Feb. 17, 1931. R. S. COCHRAN 1,793,209

FURNACE

Filed May 18, 1929 2 Sheets-Sheet 1

Fig. 3

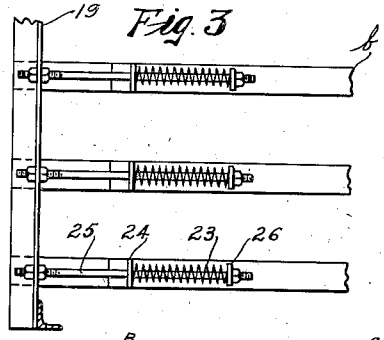


Fig. 1

Fig. 7

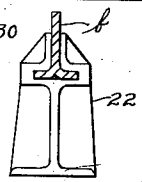


Fig. 4

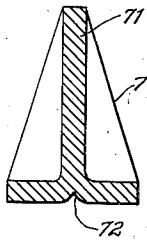


Fig. 2

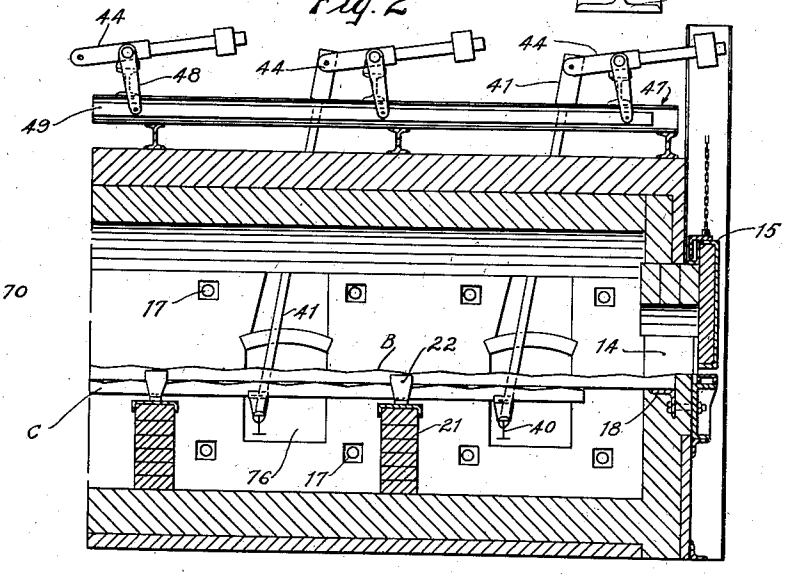


Fig. 5

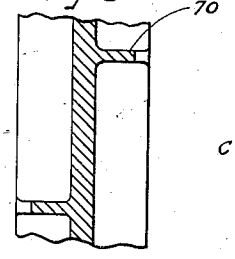
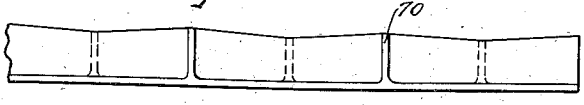


Fig. 6



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Fig. 8

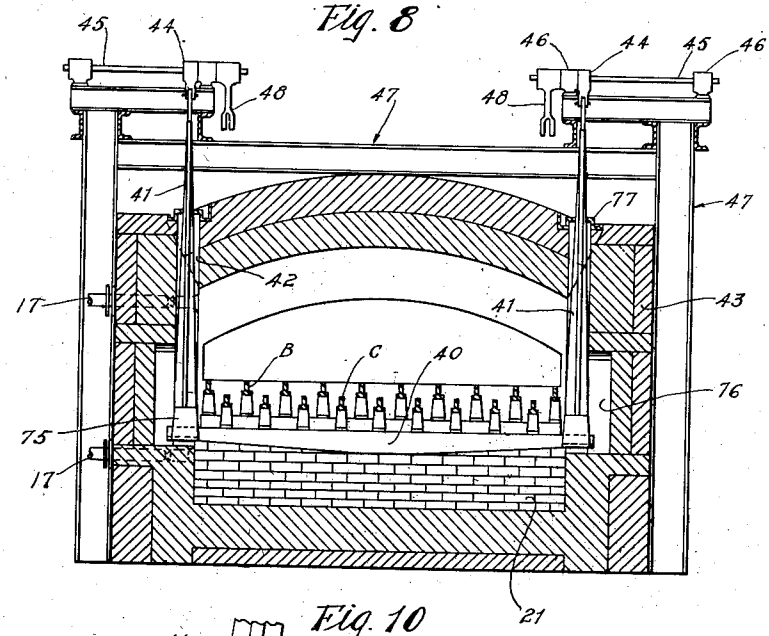


Fig. 10

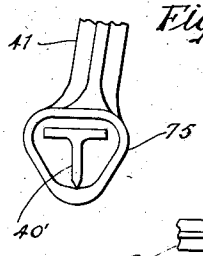


Fig. 11

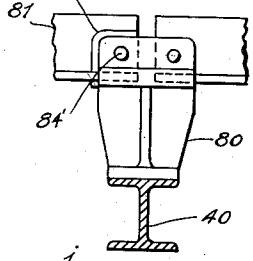


Fig. 9

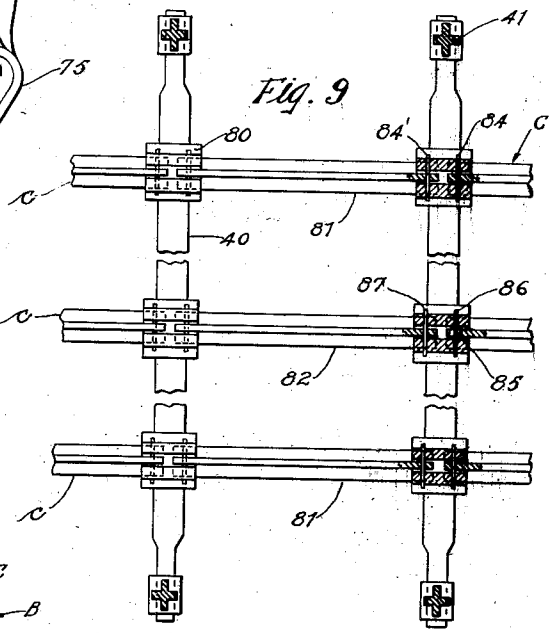


Fig. 12

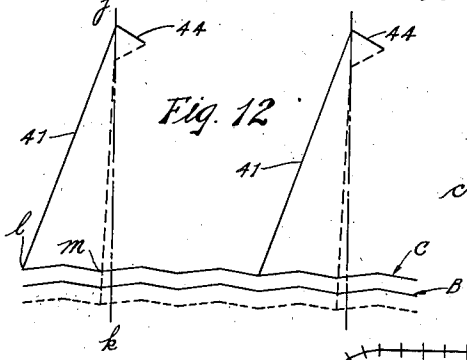
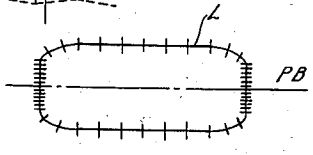


Fig. 13



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UNITED STATES PATENT OFFICE

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FURNACE

Application filed May 18, 1929. Serial No. 364,117.

This invention relates to a continuous heating furnace embodying means for moving the work such as sheet metal through the furnace in a series of steps and has among its objects to provide a conveying mechanism of such type that the number of openings through which air may leak into the furnace chamber shall be reduced to a minimum; to provide means for maintaining the work supporting bed rails under longitudinal tension; to provide means for compensating for the expansion and contraction of the rails of which the work-conveying frame is composed; to provide for operating the work-conveying frame in such a manner that vibration and lateral oscillation of the frame shall be reduced to a minimum, and provide other improvements hereinafter more fully appearing.

Referring to the drawings, Fig. 1 is a view of the charging end of the furnace in vertical section and showing how the work-loading end of the work-conveying frame is supported exteriorly of the furnace, the frame being shown at the forward limit of its horizontal stroke and in position to be lowered below the plane of the fixed work supporting bed.

Fig. 2 is a view in vertical section of the discharging end of the furnace, the work-conveying frame being shown below the fixed work-supporting bed and in position to be elevated above the plane thereof to lift the work therefrom.

Fig. 3 is an enlarged detail in bottom plan of a fragment of the fixed work-supporting bed showing how the rails of which the bed is composed are kept under longitudinal tension.

Fig. 4 is an enlarged transverse section of the rails of which both the work-supporting bed and work-conveying frame are composed.

Fig. 5 is a horizontal section through the rail shown in Fig. 4.

Fig. 6 is a side elevation of the rails of which the work-supporting and work-conveying frame are composed, the view being on a reduced scale as compared with Figs. 4 and 5.

Fig. 7 is a detail showing the saddles in which the rails of the work-supporting bed are mounted.

Fig. 8 is a vertical transverse section through the furnace.

Fig. 9 is an enlarged detail view of a portion of the work-conveying frame showing how the sides and intermediate rails (only one of which is shown) of the frame are secured to the cross bars of the bifilar suspensions in a manner to permit free longitudinal movement of the intermediate rails independently of the side rails which latter are non-movably secured to said cross bars.

Fig. 10 is a side elevation of the connection between the bifilar suspension side arms and the cross bar thereof.

Fig. 11 is an enlarged detail view showing how the side rails of the work-conveying frame are secured against relative movement.

Fig. 12 is a schematic view illustrative of the manner in which the work-conveying frame is moved relatively to the fixed work-supporting bed.

Fig. 13 is a diagram showing the path traversed by the work-conveying frame.

The furnace chamber is of tunnel form having end openings 14 cooperating with which are doors 15 adapted to be raised and lowered in any suitable manner, the openings being above the floor 16 of the chamber. There is no stack, the heating gases finding exit through the end openings of the furnace chamber, the furnace being heated by fluid fuel burners such as gas burners 17 positioned in the chamber side walls and firing directly into the chamber.

There is a work-supporting bed or hearth generally indicated at B on which the sheets or work rest between periods of translation by a work-conveying frame generally indicated at C. Said bed and frame are laterally discontinuous and consist of rails of the type shown in Figs. 4, 5 and 6. For convenience of description the rails comprising the hearth or bed B will be identified by reference character *b*; the side rails of the frame C by *c* and the rails therebetween by *c'*.

The rails of the work-supporting bed B are non-movably secured at one end of the furnace preferably at the exit end as indicated in

Fig. 2, in any suitable manner as by being welded to a transversely extending angle member 18 which is rigidly connected to the exterior shell of the furnace in any appropriate manner. These rails extend through the charge end opening of the furnace and are slidably supported on a cross bar 19 which in turn is supported on suitable standards 20. For illustrative purposes an intermediate portion of the bed rails in Fig. 1 is broken away. The rails intermediate their ends are supported on piers 21 provided with fixed saddles 22 (see Fig. 7) wherein the rails are free to slide longitudinally as they expand and contract.

In order to minimize any tendency of the bed rails *b* to bend laterally as they expand, they are maintained under tension in any suitable manner as by heavy coil springs 23 confined between suitable abutments one of which is affixed to the rail. The arrangement is clearly shown in Figs. 1 and 3 and as shown each rail *b* is provided with an angular abutment 24 through which and through the spring 23 extends a rod 25 adjustably secured to the cross bar 19 and provided with an abutment 26 between which and the rail abutment 24 the spring is confined. By maintaining the bed rails *b* under individual tension as above described the rails are always maintained in parallelism within the furnace, the arrangement materially contributing to the successful operation of the furnace as a whole and constituting an important feature of the present invention.

It has been demonstrated by practical experience that complicated and delicate thermo-electric temperature controllers are practically valueless in the ordinary steel mill. There is usually no suitable place for the instrument and the men operating the furnace as a rule disregard such instruments and prefer to regulate the temperature according to their own notions. The problem has been to devise some simple and practical temperature controlling mechanism which the average furnace operator could understand and repair when necessary.

By utilizing the expansion and contraction of the bed rails *b* I am enabled to provide a temperature controlling mechanism which is simple in construction and admirably adapted to ordinary steel mill conditions. 27 indicates a cable secured at one end to the free end of one of the bed rails *b* the other end of the cable being connected to the operating arm 28 of a fuel controlling valve 29 in a supply pipe 30 from which branch pipes lead to the burners 17. Carried by the valve arm is an adjusting screw 31 the cable being secured to one end thereof as by a swivel connection 32, the screw being manually adjustable as by a hand wheel 33 at the end of a rod which is suitably connected to the screw. A spring 34 tends to turn the valve in a manner to open it and tends to keep the cable taut. As the bed rails *b* become heated they expand. The elongation of the rail to which the cable is secured tends to close the fuel valve, the valve spring 34 on the other hand tending to open it. Adjustment of the screw 31 determines the slack in the cable that must be taken up by the expanding rail before the valve may be operated by the cable. The furnace operator by merely turning the hand wheel 33 can easily regulate the setting as will be readily appreciated. 35 indicates a main shut-off valve in the supply pipe 30.

The hearth or bed B is of course laterally discontinuous since the rails *b* of which the bed is composed are in laterally spaced relation. The work-moving or conveyer frame C is likewise laterally discontinuous and is vertically movable through the plane of said bed, the rails of the bed and frame being in interdigitated relation as will be clearly seen by reference to Fig. 8. Said frame is of a length to extend outwardly of the furnace at its charge end for a suitable distance to permit the sheets or other work to be loaded on the conveyer.

The work-moving frame C is supported on a series of bifilar suspensions the cross bars or beams of which are indicated at 40 and the side arms at 41, the cross bars being wholly within the furnace chamber and the side arms projecting upwardly out of the furnace through slots 42 along the side walls 43 of the furnace chamber the upper ends of the arms being connected to rocker arms 44 affixed to shafts 45 mounted in suitable bearings 46 supported on a suitable framework generally indicated at 47. Vertical movement is imparted to the frame C by rocker arms 44 there being affixed to each rocker arm shaft 45 a rocker arm 48, a link 49 connecting the rocker arms 48 for simultaneous operation, there being provided a link for each set of rocker arms at opposite sides of the furnace as will be readily understood.

Rocking movement is imparted to the bifilar suspension rocker arms by means including a cam 50 through intermediate mechanism including a rocker 51, a link 52 and a rocker arm 53 affixed to the overhead shafts 45. Horizontal reciprocatory movement is imparted to the frame C by means including a cam 55, a rocker 56 and a link 57 suitably connected to the frame. The layout of the mechanism for imparting vertical and horizontal reciprocation to the conveyer frame C is more or less schematic for illustrative purposes. In actual practice the cams are mounted on a common shaft which is driven in any suitable manner. The cams are of such forms and in such relation to each other that the path traversed by a point in the conveyer frame is substantially as shown by the

diagram in Fig. 13. This motion will be more fully explained hereinafter.

That portion of the conveyer frame C which projects beyond the charging opening of the furnace is preferably supported from below by mechanism which will reduce to a minimum any tendency to lateral sway of the frame, while it is being reciprocated. 60 indicates a platform provided with top cross beams 61 which in turn are provided with a series of laterally spaced blocks or chairs 62 to which the individual rails of the frame C are affixed. These blocks are of a height to permit the frame C to be elevated above the plane of the bed B the required distance as will be readily understood. The platform rides on rollers 63 carried by the upper ends of rockers 64 which latter are connected by a link 65 for simultaneous operation, the link being connected to the rocker arm 51 previously referred to. Inclined runways 66 beneath the platform for the rollers 63 cooperate with the other parts of the mechanism in a manner to impart to the platform a cycle of movement in conformity with that indicated in Fig. 13.

Before describing other features of the invention the cycle of movement of the conveyer frame C will first be described. Referring to Fig. 13, PB indicates the plane of the bed or hearth B and the endless line L the path of movement of a point on the top of the conveyer frame C. The short lines cutting the line L indicate equal degrees of rotation of the cams 50 and 55 which as previously explained rotate together at the same rate of speed. The cams are of such form that relatively slow uniform vertical motion is imparted to the frame in passing through the plane PB of the bed B after which the rate of movement is increased, it being noted that the transition from vertical to horizontal movement is by an arcuate path. The combination of means for effecting the described movement of the conveyer frame in accordance with Fig. 13 is described and claimed in my application Serial No. 272,020 filed April 23, 1928 (patented December 16, 1930, No. 1,784,812).

Fig. 12 is a diagrammatic representation of the movements of the conveyer frame C with respect to the overhead supports for the bifilar suspensions on which the said frame is supported. Before explaining these movements it should be pointed out that the upper surface of the rails of which the hearth B and frame C are composed is of undulatory form. The distance between the crests of the undulations is the same as the length of the step of the conveyer or in other words is the same as the distance between the limits of the horizontal stroke of the conveyer frame C. However, as regards the movement now to be explained it is quite immaterial what may be the surface form of said rails. Line *j*—*k* indicates the vertical plane wherein the side arms 41 of the bifilar suspension would naturally come to rest under the influence of gravity. Points *l* and *m* indicate the extreme limits of horizontal reciprocation of the conveyer frame. It will be noted that both of the points *l* and *m* are at the same side of the vertical line *j*—*k*. The conveyer frame C is shown as elevated above the fixed bed B and in position to move from point *l* to point *m*. In normal operation the frame would have lifted a sheet from the bed B and be ready to move the sheet forwardly, that is to say, toward point *m*. If the frame C were free to swing it would obviously oscillate back and forth until it finally came to a natural position of rest as indicated by the vertical line *j*—*k*. It will also be appreciated that while the frame is at point *l* there is a gravity pull on the rails from left to right. Any slack in the frame is therefore taken up. If the point *l* were at the right of the neutral position *j*—*k* the pull on the rails would of course be from right to left.

In accordance with the present invention the natural oscillation of the bifilar suspension forwardly i. e. to the right of point *l* is arrested, this arrest preferably taking place before the suspension passes through its natural point of rest in the vertical *j*—*k* this point of arrest being indicated at *m*. At point *m* the suspension and hence the frame is lowered below the plane of the bed B as indicated by the short broken lines, the cycle being as shown in Fig. 13. It will now be clear that by arresting the forward oscillation of the frame as aforesaid the frame rails will always be maintained under gravity pull or tension in a direction from left to right with reference to the drawings and back-lash in the conveyer mechanism as a whole effectually prevented. It will also be readily apparent that by arresting the forward movement of the frame before it passes through the vertical *j*—*k* and hence before the pull of gravity on the frame is reversed there is no tendency for the cam engaging rocker arm 50 to leave its cam. Other advantages of the arrangement will be readily apparent to those skilled in the art.

Referring to Fig. 1 it will be observed that the conveyer frame C and bed B are in the same plane and that the undulations in the upper surface of the rails are laterally alined, the frame being at the right or forward limit of its stroke. As previously stated the distance between adjacent crests of the undulation is the same as the length of horizontal stroke of the frame. A sheet resting on the conveyer frame will therefore be deposited on the bed B without change in curvature. An undulating rail surface tends to impart an undulatory form to the sheets supported thereon such form tending to prevent the side edges of the sheet from sagging and

consequently from becoming wedged between the bed and conveyer-frame rails as the frame passes through the plane of the bed.

Conveyer rails embodying an undulatory work-supporting surface are disclosed and claimed in my copending application, Serial No. 310,031 filed October 3, 1928. The rails are preferably of inverted T-form and are provided with a series of side webs 70, the webs on one side being positioned midway the webs on the other side. These webs while serving to brace the upstanding portion 71 of the rails also serve to prevent the side edges of the sheets from becoming wedged between the rails of the bed and frame as the latter passes through the bed.

The base of the rails beneath the upright portion 71 is preferably cusped as indicated at 72 in a manner to make the heat capacity at the head of the T substantially the same as the side portions of the base thereby reducing the tendency of the head while cooling after casting to remain hotter than the adjacent portions of the rails with consequent elimination of unequal expansion between the upper and lower surfaces of the rail such unequal expansion tending to cause the rail to assume a longitudinally curved form.

It will be noted that the burners 17 are positioned to fire both above and below the conveyer frame. The hearth or bed supporting piers 21 adjacent the ends of the furnace are preferably imperforate thereby serving as baffles for preventing such air as may enter through the end opening 14 of the furnace from flowing beyond the piers.

The bifilar suspension side arms 41 are preferably of the cross section shown in Fig. 9, i. e., in the form of a cross, and tapered as clearly shown in Fig. 8. A side arm of this type is unusually strong and rigid and does not tend to vibrate as would, for example, a uniformly round rod under tension. Where a conveying frame is supported on a series of bifilar suspensions as in the present furnace the combined effect of vibration in the side arms is most objectionable since these vibrations are communicated to the conveying frame. The importance of reducing vibration in the side arms will therefore be readily appreciated.

The conveyor-supporting cross beams 40 except at their ends are preferably of I-form in cross section as shown in Fig. 11. At their ends these beams are preferably of T-form as shown in Fig. 10 and are seated in stirrups 75 provided at the lower ends of the side arms 41 whereby there is provided a bearing of the line or knife-edge type, the stirrup being relatively wide longitudinally of the beam 40 as clearly indicated in Figs. 8 and 9. A bearing of this type has unusual utility in a furnace embodying bifilar suspensions for the conveyor. It need not be machined as would a round bearing, thereby effecting a material saving in cost of manufacture, and it will not bind but on the contrary will readily adjust itself to irregularities in alinement of the moving parts and of course need not be lubricated.

Referring to Fig. 10 it will be noted that the side arm is inclined to the vertical or in other words to the upright portion 40′ of the cross beam. This is due to the fact that when the side arm is at the right or forward limit of its swing as shown in Fig. 1 corresponding to point *m* in Fig. 12 the arm is at an angle to the vertical as previously explained in conection with Fig. 12. The type of bearing herein disclosed is an improvement on the bearing disclosed in my copending application Serial No. 272,020 filed April 23, 1928 as are also other features of this invention.

Where the cross beams 40 of the bifilar suspensions are wholly within the furnace chamber, the chamber side walls are preferably provided with reentrant portions 76 into which the ends of the cross beams project and from which the side arms 41 project upwardly out of the chamber through the side passages 42, the tops of these passages being capped by plates 77 which are slidably carried by the side arms as will be readily understood.

The construction of the conveyer frame C forms an important feature of the invention and will now be described, reference being had more particularly to Figs. 9 and 11. For simplicity of illustration Fig. 9 shows but one of the rails between the boundary side walls *c*, the details of construction of the intermediate rails being the same. Mounted on the cross beams 40 are pedestals or saddles 80 wherein the respective rails are seated. Both the outer and inner rails are composed of similar sections 81 and 82 respectively and are of a length to extend between the cross beams 40 of the bifilar suspensions some clearance being allowed between adjacent ends of the sections. One end of each rail section 81 is immovably secured to its pedestal as by being welded thereto such welding being indicated at 83 in Fig. 11 the other end being anchored to its pedestal by a pin 84. The welded end of the rail section is also shown as provided with a pin 84′ but this pin serves to initially hold the section in place while the frame is being put together, the pin not serving as a pivot as does pin 84.

Since the rail sections 81 expand when heated the cross beams 40 will obviously assume a different space relation than when said rail sections are cold. In accordance with this invention the space relation of the cross bars when the rail sections 81 are cold is such that the distance between the longitudinal axes of adjacent cross beams 40 is less than the distance between the adjacent overhead points of suspension of the side

arms 41 by an amount equal to the expansion of said sections. It follows therefore that when the frame is heated the distance between the longitudinal axes of said cross beams 40 will be substantially the same as the distance between points of suspension of the side arms longitudinally of the furnace.

The intermediate rail sections 82 are rigidly secured at one end but are slidably secured at the other end. Thus one end of such rail section may be provided with a slot 85 through which is passed a pin 86 the other end being non-movably secured by pin 87 or by being welded in place in its pedestal, the pins 87 having utility in assemblying the rail sections 82 as will now be readily understood.

A conveyer frame constructed as aforesaid is substantially free from warping since any difference in expansion between the side rails *c* and the intermediate rails *c'* is compensated for by allowing the intermediate rail sections to adjust themselves as they will. The side rails *c* being in effect continuous give rigidity to the frame as a whole.

Although the invention has been described with considerable particularly it will nevertheless be obvious that many changes may be made in size, shape and arrangement of certain parts without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In a furnace, the combination of a work-supporting bed embodying parallelly extending rails and means for maintaining the rails under tension.

2. In a furnace, the combination of a work-supporting bed embodying laterally spaced longitudinally extending rails, and means for maintaining the rails under tension.

3. In a furnace, the combination of a work-supporting frame of rectangular form embodying parallelly extending rails, cross beams on which the rails are supported, the side rails being non-slidably secured to the cross beams, and the intermediate rails being relatively movable with respect to said side rails.

4. In a furnace, the combination of a work-supporting frame of rectangular form embodying parallelly extending rails, cross beams on which the rails are supported, the side rails being non-slidably secured to the cross beams, the intermediate rails comprising aligned rail sections the adjacent ends of said sections being relatively movable.

5. In a furnace, the combination of a work-supporting frame of rectangular form embodying parallelly extending rails, cross beams on which the rails are supported, the side rails being non-slidably secured to the cross beams, the intermediate rails comprising aligned rail sections one end of said sections being non-movably secured to the respective cross beams and the other end being movably supported thereon.

6. In a furnace, the combination of a group of laterally spaced rails forming a support for work, a series of floating cross beams on which said rails are supported, the side rails of said group being non-slidably secured to said beams, the rails between said side rails comprising aligned rail sections one end of the respective sections being non-slidably secured to the respective cross beams and the other end being slidably supported thereon.

7. In a furnace, the combination of a series of floating cross beams, a work-supporting frame supported on the cross beams, means swingable in a vertical plane for supporting the cross beams, and means for oscillating said frame between points which are at different distances from the natural position of rest of said frame.

8. In a furnace, the combination of a series of floating cross beams, a work-supporting frame supported on the cross beams, means swingable in a vertical plane for supporting the cross beams, and means for oscillating the frame between points which are at the same side of the natural position of rest of said frame.

9. In a furnace, the combination of a series of cross beams, a work-supporting frame supported on the cross beams, means swingable in a vertical plane for supporting the cross beams, the connections between said means and cross beams including bearings of the knife-edge type, the ends of the cross beams being of T-form in cross section.

10. In combination, a tunnel-like heating chamber having end openings through which work may enter and leave the chamber respectively, a work-conveying frame adapted to convey work through the chamber in a series of steps, a series of bifilar suspensions on which the frame is hung for oscillatory movement, said frame being of a length to extend exteriorly of the chamber, means for supporting said projecting portion comprising a platform secured to the frame therebelow, means independent of the bifilar suspensions for supporting the platform, and means for imparting to the platform a cycle of movement in substantial conformity with that imparted to the frame by the bifilar suspensions.

11. In combination, a tunnel-like heating chamber having end openings through which work may enter and leave the chamber respectively, a work-conveying frame adapted to convey work through the chamber in a series of steps, a series of bifilar suspensions on which the frame is hung for oscillatory movement, said frame being of a length to extend exteriorly of the chamber, means for supporting said projecting portion comprising a platform secured to the frame therebelow, means independent of this bifilar sus-

pensions for supporting the platform, and means including a cam actuated rocker mechanism for imparting to the platform a cycle of movement in substantial conformity with that imparted to the frame by the bifilar suspensions.

12. In combination, a work supporting bed and a relatively movable work-conveying frame both of which are laterally discontinuous to permit the frame to be moved through the plane of the bed, means for moving the frame vertically and horizontally in a manner to move the work step by step along said bed, the upper surface of both bed and frame being of sinuous form, the distance between the crests being such that on movement of the frame through the plane of said bed the crests of the bed and of the frame shall be in register whereby sheets may be elevated from the support and redeposited thereon by the frame without flexing.

13. In a heating furnace, the combination of a longitudinally extending work-supporting bed, a longitudinally extending member adapted to be moved longitudinally and transversely of said bed, links pivoted to said member and extending upwardly therefrom for supporting it, means pivoted to the upper end of the links for elevating the links whereby to elevate said member above said bed, and means for confining the longitudinal path of travel of said member between points which are at relatively different distances from the natural position of rest of said member.

14. A furnace conveyer comprising a work support and a work-moving member disposed side by side, said member being adapted to move vertically and longitudinally relative to said support, links pivoted at one end to said member and extending upwardly therefrom for supporting it, said links being oscillatable in directions parallel with the length of said member, means pivoted to the upper end of the links for elevating the links whereby to elevate said member with respect to the work support, and mechanism connected to said member for longitudinally moving it between points at relatively different distances from the natural point of rest of said member.

15. In a furnace, the combination of a longitudinally extending support for work, a frame movable through the plane of said support, links pivoted to the sides of the frame and extending upwardly therefrom, means to which the upper ends of the links are pivoted, said frame unless otherwise controlled being free to oscillate longitudinally of said support, mechanism including a cam for limiting the longitudinal displacement of said frame to a path the middle point of which is at one side of the natural point of rest of said frame whereby gravity tends to move the frame beyond said middle point in a direction towards said natural point of rest, means for rotating said cam; and means for actuating the link-supporting means in a manner to raise and lower the frame with respect to the work support.

16. In a furnace, the combination of a work bed, a work-moving frame associated with said bed, a series of swingable links for supporting said frame, supports to which the upper ends of the respective links are pivoted, the connections between said links and frame each comprising a loop at the lower end of each link and a bearing of the knife-edge type projecting laterally from the frame and seated in said loop, each link being of gradually increasing cross section from top to bottom and being in the form of a cross in cross section whereby to dampen vibration in the link.

In testimony whereof I affix my signature.

RALF S. COCHRAN.