Oct. 13, 1931. F. A. FAHRENWALD 1,827,079

FURNACE

Filed Sept. 16, 1927 4 Sheets-Sheet 1

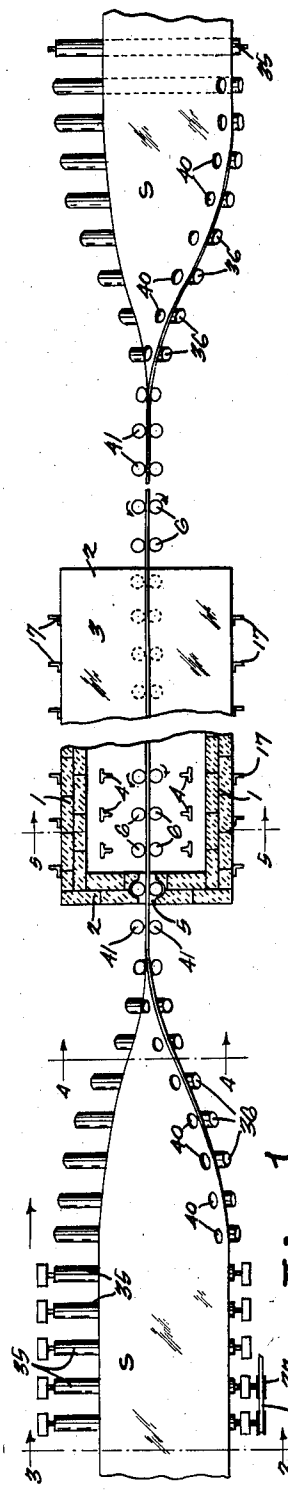


Fig. 1

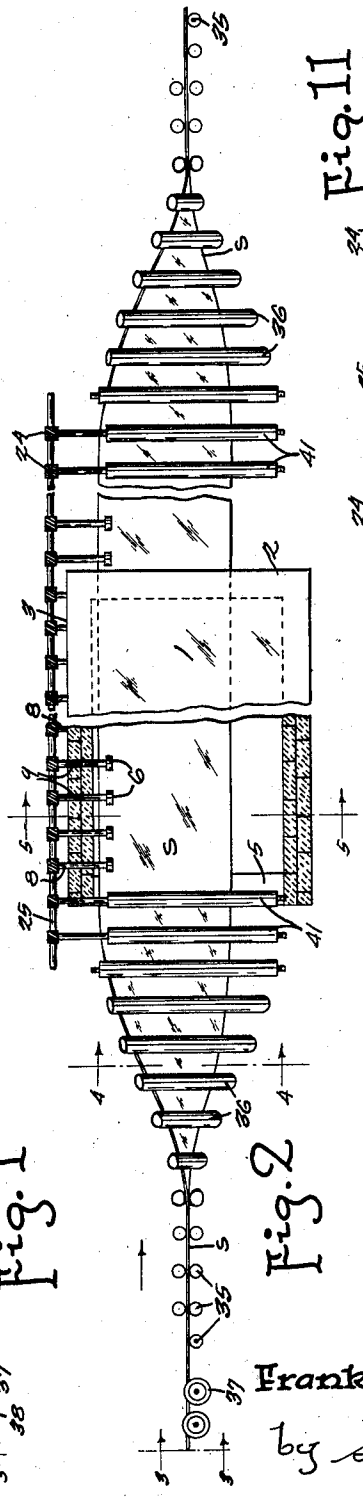


Fig. 2

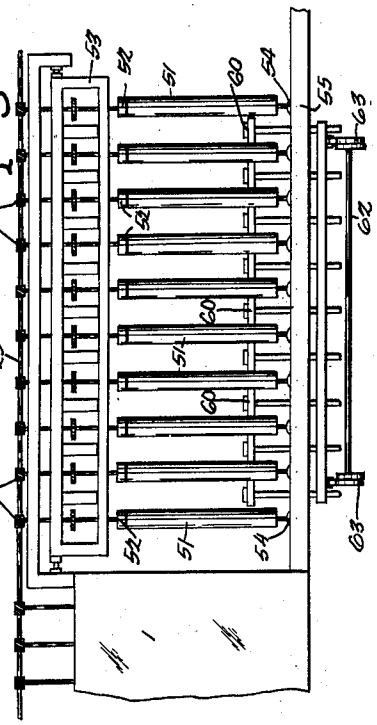


Fig. 11

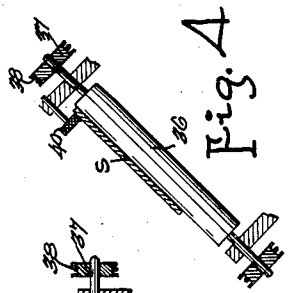


Fig. 4

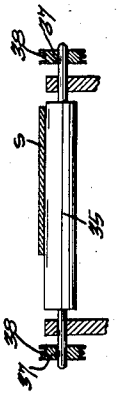


Fig. 3

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FURNACE

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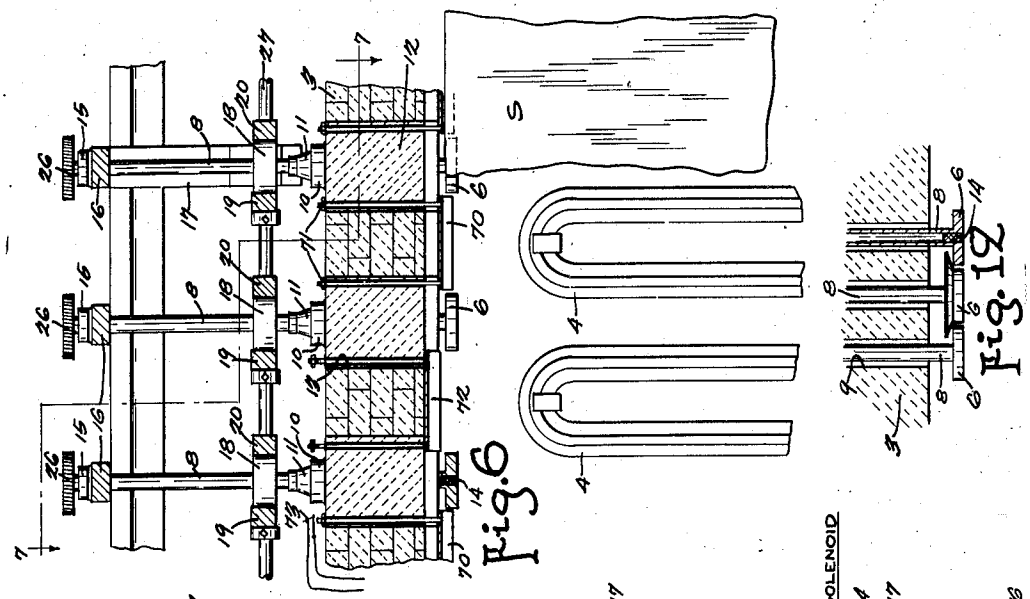


Fig. 6

Fig. 12

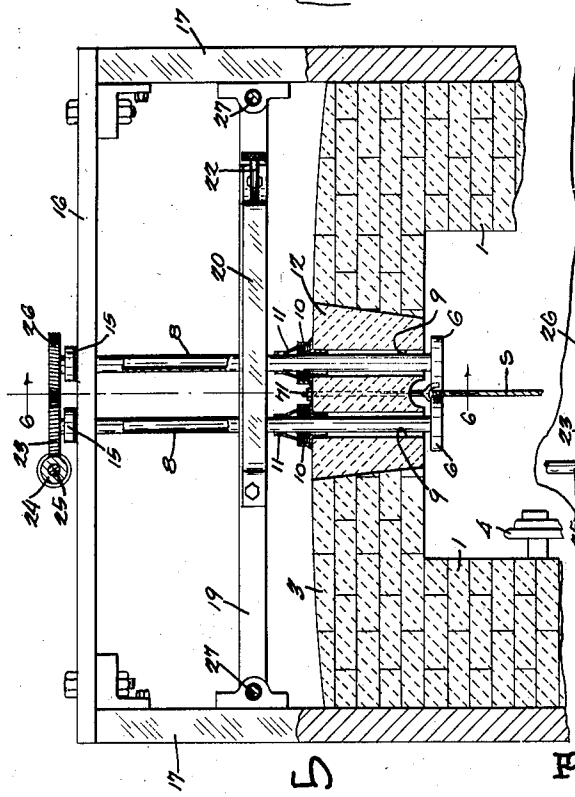


Fig. 5

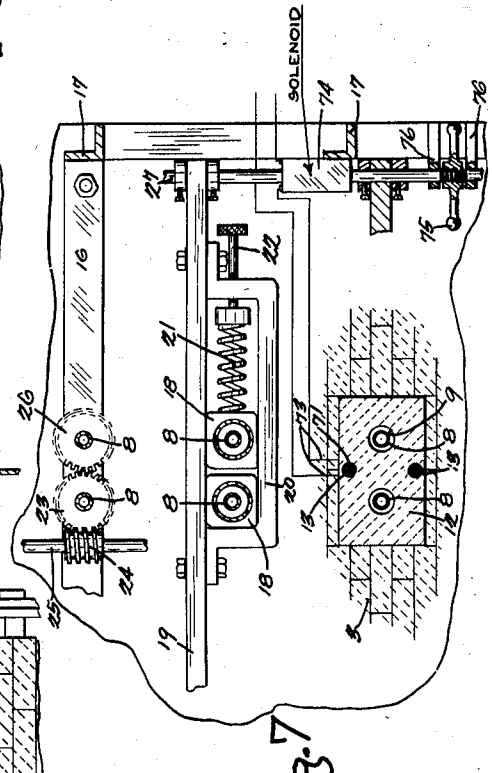


Fig. 7

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FURNACE

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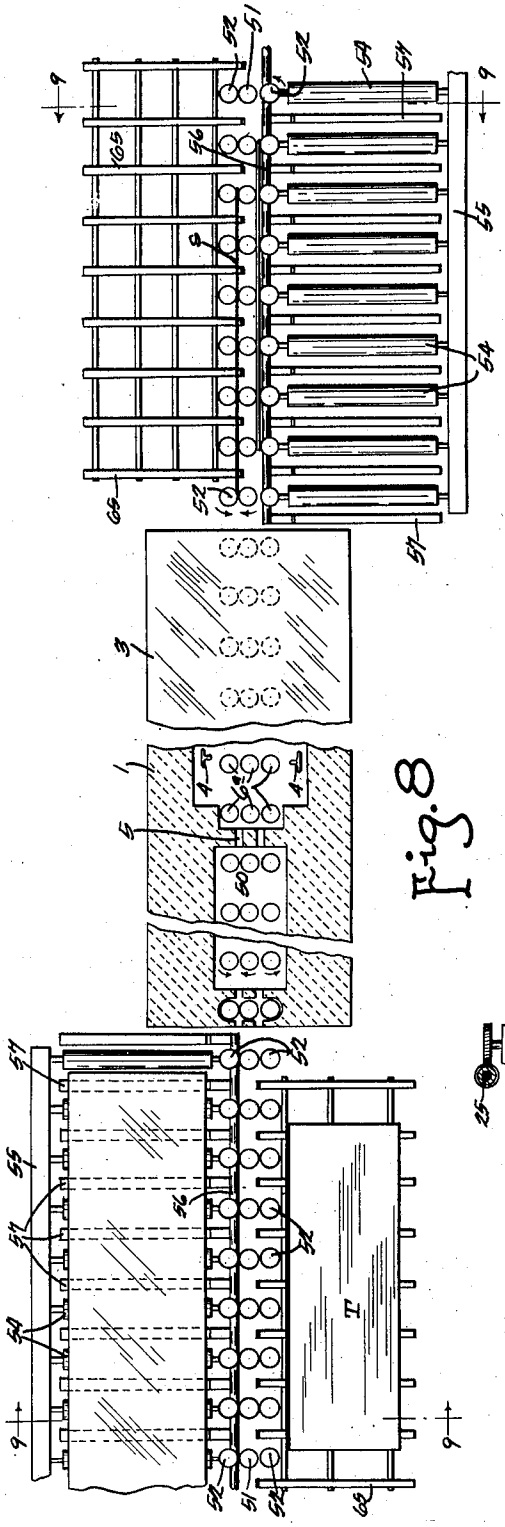


Fig. 8

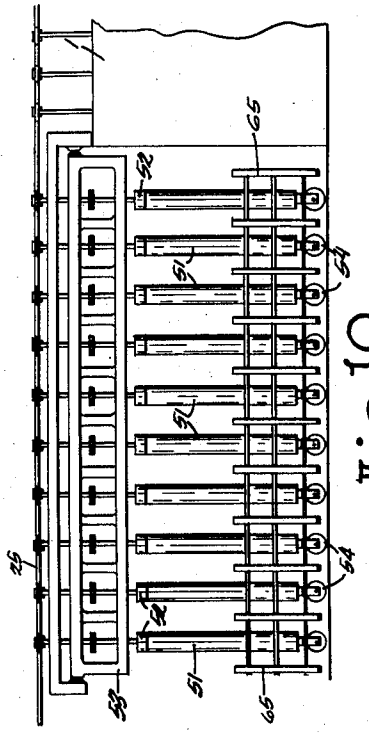


Fig. 10

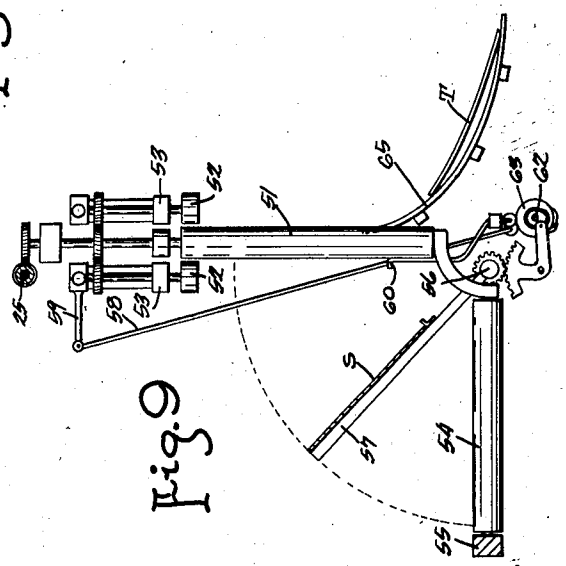


Fig. 9

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FURNACE

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Fig. 14.

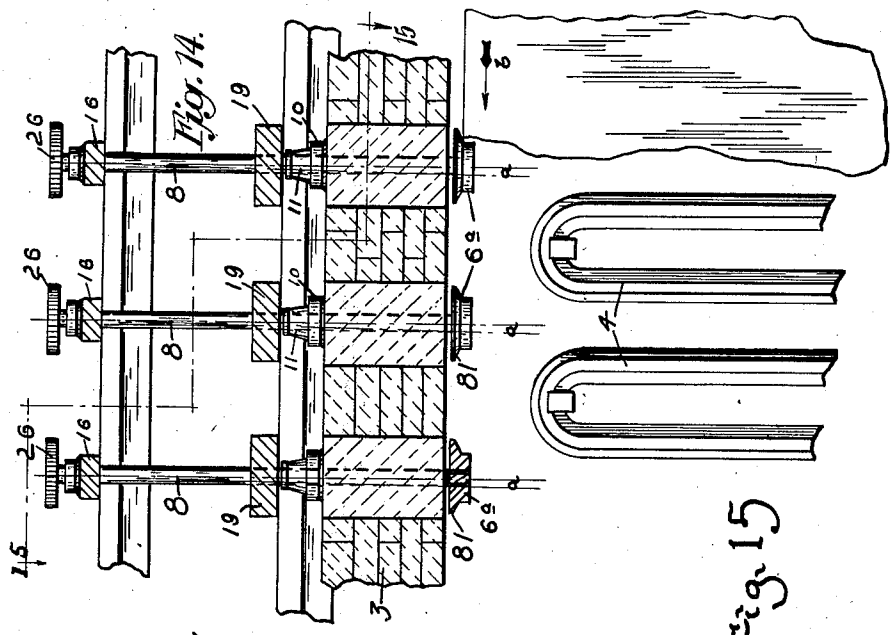


Fig. 15

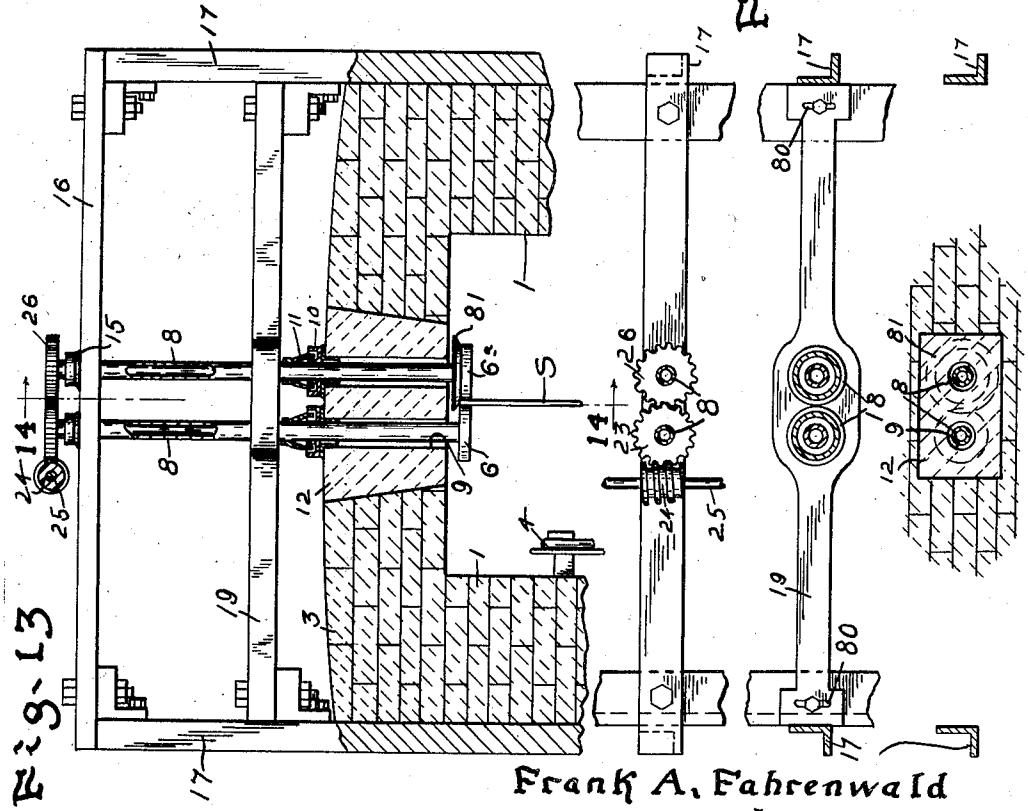


Fig. 13

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Patented Oct. 13, 1931 1,827,079

UNITED STATES PATENT OFFICE

FRANK A. FAHRENWALD, OF CHICAGO, ILLINOIS

FURNACE

Application filed September 16, 1927. Serial No. 219,886.

This invention relates to furnaces for heat-treatment of metal sheets or plates and has for its object the provision of a new and improved construction and arrangement of continuous process furnace whereby flat sheets or plates may be transported through the heated chamber in vertical position, with no contact between either surface of the sheet and any portion of the furnace or conveyor mechanism. Further objects of the invention comprise the provision of a furnace which shall be particularly economical both in ground space and in heat consumption; the provision of a furnace wherein the conveying mechanism is mounted above the same; while further and subsidiary objects and advantages of the invention will become apparent as the description proceeds.

Furnaces of the type described find their major utility in the annealing or normalizing of steel sheets, such for example as used in the manufacture of automobile body parts and the like, in which it is necessary to secure deep drawing characteristics and high ductility, for which, in the case of steel, it is often necessary to heat the sheet to temperatures as high as 1950° F., and subsequently cool the same either rapidly or slowly as the particular requirement may demand. However, my invention is not limited to the treatment of ferrous metal or to any given temperature conditions, and wherever steel is mentioned herein it is intended, not as a limitation, but as an example.

Steel sheets having the above described characteristics of deep drawing and high ductility have only become known or available within a comparatively short period of time, due to improvements in metallurgical apparatus and methods caused by the demands largely of automobile manufacturers. Formerly such annealing as was done was accomplished by piling such sheets one upon the other and either transferring the entire mass into a furnace chamber, to be left for such period of hours as was necessary to bring the whole more or less uniformly to an elevated temperature, or to build a furnace over the pile and heat the same in situ. In either case it was impossible to produce uniform temperatures throughout, and the highest temperatures were always limited by the danger of melting the outermost portions and the certainty of sticking together and deforming the lowermost sheets if heated to a plastic condition. The practice was next adopted of transporting the sheets singly through the furnace by means of rollers or other carriers, such for example as set forth in my Patents, Numbers 1,539,833 and 1,623,469 which permitted a great increase in the temperature, and substantial uniformity in the heat treatment, but the necessary contact of the supporting rollers with the lower surface of the sheet, at the high temperatures employed, inevitably produced small imperfections at that point which it is desirable to avoid, for which purpose I herein carry the sheets through the furnace vertically, suspended from their upper edges in such a manner that excepting for a narrow region near such upper edge, neither surface comes in contact with any object whatever during the entire heat-treating operation.

In the drawings accompanying and forming a part of my application I have illustrated certain physical structures in which my inventive ideas are embodied, although it will be understood that the same are to a considerable extent merely diagrammatic, and are intended generally to be illustrative rather than limiting upon me. Fig. 1 is a top plan view, largely diagrammatic in its nature, showing one of my improved furnaces together with one mode of manipulating the sheet; Fig. 2 is a side elevation of the parts shown in Fig. 1; Figs. 3, 4, and 5 are cross sectional views corresponding respectively to the lines 3—3, 4—4, and 5—5 of Figs. 1 and 2; Fig. 6 is a sectional view corresponding to the line 6—6 of Fig. 5; Fig. 7 is a sectional view corresponding to the broken line 7—7 of Fig. 6; Fig. 8 is a diagrammatic view similar to Fig. 1 illustrating a modified type of furnace and a modified construction of plate feeding and removing apparatus; Fig. 9 is a sectional view corresponding to either of the lines 9—9 of Fig. 8; Fig. 10 is a side elevation of the unloading stations shown in Fig. 8; Fig. 11 is a side elevation of the loading stations thereof;

Fig. 12 illustrates a modified roller construction; Fig. 13 is a transverse sectional view similar to Fig. 5 but showing a modification; Fig. 14 is a sectional view corresponding to the line 14—14 of Fig. 13; and Fig. 15 is a sectional view corresponding to the broken line 15—15 of Fig. 14.

Any suitable or desired construction of furnace can be employed, made of any suitable refractory materials and generally comprising side walls 1—1, end walls 2—2 and roof 3, heated in any suitable or desired manner as by electrical resistance elements 4—4 hung on the side walls. Formed in each end wall is a narrow vertical slot 5 for the passage of the sheet, and mounted in the roof of the furnace are a plurality of paired vertical rolls 6—6 adapted to receive the sheet S between them, said rolls being pressed together with sufficient force to hold the sheet by friction alone from dropping vertically, and driven in such direction and at such speed to cause said sheet to pass steadily and uniformly through the furnace from end to end. These pairs of rolls are placed closely enough together, one after the other throughout the length of the furnace, to provide the necessary holding force for large sheets and also to make possible the passage through the furnace of relatively short sheets of the same or different lengths without adjustment. The drive may be exerted either through one roll, with the second roll of each pair serving as an idler, or the rolls can be geared together so that each is positively driven.

While many different detail constructions can be made within the limits of the foregoing general requirements, I have selected the mechanism of Figs. 5, 6, and 7 as illustrating in a practical way the chief requirements. The rolls 6—6 are made of a high temperature alloy and are preferably integral with the shafts 8—8 which project through vertical apertures 9 in the top of the furnace, upflow of heated gases therealong being prevented by some kind of seal, such as an annular channel as shown at 10 containing sand, mercury, oil, or water and coacting with a suitable bell 11. I have shown a special tile 12 suitably inset in the furnace roof and formed both with the apertures 9 and with other apertures 13 for a purpose to be explained later.

I have shown these shafts as hollow to decrease the heat-conductivity and plugged at their lower ends 14, to prevent gas convection therethrough. The upper ends of the shafts are journaled in bearings 15 carried by cross bars 16 secured to the upper ends of the uprights 17 ordinarily provided at the sides of such a furnace to steady and support the brickwork.

Surrounding each of the shafts 8 I have shown a second bearing 18, one bearing of each pair being rigidly secured to a horizontal cross bar 19 located transversely of the furnace top, the other being free to move laterally along said bar on the path defined by the guide 20 but urged continuously toward the fixed bearing in some suitable manner as by the spring 21, the tension of which is adjustable by the screw 22. A weight could be substituted but is not so convenient and has greater inertia. If carefully made the spring of the shafts themselves is sufficient.

Secured to the top of each shaft in one row is a gear wheel 23 meshing with a worm 24 carried by a horizontal driving shaft 25 which extends the length and causes all the rolls to turn in the same direction and at the same speed. It is not imperative that the other shaft be driven, the roll carried thereby being treated merely as an idler, although I find it preferable to provide the upper end thereof with a companion gear 26 meshing with the gear 23. It is convenient to have these spiral gears of slight angle both to facilitate meshing with the worm and to produce smooth running.

The rolls 6 may be surfaced in any manner desired. I prefer whenever possible to have them smooth since thereby the effect upon the sheet is less marked, but it is feasible to knurl or bevel the same, either of which actions tends to some degree to increase the security of their holding upon the sheet. In case the weight of the sheet and its consequent slippage exceeds the ability of vertically positioned rolls to sustain, the difficulty is overcome by inclining the roll shafts 8 very slightly in a vertical plane along the axis of the furnace so that the edges of the rollers are tilted upwardly somewhat towards the discharge end of the furnace, thus producing a constant slight tendency to elevate the sheet and thereby overcome its tendency to drop. A very easy mode of effecting this inclination is to support the cross bars 19 on longitudinally movable horizontal rods 27. This enables the simultaneous inclination of all the shafts, as may be necessary to keep the sheet always at a uniform elevation throughout the furnace. Certain modes for operating these rods, both manually and automatically will be described hereafter. It should be noted, however, that the total amount of inclination of the shafts, either longitudinally or transversely, is very small and generally within the tolerance of the bearings 15, without any special pivoting provisions.

Whatever be the detail mode of supporting and driving these rolls, the same is continued not only throughout the length of the furnace, but also to a sufficient distance beyond the discharge end thereof to enable the proper cooling of the sheets, such cooling being more or less rapid in accordance with the nature of the material and the kind of treatment required. So far as the furnace itself is concerned, the mode of presenting and removing the sheets is immaterial, and the same may

even be done by hand. However, for purposes of convenient operation it is desirable that the same should be effected with a minimum of hand labor, wherefore I have illustrated certain mechanical expedients for the purpose in view. Thus in Figs. 1 to 4 inclusive, for the purpose of treating long or continuous sheets, especially of thin gauge, I provide a conveyor consisting of a horizontal series of spaced horizontal rollers 35 extending to a point near the furnace at each end and communicating therewith through the mediation of a series of other rolls 36 of gradually increasing inclination at the entering end of the furnace and gradually decreasing inclination at the discharge end thereof. These rolls are driven in any suitable or desired manner, the mode herein illustrated comprising grooved sheaves 37 and cables 38 wrapped about the same, since this mode lends itself more easily than others to the varying inclination. As soon as the sheet S is given any substantial inclination as a result of the position of the rollers 36, companion rollers 40 are preferably furnished as shown in Figs. 1 and 4. These can be driven if desired but I have shown the same as mere idlers. Also in view of the softness of the sheet inside the furnace it is desirable to protect the same from irregularities in the operation of the conveyor at either end thereof, which I effect by forming certain of the vertical rolls adjacent each end of the furnace of the complete height of the furnace as shown at 41 in Fig. 2, and driving these at the same rate as the rolls 6 by means of the same driving shaft 25. Inasmuch as these rolls 41 occur in pairs and grip the sheet tightly throughout its entire vertical extent, the variation of the conveyor operation outside thereof is neutralized.

In Fig. 8 I have illustrated a modified form of furnace and a modified feeding and receiving mechanism. The furnace, instead of having the rolls 6 arranged merely in two rows has similar rolls 6^a arranged in such a number of rows and so rotated as to effect the simultaneous handling of two sheets S and T which accordingly progress in opposite directions. Two major advantages are produced by this arrangement: first, that a single furnace will handle twice as much sheet as before with the addition merely of a few more rolls; and, second, that the thermal-economy of the furnace is substantially improved inasmuch as the heat carried by the treated plate upon its emergence from the furnace at each end is in large part absorbed by the entering cold plate, this heat transfer being facilitated, at the side, by the provision of a vestibule chamber 50 at each end of the heated chamber.

Each end of the furnace is accordingly provided with both a loading and an unloading station, the rolls being carried to the extreme of each station in the same grouping as in the furnace but with the exception that the middle rolls are preferably elongated as indicated at 51 so as to separate each loading and unloading station, and the outer rolls 52—52 of each set are journaled in pivoted frames 53—53 adapted to be swung outwardly to receive and discharge the plates. In connection with each loading station I have shown a conveyor comprising horizontal rollers 54 journaled in a frame 55 along one side of the vertical rollers 51. Journaled below said vertical rollers and at one side of the horizontal rollers is a rock shaft 56 provided with a plurality of radial arms 57 adapted in one position to lie between the rollers 54 as shown in Fig. 8 and in another position to be raised up alongside the rolls 51 as shown in Fig. 9 carrying the plate S therewith. Arrived at the last named position the corresponding frame 53 is released in any suitable manner as by the push rod 58 and arm 59, at the same time that the plate S is elevated edgewise into the space between the rollers in any suitable manner as by the pushers 60. In Fig. 9 I have shown a rotating shaft 62 provided with cams 63 adapted to effect the three-fold function of raising the arms 57, opening and closing the space between the rolls, and elevating the plate into such space. The discharge of the plate may obviously be accomplished by the use of the same mechanism, but it is even simpler merely to rock the frame 53 and allow the plate to fall upon curved skids 65 by which it is conveyed away. In the arrangements last described, the rolls 51 and 52 are driven at the same speed as the rolls 6^a by the fact that all of the same are operatively connected to one and the same drive shaft 25.

To arrest any down-slipping tendency on the part of a heavy sheet it is sometimes desirable to incline the rolls gradually lengthwise of the furnace, and one mode of doing this is shown in Figs. 5, 6, and 7. The upper bearings 15 of the shafts 8 are mounted on fixed cross-bars 16, while the lower bearings 18 are carried by cross bars 19 so supported as to be movable longitudinally of the furnace. In the present embodiment this is effected by supporting the bars 19 on horizontal rods 27 located one at each side of the furnace. These rods are slidable in yokes carried by the uprights 17, while relative movement between the rods 27 and cross bars 19 is prevented by suitable collars on the cross bars as shown in Fig. 7. These rods can be moved to adjust the inclination of the shaft 8 either manually by means of a hand-wheel 75 screwed thereon and working between abutments 76 carried by the furnace-frame (see Fig. 7) or electrically by means of a solenoid 74. When both hand-wheel and solenoid are used a small amount of space is left between the hub of wheel 75 and the abut-

ments 76, since this automatic operation when employed at all (and it is seldom necessary) is always confined to a small range.

In order to assist in guiding the sheets through the furnace I have shown inverted troughs 70 in Figs. 5 and 6, supported by means of vertical bolts 71 passing through the holes 13 heretofore mentioned. Obviously these channels might be secured tightly and employed for forcible guiding, but it is preferable in some cases to employ mechanism to automatically shift the position of the rolls in accordance with the position of the sheet and one simple means of so doing is shown in Figs. 5, 6, and 7. To this end the channels are suspended loosely, the bolts 71 being of such length as to restrain the downward movement of the same at a level position while permitting them to rise freely as shown at 72 in Fig. 6. Above certain of the bolts are placed electric contacts 73 in series with solenoids 74 so arranged as to control the position of the rods 27. For example, the shafts are all set at such an angle as to cause the sheet to rise gradually, and the solenoid so set that when the contacts 73 are manipulated the rods 27 restore the shafts to vertical position or thereabout, so that the sheet gradually settles, thus finally causing the manipulation of said contacts in a reverse sense. This may be done in many other ways.

In Figs. 13, 14, 15 I have shown the same elevation-maintaining features embodied in a simpler form. The shafts 8, 8, are arranged in pairs as shown in Fig. 5, the cross-bars 19 being displaced relatively to the cross-bars 16 (as by slots 80) so that each shaft makes a small angle to the vertical as shown at *a* in Fig. 14. The sheet is assumed to travel from right to left as shown by the arrow *b* and the direction of inclination of the shafts is such as to tend to elevate the sheet gradually as it passes through the furnace, this elevation being resisted by forming one roller, 6^a, of each set with a flange 81 overlapping the edge of the sheet.

It is not necessary to incline both shafts to achieve this result. One shaft of each set can be fixed in vertical position and the other shaft or shafts inclined. This is particularly useful in the three-row arrangement shown in Fig. 8.

I am aware that the idea of heat-treating metal sheets in a vertically suspended position is not broadly new, since it has heretofore been suggested to employ an overhead mono-rail for holding the sheet suspended during its passage through the furnace. I do not, therefore, claim the basic idea of edgewise transport but I believe I am the first to accomplish this by the use of vertical rolls engaging merely a narrow region along the margin of the sheet which edge is seldom, if ever, used in any case. Accordingly I claim this feature of my invention broadly and without limitation to accessory features. It will also be understood that many changes in detail can be made within the scope of the attached claims which I desire may be construed each independently of limitations contained in other claims.

Having thus described my invention what I claim is:

1. In a metallurgical furnace the combination with a heated chamber of a plurality of vertical rolls supported in a plurality of horizontal rows in said chamber, and means for rotating in the same direction the rolls of one of said rows, the length of the rolls being less than the height of the chamber.

2. In a metallurgical furnace the combination with a heated chamber of a plurality of vertical rolls supported in a plurality of horizontal rows in said chamber, and means for rotating in the same direction the rolls of at least one of said rows, and means for adjusting the rolls of the different rows toward and from each other transversely of the furnace to receive metal sheets between them.

3. In a metallurgical furnace the combination with a heated chamber of a plurality of vertical rolls supported in a plurality of horizontal rows in said chamber, and means for rotating in the same direction the rolls of at least one of said rows, the said rolls being located adjacent to the roof of the chamber and the vertical dimension of the roll face being less than the vertical width of the sheets supported thereby.

4. In a metallurgical furnace the combination with a heated chamber of a plurality of vertical rolls supported in two straight rows adjacent to the roof of said chamber, means for rotating said rolls, and means for inclining the axes of all of said rows in the vertical plane containing the longitudinal axis of the furnace.

5. In a metallurgical furnace the combination with a heated chamber of a plurality of vertical rolls supported in a row therein, means for rotating said rolls in one direction, at uniform speed, a second row of rolls supported at one side of said first row and movable transversely of the furnace, and means yieldingly moving each roll of said second row toward its companion roll in said first row.

6. A sheet annealing furnace having mounted in its roof a plurality of paired vertical rolls adapted to receive the upper edge of the sheet between them, means pressing said rolls together laterally of the furnace with sufficient force to hold the sheet from dropping vertically, and means for driving said rolls to cause said sheet to pass gradually through the furnace from end to end.

7. A sheet annealing furnace having mounted in its roof a plurality of paired vertical rolls adapted to receive the upper edge of the sheet between them, means pressing

said rolls together laterally of the furnace with sufficient force to hold the sheet from dropping vertically, means for driving said rolls to cause said sheet to pass gradually through the furnace from end to end and means for inclining the shafts of all said rolls in a vertical plane parallel to the longitudinal axis of the furnace whereby slippage of the sheet is counterbalanced.

8. In a metallurgical furnace for the heat-treatment of metal sheets, the combination of furnace walls defining a heating chamber, a plurality of rows of vertical rolls mounted in the roof of the furnace adapted to receive the upper edge of the sheet between them, the vertical dimension of the sheet being greater than that of the rolls, means pressing said rolls together with sufficient force to hold the sheet by friction alone from dropping vertically, and means driving said rolls in such direction and at such speed as to cause said sheet to pass steadily and uniformly through said chamber, certain of the rolls adjacent to the wall of said furnace but outside of the heating chamber being of greater vertical extent than the rolls inside said heating chamber and geared thereto.

9. In a metallurgical furnace for the heat-treatment of metal sheets, the combination of furnace walls defining a heating chamber, a plurality of rows of vertical rolls mounted at the top of said chamber, the rolls of different rows being arranged adjacent to each other and rotating in opposite directions and adapted to receive between them the upper edge portion of a vertical sheet, the width of the sheet being greater than the length of the engaging portions of said rolls, means for rotating said rolls at uniform speed, and means forcing together the companion rolls of the different rows into gripping engagement with said sheet.

10. In apparatus for heat-treating sheets, a conveyor for flat horizontal sheets, means for automatically raising said sheets to vertical position in the vicinity of the furnace, means automatically gripping the upper margins of the sheets and conveying the same through the furnace without other contact to the faces thereof, said means serving after the emergence of said plates from the furnace to uphold the same in vertical position until sufficiently cooled and subsequently delivering them substantially to horizontal position.

11. The combination with a sheet-annealing furnace of a conveyor comprising a horizontal series of spaced horizontal rolls extending to a point near the furnace at each end and a series of other rolls of gradually increasing inclination at the entering end of the furnace and gradually decreasing inclination at the discharge end thereof, in combination with conveyor mechanism adapted to convey said sheets through the furnace in vertical suspended position.

12. In a sheet-treating furnace, the combination with top and side walls defining a chamber of a plurality of parallel rolls therein having their axes approximately upright, journal bearings for said rolls above said chamber, means for moving said bearings relative to each other to produce such an inclination of the roll-axes as to cause a gradual upward or downward movement of the sheet, and means for shifting certain of said bearings lengthwise of said chamber to vary the inclination of the roll-axes.

13. In a furnace the combination with a heated chamber of a plurality of vertical rolls supported in two straight rows adjacent to the roof of said chamber adapted to receive between them the upper edge of the vertical sheet, means for rotating said rolls, and means for inclining the axes of all of said rolls parallel to the vertical plane containing the axis of the furnace to counteract any down-slip of the sheet carried thereby.

14. In a furnace the combination with a heated chamber of a plurality of vertical rolls supported in two straight rows adjacent to the roof of said chamber adapted to receive between them the edge of a vertical sheet, means for rotating said rolls, and means for inclining the axes of all of said rolls parallel to the vertical plane containing the axis of the furnace to counteract any down-slip of the sheet carried thereby, and means for engaging the upper edge of the sheet to limit its upward movement.

15. In a furnace the combination with a heated chamber of a plurality of vertical rolls supported in two straight rows adjacent to the roof of said chamber adapted to receive between them the edge of a vertical sheet, means for rotating said rolls, and means for inclining the axes of all of said rolls parallel to the vertical plane containing the axis of the furnace to counteract any down-slip of the sheet carried thereby, certain of said rolls being provided adjacent their upper ends with flanges adapted to engage the upper edge of said sheet to limit its upward movement.

16. A metallurgical furnace having a plurality of vertical rolls therein defining two adjacent lines of movement for articles to be treated in said furnace, and means rotating said rolls in such directions as to cause articles in different lines to move in opposite directions whereby the entering articles are enabled to absorb the residual heat of the emerging articles.

17. A metallurgical furnace having a plurality of vertical rolls therein arranged in rows, means for rotating all the rolls of one row in one direction and of another row in an opposite direction to cause articles between said rolls to move in opposite directions through said furnace, whereby the entering articles are enabled to absorb the residual heat of the emerging articles.

18. In a metallurgical furnace for the heat-treatment of metal sheets, the combination of furnace walls defining a heating chamber and three rows of vertical rollers mounted at the top of said chamber, the rolls of adjacent rows being arranged opposite each other, means for rotating the rolls of said middle row whereby the sheets on opposite sides thereof will be moved in opposite directions, and means for forcing the rolls of the outer rows towards those of the middle row to grip in supporting relation the edges of sheets presented thereto.

In testimony whereof I hereunto affix my signature.

FRANK A. FAHRENWALD.