending the skelp into tubular form preparatory to butt welding, the juxtaposed edges of the bent skelp corresponding in thickness substantially to that of the body thereof, of a heating transformer having one or more sets of contact terminals leading from the

secondary or low tension side thereof to points on the moving skelp adjacent to the juxtaposed edges thereof and one or more contact terminals in engagement with both
5 edges of the skelp.

23. In an apparatus for electrically welding traveling tube skelp, the combination with a heating transformer, of two frames mounted thereon, each of said frames being
10 electrically connected with one of the low tension or secondary terminals of said transformer, side contact rollers mounted upon and electrically connected with one of
15 said frames, and a central contact pivotally mounted upon and in electric contact with the other one of said frames, said central contact being adapted to be shifted out of action.

24. In an apparatus for electrically welding traveling tube skelp, the combination
20 with a heating transformer, of two frames

mounted thereon, each of said frames being electrically connected with one of the low tension or secondary terminals of said transformer, side contact rollers mounted
25 upon and electrically connected with one of said frames, a central contact pivotally mounted upon and in electric contact with the other one of said frames, said central contact being adapted to be shifted out of
30 action, means for exerting pressure by said central contact upon the tube operated upon, and means for varying the pressure so exerted.

Signed at Harrisburg, in the county of Dauphin and State of Pennsylvania, this
25th day of November, A. D. 1908.

ELIAS E. RIES.

Witnesses:

WM. C. FRICK,
CHAS. E. CONNS.