No. 800,951. PATENTED OCT. 3, 1905.

D. M. SOMERS.

APPARATUS FOR FORMING THIN METALLIC PLATE.

APPLICATION FILED MAR. 24, 1904.

7 SHEETS—SHEET 1.

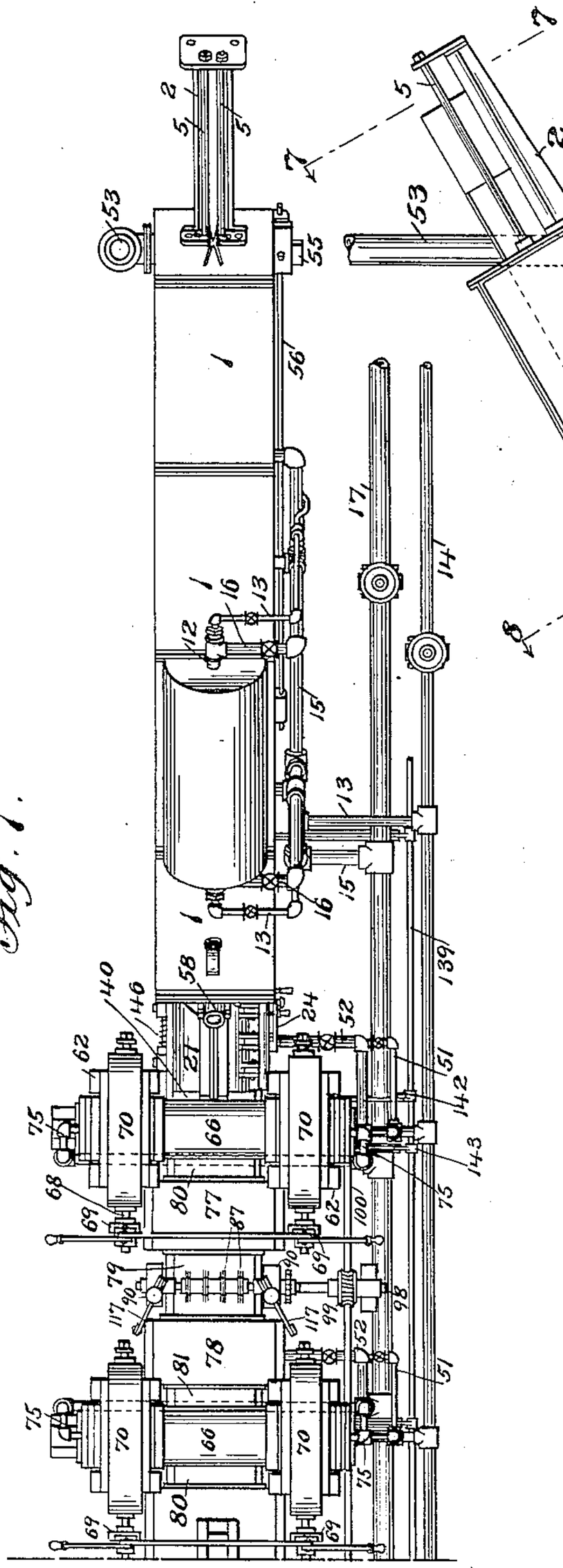

Fig. 1.

Fig. 2.

Witnesses
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H. Galiani.

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7 SHEETS—SHEET 2.

Fig. 3.

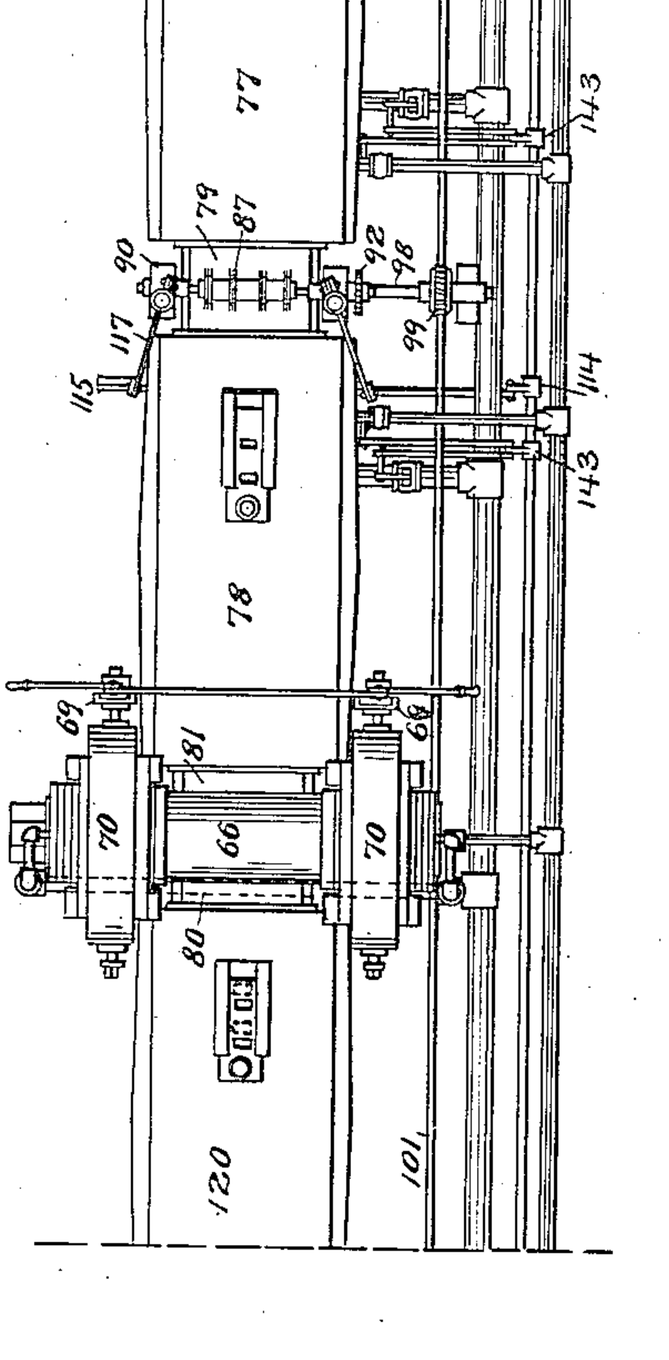
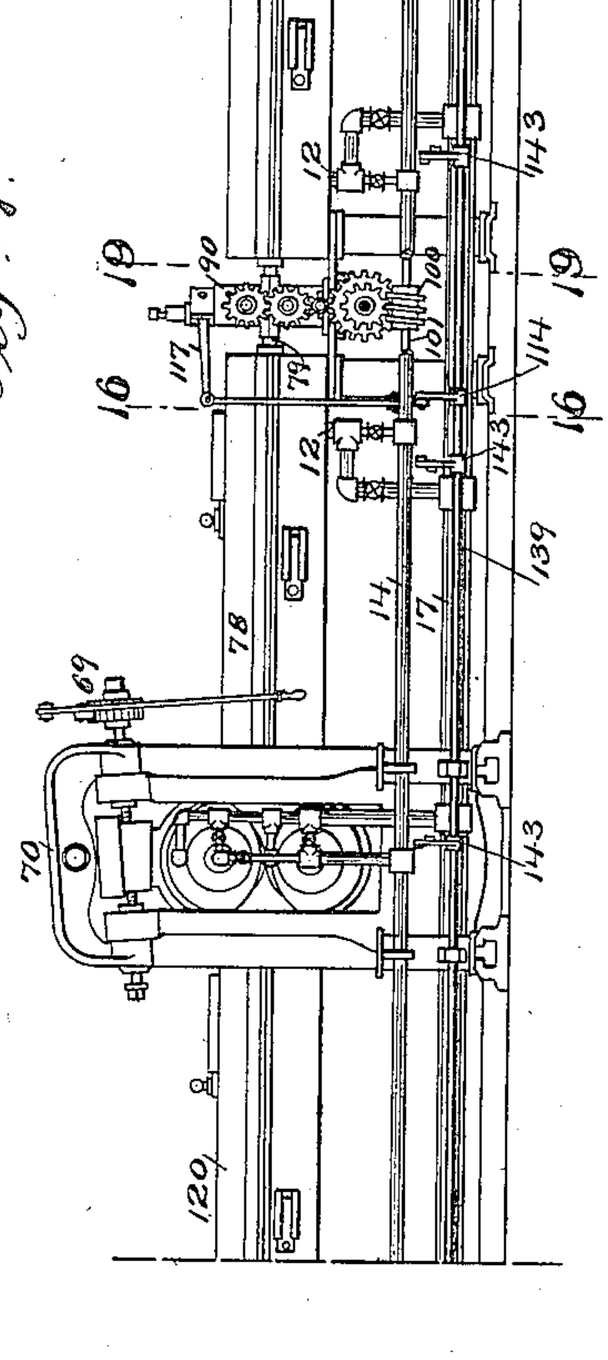


Fig. 4.



Witnesses
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7 SHEETS—SHEET 3.

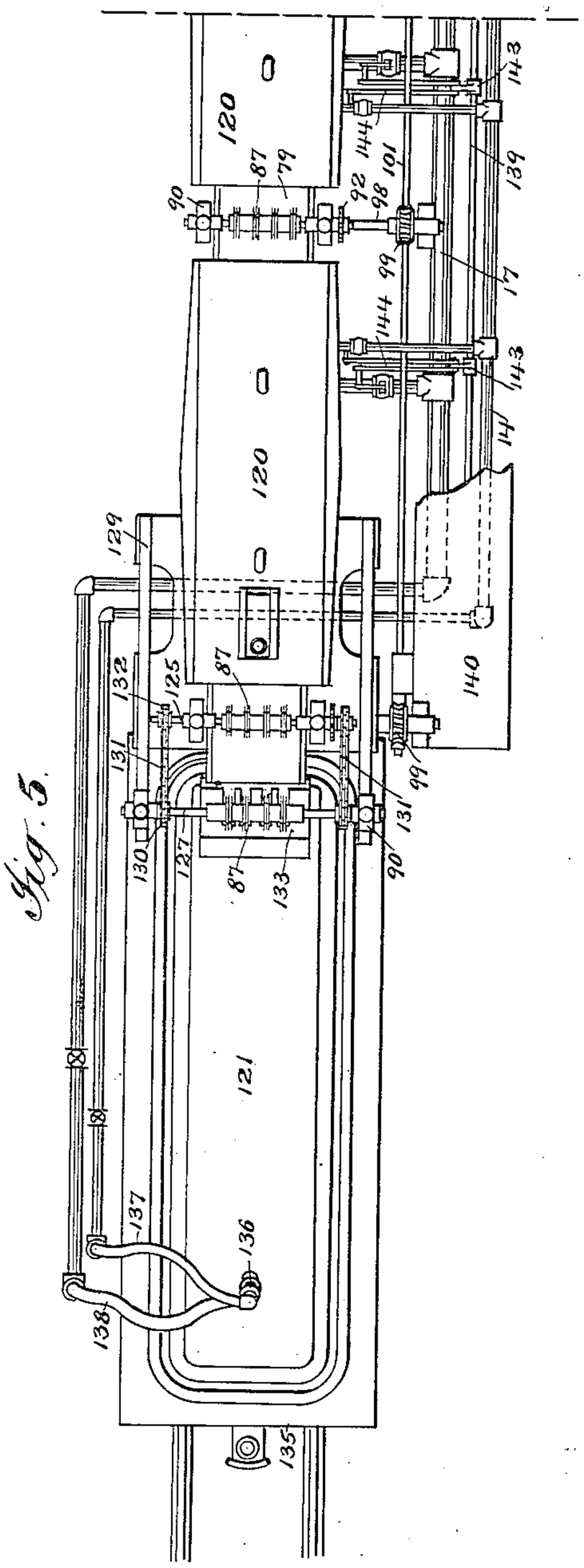

Fig. 5.

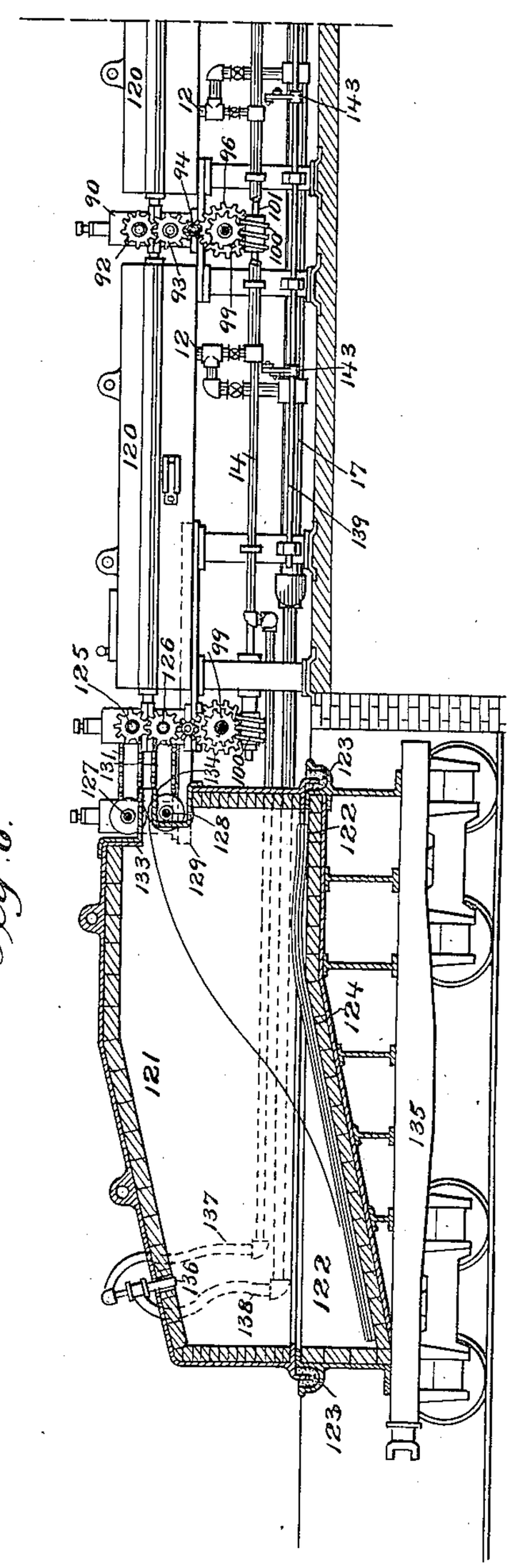

Fig. 6.

Witnesses
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7 SHEETS—SHEET 4.

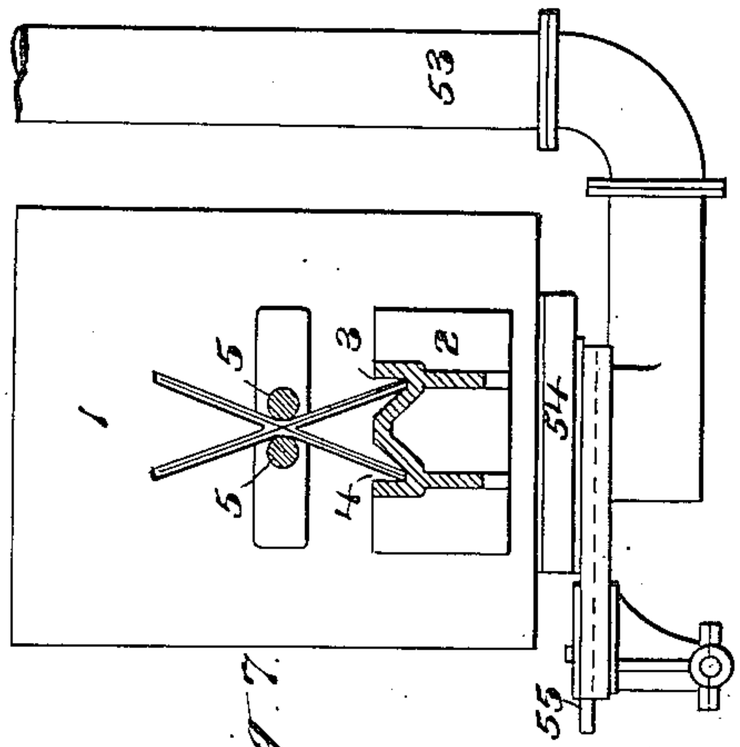

Fig. 7.

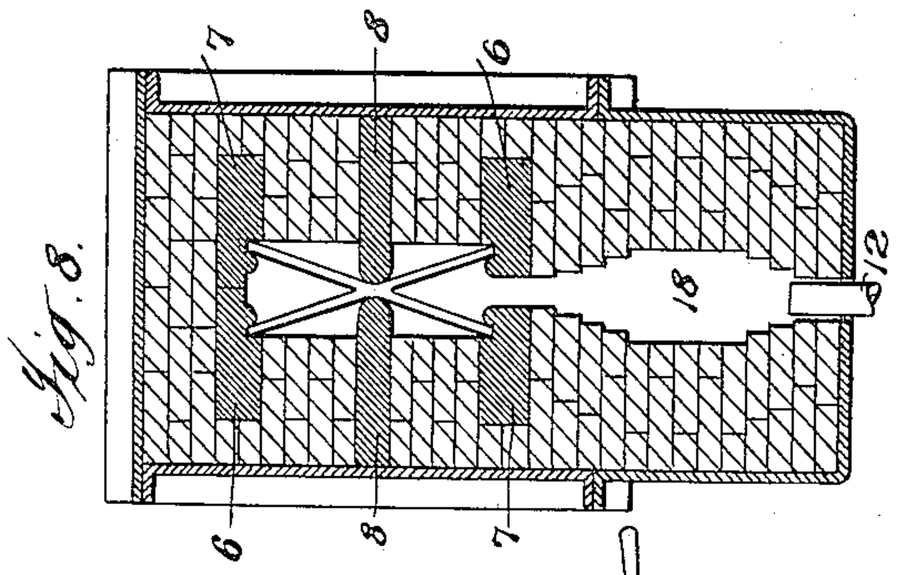

Fig. 8.

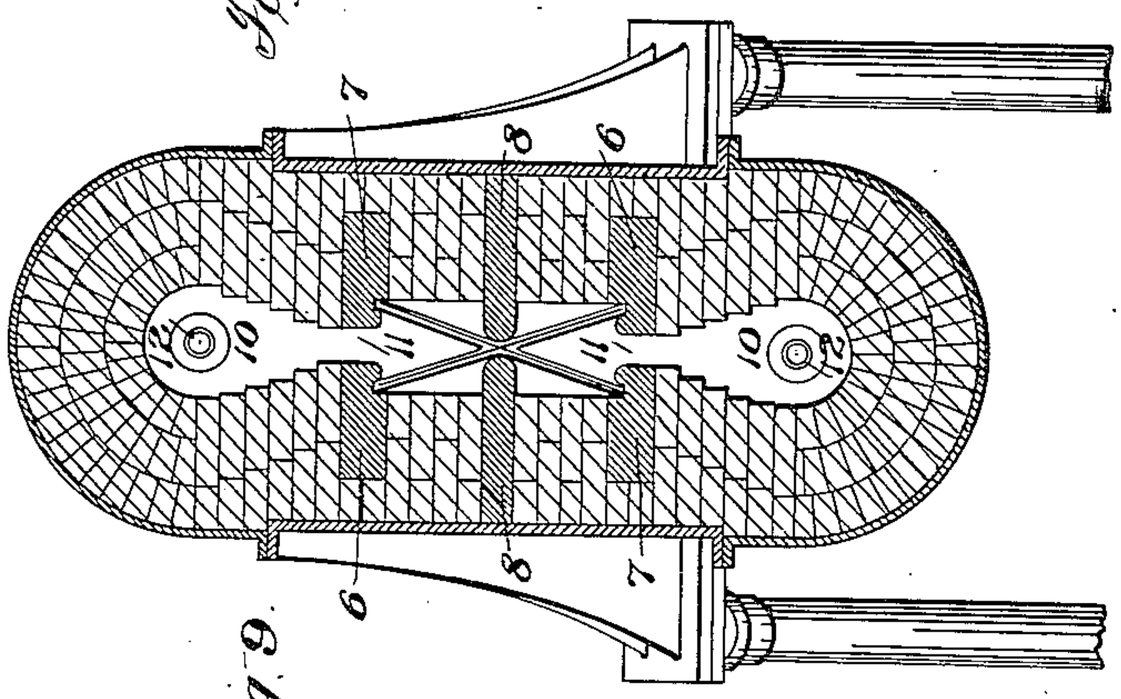

Fig. 9.

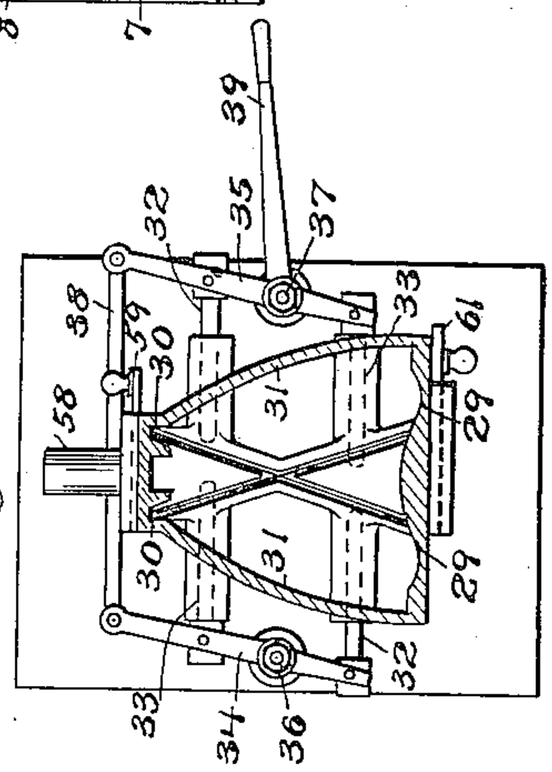

Fig. 11.

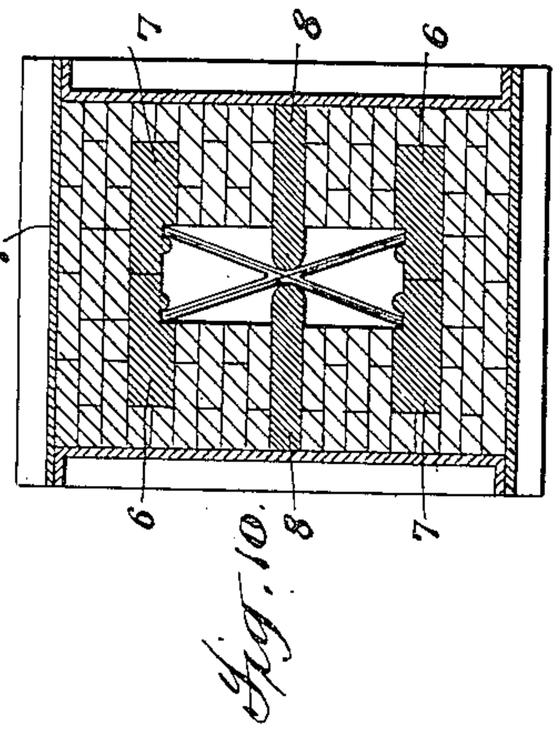

Fig. 10.

Witnesses
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7 SHEETS—SHEET 5.

Fig. 12.

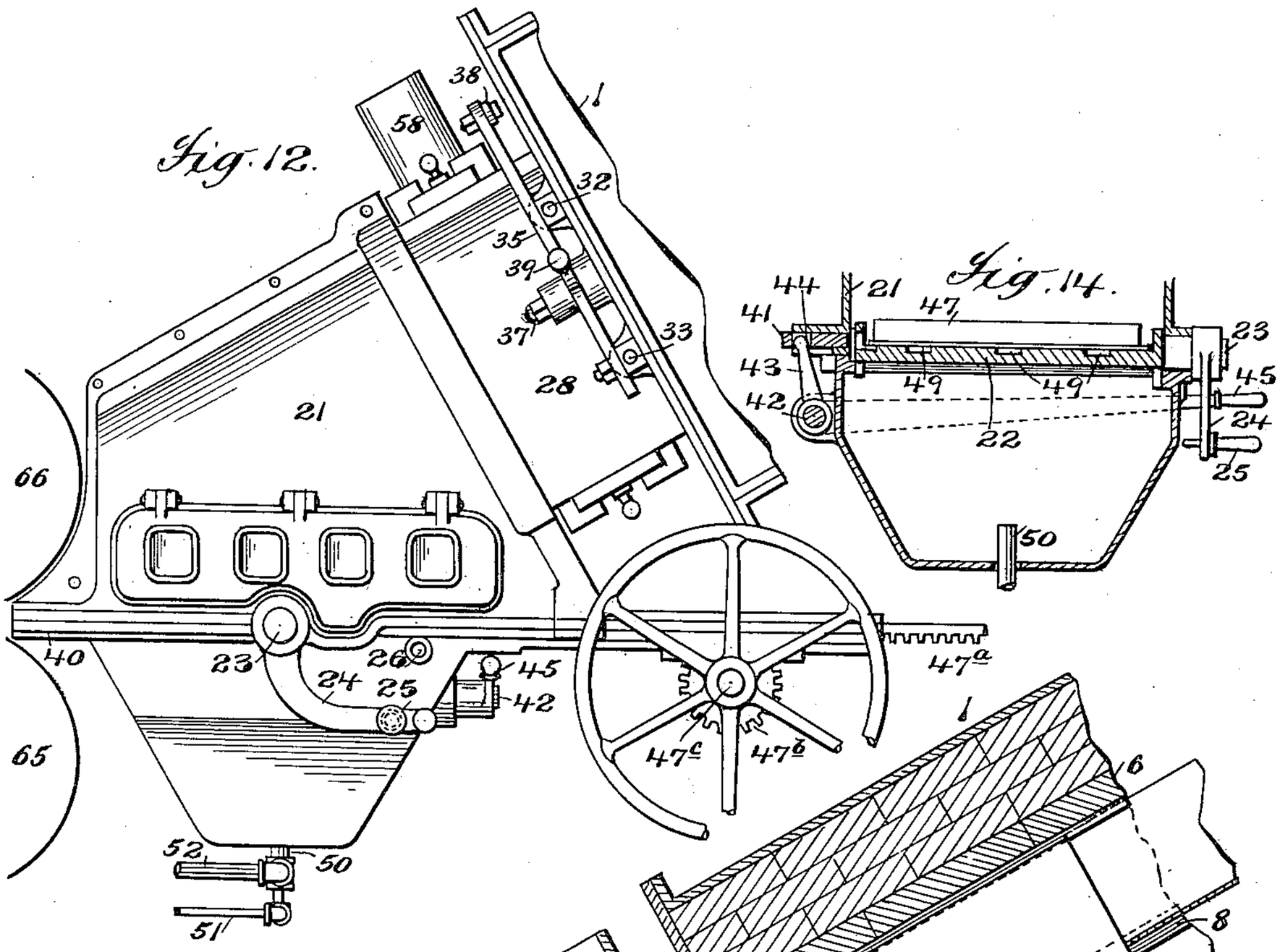
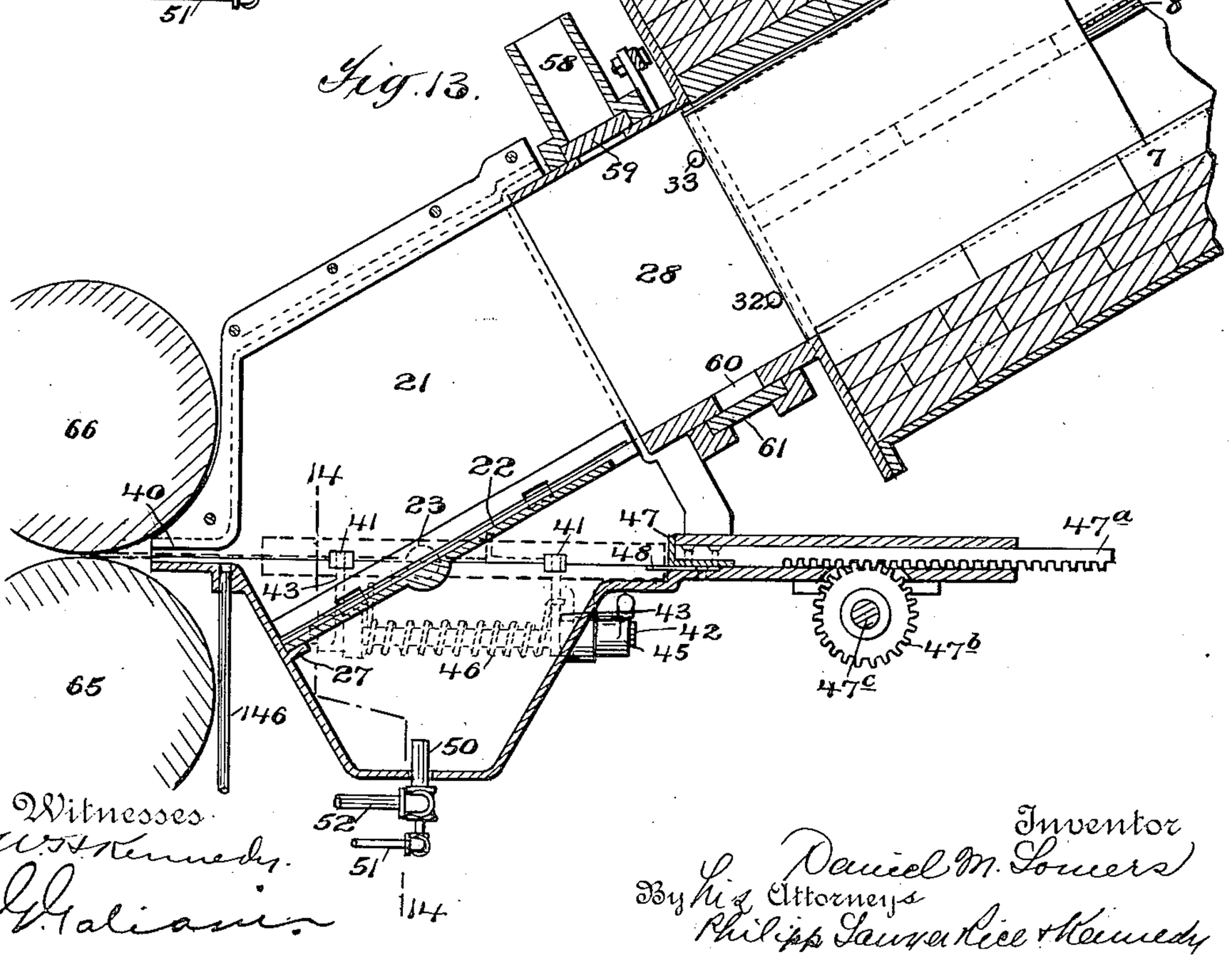


Fig. 14.

Fig. 13.



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7 SHEETS—SHEET 6.

Fig. 15.

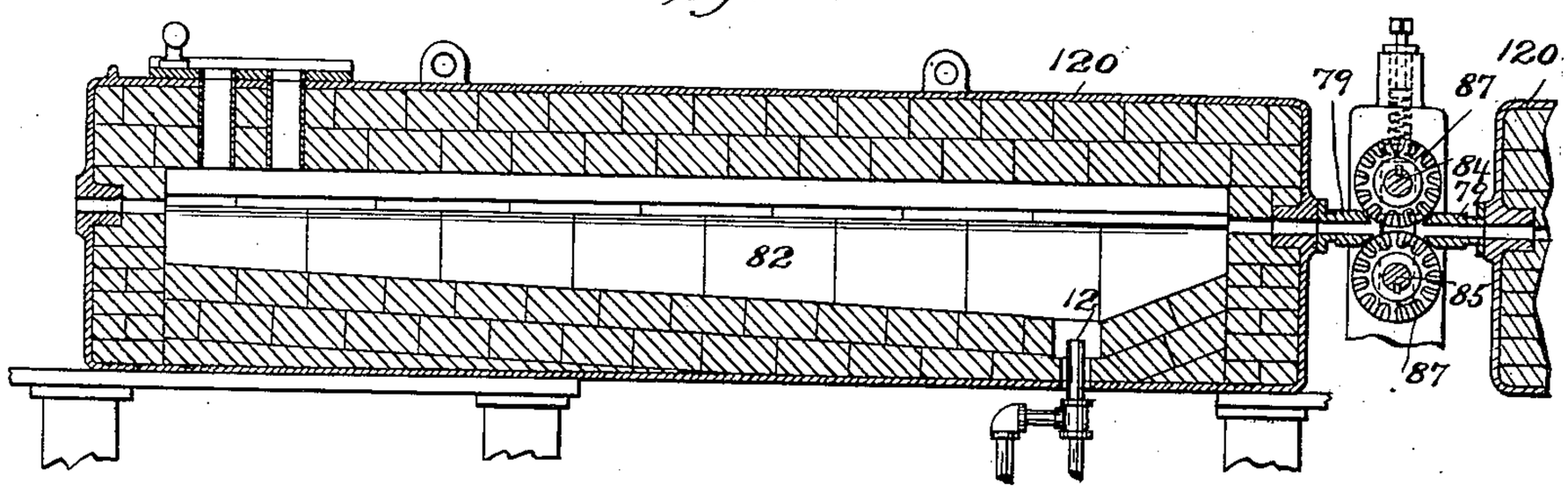


Fig. 16.

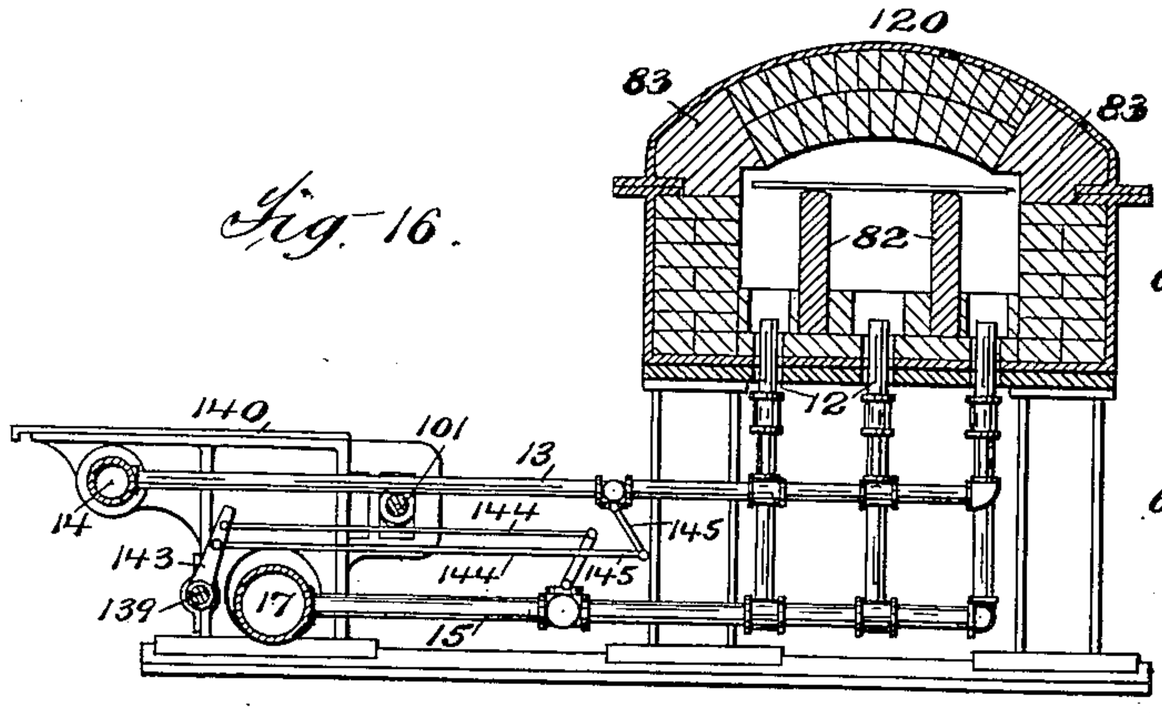


Fig. 18.

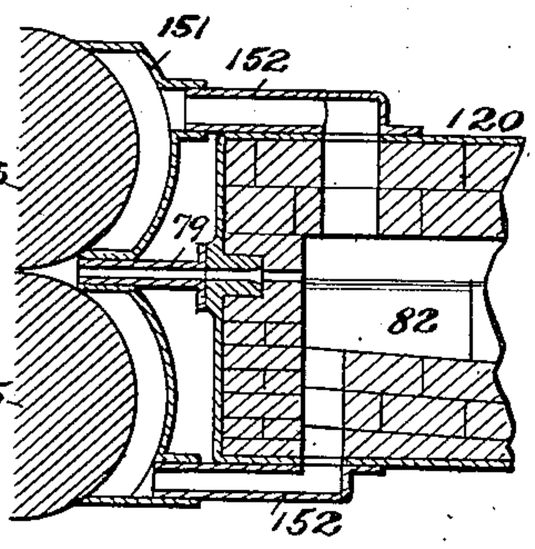
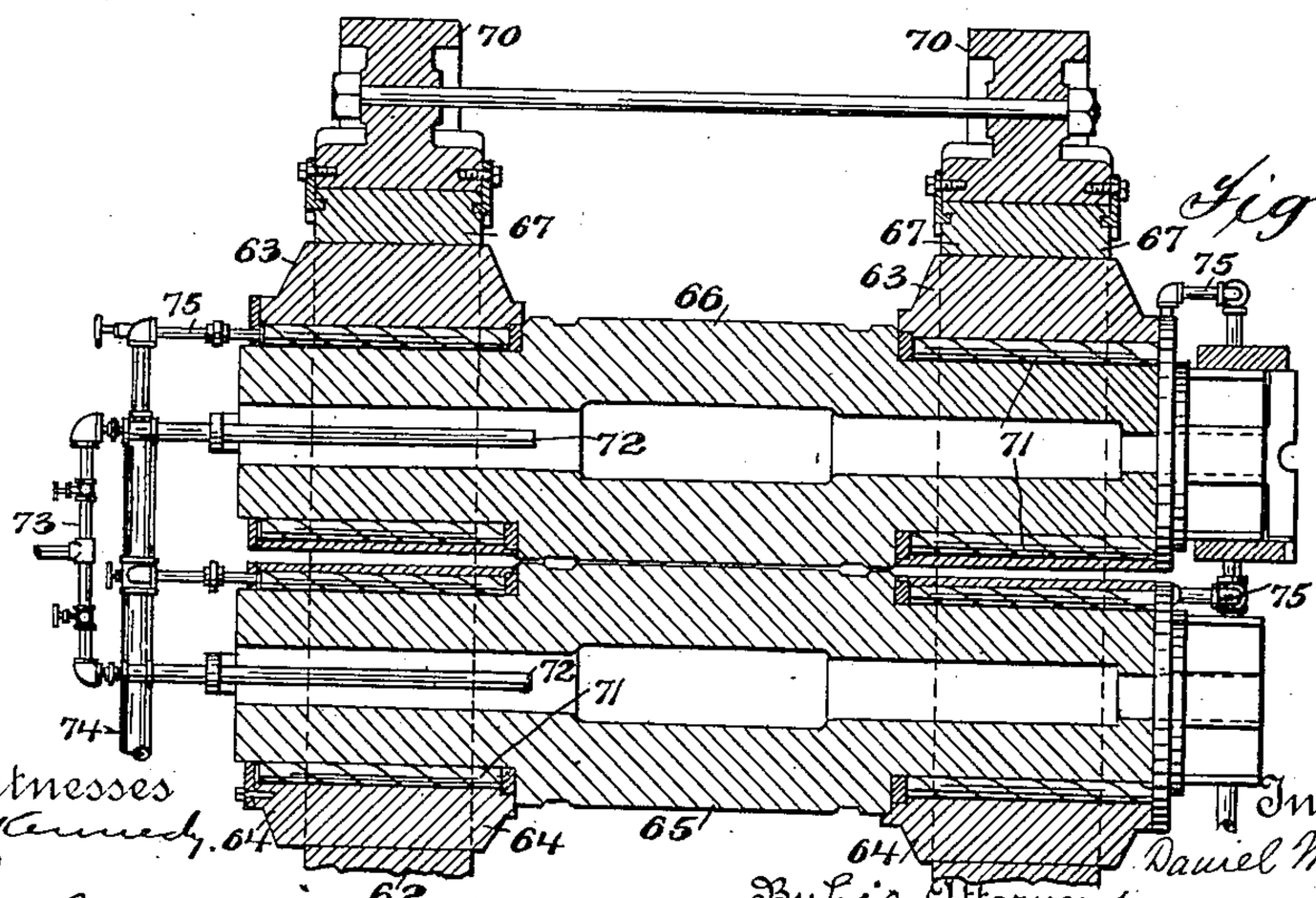


Fig. 17.



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7 SHEETS—SHEET 7.

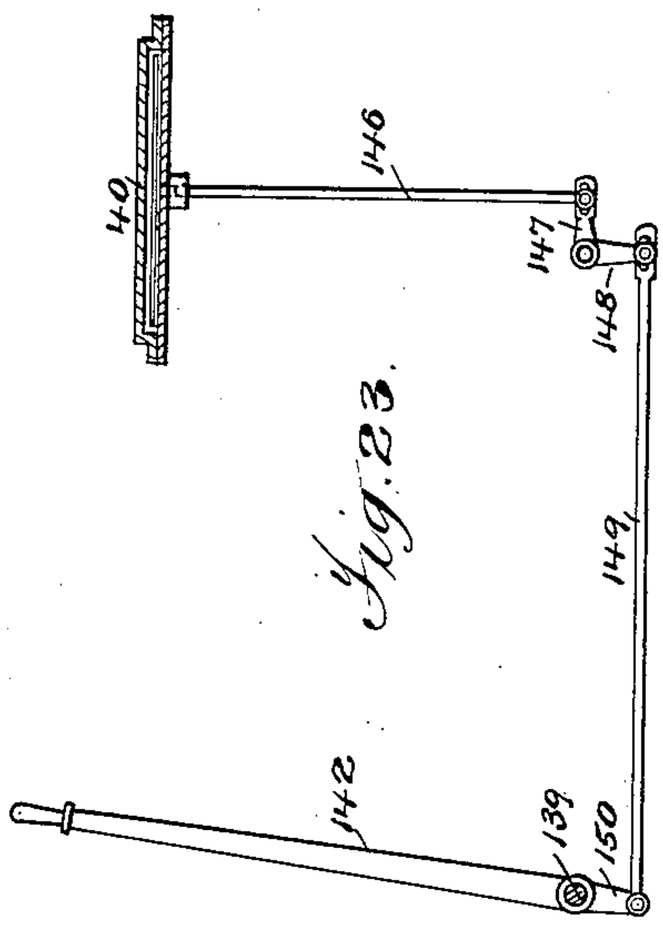

Fig. 23.

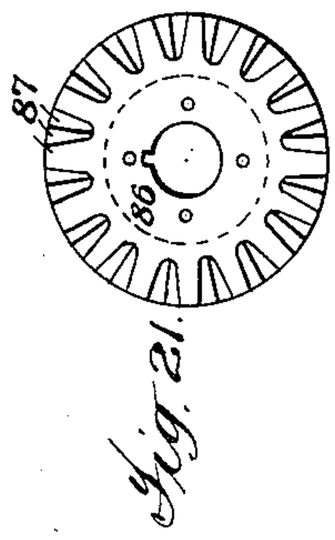

Fig. 21.

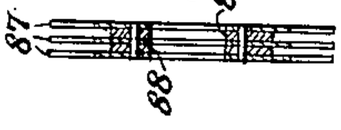

Fig. 22.

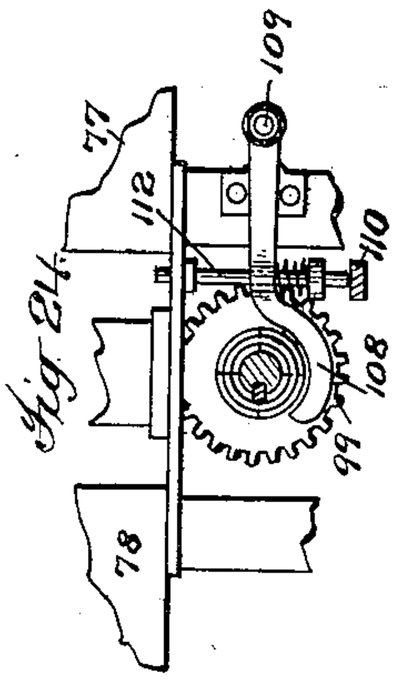

Fig. 24.

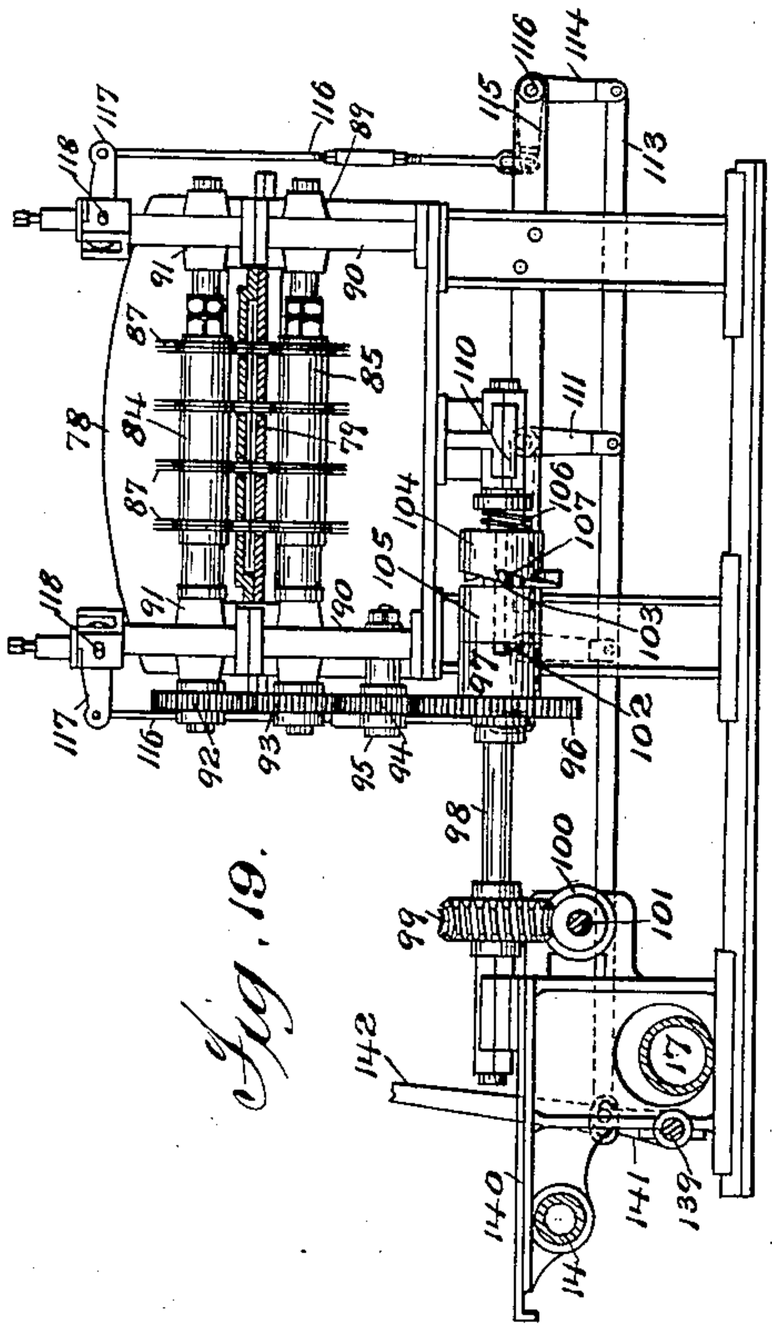

Fig. 19.

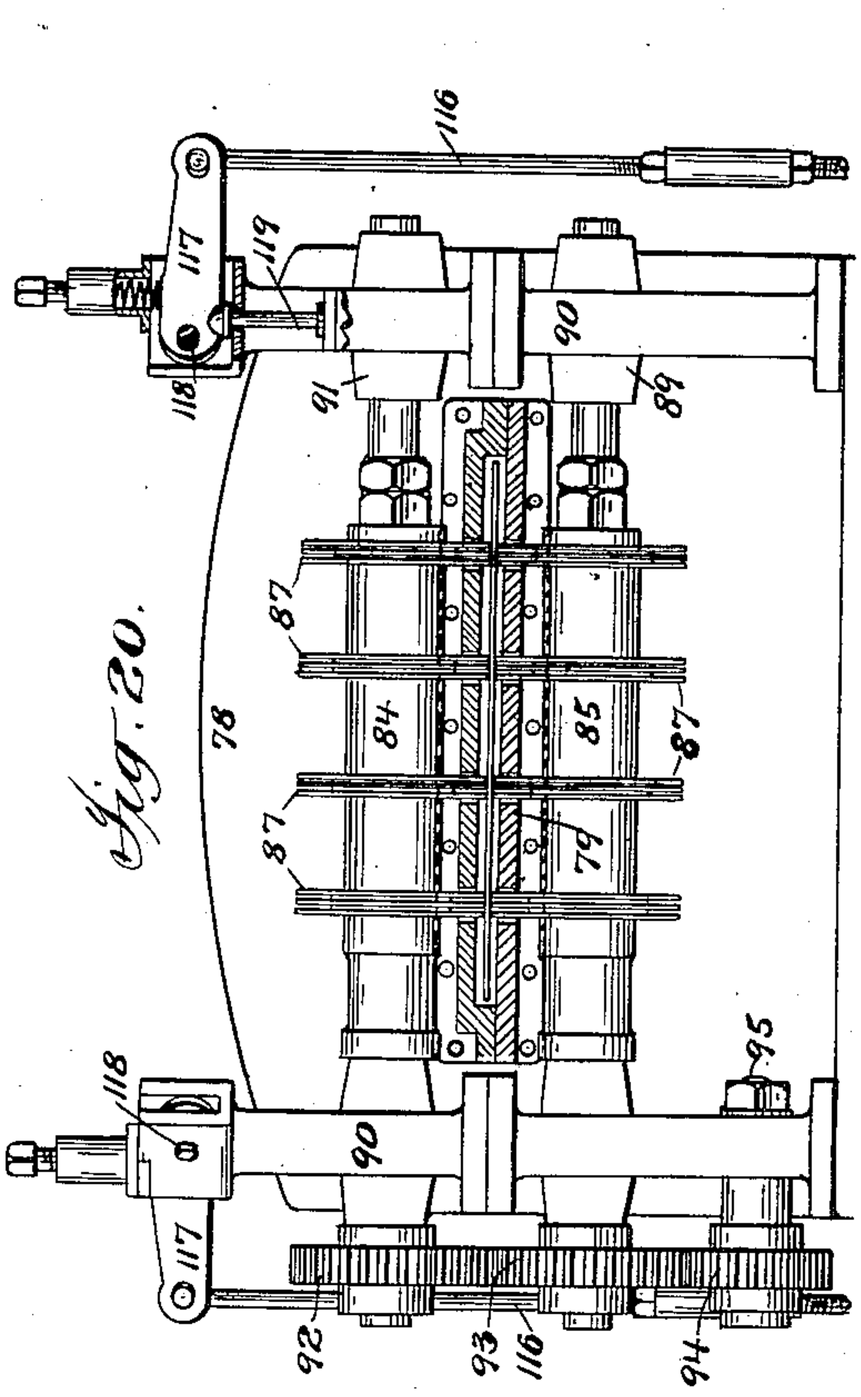

Fig. 20.

Witnesses
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UNITED STATES PATENT OFFICE.

DANIEL M. SOMERS, OF NEW YORK, N. Y.

APPARATUS FOR FORMING THIN METALLIC PLATE.

No. 800,951. Specification of Letters Patent. Patented Oct. 3, 1905.

Application filed March 24, 1904. Serial No. 199,831.

To all whom it may concern:

Be it known that I, DANIEL M. SOMERS, a citizen of the United States, residing at New York, county of Kings, and State of New York, have invented certain new and useful Improvements in Apparatus for Forming Thin Metallic Plate, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

This invention relates to certain improvements in apparatus for forming thin sheets of metallic plate, and more especially to apparatus for forming that class of sheet-metal plate which is to be used as the base for commercial tin-plate.

In forming the thin metal plate ordinarily used as the base for tin-plate it is customary at the present time to heat plate-bars in a suitable furnace and after heating to subject these bars to the action of rolls. According to what is known as the "Welsh process" the plates formed from these bars are doubled, heated, and again rolled, the doubling, heating, and rolling continuing until the plates are of the proper thickness. According to the process used in this country, however, after the first heating and rolling the sheets are superposed and are trimmed, if necessary, this process being known as "matching." After the matching the rolling and doubling continues in the manner hereinbefore set forth. These operations are slow. The shearing or trimming which is necessary occasions a waste of material, and the process requires the employment of a number of skilled workmen. The final rolling produces a pack of thin sheets, which pack is opened and the sheets are then pickled to remove the scale. After the pickling the plates are subjected to the usual annealing processes, after which they are ready for the subsequent operations, which transform them into what is commercially known as "tin-plate."

The present invention has for one of its objects to produce an improved apparatus for forming thin sheets or plate in which the doubling and shearing heretofore employed is done away with, the successive operations being rapidly carried forward, so that great saving in time and labor is effected, this apparatus being adapted to operate upon sheets which are pickled prior to the preliminary heating.

A further object of the invention is to produce an improved mechanism for advancing plate from the preliminary "reheating-furnace" to the rolls by which they are first acted upon.

A further object of the invention is to produce an improved rolling mechanism and connected devices by which the successive rolling operations may be rapidly carried forward.

A further object of the invention is to produce an improved apparatus for forming plate in which the plate is transferred from the last set of rolls directly to an annealing-furnace without giving the plate an opportunity to cool.

A further object of the invention is to produce an apparatus by which the several operations necessary to convert the reheated plate into thin sheets may be carried on without exposing the plate to the action of atmospheric air, thereby rendering it possible to pickle the plate prior to reheating and to prevent the formation of scale, thus rendering the pickling subsequent to annealing unnecessary.

A further object of the invention is to improve the mechanical devices by which the various operations performed are speedily and economically effected.

With these and other objects in view not specifically referred to the invention consists in certain constructions and in certain parts, improvements, and combinations, as will be hereinafter fully described and then specifically pointed out in the claims hereunto appended.

Referring to the drawings, which illustrate a preferred form of apparatus by which the invention is carried into effect, Figure 1 represents in plan view a furnace and a part of the train of rolls to the action of which the plate is subjected after being reheated in the furnace. Fig. 2 is a side elevation, partly in section, of the construction shown in Fig. 1. Figs. 3 and 4 illustrate in plan and side elevation, respectively, a subsequent part of the train of rolls and a part of the annealing-furnace. Fig. 5 illustrates in plan the remainder of the annealing-furnace and the annealing-box. Fig. 6 represents in side elevation that portion of the annealing-furnace which is illustrated in Fig. 5 and illustrates the annealing-box in section. Fig. 7 is a section on the line 7 7 of Fig. 2. Fig. 8 is a section on the line 8 8 of Fig. 2. Fig. 9 is a section on the line 9 9 of Fig. 2. Fig. 10 is a section on the line 10 10 of Fig. 2, and Fig. 11 is a section on the line 11 11 of Fig. 2. Figs. 12 and 13 are side elevations and vertical cross-sections, respectively, of the receiving-chamber, into which the

plate passes from the reheating-furnace. Fig. 14 is a sectional detail view illustrating the receiver and the plate-truing mechanism. Fig. 15 is a longitudinal section through a part of one of the furnaces intermediate the rolls. Fig. 16 is a section on the line 16 16 of Fig. 4. Fig. 17 is a vertical central section taken through one of the sides of the hot rolls, illustrating more particularly the heating devices. Fig. 18 illustrates a modified form of hot rolls. Fig. 19 is a section on the line 19 19 of Fig. 4. Fig. 20 is an enlarged sectional view illustrating a part of the construction shown in Fig. 19. Figs. 21, 22, 23, and 24 are detail views.

The apparatus in which the invention is embodied will in its preferred form include a reheating-furnace. While this furnace may be widely varied in its constructional details, it will in the preferred form be of such a character as to inclose a plurality of packs or sheets of plate. It is here remarked that in practicing the invention the greatest economy will be secured where the plates to be treated are handled in packs, although it will be obvious that single plates may, if desired, be subjected to the same operations as the packs of plates. In the preferred construction this reheating-furnace will be of such a construction as not only, as before stated, to inclose a plurality of packs or sheets, all of which are being simultaneously subjected to the reheating action; but it will also be of such a character that the plates will be forwarded therethrough by their own gravity. In the particular construction illustrated (see Figs. 1 and 2) there is provided a furnace 1, which is inclined to the horizontal, the inclination being such as to enable the plates or packs to readily move therethrough by gravity. The furnace may be supported in any usual manner, as by suitable pillars, the illustration of which is omitted in the interest of clearness. The upper end of the furnace 1 will be provided with means for supplying the plates thereto. This supplying mechanism may be of any suitable form. As shown, there is provided a support 2, which (see Fig. 7) preferably consists of a plate having grooves 3 4, which receive the bottom edges of packs or plates. About this support are located bars 5, which support the middle of the packs or plates. This construction enables the packs or plates to be fed on edge and with their ends crossed, so that each pack or plate is forwarded and kept in position by the succeeding pack or plates. The end of the furnace when the supplying mechanism before described is employed is provided with crossing slits, these slits being wide enough to receive the plate or packs of plates to be reheated.

The interior of the furnace is provided with means for controlling the passage of the plates or packs therethrough. While this means may be widely varied in its form and construction, it will preferably embody a construction in which the edges of the packs when the furnace is operating upon packs, as will usually be the case, are kept in register, and successive packs or sheets when single sheets are being subjected to the action of the furnace are caused to take the same path through the furnace. Various forms of edge guides may be employed. As shown, however, the furnace is provided with an edge guide composed of grooved blocks 6 and with a second edge guide composed of grooved blocks 7. These guides extend through the furnace from end to end and are composed of a suitable refractory material which will stand the heat and at the same time will not wear to any great extent under the action of the plates.

To prevent the sheets from buckling, additional guides 8 may be employed, these guides being opposed to each other near the center of the sheets.

If the furnace be given the proper inclination, it will be seen that the plates will slide under the action of gravity down through the furnace, the guides, whatever their construction may be, forming a runway for the plates. The grooved guide-blocks form a very efficient means for feeding the packs or sheets with their ends crossing each other if it be desired to employ this method of supplying the furnace. As has been before pointed out, the invention in no way depends upon this manner of supplying the furnace.

The heating means for the furnace may be of any suitable character. In the preferred construction, however, the heating of the furnace will be effected by the combustion of hydrocarbon fuel, this fuel having distinct advantages, as will hereinafter appear.

The specific means by which the hydrocarbon fuel is burned in the furnace may be widely varied. In the construction shown the furnace is enlarged somewhat between its ends to provide combustion-chambers 10, these chambers communicating through choked openings 11 with the interior or plate-containing part of the furnace, these openings being preferably of the same length as the combustion-chambers.

The hydrocarbon fuel, which will preferably be in the form of producer-gas, is introduced through burner-pipes 12, these pipes communicating through branch pipes 13 with a main 14. These burner-pipes are surrounded by air-pipes 15, which communicate through branches 16 with a main 17, the burner construction being the well-known Bunsen form. If desired, an additional combustion-chamber 18 may be located in advance of the main combustion-chamber just described, this being shown in section in Fig. 8.

The construction of the combustion-chambers and furnace are of such a character as to afford a high and even heat to be obtained, it

being understood, of course, that this heat should not be sufficient to either weld the sheets in the furnace or to so heat them that they will in any way adhere or stick together by the subsequent action of the rolls. The furnace is prolonged somewhat beyond the combustion-chambers which have just been described, so that an evening of the heat or a soaking effect may be obtained, as will be hereinafter more fully described. A section through this prolongation of the furnace is illustrated in Fig. 10.

The usual platform 19 is provided, which is reached by steps 20, this platform affording access to the furnace and to the valves by which the combustion in the furnace is regulated. The furnace is or may be provided with inspection-openings or peep-holes.

In the preferred construction the furnace instead of delivering directly to the rolling mechanism hereinafter described will deliver to an intermediate chamber located between the rolls and the furnace, and this chamber may be utilized for the performance of such operations as are necessary or desirable to place the plates in proper relation to be fed to the rolls. This chamber is marked 21. Inasmuch as the plates will ordinarily pass through the rolls in a substantially horizontal position and inasmuch as the furnace is inclined to the horizontal, this delivery-chamber will preferably be provided with a receiver, to which the plates are delivered and from which they pass to the rolls. This receiver may be of any suitable construction; but in the form illustrated it consists of a table or platen 22, mounted on journals 23, which extend through the walls of the delivery-chamber. One of these journals is or may be provided with a handle 24, by which the table is operated. The table normally occupies a horizontal position, but may be swung up into an inclined position in substantially the same plane with the guides of the furnace and when so swung held by means of a stop-pin 25, which engages in a suitable boss 26, secured to one of the walls of the chamber. A stop 27 is provided located on the inside of the top, against which the lower edge of the plate abuts when the plate is in its inclined position.

When the plates, as in the construction shown, are fed through the furnace on edge, they should be turned into a substantially horizontal position before they strike the receiver before referred to. While this may be effected in any desired way, in the construction shown there is located between the receiver-chamber and the furnace a receiving-throat 28. The floor of this throat (see Fig. 11) is provided in the construction shown with inclined guide-surfaces 29, said surfaces sloping in opposite directions from the center of the floor and being so located that the edges of the packs or plates will strike the upper part of these surfaces as they issue from the slots in the delivery end of the furnace. The top wall of this throat is provided with grooves 30, which coöperate with the guide-surfaces 29 in the first instance and hold the edges of the plates. As the plates pass into the throat their bottom edges slip down the guiding-surfaces 29, these surfaces operating to turn the plates into a horizontal position, as will be readily understood. In the preferred construction the side walls 31 of this throat 28 are curved, as shown, so as to afford guides which control the movement of the upper edges of the plates as they turn from their inclined into their horizontal position.

It may be desirable to regulate the rate of speed at which the plates or packs of plates issue from the furnace, and in the preferred construction a feed-controller will be provided for this purpose. This feed-controller may be located at any suitable point and may be widely varied in construction. As shown, this feed-controller comprises two sets of slides 32 32 and 33 33, the slides 32 controlling the plates which issue from the furnace through one of the crossed delivery-slits and the other slides 33 controlling the plates which issue from the other delivery-slit. These slides will be preferably so constructed that the act of throwing one into position throws the other out. The mechanism by which this is accomplished may be of any suitable construction. As shown, there are provided two levers 34 35, the lever 34 being pivoted at 36 and the lever 35 being pivoted at 37 to the lower outside wall of the furnace. These two levers 34 35 are connected at their upper ends by a link 38. The upper slide 32 is pivoted to the lever 35, and the lower slide 32 is pivoted to the lever 34. Similarly, the upper slide 33 is pivoted to the lever 34 and the lower slide 33 to the lever 35. Connected to the lever 35 is a suitable operating-handle 39. It will be seen that by operating the handle either one or the other set of slides is thrown into the path of an advancing pack of plates, and this pack will be stopped, thus stopping all the packs in the furnace. An operator stationed at this point can, therefore, control the feed of the plates through the furnace and to the rolling mechanism.

The delivery-chamber 21 is preferably provided with a contracted outlet 40, through which the plates are fed to the first pair of rolls, to be hereinafter described, this outlet being preferably so located with respect to the rolls as to deliver a pack of plates to the rolls without any substantial loss of heat.

After a pack of plates has been turned in the delivery-throat in the manner hereinbefore described and been received on the receiver, the receiver at that time being in the position illustrated in Fig. 13, the receiver is turned into a horizontal position, as is illustrated in Fig. 14, for instance, so as to bring

the pack of plates into register with the delivery-mouth of the chamber.

In the preferred construction devices will be provided for truing up the plates prior to their being forwarded to the rolls. This truing-up mechanism may be widely varied in construction. As shown, it includes a pair of slides 41, these slides passing through small orifices in the side of the delivery-chamber. The means for operating these slides may be of any suitable character; but in the construction shown there is provided a rock-shaft 42, journaled in suitable bearings secured to the side of the delivery-chamber, this rock-shaft having extending therefrom arms 43, which engage in openings 44 in the slides 41. The shaft 42 has an operating-handle 45 connected thereto and, if desired, may be provided with a torsion-spring 46 (see Fig. 13) to return the shaft and the slides to their inoperative position after the plates have been trued.

The means for advancing the plates into the bite of the rolls, to be hereinafter described, may be of any desired character. As shown, there is provided a pusher 47, which strikes the rear edge of the pack of plates, this pusher in the preferred construction being further provided with fingers 48, which underlie the lower edge of the pack. In the construction shown the receiver 22 is provided with grooves 49, in which these fingers move. The means for operating the pusher may be of any suitable character. As shown, this pusher is carried by a pair of rack-bars 47^a, these rack-bars being in mesh with gears 47^b, mounted on a hand-wheel shaft 47^c.

In the preferred construction the delivery-chamber 21 will preferably be provided with suitable heating means, and preferably this heating means will employ devices by which hydrocarbon fuel can be burned. In the construction shown there is provided the usual Bunsen burner 50, which is connected by means of a branch 51 to the gas-main and by means of a branch 52 to the air-main.

The furnace is provided with a flue through which the waste products of combustion escape, this flue being located near the upper end of the furnace and being marked 53. In the preferred construction this flue taps a box 54, located on the lower side of the furnace, the opening of the flue being controlled by a slide-valve 55, which may be operated in any suitable manner—as, for instance, by means of a rock-shaft 56, having a handle 57. This valve or damper will be so regulated as to maintain a pressure in the furnace at least equal to and preferably somewhat above atmospheric pressure. It will be seen from the construction of the furnace that substantially no air can enter it except that which is fed in with the producer-gas to support the combustion. The openings in the furnace are all narrow, and, furthermore, the only opening through which air could enter is the narrow opening 40, which forms the delivery-opening for the delivery-chamber. Inasmuch as combustion will ordinarily be kept up in this chamber there will be a current of gas out through this opening which will prevent any air from entering.

In order that the condition of the furnace may be readily regulated, there is preferably provided a flame-orifice 58, which may be conveniently located in the delivery-throat 28, this orifice being controlled by a slide-damper 59. Under ordinary working conditions the pressure in the furnace should be such as to cause a slight escape of flame from this flame-orifice.

A suitable air-inlet opening may be provided through which air may be admitted to the furnace should it be desired to cool it down for any purpose. This opening may be located at any convenient point; but in the construction shown it is located in the under side of the throat 28. This opening is marked 60 and is controlled by a slide-damper 61.

By means of the mechanism described the travel of the packs of plates or sheets through the furnace will be so controlled that the plates may be heated up to the desired rolling temperature. Furthermore, by maintaining the pressure above atmospheric pressure in the furnace and by excluding atmospheric air from the furnace a soaking effect is obtained, this being a very important result in the manufacture of thin sheets of the character intended to be treated in this apparatus.

The rolling mechanism employed will consist of a plurality of sets of rolls, these sets varying in number according to the number of rolling operations to which it is desired to subject the plates. Each set of rolls will, as usual, comprise an upper and lower roll, and these rolls may be of any desired construction and may be mounted and operated in any desired manner. Preferably, however, in order to avoid cooling the plates, these rolls will be provided with means for heating them instead of, as is usual in this class of apparatus, allowing the rolls to be heated by the passage of the plates. In the construction shown four sets of rolls are illustrated; but as these sets are duplicates a description of one set will suffice for all.

The apparatus is provided with pairs of housings 62, between which upper and lower bearings 63 64 are mounted, the lower bearings serving to support the lower rolls 65 and the upper bearings serving to support the upper rolls 66. (See Fig. 17.) The upper and lower roll of each pair will run in contact with each other, the proper pressure between the rolls being secured in any desired manner. As shown, a pair of wedges 67 is employed for this purpose, these wedges being operated by screws 68. The screws in turn are operated by pawl-and-ratchet mechanism

69. These wedges 67 are inserted between the bearings 63 and the cross-pieces 70 of the housings. In the preferred construction, furthermore, suitable antifriction devices will be introduced between the bearings and the journaled portions of the rolls. These antifriction devices, as illustrated, consist of hollow rolls 71.

As before stated, the rolls will be heated, so as to avoid lowering the temperature of the plate as it passes therethrough. This heating may be effected in any desired manner. Preferably, however, the rolls will be hollow, as shown, and suitable burners 72 will be employed to carry the hydrocarbon fuel thereinto, this hydrocarbon fuel being preferably that heretofore referred—to wit, producer-gas. These burners are of the usual Bunsen form, the gas being supplied by a branch 73, connecting with the gas-main and the air being supplied by a branch 74, connecting with the air-main. In the preferred construction the bearings for the rolls will be cooled, this being effected by means of branch air-pipes 75, which lead into the bearings. The roller mechanism illustrated in Fig. 17 embodies novel features, which form the subject-matter of an application filed by me of even date herewith, Serial No. 199,830.

Heating means is provided between each set of rolls, so that the temperature of the plate may be kept up to the proper point, so as to render the operation of each set of rolls effective. The construction of the heating means between adjacent sets of rolls may be widely varied; but in the preferred form it will include a suitable furnace the particular construction of which may be varied within wide limits. In the construction illustrated each of these intermediate furnaces consists of two chambers 77 78. These chambers are substantial duplicates and are connected by a contracted channel 79. The interior of these furnaces is well illustrated in Figs. 15 and 16.

Each furnace will preferably be provided with a receiving mouth or channel 80, which is located in close proximity to the rolls from which it is to receive the plate and with a delivery mouth or channel 81, located in close proximity to the rolls to which it is to deliver the plate. These furnaces are preferably provided with interior supporting-guides 82, which are well illustrated in Figs. 15 and 16 and which serve to support the plate during its passage through the channel. Side and top guides are also preferably provided, so that the movement of the plate through these furnaces may be properly controlled. While these side and top guides may be of any suitable construction, in the preferred construction the side walls of the furnace preferably have angular guide-blocks 83 inserted therein, these guide-blocks forming part of the side and top walls of the furnace and serving in connection with the supporting-guides to control the movement of the plate.

While the rolls might be so spaced with relation to each other that each set of rolls would serve to forward the plate through the furnace which receives it from the rolls and into the bite of the next set of rolls, in the preferred construction the sets of rolls will preferably be so spaced that one set completes its action on the plate before the next set begins, and feeding devices are used to forward the plate through the furnaces. The construction and location of these feeding devices may be widely varied. Preferably, however, the feeding devices will be so located that they work through narrow slots in the contracted channels 79. As shown, the feeding devices will preferably be of rotary form and will be of such a character that their area of contact with the plate will be small. In the preferred form of the construction each feeding device will consist of sets of disks mounted on rotating shafts, one of these shafts, (see Fig. 20,) marked 84, being located above the contracted channel 79, and the other, 85, being located below the channel. Each of the disks, which are marked 86, is cut out to form a series of teeth 87. In assembling the disks three of them in the preferred construction constitute a set, and these three disks are arranged so that the teeth of each disk are staggered with relation to the disk next it. The disks may be secured on the shaft in any desired manner—as, for instance, by a feather. With this construction it will be understood that as the disks rotate each disk makes contact with the plate in the channel only for the length of one tooth at a time. While disks having an uninterrupted circular outline might be employed, with disks of this character there is danger of producing a chilled line extending lengthwise of the plate should the disk happen to be too cool. Furthermore, as will be readily understood, serrated disks will bite the plate better and insure a better feed. It will be observed (see Fig. 22) that the disks are spaced by means of collars 88. By employing thin disks spaced from each other in the manner described the disks are heated readily by the escape of the products of combustion through the slots in which they work, so that they may be kept near the temperature of the plate.

The construction for operating the disks is located outside the furnace, and the difficulties which would result from overheating the operating mechanism for the feeding devices are avoided. The shafts by which the feeding-disks are driven may be mounted and operated in any suitable manner. In the construction shown the shaft 85 is mounted in boxes 89, mounted in slots in standards 90. The shaft 84 is similarly mounted in boxes 91, located in the slots in the standards 90. This

construction permits the shaft 84 to have a rising-and-falling movement the purpose of which will be hereinafter explained. The shaft 84 is provided with a gear 92, which meshes with a gear 93, mounted on the shaft 85. This gear 93 is in mesh with a pinion 94, mounted on a stud 95, extending from one of the standards 90. This pinion 94 is driven by a gear 96, connected to a hub 97, this hub being in turn mounted on a shaft 98, which is supported in suitable bearings in the machine-frame. This shaft 98 is provided with a worm driving-gear 99, which meshes with a worm 100 on a worm-shaft 101. This worm-shaft extends along the side of the furnace for its entire length and operates all the driving mechanism, it being understood that all the feeding mechanisms are duplicates both as to their construction and their method of driving.

Means are provided for interrupting the driving of the feeding mechanisms when desired, which means may be of any suitable or desired character. In the construction shown the hub 97, to which the gear 96 is connected, is loosely mounted on the shaft 98 and is clutched to and unclutched from the shaft when it is desired to start or stop the feeding mechanism. While any desired form of clutch may be used, in the construction illustrated the hub 97 is provided with a notch 102, which is engaged by a pin 103, fast to a notched collar 104, which is mounted to turn with the shaft 98. This pin 103 passes through a guide-collar 105, which is also mounted to turn with the shaft and with the notched collar 104. The collar 104 and the pin are normally held forward, so that the pin engages with the notch 102 by means of a spring 106 or in any other suitable manner. The notches in the collar 104 are marked 107, these notches affording cam-surfaces by which the clutch is disengaged when desired.

The disengagement of the clutch is effected by means of a latch 108, (see Fig. 24,) pivoted on a stud 109, secured to the frame. This latch is lifted at the proper time by a bell-crank lever 110 111. The arm 110 of this bell-crank takes under a spring-pin 112, which passes through the latch 108. The other arm 111 of this bell-crank lever is pivoted to a slide-rod 113, which is connected to one of the arms 114 of a bell-crank 114 115, pivoted at 116 to a bar projecting from the frame. The other arm 115 of this bell-crank lever is connected, by means of an adjustable link 116, to a lever 117, which is pivoted at 118 to the top of one of the standards 90. Resting on the box 91 of the shaft 84 is a plunger-pin 119, which bears against the under side of the lever. The other side of the feeding-roll is provided with a similar lever 117 and link 116, which goes to a similar bell-crank similarly connected to the slide-rod 113. It is apparent, therefore, that if the roll 84 is raised either at one side or the other or at both sides the clutch will be shifted and the feeding mechanism stopped.

It is here remarked that the feeding-rolls 84 85 are driven at a surface speed which is considerably less than the surface speed of the hot rolls. By this construction the plate is fed slowly through the intermediate furnaces and may be thus maintained at the proper rolling temperature, the heat lost during any rolling operation being restored by the intermediate furnace before the next rolling operation is begun.

In the preferred construction an annealing heating-furnace will be employed, which annealing heating-furnace is arranged so as to receive the plate immediately from the last set of rolls. While this annealing heating-furnace, which is marked 120 in the drawings, may be of any desired construction, it will preferably be substantially similar to the heating-furnaces hereinbefore described, and no specific description of it is therefore necessary. This annealing heating-furnace will of course be necessarily longer than any of the intermediate furnaces, because of the elongating action on the plate of the last set of rolls. While the fuel employed and the means for burning it are the same as that employed in the intermediate furnaces before referred to, it will be understood by those skilled in the art that a higher degree of heat is maintained in this annealing heating-furnace than in the intermediate furnaces. In the preferred construction this annealing heating-furnace will deliver to an annealing-box, the construction of which may be widely varied. In the preferred form, however, this box will be a portable box and have sufficient capacity to receive the product of the furnace during one shift—that is to say, about eight hours. In the particular construction shown, this box consists of upper and lower parts 121 122, these parts being connected by a sand-joint 123, as is usual. The bottom of the box 124 is arranged in the preferred construction on an incline, as shown, so that the sheet of hot metal which is fed into the box will slide readily down into position, thus avoiding any buckling, it being understood, of course, that the metal at this stage of the proceeding is very hot and soft and will buckle easily.

The devices for transferring the plate from the annealing heating-furnace to the box may be of any desired description. In the construction shown, however, two sets of feeding-rolls are employed, the operating parts of these rolls consisting of staggered disks similar to the feeding-rolls hereinbefore described. The first set of rolls, the shafts of which are marked 125 126, is driven from a train of gearing from the worm-shaft 101 in the same manner as the shaft of the feeding-rolls hereinbefore referred to. The second set of feeding-rolls, the shafts of which are marked 127

128, is mounted in bearings carried on beams 129, extending from the furnace-frame. The shafts 127 128 are provided with sprocket-wheels 130, these sprocket-wheels being operated by chains 131, which extend over sprocket-wheels 132 on the shafts 125 126, before referred to.

The side and top walls of the annealing-box are preferably cut away, as shown, to form an angle or jog, and this jog is closed by an angle-plate 133, which is formed to produce a feeding-throat 134, through which the plate is delivered into the box, this feeding-throat having slots through which the feeding-disks on the shaft 127 128 work. It has been before stated that in the preferred construction this annealing-box will be portable, and to this end it is mounted on trucks 135, so that it may be readily transported to and away from the furnace. When it is moved away from the furnace, it will of course be understood that the openings in the plate 133 will be closed so that the box is sealed. This annealing-box may be heated in any desired manner; but it will preferably be heated as all the furnaces are heated—namely, by hydrocarbon fuel in the form of producer-gas, the quantity of gas burned, however, being moderate, but being sufficient to prevent any atmospheric air from entering the box through the feeding-slots. In the construction shown the gas is introduced by means of a burner 136, which is connected by a branch 137 to the gas-main and by a branch 138 to the air-main 17.

It has been heretofore stated in the description of the feeding mechanism that each feeding mechanism may be disconnected from the operating worm-shaft 101, and the construction has been described by which this is effected, it being apparent that any rising of the upper roll of any set, such as would result from introducing more than the normal quantity of plate between the rolls, will effect this disconnection of the feeding devices, and thus prevent a choke of the apparatus at any one of the various feeding-points throughout it. Connections are, however, preferably provided, so that the stoppage of any set of rolls automatically stops the feeding-rolls of the other intermediate furnaces. While these connections may be varied in form, in the construction shown there is provided a rock-shaft 139, which extends along the apparatus. This rock-shaft is mounted under a platform 140, which extends along the side of the apparatus and which, in addition to affording a means by which the inspector reaches the various parts of the apparatus, also serves to support certain of the various bearings and housings which have not been specifically referred to herein. This shaft 139 has a series of rocker-arms 141 extending out from it, to which the sliding bars 113 are connected. When any sliding bar is operated, therefore, by the rising of the upper feed-roll with which it is connected, all the sliding bars will be operated and all the clutches will be operated, so that each set of feeding-rolls will be stopped. It will be observed that the clutch connections have been omitted from the feeding-rolls which advance the plate through the annealing heating-furnace and into the annealing-box, it being obvious that it is unnecessary to prevent any choke at these points. In the preferred construction, furthermore, this rock-shaft 139 will be provided at suitable points with operating-handles 142, (see Figs. 19 and 23,) by which the rock-shaft may be operated by hand and the feeding mechanisms stopped.

When the feeding mechanisms are stopped, it is desirable to reduce the heat throughout all the furnaces of the apparatus or system so as to prevent overheating at any point during the time when the furnace is shut down. While this may be effected in any desired manner, it is preferably automatically effected and by suitable connections to the means for disconnecting the feeding devices. The particular connections by which this cutting down of the heat is effected may be varied within wide limits. As shown, the rock-shaft 139 (see Fig. 16) is provided with a series of rocker-arms 143, these arms being connected by links 144 to valve-levers 145, which control valves in the branches 13 16, leading to the burners of each intermediate furnace. The parts are so adjusted that the movement of these rocker-arms does not entirely cut off the flow of gas and air, but permits a sufficient amount of combustion to take place to maintain the heat in the furnaces at the proper standing temperature. The connections by which the flow of gas and air is shut off from the reheating furnace are similar to those which have just been described, and a similar set of connections also cuts off the fuel from the hot rolls.

When the feeding mechanism are stopped, it will be observed that in the apparatus which has been described the various sets of hot rolls will still continue to run; but it is desirable to prevent the attendant or rollerman from introducing any plate into the apparatus. To this end a feed-stop is preferably provided, the particular construction of which may be varied within wide limits. In the construction shown (see Figs. 13 and 23) the delivery-mouth of the receiving-chamber 21 is provided with an opening through which works a stop 146, this stop being preferably operated from the rock-shaft 139, before referred to. In the particular construction shown the lower end of this stop 146 is connected to one of the arms 147 of a bell-crank 147 148, which is pivoted to a suitable support on the frame. The arm 148 of this bell-crank is connected by a link 149 to an arm 150, fast on the shaft 139, before referred to. When this shaft 139 is operated, therefore, this feed-stop will be

thrown up into the delivery mouth or orifice of the receiving-chamber and prevent any plate from passing therethrough.

While the rolls will, as has been before pointed out, preferably be heated and will preferably be heated by introducing the hydrocarbon fuel into their interior, they may, if desired, be otherwise heated. In Fig. 18 a construction is shown by which the rolls are exteriorly heated. This is effected by surrounding the rolls in part by curved hoods 151, which hoods are connected by pipes 152 to openings in the adjacent intermediate furnaces. While in Fig. 18 the hoods and connections are shown on one side only of the rolls, it will be understood that these hoods and connections will be employed on both sides of the rolls.

The working of the apparatus will be readily understood from the description hereinbefore given. While the apparatus is adapted for operating on various kinds of material, it is particularly adapted for the formation of the thin plates used in the manufacture of tin-plate and is also particularly adapted for handling in packs the sheets from which these thin plates are formed. As has been before pointed out, the apparatus in the ordinary operation thereof in the formation of these thin sheets for tin-plate purposes will have fed thereto packs of plates pickled to remove all the scale. These packs preferably consist of eight sheets twenty-eight inches wide by thirty-six inches long, each sheet being one-sixteenth of an inch thick. As these packs pass through the reheating furnace by gravity in the manner hereinbefore described they become thoroughly and evenly heated, a soaking effect being secured, due to the fact that the plates occupy a certain length of time in traveling through the furnace and to the further fact that a pressure above atmospheric pressure is maintained in this furnace. From the reheating-furnace the pack of plates passes to the first set of rolls without material loss of heat, because the delivery-chamber is close to the first set of rolls. The lost heat due to the rolling in the first set of rolls is repaired by the intermediate furnace, through which the pack passes, the speed of the pack being, as before pointed out, so regulated that the pack does not reach the second set of rolls until it has been sufficiently heated to be at a proper rolling temperature. The next set of rolls then operates and the succeeding intermediate furnace restores the heat lost, it being borne in mind that each succeeding intermediate furnace is longer than the preceding one, so as to provide for the elongation of the plates due to the rolling. While the number of the sets of rolls and the intermediate furnaces may of course be varied in the particular apparatus shown, four sets of rolls are shown, these sets of rolls increasing the length of the pack from three to fifteen feet. From the last set of rolls the pack passes to the annealing heating-furnace. They reach this furnace in a highly-heated condition, so that a great economy is secured, it being unnecessary, as is the usual practice, to raise these plates from a cold state to an annealing-heat. From the annealing heating-furnace the plates pass directly to the annealing-box.

It will be observed that the openings throughout the apparatus are all comparatively small, and by the use of the hydrocarbon fuel, preferably in the form of producer-gas, the combustion in the furnaces can be so regulated that no atmospheric air reaches the packs of plates during their travel through the apparatus or while they remain in the annealing-box, because the size of the openings in the apparatus are only sufficient to provide for the proper escape of waste products, and there is an outdraft through them during the entire time of working the apparatus. Furthermore, the exclusion of air from the annealing-box keeps the plates in a bright condition and entirely eliminates the usual subsequent pickling before cold-rolling. Furthermore, the capacity of the apparatus is very largely increased over any of the apparatus or methods employed in the formation of these thin plates now in use, and the labor required is greatly reduced.

While the apparatus which has been illustrated and described embodies the invention in a preferred form, it is to be understood that many changes and variations may be made therein without departing from the invention. It is further to be understood that certain features of the invention are capable of use independently of other features and that such independent use is contemplated.

What is claimed is—

1. An apparatus for making plate including a preliminary-heating furnace through which the plate is advanced and in which it is raised to rolling temperature, a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is directly delivered from the furnace thereto whereby the heat of the furnace is maintained in the plate for the first rolling, heating means arranged to act upon the plate immediately after it emerges from the first set of rolls whereby it is given the proper temperature to be acted upon by the next set of rolls, an annealing heating-furnace arranged to receive the plate directly from the last set of rolls whereby the heat remaining in the plate after rolling is utilized for annealing purposes, and an annealing-box for receiving the plate directly from the annealing-furnace, whereby the preliminary heating, rolling and annealing may be caused to take place as a continuous operation, substantially as described.

2. An apparatus for making plate including a preliminary-heating furnace through which

the plate is advanced and in which it is raised to rolling temperature, a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is directly delivered from the furnace thereto, whereby the heat of the furnace is maintained in the plate for the first rolling, means for heating the sets of rolls, heating means arranged to act upon the plate immediately after it emerges from the first set of rolls whereby it is given the proper temperature to be acted upon by the next set of rolls, an annealing heating-furnace arranged to receive the plate directly from the last set of rolls whereby the heat remaining in the plate after rolling is utilized for annealing purposes, and an annealing-box for receiving the plate directly from the annealing-furnace, whereby the preliminary heating, rolling and annealing may be caused to take place as a continuous operation, substantially as described.

3. An apparatus for forming plate including a preliminary-heating furnace in which the plate is raised to rolling temperature, a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is delivered directly from the furnace thereto whereby the heat of the furnace is maintained in the plate for the first rolling, and each set of rolls being so spaced from the adjacent set that the action of one set of rolls on the plate is completed before the next set begins to act, suitable feeding devices between the sets of rolls for advancing the plate, and means for heating the plate located between adjacent sets of rolls and arranged to act upon the plate directly it emerges from the rolls, substantially as described.

4. An apparatus for forming plate including a preliminary-heating furnace in which the plate is raised to rolling temperature, a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is delivered directly from the furnace thereto whereby the heat of the furnace is maintained in the plate for the first rolling, and each set of rolls being so spaced from the adjacent set that the action of one set of rolls on the plate is completed before the next set begins to act, means for heating the sets of rolls, suitable feeding devices between the sets of rolls for advancing the plate, and means for heating the plate located between adjacent sets of rolls and arranged to act upon the plate directly it emerges from the rolls, substantially as described.

5. An apparatus for forming plate including a preliminary-heating furnace in which the plate is raised to rolling temperature, a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is delivered directly from the furnace thereto whereby the heat of the furnace is maintained in the plate for the first rolling and each set of rolls being so spaced from the adjacent set that the action of one set of rolls on the plate is completed before the next set begins to act, a furnace between adjacent sets of rolls, said furnaces receiving the plate as it emerges from the rolls, and means for causing the plate to pass through the furnaces at a less speed than it passes through the rolls, substantially as described.

6. An apparatus for forming plate including a preliminary-heating furnace in which the plate is raised to rolling temperature, a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is delivered directly from the furnace thereto whereby the heat of the furnace is maintained in the plate for the first rolling and each set of rolls being so spaced from the adjacent set that the action of one set of rolls on the plate is completed before the next set begins to act, means for heating the sets of rolls, a furnace between adjacent sets of rolls, said furnaces receiving the plate as it emerges from the rolls, and means for causing the plate to pass through the furnaces at a less speed than it passes through the rolls, substantially as described.

7. An apparatus for forming plate including a preliminary-heating furnace, a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is delivered directly from the furnace thereto whereby the heat of the furnace is maintained in the plate for the first rolling, means for heating the rolls, a furnace intermediate adjacent sets of rolls, the furnaces being so located as to receive the plate directly it emerges from the rolls, a set of feeding-rolls for each intermediate furnace operating to forward plate therethrough, and means for driving the feeding-rolls at a surface speed which is less than that of the rolls, substantially as described.

8. An apparatus for forming plate including a preliminary-heating furnace, a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is delivered directly from the furnace thereto whereby the heat of the furnace is maintained in the plate for the first rolling, furnaces intermediate adjacent sets of rolls, the furnaces being so located as to receive the plate directly it emerges from the rolls, a set of feeding-rolls for each intermediate furnace operating to forward plate therethrough, means for driving the feeding-rolls at a surface speed which is less than that of the rolls, an annealing heating-furnace, and an annealing-box to which the product is delivered, substantially as described.

9. An apparatus for forming plate including

a preliminary-heating furnace, a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is delivered directly from the furnace thereto whereby the heat of the furnace is maintained in the plate for the first rolling, means for heating each set of rolls, furnaces intermediate adjacent sets of rolls, the furnaces being so located as to receive the plate directly it emerges from the rolls, a set of feeding-rolls for each intermediate furnace operating to forward plate therethrough, means for driving the feeding-rolls at a surface speed which is less than that of the rolls, an annealing heating-furnace, and an annealing-box to which the product is delivered, substantially as described.

10. An apparatus for forming plate including a preliminary-heating furnace in which the plate is raised to rolling temperature, a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is delivered directly from the furnace thereto whereby the heat of the furnace is maintained in the plate for the first rolling, and each set of rolls being so spaced from the adjacent set that the action of one set of rolls on the plate is completed before the next set begins to act, means for heating each set of rolls, furnaces between adjacent sets of rolls, said furnaces being arranged to receive the plate directly it emerges from the rolls, means for causing the plate to pass through the furnace at a less speed than it passes through the rolls, an annealing heating-furnace receiving the plate from the last set of rolls, and an annealing-box to which the product is delivered, substantially as described.

11. In an apparatus for forming plate, the combination with a rolling mechanism through which the plate to be rolled passes in a horizontal position, of a furnace stationary with respect to the rolling mechanism and inclined to the horizontal, and means whereby plate may be fed continuously therethrough by gravity and delivered to the rolling mechanism without substantial loss of heat, said furnace being constructed to impart to the plate during its continuous movement through such furnace the proper rolling temperature, substantially as described.

12. In an apparatus for forming plate, the combination with a rolling mechanism through which the plate to be rolled passes in a horizontal position, of a furnace stationary with respect to the rolling mechanism and inclined to the horizontal, and means whereby the plate may be fed continuously therethrough by gravity and delivered to the rolling mechanism without substantial loss of heat, said means operating to control opposite edges of the plate, said furnace being constructed to impart to the plate during its continuous movement through such furnace the proper rolling temperature, substantially as described.

13. In an apparatus for forming plate, the combination with a rolling mechanism through which the plate to be rolled passes in a horizontal position, of a furnace stationary with respect to the rolling mechanism and inclined to the horizontal, means whereby the plate may be fed continuously therethrough by gravity and delivered to the rolling mechanism without substantial loss of heat, said means operating to control and guide opposite edges of the plate, said furnace being constructed to impart to the plate during its continuous movement through such furnace the proper rolling temperature, and means for preventing the center of the plate from buckling, substantially as described.

14. In an apparatus for forming plate, the combination with a rolling mechanism through which the plate to be rolled passes in a horizontal position, of a furnace inclined to the horizontal through which the plate passes continuously by gravity, said furnace being stationary with respect to the rolling mechanism and constructed to impart to the plate during its continuous movement through such furnace the proper rolling temperature, and means whereby the plate may be presented to the rolling mechanism in a horizontal position, substantially as described.

15. In an apparatus for forming plate, the combination with rolling mechanism through which the plate passes in a horizontal position, of a furnace inclined to the horizontal, means whereby packs or sheets may be fed therethrough by gravity, a feed-controller, and means for positively presenting the packs or sheets to the bite of the rolls of the rolling mechanism, substantially as described.

16. In an apparatus for forming plate, the combination with a rolling mechanism through which the plate passes in a horizontal position, of a furnace inclined to the horizontal, means for feeding packs or sheets therethrough by gravity, a feed-controller, truing devices for the packs or sheets, and means for positively presenting the packs or sheets to the bite of the rolls of the rolling mechanism, substantially as described.

17. In an apparatus for forming plate, the combination with a rolling mechanism through which the material passes in a horizontal position, of a furnace inclined to the horizontal, means for feeding packs or sheets on edge therethrough by gravity, a feed-controller, means for permitting the packs or sheets to turn into a horizontal position, truing devices for the packs or sheets, and means for positively advancing the packs into the bite of the rolls of the rolling mechanism, substantially as described.

18. In an apparatus for forming plate, the combination with a rolling mechanism through

which the material passes in a horizontal position, of a furnace inclined to the horizontal, means whereby packs or sheets may be fed therethrough by gravity, the plane of movement of any pack or sheet not being parallel to the plane of inclination of the furnace, a feed-controller including means for engaging the forward edges of the packs or sheets, lever mechanism for operating the controller, and means whereby the packs or sheets are presented to the rolling mechanism in a horizontal position, substantially as described.

19. In an apparatus for forming plate, the combination with a rolling mechanism through which the plate passes in a horizontal position, of a furnace inclined to the horizontal, means whereby packs or sheets may be fed therethrough by gravity, the plane of movement of any pack or sheet not being parallel to the plane of inclination of the furnace, a feed-controller comprising two sets of devices for engaging the forward edges of successive packs or sheets, means for operating the controller so as to cause one set to pass into engaging position as the other set passes out, and means for presenting the packs to the rolling mechanism in a horizontal position, substantially as described.

20. In an apparatus for forming plate, the combination with a rolling mechanism through which the plate to be rolled passes in a horizontal position, of a furnace inclined to the horizontal, means for feeding packs or sheets therethrough on edge by gravity, the plane of movement of any pack or sheet not being parallel to the plane of inclination of the furnace, a feed-controller including opposing slides, lever mechanism for throwing one slide into operative position as the other slide passes out of operative position, and means for presenting sheets or packs to the rolling mechanism in a horizontal position, substantially as described.

21. In an apparatus for forming plate, the combination with rolling mechanism to which the plate is presented in a horizontal position, of a furnace inclined to the horizontal, means whereby successive charges of plate are forwarded therethrough on edge by gravity, a receiving-throat, an inclined guide-surface down which the lower edge of the charge of plate slips as it passes through the throat, and means for controlling the upper edge of the charge, whereby the charge turns from an inclined to a horizontal position.

22. In an apparatus for forming plate, the combination with rolling mechanism to which the plate is presented in a horizontal position, of a furnace inclined to the horizontal, means whereby successive charges of plate are forwarded therethrough on edge by gravity, a receiving-throat, and an inclined guide-surface down which the lower edge of the charge of plate slips as it passes through the throat, a wall of the throat being located so as to form a guide for the opposite edge of the charge, whereby the charge is turned from an inclined to a horizontal position, substantially as described.

23. In an apparatus for forming plate, the combination with rolling mechanism through which the plate passes in a horizontal position, of a furnace inclined to the horizontal, means whereby successive charges of plate may be forwarded therethrough in planes inclined to the plane of inclination of the furnace, the planes of movement of successive charges being at angles to each other, a receiving-throat having oppositely-inclined guide-surfaces on its bottom down which the edges of successive charges of plate slide in opposite directions, and means for controlling the upper edges of the plate whereby successive charges of plate are turned in opposite directions from an inclined to a horizontal position, substantially as described.

24. In an apparatus for forming plate, the combination with rolling mechanism through which the plate passes in a horizontal position, of a furnace inclined to the horizontal, means whereby successive charges of plate may be forwarded therethrough in planes inclined to the plane of inclination of the furnace, the planes of movement of successive charges being at angles to each other, and a receiving-throat having oppositely-inclined guide-surfaces on its bottom down which the edges of successive charges of plate slide in opposite directions, the opposite walls of the throat being located so as to form guides for the upper edges of the charges whereby successive charges of plate are turned in opposite directions from an inclined to a horizontal position, substantially as described.

25. In an apparatus for forming plate, the combination with a rolling mechanism, of a furnace inclined to the horizontal, and through which the plate is passed by gravity, a receiver, and means whereby the receiver may be moved to an inclined position to receive the plate from the furnace and into a delivery position with respect to the rolling mechanism, substantially as described.

26. In an apparatus for forming plate, the combination with a rolling mechanism, of a furnace inclined to the horizontal, and through which the plate is passed by gravity, a receiver, means for moving the receiver into an inclined position to receive the plate from the furnace and into a delivery position with respect to the rolling mechanism, and a pusher for advancing the plate from the receiver to the rolling mechanism, substantially as described.

27. In an apparatus for forming plate, the combination with a rolling mechanism, of a furnace inclined to the horizontal, and through which the plate is passed by gravity, a re-

ceiver, means for moving the receiver into an inclined position to receive the plate from the furnace and into a delivery position with respect to the rolling mechanism, a pusher for advancing the plate from the receiver to the rolling mechanism, and a truing mechanism operating on the plate on the receiver, substantially as described.

28. In an apparatus for forming plate, the combination with a rolling mechanism, of a furnace inclined to the horizontal, and through which the plate is passed by gravity, a pivoted receiver, and means for swinging the receiver into an inclined position to receive the plate from the furnace and into a delivery position with respect to the rolling mechanism, substantially as described.

29. In an apparatus for forming plate, the combination with a rolling mechanism, of a furnace inclined to the horizontal, and through which the plate is passed by gravity, a receiver, means for moving the receiver into an inclined position to receive the plate from the furnace and into a delivery position, a slide mechanism for truing up the plate, and a pusher engaging the bottom and side of the plate and serving to advance the plate into the bite of the rolls of the rolling mechanism, substantially as described.

30. The combination with a preliminary-heating furnace through which metal to be heated is advanced and in which it is raised to rolling temperature, said furnace being sealed against the admission of air, of a set of rolls so located with respect to the furnace that the metal is delivered directly thereinto from the furnace without substantial exposure to the air, an annealing heating-furnace, means whereby the metal is conveyed after rolling into the annealing heating-furnace without substantial exposure to the air, and an annealing-box to which the annealing-furnace delivers, the metal passing from the annealing-furnace to the box without substantial exposure to the air, whereby the heating, rolling and annealing may be caused to take place as a continuous operation and without exposing the metal to oxidation, substantially as described.

31. The combination with a preliminary-heating furnace through which metal is advanced and in which it is raised to rolling temperature, said furnace being long enough to inclose a plurality of sheets or packs and being sealed against the admission of air, of a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is delivered directly thereinto from the furnace and without substantial exposure to the air, furnaces intermediate adjacent sets of rolls, said furnaces being sealed against the admission of air and receiving the plate from one set of rolls and delivering it to the next set without substantial exposure to the air, an annealing heating-furnace located closely adjacent to the last set of rolls which furnace is sealed against the admission of air, and an annealing-box which receives the plate without substantial exposure to the air from the annealing heating-furnace, whereby the preliminary heating, rolling and annealing may be caused to take place as a continuous operation and without exposing the metal to oxidation, substantially as described.

32. The combination with a preliminary-heating furnace through which metal is advanced and in which it is raised to rolling temperature, said furnace being long enough to inclose a plurality of sheets or packs of plate and being sealed against the admission of air, of a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is directly delivered thereinto from the furnace and without substantial exposure to the air, said sets of rolls being spaced from each other so that each set completes its action on the plate before the next set begins to act, furnaces intermediate adjacent sets of rolls, said furnaces being sealed against the admission of air and receiving and delivering the plate from and to the rolls without substantial exposure to the air, feeding means for forwarding the plate through the furnaces, an annealing heating-furnace located closely adjacent to the last set of rolls which furnace is sealed against the admission of air, and an annealing-box which receives the plate without substantial exposure to the air from the annealing heating-furnace, whereby the preliminary heating, rolling and annealing may be caused to take place as a continuous operation and without exposing the metal to oxidation, substantially as described.

33. The combination with a preliminary-heating furnace through which metal to be heated is advanced and in which it is raised to rolling temperature, of means for maintaining a pressure of the products in the heating-chamber of the furnace which is equal to or greater than atmospheric pressure, a set of rolls so located with respect to the furnace that the metal is delivered directly thereinto from the furnace without substantial exposure to the air, an annealing heating-furnace, means whereby the metal is conveyed after rolling into the annealing heating-furnace without substantial exposure to the air, and an annealing-box to which the annealing-furnace delivers, the metal passing from the annealing-furnace to the box without substantial exposure to the air, whereby the heating, rolling and annealing may be caused to take place as a continuous operation and without exposing the metal to oxidation, substantially as described.

34. The combination with a preliminary-heating furnace through which metal is advanced and in which it is raised to rolling

temperature, said furnace being long enough to inclose a plurality of sheets or packs, of means for maintaining a pressure of the products in the heating-chamber of the furnace which is equal to or greater than atmospheric pressure, a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is delivered directly thereinto from the furnace and without substantial exposure to the air, furnaces intermediate adjacent sets of rolls, means for maintaining a pressure of the products in the heating-chambers of said furnaces which is equal to or greater than atmospheric pressure, said furnaces receiving the plate from one set of rolls and delivering it to the next set without substantial exposure to the air, an annealing heating-furnace located closely adjacent to the last set of rolls, means for maintaining a pressure of the products in the heating-chamber of said annealing-furnace which is equal to or greater than atmospheric pressure, and an annealing-box which receives the plate without substantial exposure to the air from the annealing heating-furnace, whereby the preliminary heating, rolling and annealing may be caused to take place as a continuous operation and without exposing the metal to oxidation, substantially as described.

35. The combination with a preliminary-heating furnace through which metal is advanced and in which it is raised to rolling temperature, said furnace being long enough to inclose a plurality of sheets or packs of plate, of means for maintaining a pressure of the products in the heating-chamber of the furnace which is equal to or greater than atmospheric pressure, of a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is directly delivered thereinto from the furnace and without substantial exposure to the air, said sets of rolls being spaced from each other so that each completes its action on the plate before the next set begins to act, furnaces intermediate adjacent sets of rolls, means for maintaining a pressure of the products in the heating-chambers of said furnaces which is equal to or greater than atmospheric pressure, said furnaces receiving and delivering the plate from and to the rolls without substantial exposure to the air, feeding means for forwarding the plate through the furnaces, an annealing heating-furnace located closely adjacent to the last set of rolls, means for maintaining a pressure of the products in the heating-chamber of said annealing-furnace which is equal to or greater than atmospheric pressure, and an annealing-box which receives the plate without substantial exposure to the air from the annealing heating-furnace, whereby the preliminary heating, rolling and annealing may be caused to take place as a continuous operation and without exposing the metal to oxidation, substantially as described.

36. In an apparatus for forming plate, the combination with a plurality of sets of rolls, the sets being spaced from each other so that one set ceases to act on the plate before the next set begins to act, furnaces between adjacent sets of rolls, each furnace being arranged to receive the plate directly from the set of rolls ahead of it and deliver it directly to the set behind it, means for forwarding plate through the furnaces, and guides for controlling the movement of the plate, substantially as described.

37. In an apparatus for forming plate, the combination with a plurality of sets of rolls, the sets being spaced from each other so that one set ceases to act on the plate before the next set begins to act, furnaces between adjacent sets of rolls, each furnace being arranged to receive the plate directly from the set of rolls ahead of it and deliver it directly to the set behind it, means for forwarding plate through the furnaces, and supporting-guides and side guides for controlling the movement of the plate, substantially as described.

38. In an apparatus for forming plate, the combination with a plurality of sets of rolls, the sets being spaced from each other so that one set ceases to act on the plate before the next set begins to act, furnaces between adjacent sets of rolls, each furnace being arranged to receive the plate directly from the set of rolls ahead of it and deliver it directly to the set behind it, means for forwarding plate through the furnaces, and supporting-guides, side guides and top guides for controlling the movement of the plate, substantially as described.

39. In an apparatus for forming plate, the combination with a plurality of sets of rolls, the sets being spaced from each other so that one set ceases to act on the plate before the next set begins to act, furnaces between adjacent sets of rolls, each furnace being arranged to receive the plate directly from the set of rolls ahead of it and deliver it directly to the set behind it, means for forwarding plate through the furnaces, and supporting-guides, the walls of the furnaces being formed to afford side and top guides, substantially as described.

40. In an apparatus for forming plate, the combination with a plurality of sets of rolls, the sets being spaced from each other so that one set ceases to act on the plate before the next set begins to act, furnaces between adjacent sets of rolls, each furnace being arranged to receive the plate directly from the set of rolls ahead of it and deliver it directly to the set behind it, and feeding-rolls working through narrow slits in the furnace-walls, substantially as described.

41. In an apparatus for forming plate, the combination with a plurality of sets of rolls,

the sets being spaced from each other so that one set ceases to act on the plate before the next set begins to act, furnaces between adjacent sets of rolls, each furnace being arranged to receive the plate directly from the set of rolls ahead of it and deliver it directly to the set behind it, and feeding-rolls working through narrow slits in the furnace-walls, said rolls having staggered feeding-faces, substantially as described.

42. In an apparatus for forming plate, the combination with sets of rolls, of a two-part furnace located between adjacent sets of rolls, the parts of the furnace being connected by a contracted channel, and feeding-rolls working through narrow slits in the walls of the channel, substantially as described.

43. In an apparatus for forming plate, the combination with sets of rolls, of a two-part furnace located between adjacent sets of rolls, the parts of the furnace being connected by a contracted channel, and feeding-rolls having staggered feeding-faces working through narrow slits in the walls of the channel, substantially as described.

44. In an apparatus for forming plate, the combination with sets of rolls, of a two-part furnace located between adjacent sets of rolls, the parts of the furnace being connected by a contracted channel, and feeding-rolls comprising slotted staggered disks working through narrow slits in the walls of the channel, substantially as described.

45. In an apparatus for forming plate, the combination with sets of rolls, of a two-part furnace located between adjacent sets of rolls, the parts of the furnace being connected by a contracted channel, feeding-rolls working through narrow slits in the walls of the channel, and means for driving the feeding-rolls at a lesser speed than the sets of rolls, substantially as described.

46. In an apparatus for forming plate, the combination with sets of rolls, of a two-part furnace located between adjacent sets of rolls, the parts of the furnace being connected by a contracted channel, feeding-rolls having staggered feeding-faces working through narrow slits in the walls of the channel, and means for driving the feeding-rolls at a lesser speed than the sets of rolls, substantially as described.

47. In an apparatus for forming plate, the combination with sets of rolls, of a two-part furnace located between adjacent sets of rolls, the parts of the furnace being connected by a contracted channel, feeding-rolls comprising slotted staggered disks working through narrow slits in the walls of the channel, and means for driving the feeding-rolls at a lesser speed than the sets of rolls, substantially as described.

48. In an apparatus for forming plate, the combination with a preliminary-heating furnace long enough to inclose a plurality of sheets or packs of plate and through which the plate is forwarded, of a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is delivered directly from the furnace thereinto without substantial exposure to the air, means for maintaining a pressure of the products in said furnace which is equal to or greater than atmospheric pressure, a two-part furnace located between adjacent sets of rolls and receiving and delivering the plate from and to said rolls without substantial exposure to the air, the parts of the furnaces being connected by a contracted channel, feeding-rolls working through narrow slits in the walls of the channels, and means for maintaining a pressure of the products in the two-part furnaces which is equal to or greater than atmospheric pressure, substantially as described.

49. In an apparatus for forming plate, the combination with a preliminary-heating furnace long enough to inclose a plurality of sheets or packs of plate and through which the plate is forwarded, of a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is delivered directly from the furnace thereinto without substantial exposure to the air, means for maintaining a pressure of the products in said furnace which is equal to or greater than atmospheric pressure, a two-part furnace located between adjacent sets of rolls and receiving and delivering the plate from and to said rolls without substantial exposure to the air, the parts of the furnaces being connected by a contracted channel, feeding-rolls working through narrow slits in the walls of the channels, means for maintaining a pressure of the products in the two-part furnaces which is equal to or greater than atmospheric pressure, an annealing heating-furnace, and an annealing-box, substantially as described.

50. In an apparatus for forming plate, the combination with a preliminary-heating furnace long enough to inclose a plurality of sheets or packs of plate and through which the plate is forwarded, of a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is delivered directly from the furnace thereinto without substantial exposure to the air, means for maintaining a pressure of the products in said furnace which is equal to or greater than atmospheric pressure, a two-part furnace located between adjacent sets of rolls and receiving and delivering the plate from and to said rolls without substantial exposure to the air, the parts of the furnaces being connected by a contracted channel, feeding-rolls having staggered feeding-faces working through narrow slits in the walls of the channels, and means for maintaining a pressure of the prod-

ucts in the two-part furnaces which is equal to or greater than atmospheric pressure, substantially as described.

51. In an apparatus for forming plate, the combination with a preliminary-heating furnace long enough to inclose a plurality of sheets or packs of plate and through which the plate is forwarded, of a plurality of sets of rolls arranged to act successively on the plate, the first set being so located with respect to the furnace that the plate is delivered directly from the furnace thereinto without substantial exposure to the air, means for maintaining a pressure of the products in said furnace which is equal to or greater than atmospheric pressure, a two-part furnace located between adjacent sets of rolls and receiving and delivering the plate from and to said rolls without substantial exposure to the air, the parts of the furnaces being connected by a contracted channel, feeding-rolls having staggered feeding-faces working through narnow slits in the walls of the channels, means for maintaining a pressure of the products in the two-part furnaces which is equal to or greater than atmospheric pressure, an annealing heating-furnace, and an annealing-box, substantially as described.

52. In an apparatus for forming plate, the combination with a furnace in which the plate is given its preliminary heating, of means for burning hydrocarbon fuel therein and for maintaining a pressure of the products equal to or greater than atmospheric pressure, a plurality of sets of rolls, the first set being located so as to receive the plate directly from the preliminary-heating furnace and without substantial exposure to the air, means for heating the rolls, a furnace intermediate said first set of rolls and the succeeding set, said furnace being arranged to receive the plate directly from the first set and deliver it directly to the second set, whereby the plate is received from and delivered to the rolls without substantial exposure to the air, means for burning hydrocarbon fuel therein and for maintaining a pressure of the products which is equal to or greater than atmospheric pressure, substantially as described.

53. In an apparatus for forming plate, the combination with a furnace in which the plate is given its preliminary heating, of means for burning hydrocarbon fuel therein and for maintaining a pressure of the products equal to or greater than atmospheric pressure, a plurality of sets of rolls, the first set being located so as to receive the plate directly from the preliminary-heating furnace and without substantial exposure to the air, means for heating the rolls, a furnace intermediate said first set of rolls and the succeeding set, said furnace being arranged to receive the plate directly from the first set and deliver it directly to the second set, whereby the plate is received from and delivered to the rolls without substantial exposure to the air, means for burning hydrocarbon fuel therein and for maintaining a pressure of the products which is equal to or greater than atmospheric pressure, an annealing heating-furnace, means whereby the plate is caused to enter said furnace without substantial exposure to the air, means for burning hydrocarbon fuel in said annealing-furnace and for maintaining a pressure therein which is equal to or greater than atmospheric pressure, an annealing-box receiving the plate directly and without substantial exposure to the air from the annealing-furnace, and means for burning hydrocarbon fuel in said box, substantially as described.

54. In an apparatus for forming plate, the combination with a set of rolls, of means for giving the plate a preliminary heating without substantial exposure to the air and for causing it to reach the rolls without substantial exposure to the air, a furnace behind the set of rolls, said furnace receiving the plate directly from the rolls without substantial exposure to the air, and means for maintaining a pressure of the products in said furnace which is equal to or greater than atmospheric pressure, substantially as described.

55. In an apparatus for forming plate, the combination with a set of rolls, of means for giving the plate a preliminary heating without substantial exposure to the atmosphere and for causing it to reach the rolls without substantial exposure to the atmosphere, a second set of rolls, a furnace behind said set of rolls, said furnace having contracted entrance and delivery openings, the entrance-opening being located close to the first set of rolls and the delivery-opening being located close to the second set of rolls, whereby the plate is received by and delivered from the furnace without substantial exposure to the atmosphere, and means for burning hydrocarbon fuel in said furnace and maintaining a pressure of the products therein which is equal to or greater than atmospheric pressure, substantially as described.

56. In an apparatus for forming plate, the combination with a set of rolls, of means for giving the plate a preliminary heating without substantial exposure to the atmosphere and for causing it to reach the rolls without substantial exposure to the atmosphere, a second set of rolls, a furnace behind said set of rolls, said furnace having contracted entrance and delivery openings, the entrance-opening being located close to the first set of rolls and the delivery-opening being located close to the second set of rolls, whereby the plate is received by and delivered from the furnace without substantial exposure to the atmosphere, means for burning hydrocarbon fuel in said furnace and maintaining a pressure of the products therein which is equal to or greater than atmospheric pressure, an annealing heating-furnace, means for causing

the plate to reach the annealing-furnace from the rolls without substantial exposure to the atmosphere, means for maintaining a pressure of the products in the annealing heating-furnace which is equal to or greater than atmospheric pressure, and an annealing-box receiving the plate directly from the annealing-furnace and without substantial exposure to the air, substantially as described.

57. In an apparatus for forming plate, the combination with a plurality of sets of rolls, of furnaces intermediate the sets of rolls, means for burning hydrocarbon fuel in said furnaces, a set of feeding-rolls for each intermediate furnace, a driving mechanism for the feeding-rolls, means whereby the entry of more than the normal quantity of plate between any set of feeding-rolls throws that set of rolls out of operation, and connections whereby the stoppage of any set of feeding-rolls stops all the sets and diminishes the supply of hydrocarbon fuel, substantially as described.

58. In an apparatus for forming plate, the combination with a furnace in which the plate is given a preliminary heating, of means for burning hydrocarbon fuel in said furnace, a plurality of sets of rolls, furnaces intermediate said sets of rolls, means for burning hydrocarbon fuel in the intermediate furnaces, a set of feeding-rolls for each intermediate furnace, driving mechanism for the feeding-rolls, means whereby the entry of more than the normal amount of plate between any set of feeding-rolls will disconnect that set of rolls from its driving mechanism, connections whereby the stoppage of any set of feeding-rolls disconnects all the sets from the driving mechanism, and connections whereby the stoppage of the feeding-rolls diminishes the supply of hydrocarbon fuel in all the furnaces, substantially as described.

59. In an apparatus for forming plate, the combination with a furnace in which the plate is given a preliminary heating, of means for burning hydrocarbon fuel in said furnace, a plurality of sets of rolls, means for heating these rolls by hydrocarbon fuel, furnaces intermediate said sets of rolls, means for burning hydrocarbon fuel in the intermediate furnaces, a set of feeding-rolls for each intermediate furnace, driving mechanism for the feeding-rolls, means whereby the entry of more than the normal amount of plate between any set of feeding-rolls will disconnect that set of rolls from its driving mechanism, connections whereby the stoppage of any set of feeding-rolls disconnects all the sets from the driving mechanism, and connections whereby the stoppage of the feeding-rolls diminishes the supply of hydrocarbon fuel in all the furnaces, and to all the sets of rolls, substantially as described.

60. In an apparatus for forming plate, the combination with a furnace in which the plate is given its preliminary heating, of a plurality of sets of hot rolls, a furnace behind and adjacent each set of hot rolls, a set of feeding-rolls for each furnace, driving mechanism for the feeding-rolls, means whereby the entry of more than the normal amount of plate between any set of feeding-rolls disconnects that set from its driving mechanism, connections whereby the stoppage of any set of feeding-rolls disconnects all the feeding-rolls, a feed-stop coöperating with the first set of hot rolls, and means whereby the disconnection of any set of feeding-rolls operates the feed-stop and prevents plate from being fed to said first set of rolls, substantially as described.

61. In an apparatus for forming plate, the combination with a furnace in which the plate is given its preliminary heating, of means for burning hydrocarbon fuel in said furnace, a plurality of sets of hot rolls, means for heating these rolls by means of hydrocarbon fuel, a furnace behind and adjacent to each set of hot rolls, feeding-rolls coöperating with these furnaces, driving mechanism for said feeding-rolls, means for burning hydrocarbon fuel in the intermediate furnaces, a feed-stop between the first set of hot rolls and the preliminary-heating furnace, connections whereby the entry of more than the normal amount of plate between any set of feeding-rolls disconnects that set from the driving mechanism, connections whereby the stoppage of any set of feeding-rolls disconnects all the sets from their driving mechanism, connections whereby the stoppage of any set of feeding-rolls throws the feed-stop into operation and prevents the feed to the first set of hot rolls, substantially as described.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

DANIEL M. SOMERS.

Witnesses:
W. H. KENNEDY,
G. GALIANI.